Advanced Shipboard Desalination
Industry / Applied Researcher Day

Office of Naval Research

Future Naval Capabilities Program: Advanced Shipboard Desalination

BAA 09-013: Component Development for Advanced Shipboard Desalination Systems

Opening Remarks

Paul Armistead

Office of Naval Research

Industry/ Applied Researchers' Day

February 25, 2009 Asilomar Conference Center, Pacific Grove, CA

Background

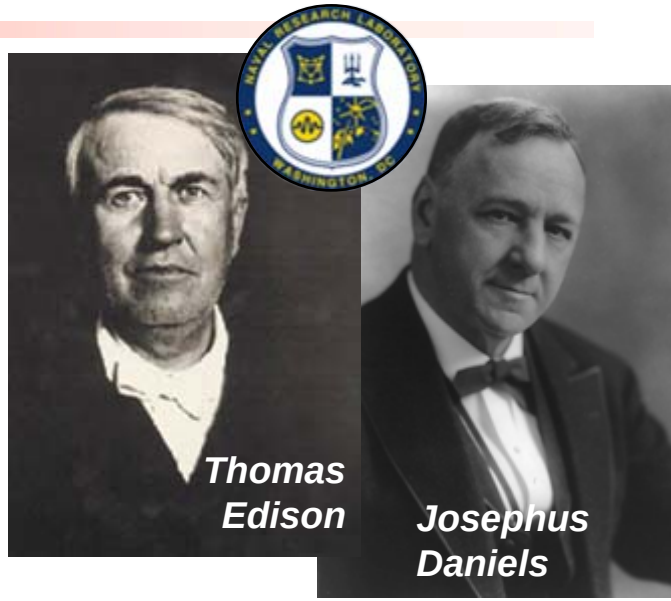
- ONR invested in membrane development for shipboard waste water treatment from about 1994-2006.
- ONR managed the Expeditionary Unit Water Purification program from 2003 to 2007 which invested in both basic and applied research towards bringing down the costs of desalination.
- Army TARDEC and NFESC Desalination Research Facility improved Army and Marine Corps desalination and purification capabilities by developing the Tactical Water Purification System and Lightweight Water Purifier.
- EUWP team developed technology demonstration units and demonstrated their performance during humanitarian missions such as in Biloxi, MS after hurricane Katrina.

Background

- Performance of EUWP technology demonstrators suggested that it was possible to build robust units that
  - were significantly smaller than current Navy units
  - used significantly less energy than current Navy units
  - would require less maintenance than current Navy units
  - AND would be able to desalination water from littoral source waters without significantly increased maintenance.

Naval Research: Statutory Mission

Naval Research Laboratory *(Appropriations Act, 1916)*:
"[Conduct] exploratory and research work…necessary… for the benefit of Government service, including the construction, equipment, and operation of a laboratory…."



Office of Naval Research *(Public Law 588, 1946)*:
"… plan, foster, and encourage scientific research in recognition of its paramount importance as related to the maintenance of future naval power, and the preservation of national security.… "

Transitioning S&T *(Defense Authorization Act, 2001)*:
"…manage the Navy's basic, applied, and advanced research to foster transition from science and technology to higher levels of research, development, test, and evaluation."

Future Naval Capability Programs

- ONR manages 6.1 funding for basic research, 6.2 funding for applied research, and 6.3 funding for advance technology demonstration.
- Future Naval Capability programs are 3 to 5 year programs to take new technologies from lab validation or early prototype to mature prototype tested in a realistic environment.
- Advanced Shipboard Desalination FNC is a 5 year program
  - 2 years of maturing promising 'component' level technologies to nearly mature prototypes (minimal risk with making a fully mature prototype)
  - 3 years to assemble components in to robust mature prototype desalination systems, and extensively test them
- BAA 09-013 Component Development for Advanced Shipboard Desalination Systems is for the first 2 years of the FNC program.

Advanced Shipboard Desalination
Future Naval Capability 2010-14

Agenda

1:30 - 1:50	Opening Remarks	**Paul Armistead** Office of Naval Research
1:50 - 2:10	Current Navy Shipboard Desalination Capabilities	**Dave Nordham** NSWCCD-SSES
2:10 – 2:30	Current Army/Marine Corps Desalination Capabilities	**Jay Dusenbury** US Army, TARDEC
2:30 – 2:50	Further Developments under ONR EUWP Program, Demonstration Units and R&D	**Mark Miller** US Army, TARDEC
2:50 - 3:10	Break	
3:10 – 3:40	Navy Unique Needs and Requirements	**John Heinzel** NSWCCD-SSES
3:40 – 4:20	The FNC Program and Phase I BAA	**Paul Armistead**
4:20 – 4:40	BAA Details, Dates, Procedures	**Ian Peek** NSWCCD-SSES
4:40 – 5:00	Government Testing Capabilities	**Bill Varnava**
NFESC Desalination Research Facility, Port Hueneme		NFESC
Bureau of Reclamation Test Sites		**Michelle Chapman** US Bureau of Reclamation
5:00 – 5:30	Questions and Discussion	**All**

Advanced Shipboard Desalination
Future Naval Capability 2010-14

Advanced Shipboard Desalination IPT

Paul Armistead	Office of Naval Research
Dave Nordham	NSWCCD-SSES, Philadelphia
Larry Johnson	Fulcrum
John Heinzel	NSWCCD-SSES, Philadelphia
Ian Peek	NSWCCD-SSES, Philadelphia
Jim Higgins	NSWCCD-Carderock
Bill Varnava	US Navy NFESC
Bob Shalewitz	US Army TARDEC
Jay Dusenbury	US Army TARDEC
Mark Miller	US Army TARDEC c/o NFESC
Michelle Chapman	US Bureau of Reclamation

Current Navy Desalination Capability

Presented by:

NAVSEA
WARFARE CENTERS
Philadelphia

Dave Nordham, NSWCCD-SSES Code 923
(215) 897-1774 david.nordham@navy.mil

U.S. Office of Naval Research Industry/Applied Researchers Day
25 February 2009

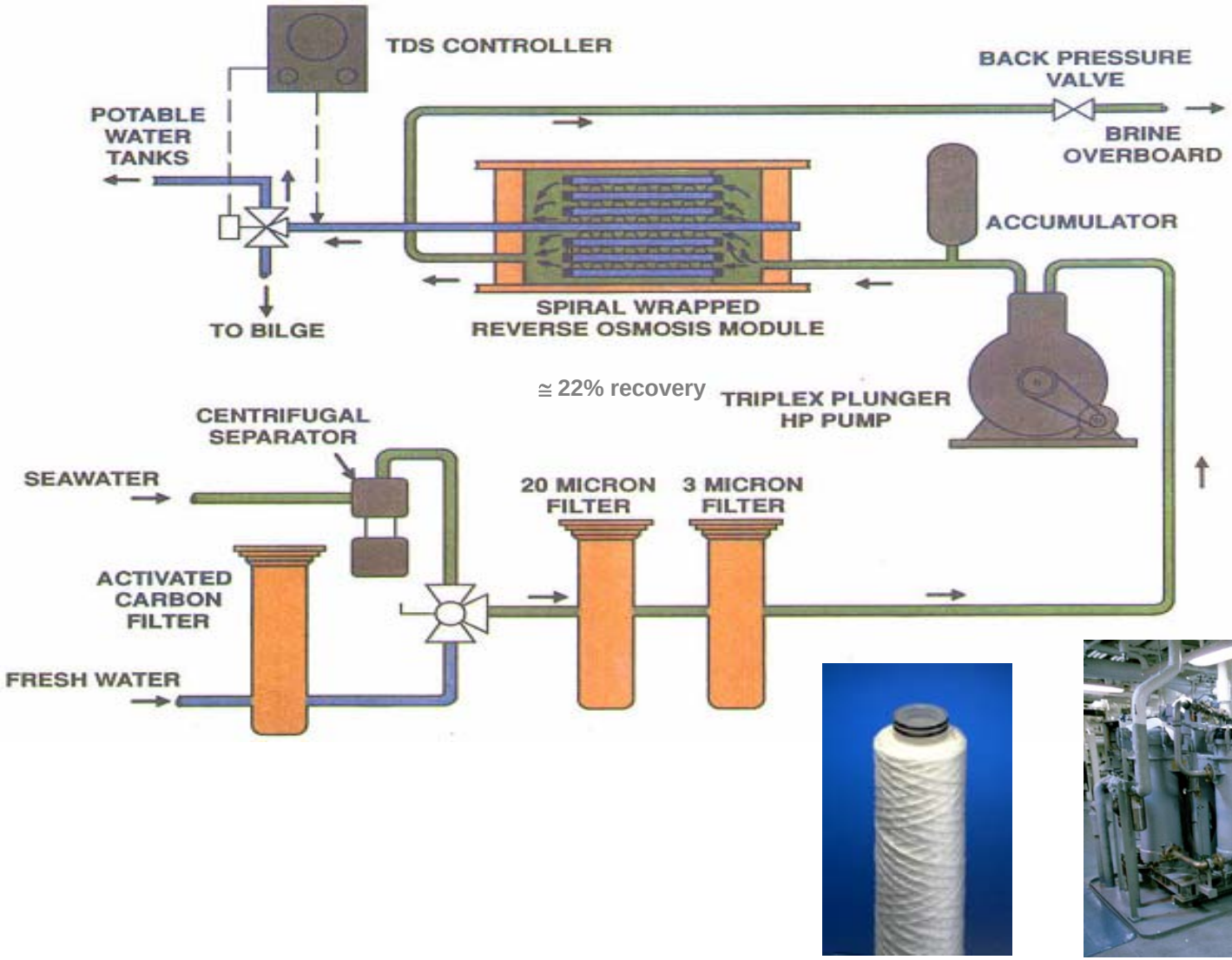
History Of Navy Shipboard Desalination

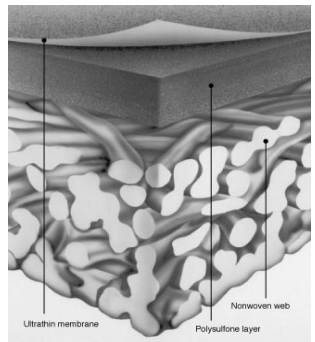
- **Navy labs began investigating Reverse Osmosis (RO) membrane desalination in 1970's**
  - ► **Replacement for high maintenance, costly distilling units**
  - ► **First two (commercially developed) RO designs failed**
  - ► **Navy-designed prototype unit installed in 1988 on USS FLETCHER**

  - – **Successful OPEVAL and follow-on deployments**
  - – **Basis for the 12,000 gal/day Navy Standard RO (NSRO) unit now in wide service in the fleet**

- **NSRO technology is design basis for production of shipboard water on new ship designs.**

Navy Standard Reverse Osmosis (NSRO) Plant





RO Desalination System Fleet Population

RO Plants Aboard US Navy Ships

Ship Class	RO Plant Capacity (gal/day)	Number In-Service/Planned
MCM 1	3,000	28
SSN/SSBN	4,000/6,000	38/100+
FFG 7 Class	6,800	42/20
DDG 51 Class	12,000	106/18
DDG 1000	12,000	0/TBD
CG 21	TBD	0/TBD
SC 21	TBD	0/TBD
CG 47 Class	12,000	24/20
LCS	2,000	0/TBD
LHA 1 Class	12,000	12/0
LPD 17 Class	24,000	12/15
LHD 8	50,000	2/--
CVN 65	12,000	4/--
CVN 21 Class	125,000	--/4+

Over 2,500,000 hours of successful operation

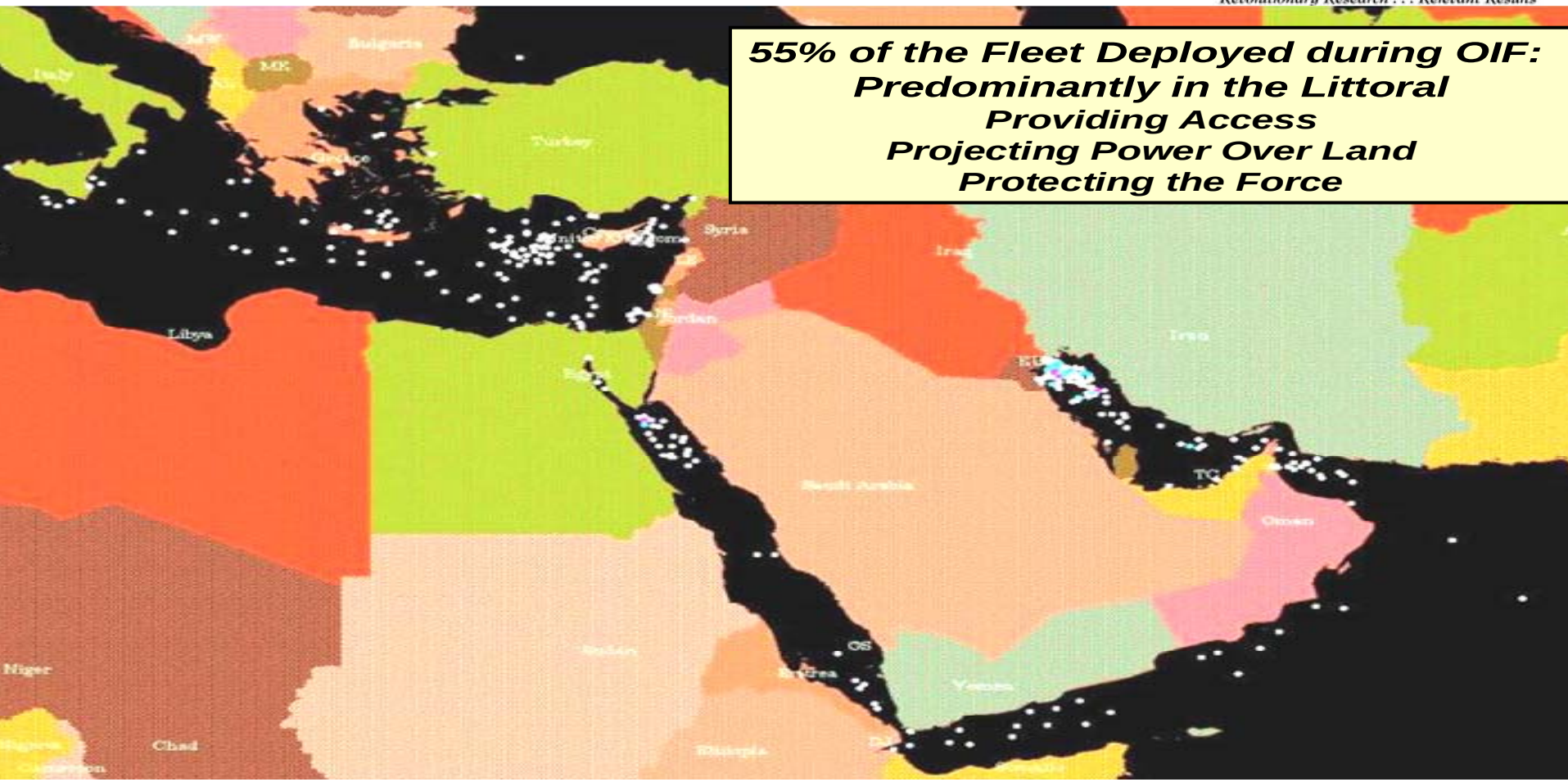
All new ship construction will use RO for desalination

RO Desalination Systems – Limitations and Issues

Pretreatment Issues

- NSRO designed for open ocean operations. Generally, long filter life and successful particle removal is being achieved in open ocean operations:
  - 4 to 6 weeks between cartridge filter replacements
    - 1 to 6 hours maintenance time
  - 3 to 5 years between RO element replacements
    - 4 to 12 hours maintenance time
- New naval strategic projections anticipate future operations likely to occur in littoral and coastal waters.
  - CNO SEA POWER 21 (Sea Shield, Sea Basing)
  - U.S. Maritime Forces A COOPERATIVE STRATEGY FOR 21ST CENTURY SEAPOWER

Revolutionary Research . . . Relevant Results



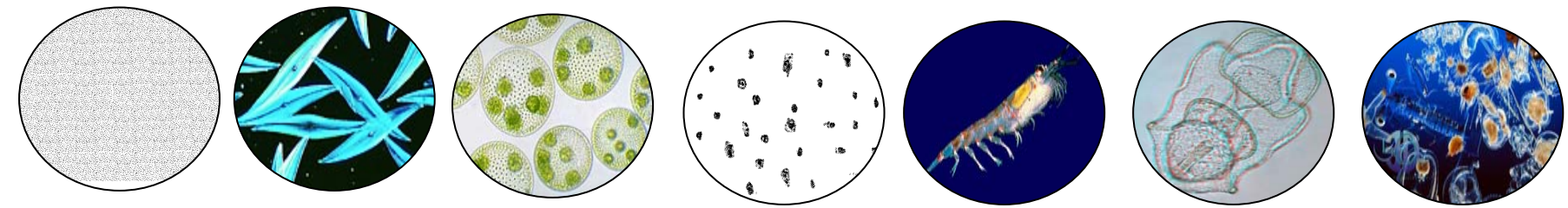
Recent Maritime Operations Highlight the Need for Assured Access in the Littoral
We Must Operate Here, and Counter Asymmetric Access-Denial Threat

CAPT Ray Spicer, N76E Deputy for Surface Ships,
"Sea Shield: Assured Access in the Littoral", 23 October 2003

RO Desalination Systems – Limitations and Issues

Pretreatment Issues

- **More demanding particle filtration is required for shipboard RO systems operating in littoral/coastal zones where feed-waters contain:**
  - **Higher suspended particle levels than open ocean operations**
  - **A greater varieties of contaminates than open ocean operations, including:**



Silt <1 - 50 µm | Bacteria <1 - 5 µm | Algae <1 - 10 µm — Micro-solids (neutrally buoyant or easily entrained)

Sand 0.01 - 0.1 mm — Very dense and heavy

Krill 1 - 2 mm | Star Fish Larva 0.1 - 1 mm | Mixed Plankton 0.1 - 2 mm — Macro-solids (neutrally buoyant)

RO Desalination Systems – Limitations and Issues

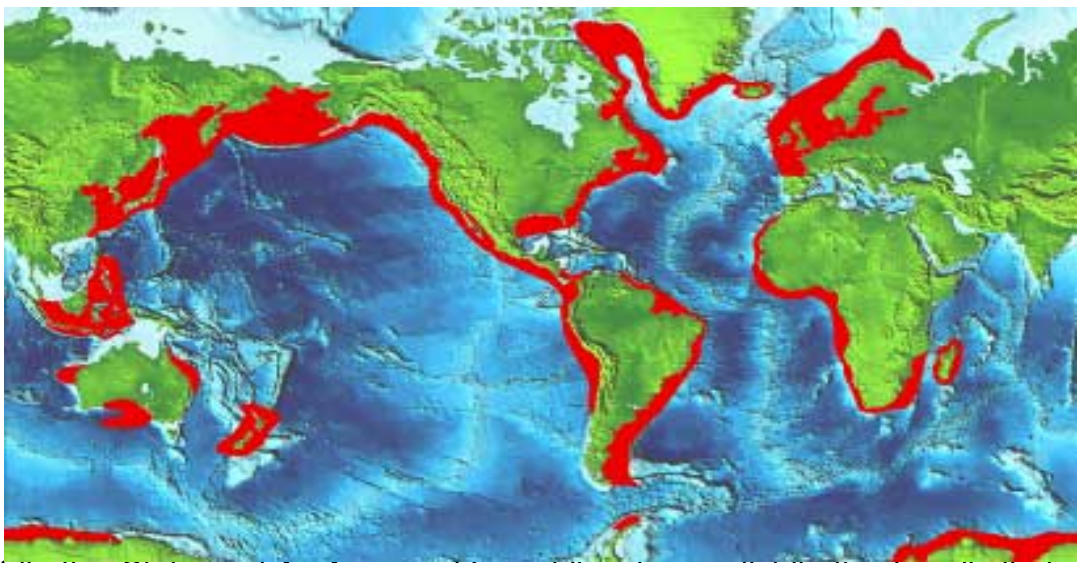
ALGAE CAUSING JUMP IN OCEAN "DEAD ZONES"

Scientists have found 200 "dead zones" in the world's oceans, a 34 percent jump from two years ago, a U.N. report yesterday showed.

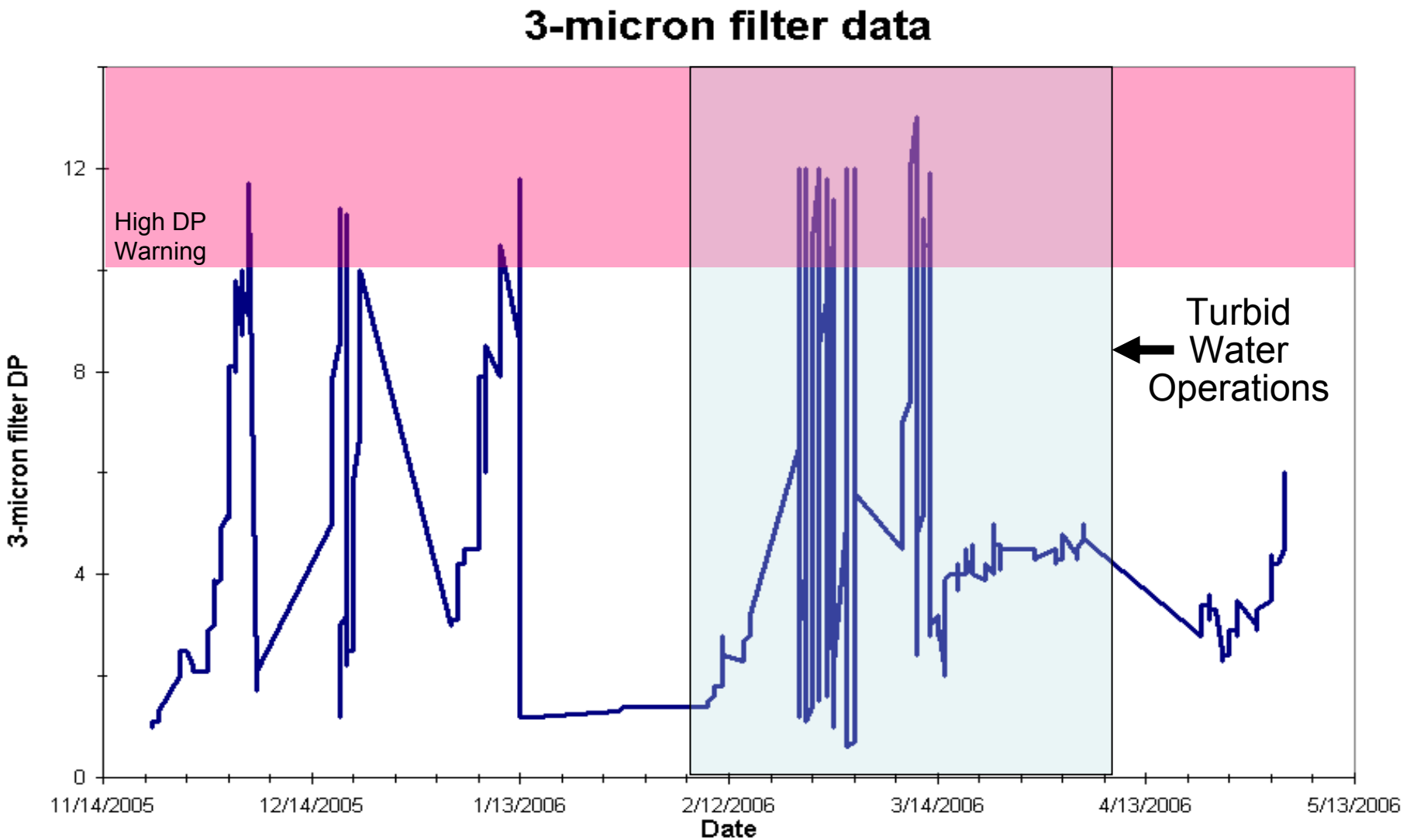
Pollution-fed algae, which deprives other living marine life of oxygen, are the cause of most of the dead zones, areas often tens of thousands of square miles in size. Scientists chiefly blame fertilizer and other farm runoff, sewage, and the burning of fossil fuels.

Those contain an excess of nutrients, particularly phosphorous and nitrogen, that cause explosive blooms of tiny plants known as phytoplankton. When they die, they sink to the bottom, where they are eaten by bacteria that use up the oxygen in the water.

Article in Washington Post 20 Oct 2006

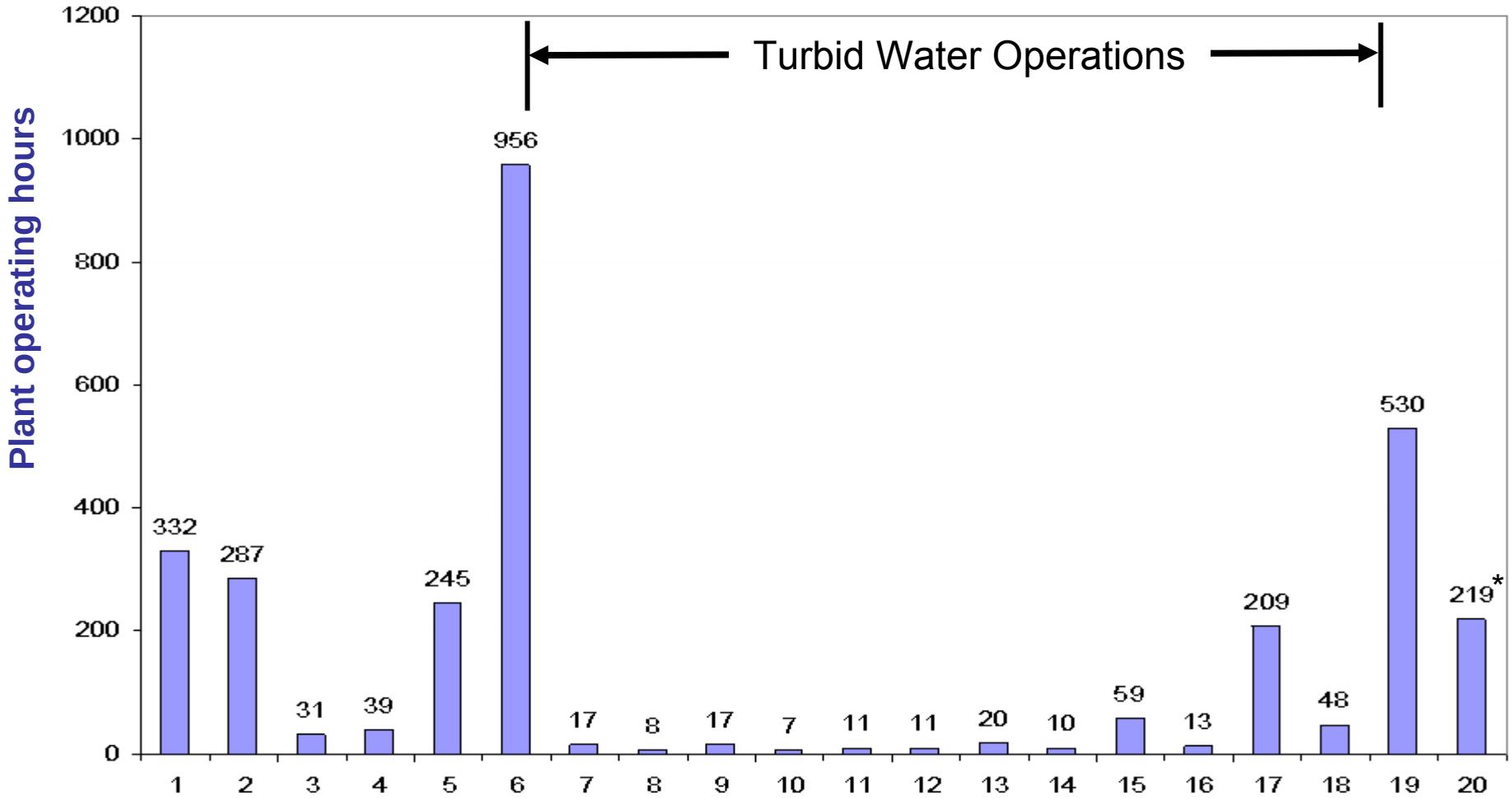


RO Desalination Systems – Limitations and Issues



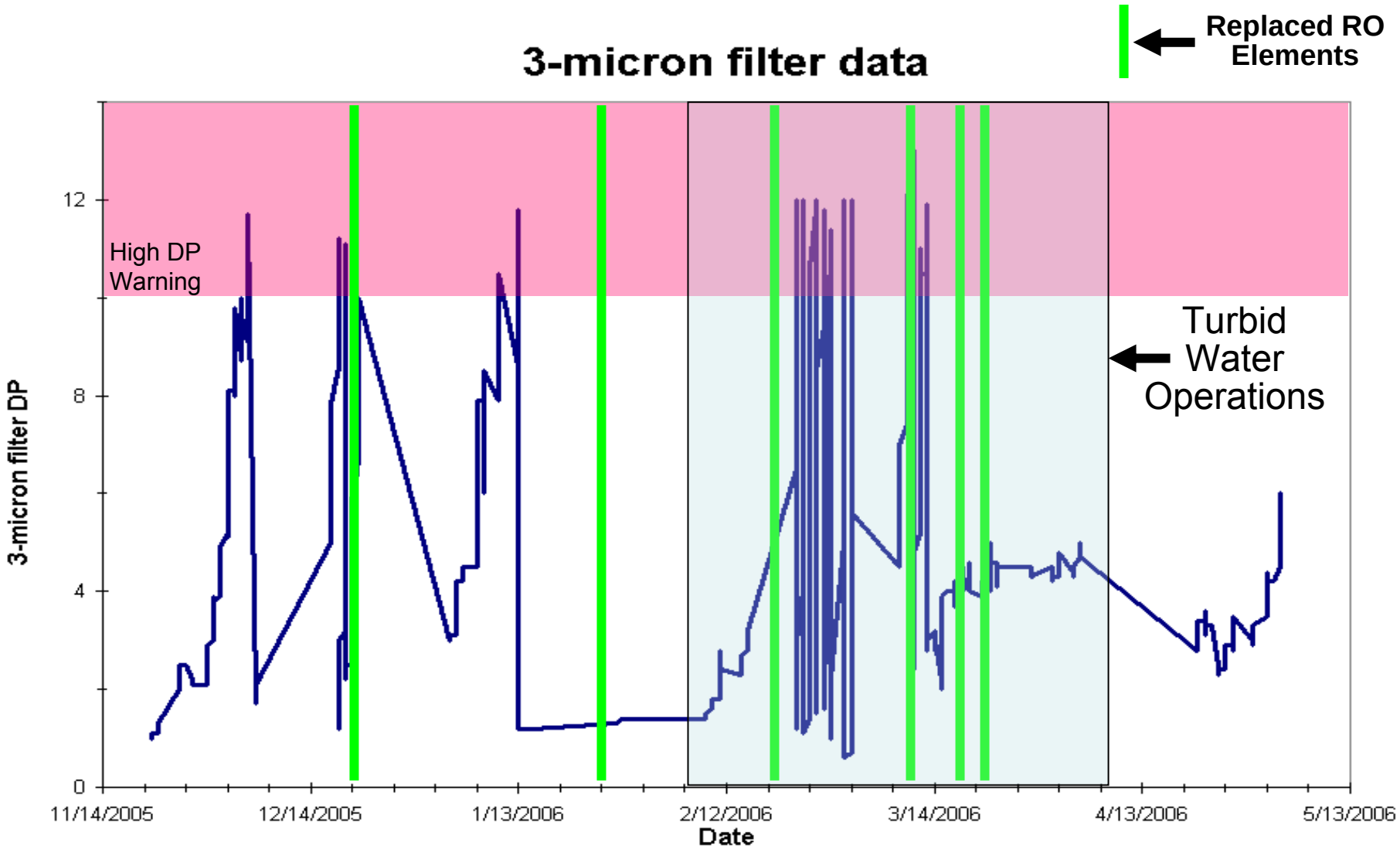
RO Desalination Systems – Limitations and Issues

Hours Between Cartridge Filter Replacements

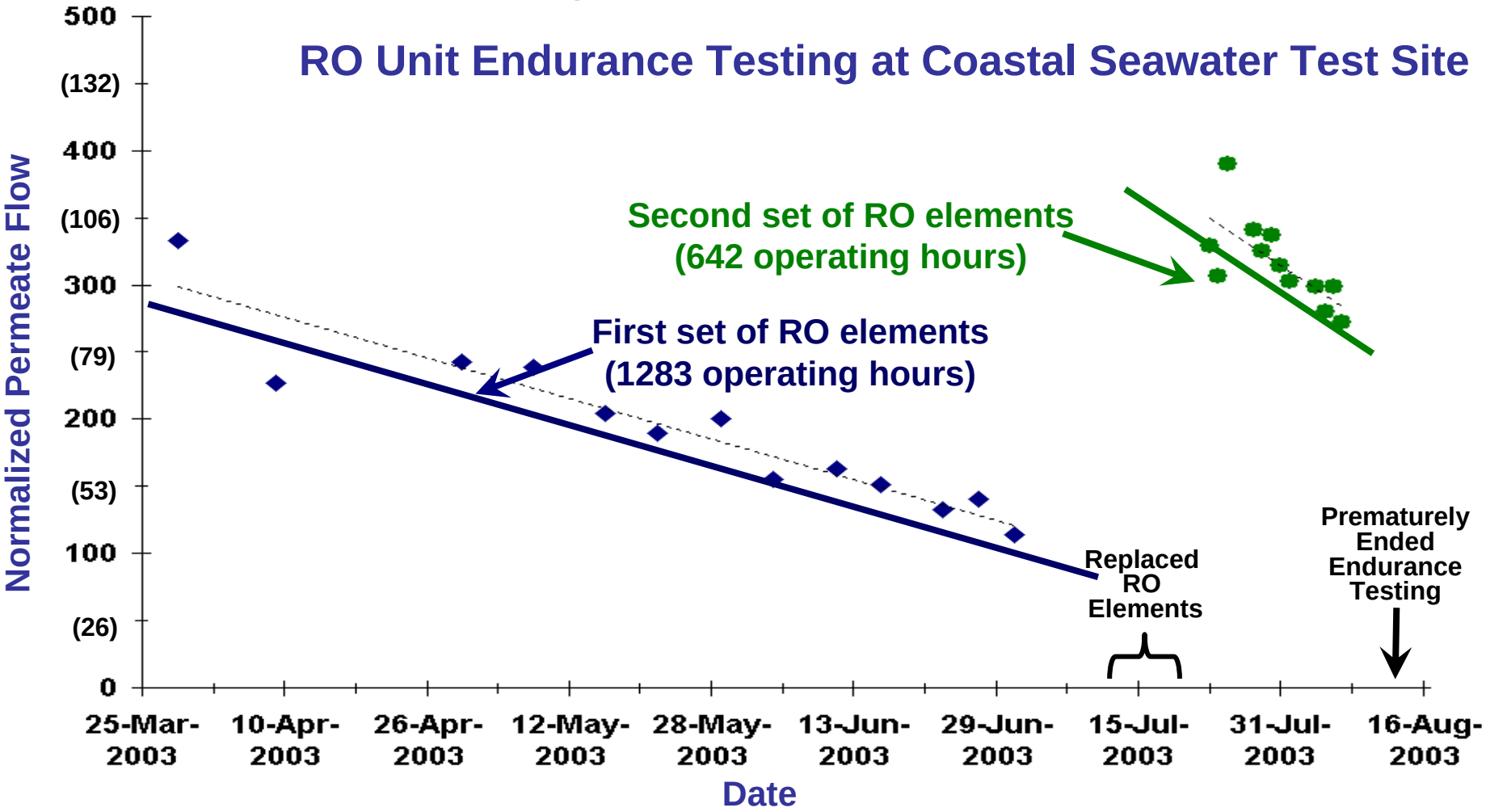


*Deployment ended

Shipboard RO Desalination Systems – Limitations and Issues



RO Desalination Systems – Limitations and Issues

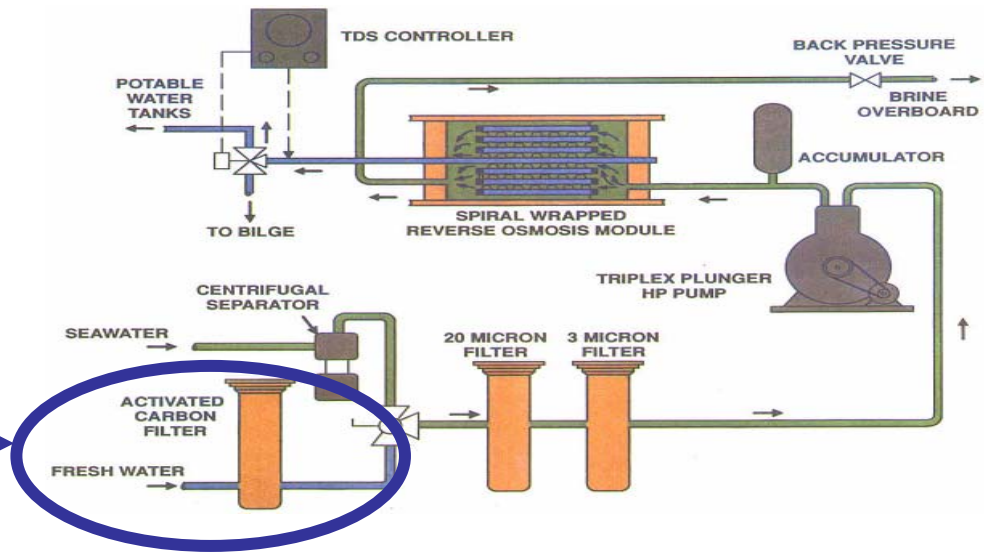


RO elements autopsy revealed accelerated fouling by primarily decaying organics and silt with particle size ranging between 0.1 and 1 µm

RO Desalination Systems – Limitations and Issues
Chlorination of seawater piping

- Biofouling and microbiological induced corrosion (MIC) protection (i.e., chlorination) of seawater systems - includes piping systems used as feed to RO plants
- RO membranes degrade in chlorinated environment:
  - ► Isolate RO system during chlorination periods
    ⇒ may be up to 4 hours per day
  - ► Have dedicated, non-chlorinated feed seawater piping
    ⇒ additional sea chests, pumps, piping, fittings, bulkhead penetrations

Potable water flush used during RO shutdown procedures. ACF required for dechlorination protection. Extra monitoring and maintenance required.



RO Desalination Systems – Limitations and Issues

Size and Weight Issues

- **Desire to increase potable water production capacity (to as high as 50 gal/person/day)**
  - ► **Current designs are 30 gal/person/day or less**
  - ► **Improved "quality of life" for sailors (no "*water hours*")**

- **However, traditional technologies used in current RO units do not adapt to larger capacity RO system designs with comparable space and weight characteristics of distillation units:**

Comparison of equivalent 100,000 gal/day plants

	Distillation Unit	Reverse Osmosis Unit*
Volume ($ft.^3$)	1900	2625 or greater
Weight (lbs.)	62,500	100,000 or greater

*** Extrapolated from existing RO units**

Summary

- Reverse osmosis technology developed in 1980's to address operation, maintenance, and cost issues associated with distillation plants and to meet all-electric ship requirements. Designed for open ocean operational scenarios.
- Traditional NSRO technologies have limitations and issues for future shipboard RO systems, including:
  - CNO SEA POWER 21 and U.S. Maritime Forces A COOPERATIVE STRATEGY FOR 21ST CENTURY SEAPOWER initiatives project more naval operations in littoral and coastal seawaters. Known limitations and problems associated with current RO pretreatment in these waters.
  - Operational concerns with chlorinated seawater
  - Space and weight limitations for desired increased water production capacities
- Advancements to RO technologies essential to being able to meet future Navy strategic goals

RDECOM

TARDEC

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Review of Current Army and Marine Corps Capabilities

25 February 2009

Jay Dusenbery
Deputy for Science and Technology
U.S. Army TARDEC Force Projection Technology

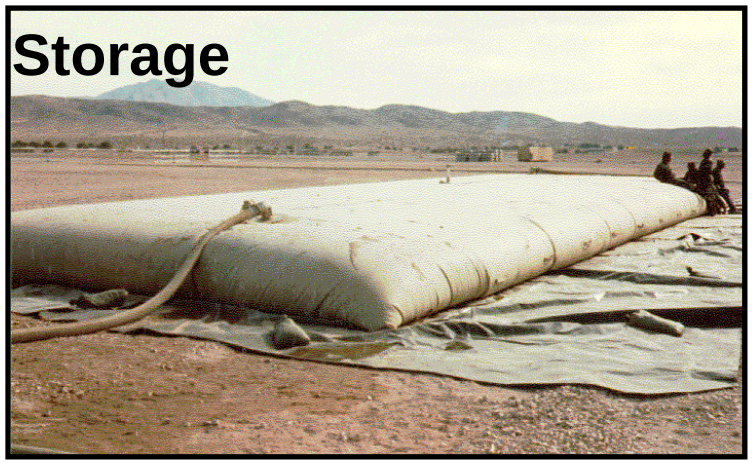
TARDEC FPT Business Area Mission Statement

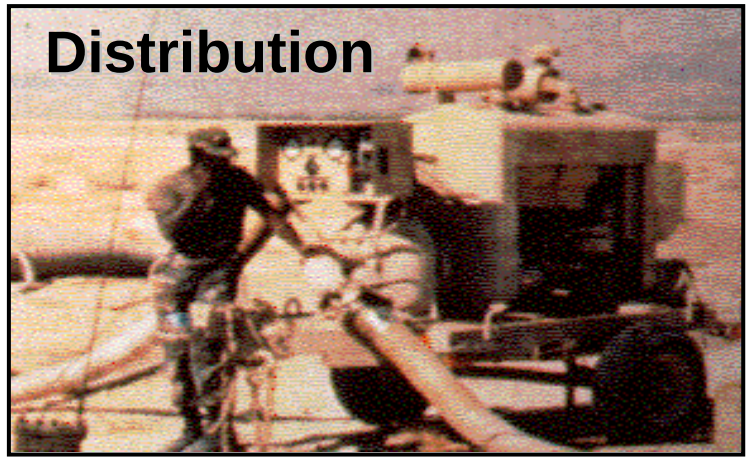
- **The Mission of the Business Area is to Perform the Research, Development and Engineering Support for the Soldier in the Following Petroleum and Water Fields of Endeavor:**

  Fuel and Water Handling Equipment
  Fuel Quality and Filtration Equipment
  Water Purification and Quality Equipment
  Fuels and Lubricants Products

- **We Also Serve as the DoD responsible Agent for All Ground Fuels and Lubricants and the Lead DoD Lab for Water Supply and Wastewater Treatment**

MISSION AREAS





TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Background

- **Drinking Water Related Health Problems in WWI lead to development of the Mobile Water Purification Unit**
- **The Mobile Water Purification Unit found to be only partially effective during WWII**
- **After WWII, multiple units developed for various types of source water**
  - **Seawater Distillation Unit**
  - **NBC Treatment Unit**
  - **Fresh Water Purifier (ERDLATOR)**
- **Use of multiple units led to logistics and training problems**
- **US Government funded research in Reverse Osmosis led to fielding of Reverse Osmosis Water Purification Units (ROWPUs) in the 1980's**

Military Water Treatment Equipment

- **600 ROWPU – Fielded 1981**
- **3000 GPH ROWPU - Fielded 1989**
- **1500 GPH Tactical Water Purification System (TWPS) Fielded 2004**
- **Lightweight Water Purifier (LWP) – Fielded 2005**

600 GPH ROWPU

- Feed flow – 30 gpm
- Multi-media filtration
  - 6-7 gal/min/sq. ft
- 5um cartridge filtration
  - 8 ea - 2.5 inch dia x 40 inch long filters
  - String wound, polypropylene
- Reverse osmosis
  - 8 ea – 6 inch dia. X 40 inch long polyamide RO elements
  - Avg salt rejection – 99.4%
  - All elements in series
  - 50% recovery on freshwater and 33% on seawater
- GAC, IX and chlorination post treatment for NBC removal
- Chlorination to 2 ppm

Characteristics

- 30 kW Generator (Army only) 2850 lb
- 5 ton Trailer (Army only) 5595 lb
- Skid mounted (USMC and AF)
  - 9.5 L x 7 W x 5.7 H ft
  - 7300 lb
- Trailer Mounted with 30kw generator
  - 19 L x 8 W x 8 H ft
  - 16,975 lb

- Three - 3K onion tanks packed w/ROWPU

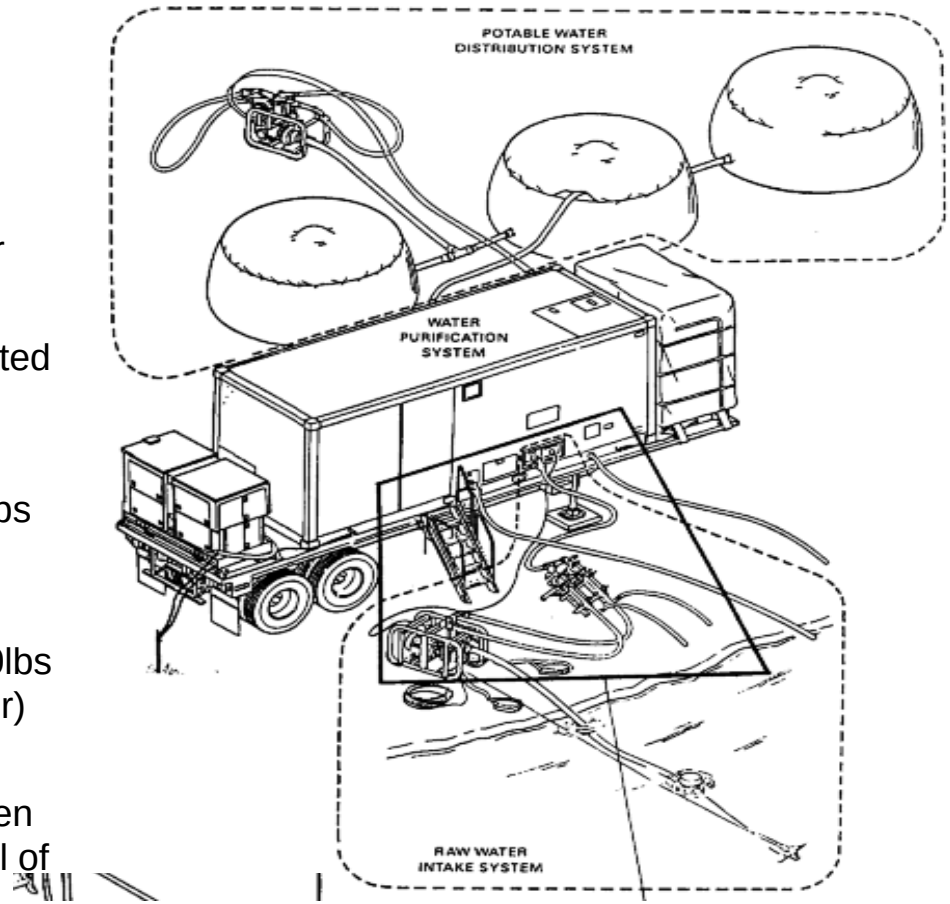
3000 GPH ROWPU

- **Feed flow – 100 gpm**
- **Multi-media filtration**
  - **12-13 gal/min/sq. ft**
- **3um cartridge filtration**
  - **12 ea - 2.5 inch dia x 40 inch long filters**
  - **String wound, polypropylene**
- **Reverse osmosis**
  - **12 ea – 8 inch dia. X 40 inch long polyamide RO elements**
  - **Avg salt rejection – 99.4%**
  - **2x1x1 array**
  - **50% recovery on freshwater and 33% on seawater**

- **GAC, IX and chlorination post treatment for NBC removal**
- **Chlorination to 2 ppm**

Characteristics

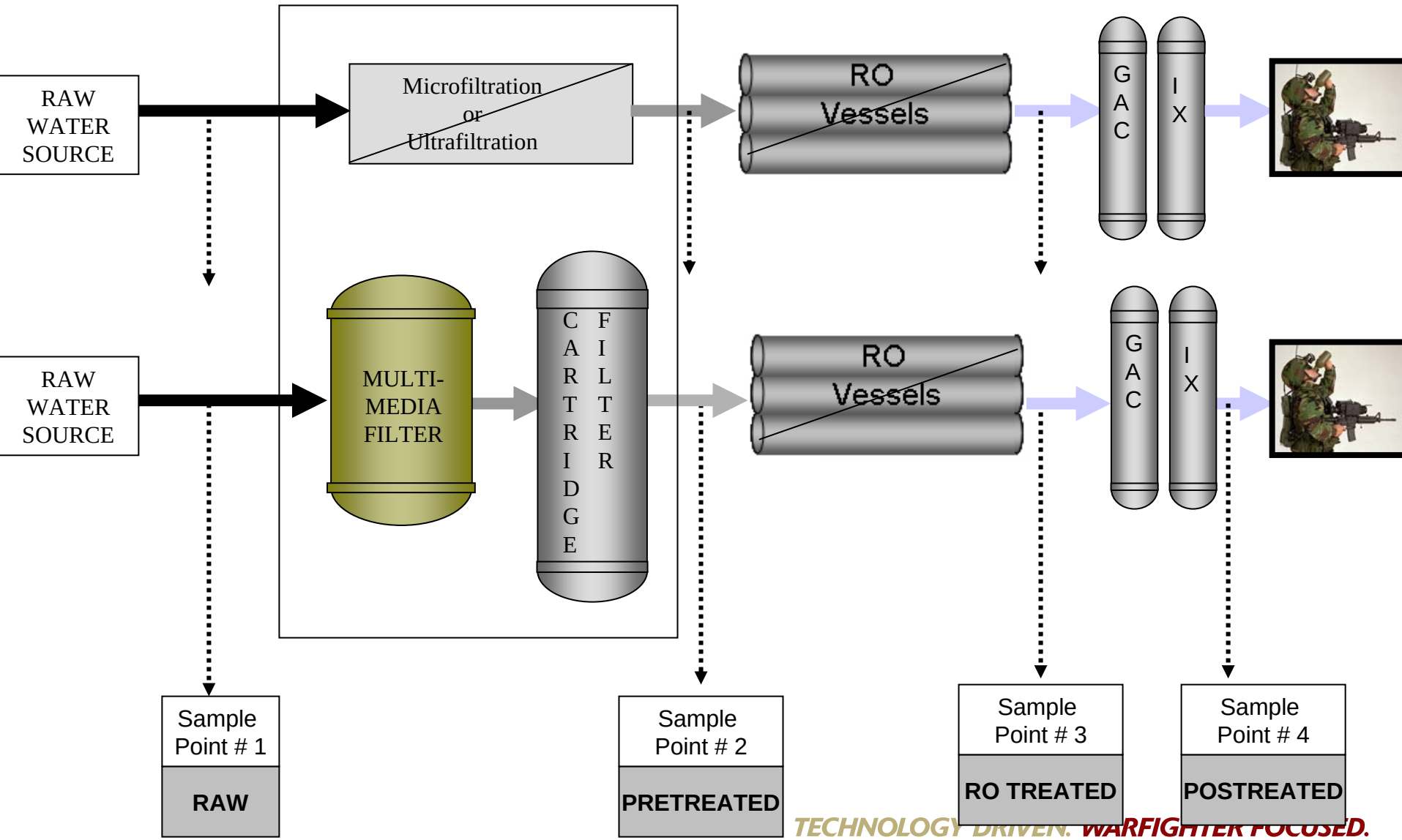
- Contained in a special ISO container with skid mounted external components
- Mounted on a standard 30ft M871 military trailer
- Powered by a 60kw diesel generator also mounted on the trailer
- Dimension & Weight: 20'L x 8'H x 8'W, 15,100lbs (fully packed container/ROWPU only)
- Dimension & Weight: 30'L x 13'H x 8'W, 37,960lbs (fully packed and mounted on trailer w/generator)
- Three - 3K onion tanks packed w/ROWPU, seven additional tanks come with the system for a total of ten at 135lbs each



ROWPU Shortfalls

- **Insufficient water production**
- **Outdated pretreatment technology (media filtration and cartridge filtration)**
  - **High cartridge filter and RO element replacement costs when operating on turbid source waters (greater than 20 NTU)**
  - **Increased time required for additional preventive maintenance checks and services (PMCS), filter backwash and filter replacement when operating on turbid waters**
  - **Operation on a very turbid water source (150 NTU) would be impractical due to the PMCS and logistical burden.**
- **Will not operate adequately in freezing temperatures (below 32°F)**
- **Not capable of providing acceptable quantities of potable water from seawater with extremely high total dissolved solids (TDS) levels (< 35,000 ppm), such as those encountered during Operation Desert Shield and Desert Storm.**
- **Not capable of providing acceptable quantities of potable water from low temperature (e.g. 32 degrees Fahrenheit) water sources**

Pretreatment System Upgrade



1500 GPH TWPS

- **Feed flow – 50 gpm**
- **Product Flow**
  - **Freshwater – 1800 GPH**
  - **Brackish/seawater 1500 GPH**
- **Strainer - 60 micron**
- **Microfiltration**
  - **MEMCOR system – 0.2 micron hollow fibers**
  - **12 MF modules/outside-in filtration**
  - **Backflushes every 15 mins for approx 1 min**
- **Reverse osmosis**
  - **10 ea – 8 inch dia. X 40 inch long polyamide RO elements**
  - **Avg salt rejection – 99.4%**
  - **50% recovery on freshwater and 40% on seawater**
- **GAC, IX and chlorination post treatment for NBC removal**
- **Chlorination to 2 ppm**

Characteristics

USMC and Army version have the same base skid-mounted treatment system

- Army system is mounted in a ISO flatrack and includes a 60kW TQG and the following kits:
  - Cold Weather
  - Chemical Cleaning Wastewater Storage
  - NBC Water Treatment
  - NBC Survivability
  - Ocean Intake Structure
- USMC orders the kits separately as required

- Dimensions and Weight

– Army	8’H X 8’W X 20’L	23,300 lbs
– USMC	6’H X 7.16’ X 13.75’ L	10,000 lbs

- Transportability
  - Army – HEMTT LHS or PLS
  - USMC - MTVR

Lightweight Water Purifier (LWP)

- **Feed flow – 5.0 gpm**
- **Product Flow**
  - **Freshwater – 125 GPH**
  - **Brackish/seawater 75 GPH**
- **Ultrafiltration**
  - **Koch system – 0.05 micron hollow fibers**
  - **3 UF modules/inside-out filtration**
  - **Backflushes every 15 mins for approx 1 min**
- **Reverse osmosis**
  - **7 ea – 2.5 inch dia. X 40 inch long polyamide RO elements**
  - **Avg salt rejection – 99.4%**
  - **50% recovery on freshwater and 30% on seawater**
- **GAC, IX and chlorination post treatment for NBC removal**
- **Chlorination to 2 ppm**

TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Characteristics

- Base Unit
  - Pretreatment Module
  - Control Module
  - High Pressure Pump Module
  - RO Module
  - Chemical Injection/Cleaning Module
- Supplemental Cold Weather Kit
- Transportability
  - M1097 HMMWV
  - UH-60 Helicopter
  - C130
  - Air Droppable
- System Dimensions and Weight
  - 2000 lbs
  - 4.25’L X 2.25’W X 4’ H (HMMWV bed size)

- Pump Module
- 3 kW generator
- 2 ea 1000 gal onion tanks

Military Water Purification Equipment Summary

Note: Values presented based on Seawater	LWP	600 ROWPU	3k ROWPU	A-TWPS	EUWP
• Production Rate (gph)	75	600	2,018	1,500	4,170
• Avg RO Flux (gfd)	8.9	12	13.7	7.6	11
• MF/UF Flux (gfd)	25	na	na	25	40
• RO Recovery (%)	30	31	33	40	50
• Weight (gpd/lb.)	1.09	1.40	1.88	1.26	2.62
• Cube (gpd/cu.ft.)	12.9	31.3	28.8	22.5	38.9
• C-130 Lift (gpd)	na	43,200	48,500	28,800	100,000

- Able to purify any source - lake, river, ocean, NBC contaminated - in sufficient quantities BUT
  - Systems have large energy (fuel) requirements
    - 20 to 50 kW-Hr/ Kgal
  - Systems have a large footprint (size/weight)
    - Systems require operational changes for certain contaminants
  - Systems are a logistics burden - large volume of consumables (filters, membranes, chemicals)

Developmental Efforts

- Military Unique Requirements
- Increase Production Capacity
- Reduce Power
- Reduce Maintenance (fouling)
- Minimize Logistics
- Maximize Reliability
- Evaluation of Commercial Products
  - RO Pretreatment Studies
    - UF/MF (PDVF)
    - Improved Filtration
    - Automated Screens
  - Chemicals
  - Seawater materials
  - Energy Recovery
- Cyanide, Arsenic, & Other Difficult to Remove Contaminants
- RO/GAC – nerve agent removal
- Ion Exchange
- Improve Palatability Water Provided
- Water Reuse and Recycle

Current P3I Efforts

- TWPS
  - Coagulant study
  - Improved chemical cleaners
  - Increase production rate
  - Training aids
- LWP
  - Noise Reduction
  - Improved chemical cleaners
  - Increase production rate
  - UF integrity testing
  - Improved solenoid valves
  - Energy recovery

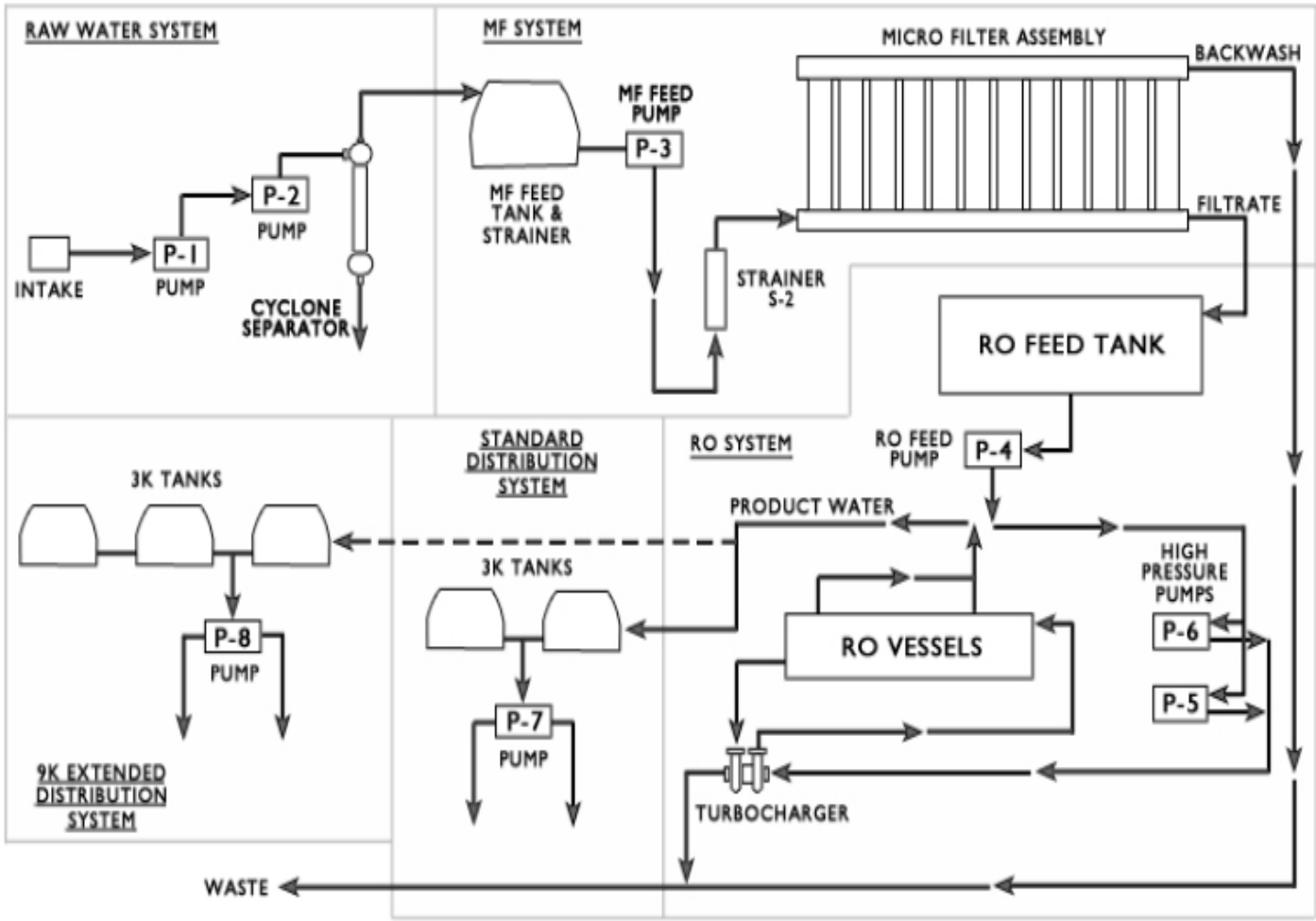
Emerging Army Requirements

- **Last Water Study conducted in 2001**
- **Army evolved to an expeditionary brigade based force which required re-looking petroleum and water support for the modular force**
- **CASCOM conducted a Petroleum & Water Capabilities Based Analysis in FY07**
- **Petroleum & Water CBA Identified 23 Capability Gaps**
- **11 Capability Gaps were identified in the water area**
- **7 of the Water Capability Gaps required material solutions**
- **6 of the 7 have Science and Technology implications**
- **Water capability gaps include generation, purification, water reuse, and monitoring**

THE WORLDS ULTIMATE WEAPON RUNS ON WATER . . .
EVERYTHING ELSE RUNS ON FUEL.

Back up Slides

1500 GPH TWPS



TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

TB MED 577
Water Quality Standards

Table C-2. Long-term field water quality standards (less than 1 year)

CONSUMPTION RATE	U.S. Tri Service (June 1996) 5 L/Day	15 L/Day	QSTAG 245 (Sep 1985) 5 L/Day	STANAG 2136 (Sep 1995) 5 L/Day
Physical Properties				
Color (Color Unit)	15	15	15	15
Odor (TON)	3	3	--	3
pH	5 - 9	5 - 9	5 - 9.2	5 - 9
Temperature (Degrees C)	15 - 22	15 - 22	15 - 22	15 - 22
TDS (mg/L)	1000	1000	1500	1000
Turbidity (NTU)	1	1	1	1
Chemical Properties				
Arsenic (mg/L)	0.06	0.02	0.05	0.06
Cyanide (mg/L)	6	2	0.5	6
Chloride (mg/L)	600	600	600	600
Lindane (mg/L)	0.6	0.2	--	--
Magnesium (mg/L)	100	30	150	100
Sulfate (mg/L)	300	100	400	300
Microbiological				
Coliform (#/100 mL)	0	0	1	1
Virus (#/100 mL)	--	--	1	1
Spores/Cysts (#/100 mL)	--	--	1	1
Radiological (μCi/L)	0.1	0.05	0.06	2.2 Bq/mL

Current EPA Std was reduced to .01 mg/L in Jan. 2006

Progress of Advanced Military Demonstration Units under EUWP Program

Presented by:

Mark Miller, US Army TARDEC, WTHE
(805) 982-1315 mark.c.miller@navy.mil

Expeditionary Unit Water Purification (EUWP) Program

EUWP Technical Approach

- Development of demonstration plants using commercially available components that would highlight and exhibit current state of the art desalination technologies
  - Generation 1 (2003) – improvements to Army/Marine Corps mobile water purification systems. Special emphasis on system portability and reducing energy consumption.
  - Generation 2 (2005) – improvements to seawater desalination systems, with emphasis on limitations and issues related to Navy shipboard desalination. Greater water production capacity than Generation 1 for municipal water purification considerations
- Fund Science & Technology (S&T) efforts for supportive and long term exploratory research in desalination. Goal of reduction in cost and energetics of desalination

EUWP Generation 1 Demonstration Plant Objective

- Develop a high-capacity, energy efficient, mobile water purification technology demonstrator capable of purifying a wide range of water sources with potential application towards nation building, homeland defense, peacekeeping, humanitarian aid, and disaster relief.
- Maximum water production within C-130 transportability constraints (two 8x8x20-ft skids, ISO compatible)

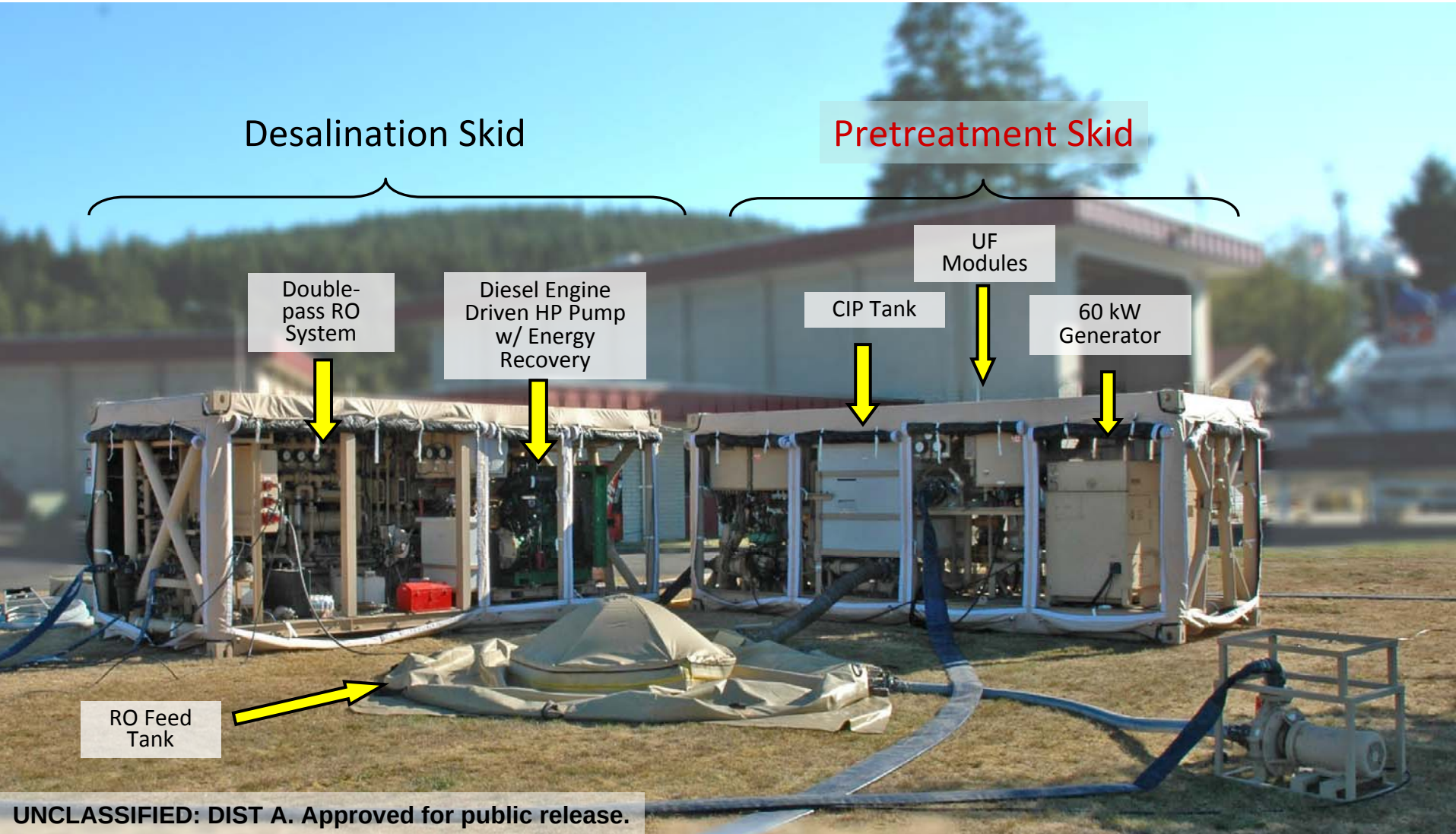
Note: Values presented based on seawater feed	600 ROWPU	3000 ROWPU	A-TWPS	EUWP GEN 1
• Production Rate (gph)	600	2,018	1,200	4,170
• Avg RO Flux (gfd)	12	13.7	7.6	11
• MF/UF Flux (gfd)	na	na	25	40
• RO Recovery (%)	31	33	37	50
• Weight (gpd/lb.)	1.40	1.88	1.26	2.62
• Cube (gpd/cu.ft.)	31.3	28.8	22.5	38.9
• C-130 Lift (gpd)	43,200	48,500	28,800	100,000

EUWP Generation 1 Demonstration Plant

Equipment Design Guidelines

- Air transportable by C-130
- Produce 100,000 gpd product water meeting Tri-service standards (USA TBMED-577) on 45,000ppm, 77°F seawater feed
- Treat feed water to 60,000ppm TDS
- Feed water temperature range from 32°F to 95°F
- Feed water turbidity to 150 NTU
- Chemical agent removal
- 40,000 gallons of product water storage
- EMI/EMC
- Blowing rain/sand/dust

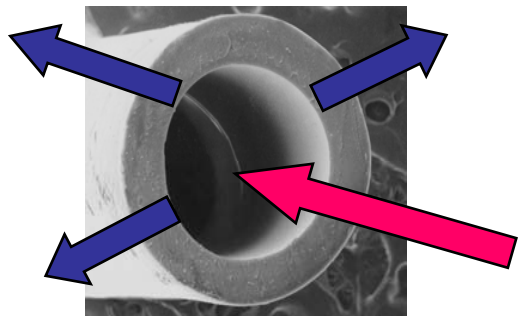
EUWP Generation 1 Demonstration Plant

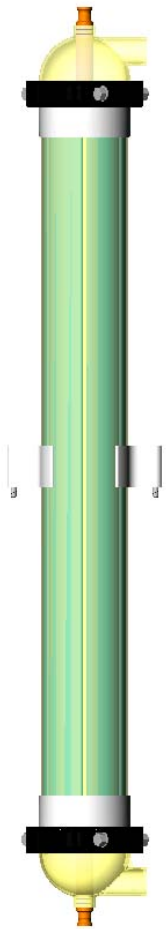


EUWP Generation 1 Demonstration Plant

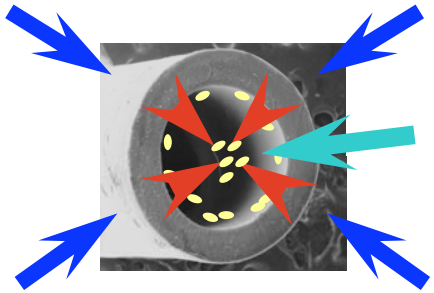
Ultrafiltration Membrane Pretreatment

- Materials:
  - ► Membrane: Polysulfone
  - ► Housing: PVC
  - ► Potting Material: epoxy
- Fiber Diameter (ID): 0.9 mm
- Molecular Weight Cutoff: 100,000 Daltons (< 0.05 microns)
- Inside-Out flow configuration
- Cross flow Operating Mode: 90% recovery
- Flux Rate: 40 GFD
- Cartridge Dimensions
  - ► 10” diameter
  - ► 48” length





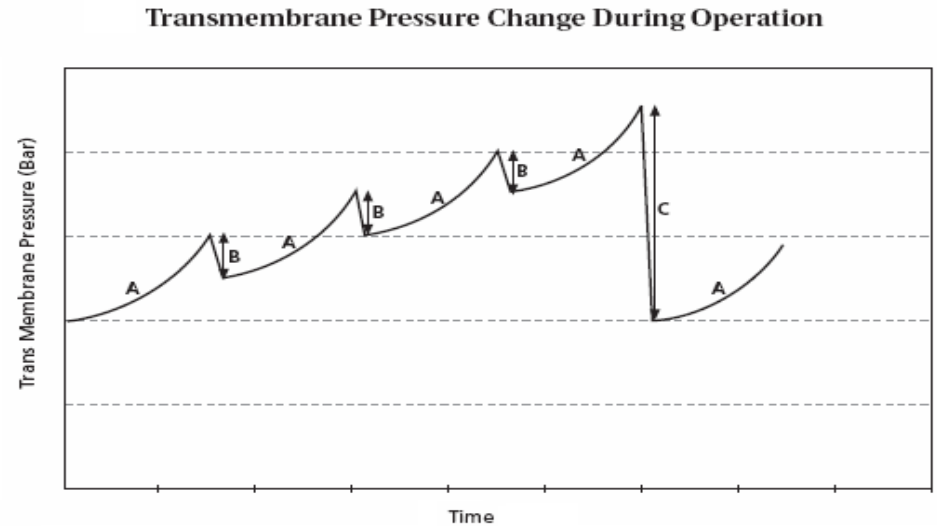
EUWP Generation 1 Demonstration Plant
Ultrafiltration Membrane Maintenance



Flush Procedure:

- Reverse flow removes deposits from membrane surface
- Fast Flush removes deposits from system

- Addition of ferric chloride chemical coagulant to feed water creates larger deposits which are easier to remove from membrane surface
- Periodic chemical cleanings enhances deposit removal

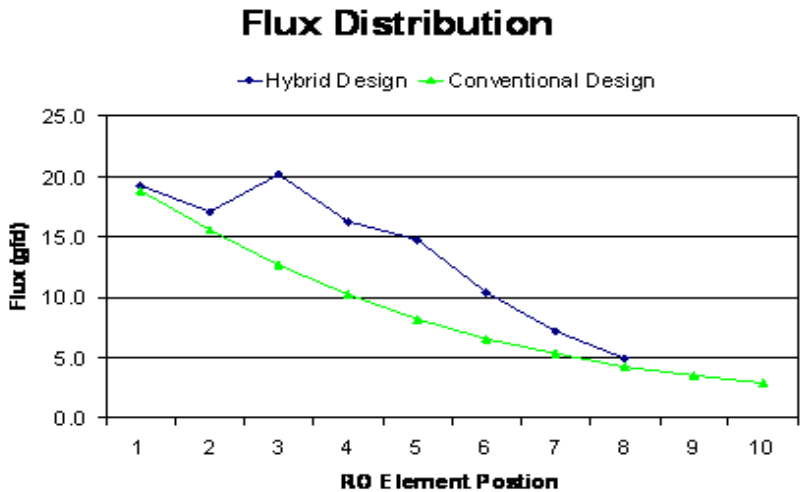


A – Normal filtration mode
B – Backflush mode (with filtrate only)
C – Chemical cleaning
(500 ppm chlorine, 1%-2% citric acid)

EUWP Generation 1 Demonstration Plant

Desalination Improvements

- Hybrid RO design utilizing new high performance membranes.
  - ► Increased average flux resulting in 50 percent reduction of RO elements
  - ► More balanced flux distribution



- Energy Recovery
  - ► Cascade configuration resulting in ~30% reduction in energy for the RO stage
  - ► 1/3 less feed flow to high-pressure pump

EUWP Generation 1 Demonstration Plant

Testing & Demonstration

- Testing at SDTF, Port Hueneme, CA and BGNDRF, Alamogordo, NM
- Emergency Response:
  - USCG, Port Clarence, AK
  - Hurricane Katrina, Biloxi & Pascagoula, MS
  - Makah Nation, Neah Bay, WA
- EPA Environmental Technology Verification:
  - Microbial Removal, Gallup, NM
  - Surface Freshwater, Lake St. Clair, MI
  - Surface Seawater, Port Hueneme, CA

EUWP Generation 2 Demonstration Plant

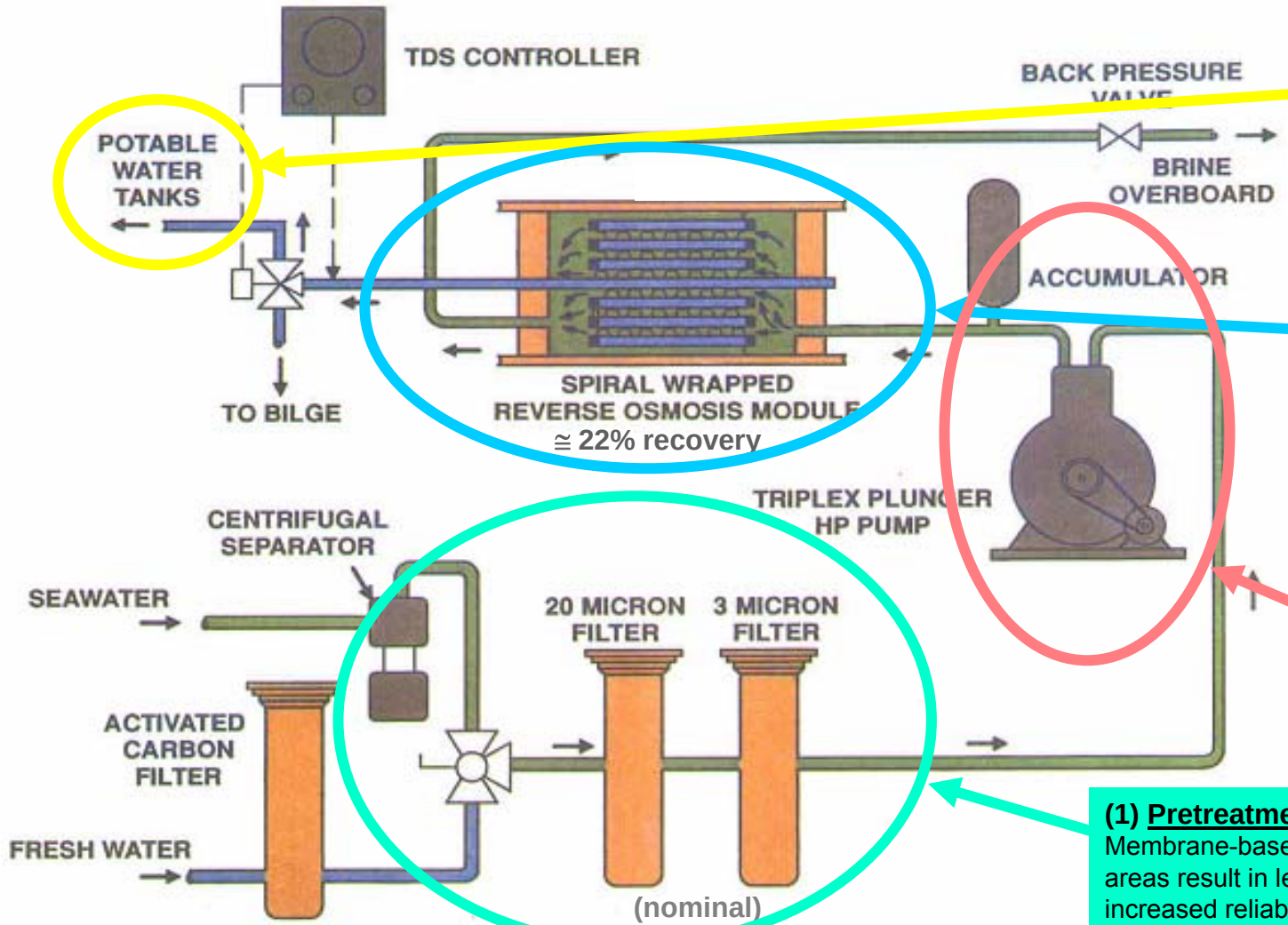
Objective

Demonstrate existing State Of Art (SOA) desalination technologies and processes for improvements to seawater desalination systems, with emphasis on limitations and issues related to Navy shipboard desalination. Greater water production capacity than Generation 1 for municipal water purification considerations.

Goals

- Allow operation in near shore areas and longer deployments in locations of higher potential particulate fouling (e.g., Persian Gulf)
- Decrease energy requirements
- Improve reliability and maintenance requirements
- Increase desalination equipment availability
- Simplify operating procedures
- Increase water production capacity for “improved quality of life”

EUWP Generation 2 Areas Of Improvement to NSRO



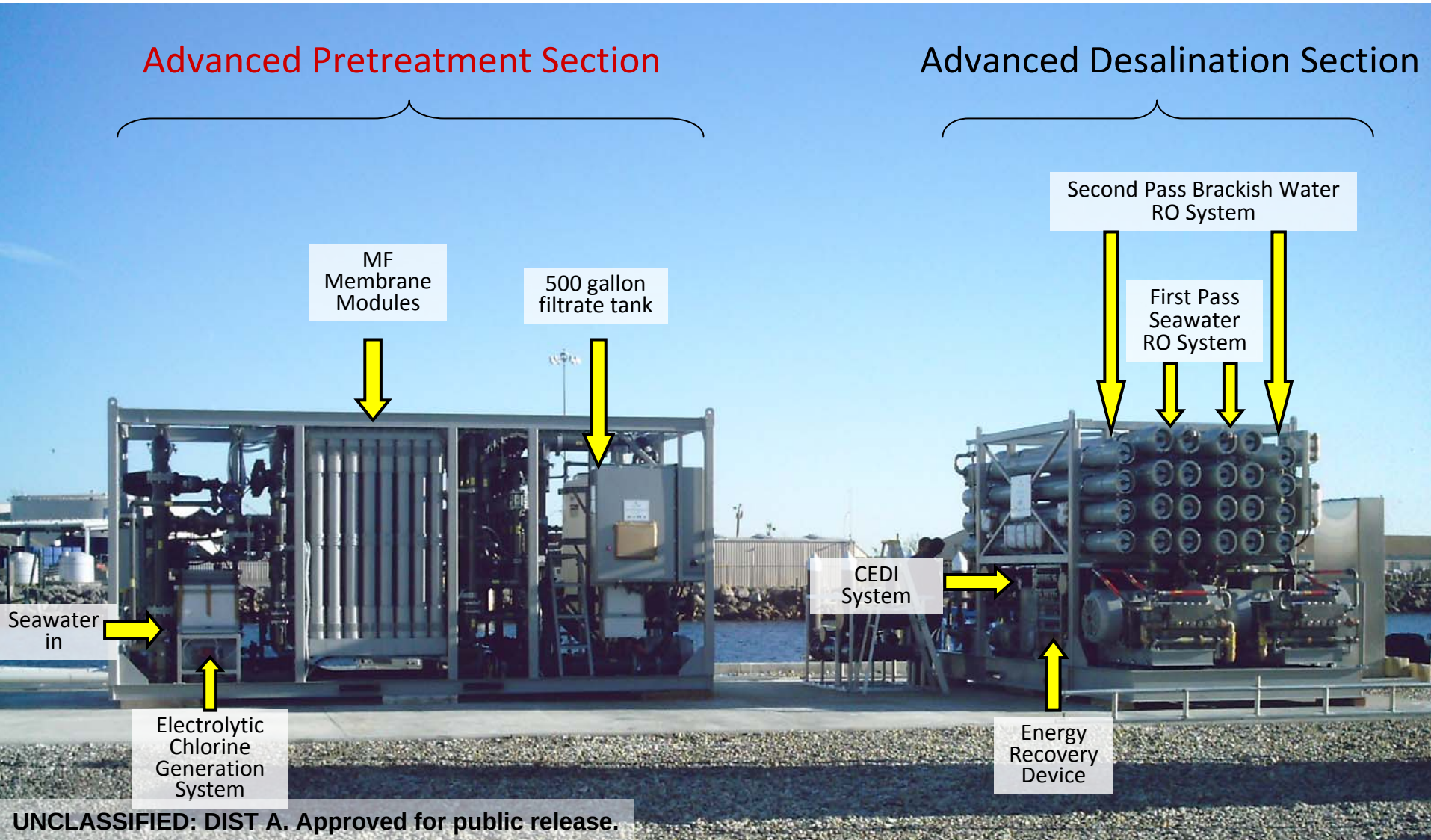
(4) Post-treatment: Advanced electro-deionization systems remove remaining minerals with reduced maintenance.

(3) Desalination: Advanced high flux, RO membranes and hybrid configurations can reduce space, weight, and energy requirements

(2) Energy Reduction: Energy recovery device can reduce energy, size, noise, and maintenance requirements.

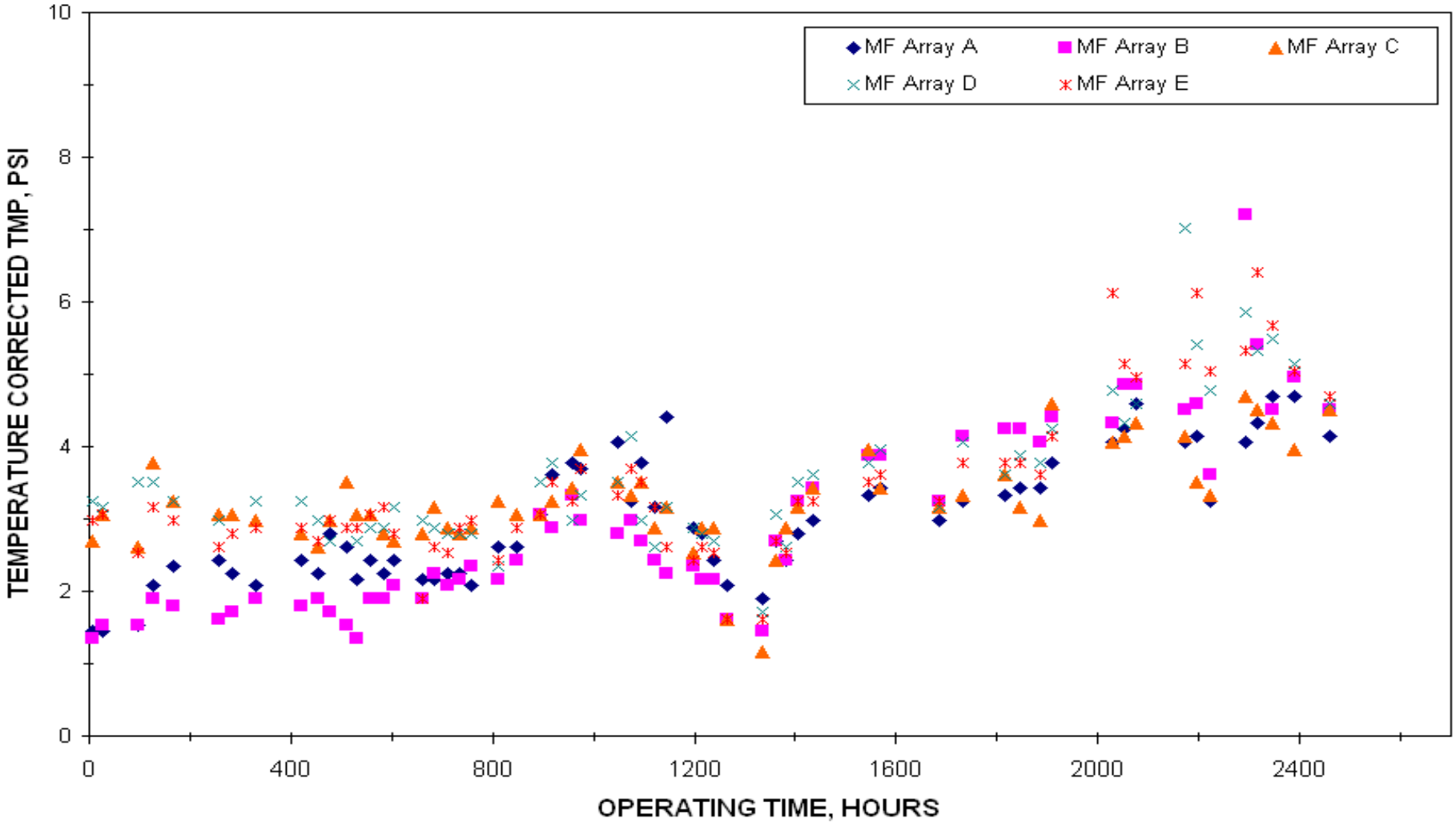
(1) Pretreatment: Membrane-based filtration in near shore areas result in less maintenance and increased reliability.

EUWP Generation 2 Demonstration Plant



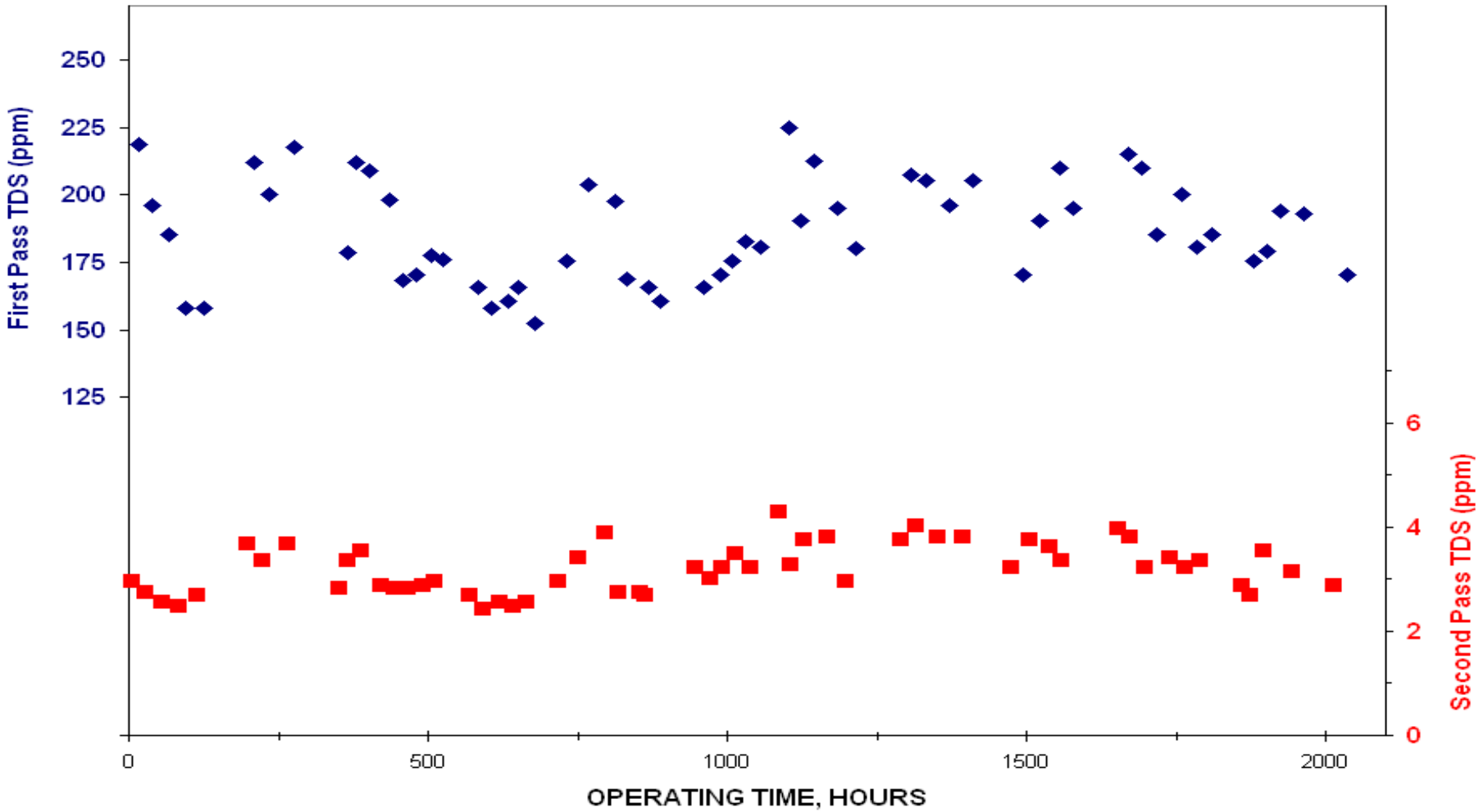
EUWP Generation 2 Demonstration Plant

MF transmembrane pressures for EUWP Generation 2 pretreatment



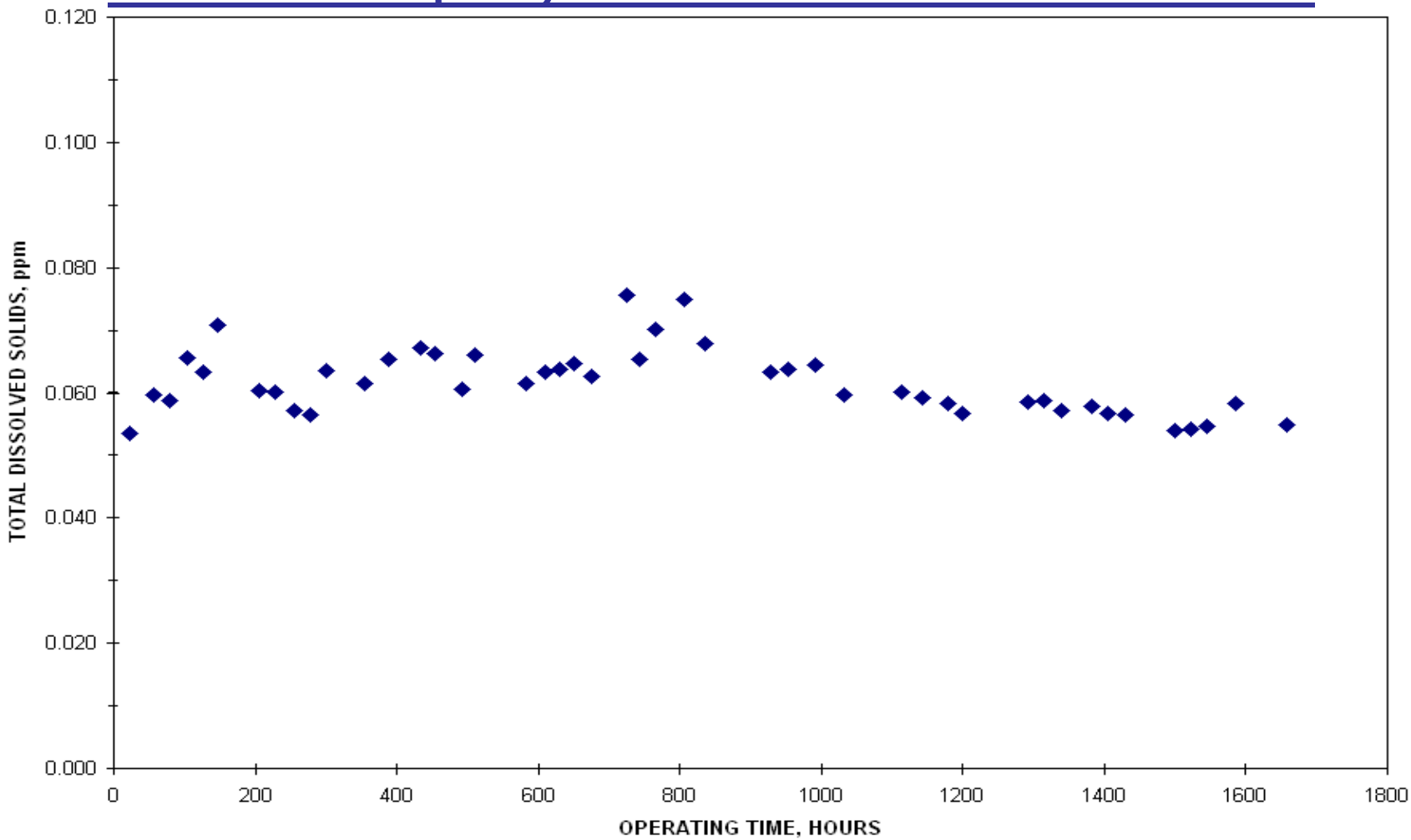
EUWP Generation 2 Demonstration Plant

Permeate quality from EUWP Generation 2 first and second pass RO



EUWP Generation 2 Demonstration Plant

Product water quality from EUWP Generation 2 CEDI unit



EUWP Science & Technology Efforts

20 S&T Efforts Since 2003

Most promising S&T efforts include:

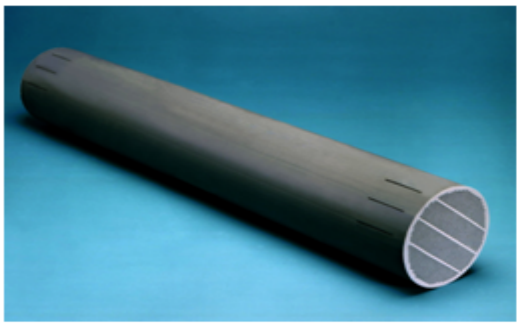
Topic	TRL	Advantages
Ceramic MF membranes	4	30 year membrane
Electro-coagulation for MF/RO pretreatment	5	no chemical storage
Chlorine Resistant RO membranes	2,3	current weakness
Increased flux RO membranes	4	reduced energy
Hybrid Energy Recovery Device	4	90% recovery, reliability
Membrane Distillation	3	low pressure, reduced weight, waste heat
Forward Osmosis - membrane development	3	higher fluxes
Forward Osmosis - magnetic draw solute	2	low pressure

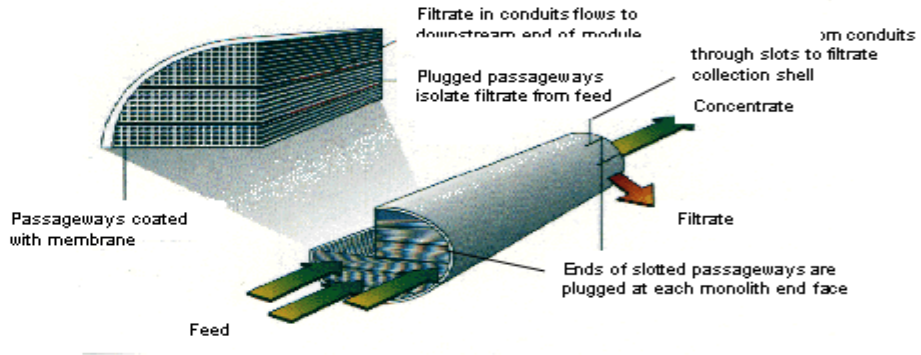
Remaining S&T efforts are still at lower TRL levels.

EUWP Science & Technology Efforts

Compact Ceramic MF/UF Membranes for RO Pretreatment

Ceramic Membrane Element
(5.6" diameter x 34" long)

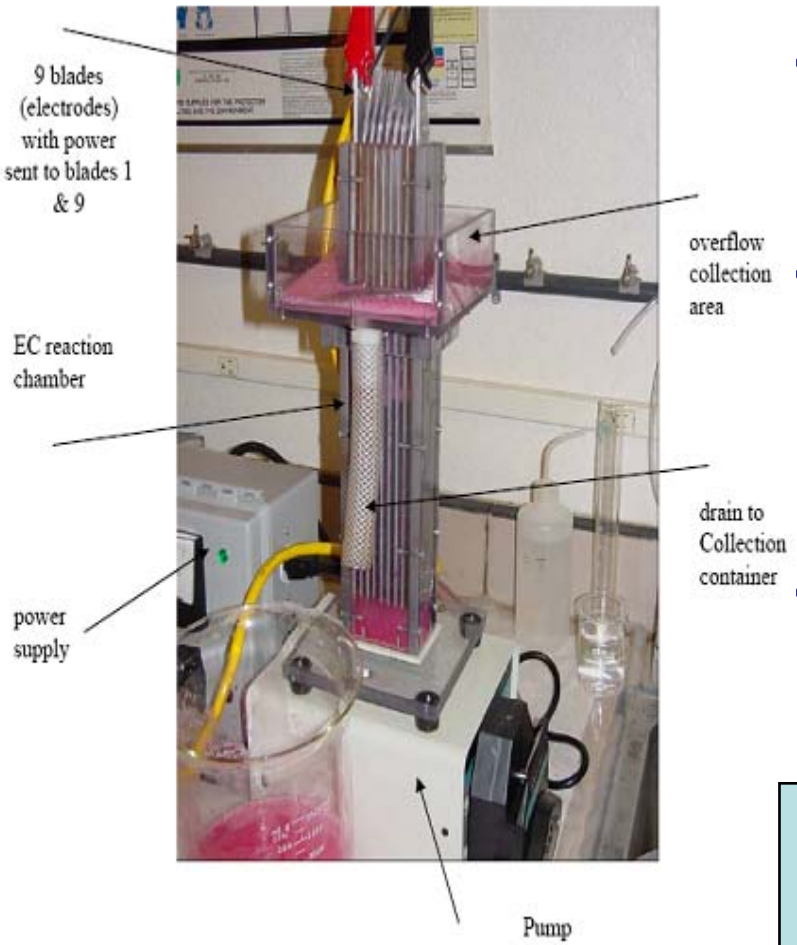




ATTRIBUTE	BENEFIT
Mechanically robust	Horizontal or vertical orientation Higher backflush pressures Less membrane breakage
Abrasion resistant membranes	May require less feed pretreatment
High surface area per element	Relatively low membrane cost
Long operational life	Very low lifecycle costs
High membrane packing density	Minimize membrane volume
Large, open feed channels	Less plugging & pressure drop
Hydrophilic, metal oxide membranes	Stable flux, easy to clean
Excellent chemical durability	Clean aggressively, e.g., NaOCl

EUWP Science & Technology Efforts

Electrocoagulation for MF Pretreatment

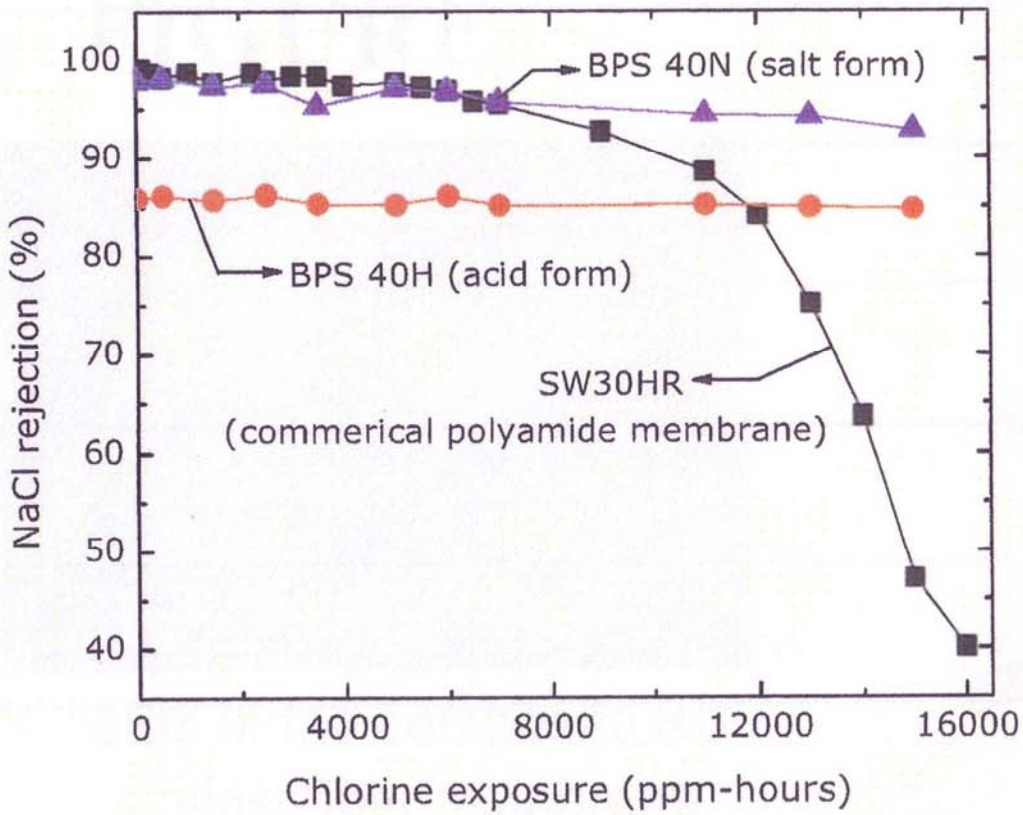


- Uses iron plates for the in-situ production of ferric ion for coagulation
  - No chemicals required
- Pulsed power generates hydronium ion (H_3O^+)
  - effective disinfection
  - very short half-life (no disinfectant removal required)
- Hydrocarbon removal from feed water

EC combined with MF may provide an ***effective*** self-cleaning low maintenance RO pretreatment system

EUWP Science & Technology Efforts

Chlorine Resistant RO Membranes



Chlorine tolerance results

Current sulfonated polymers exhibit high chlorine-tolerance in both acid and salt forms relative to commercial polyamide RO membranes.

Test conditions :
Cross-flow
pH = 9.5
Feed = 2000 ppm NaCl
Pressure = 400 psi
Flow rate = 0.8 GPM
Chlorine = 500 ppm

Summary

- Congressional Interest EUWP Program managed by ONR from FY 2003 through FY 2007 to further the state of the art in desalination technologies in effort to reduce the cost and energetics to desalinate water
- Two demonstration plants developed using commercially available components that would highlight and exhibit current state of the art desalination technologies
  - Generation 1 (2003) – improvements to Army/Marine Corps water purification systems. Special emphasis on system portability and reducing energy consumption.
  - Generation 2 (2005) – improvements to seawater desalination systems, with emphasis on limitations and issues related to Navy shipboard desalination. Greater water production capacity than Generation 1 for municipal water purification considerations
- Fund 20 Science & Technology (S&T) efforts for supportive and long term research in desalination. Several promising technologies could be further developed to address current Navy desalination issues and support future naval strategic projections by CNO and U.S. Maritime Forces initiatives.

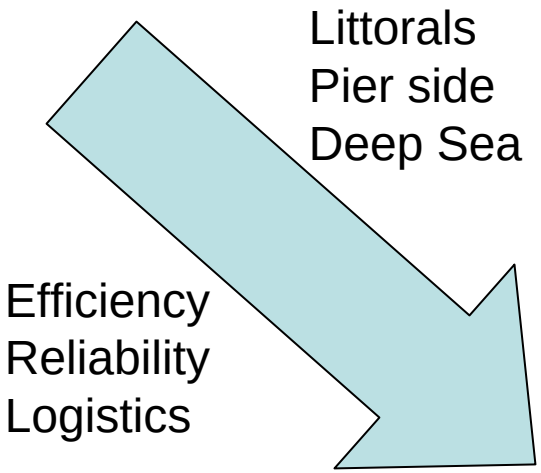
Navy Reverse Osmosis Systems - Navy Unique Needs and Requirements

Presented by:

John Heinzel, NSWCCD-SSES Code 985
(215) 897-1413 john.heinzel@navy.mil

Key Drivers

- Cheaper
- Better
- Smaller

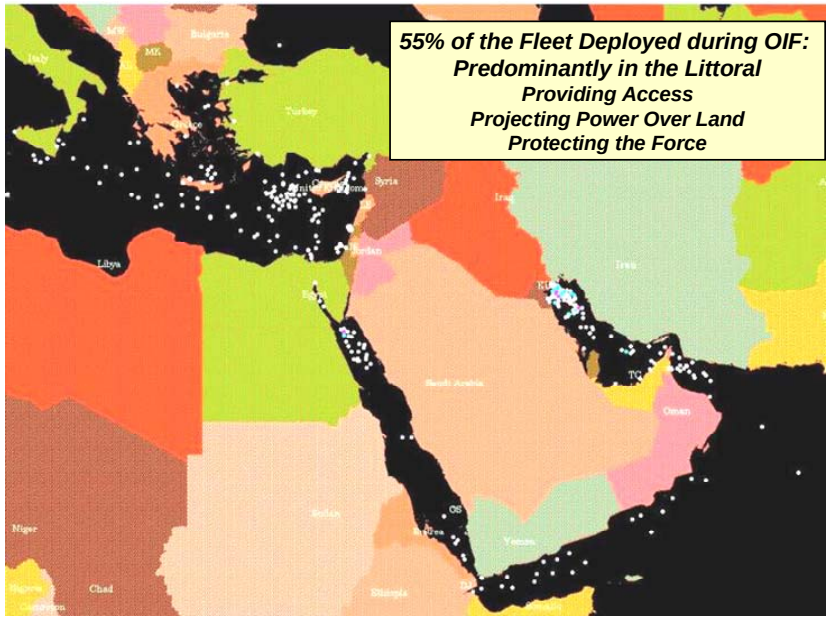


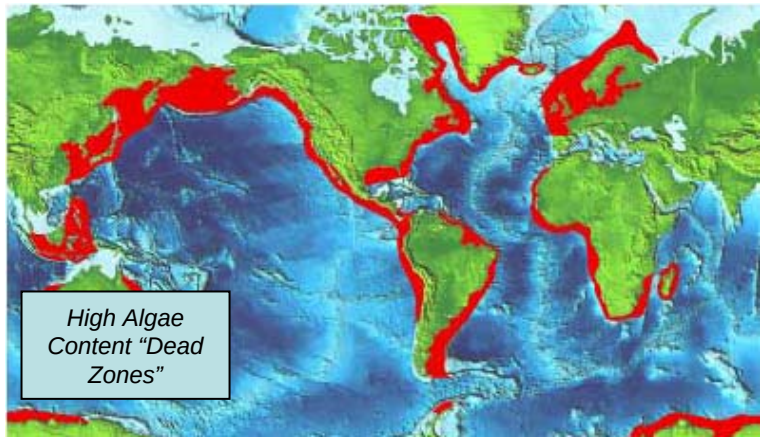
Create many unknowns, gaps, and considerations that are key to a next-gen version of NSRO

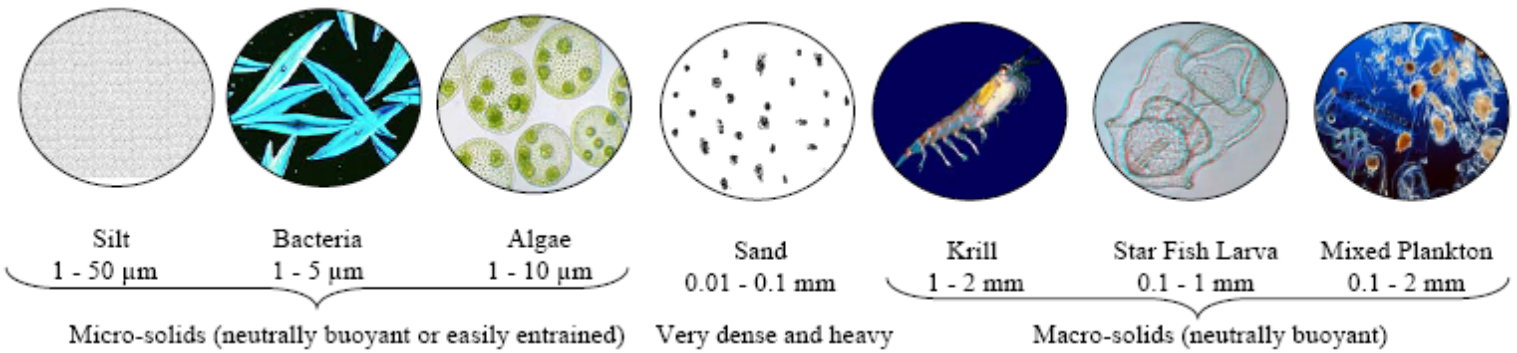
Seapower 21/MFCS

- "Sea Power 21" will employ current capabilities in new ways, introduce innovative capabilities as quickly as possible, and achieve unprecedented maritime power.
- Liquid needs are a key driver!
- Water accounts for 39% of resupply for Marine Brigades
- Integrated forces, sea-based assets and expensive energy are drivers
- Advanced technology allows the Navy to fulfill its mission
- The mission is changing – technology needs to step in more!

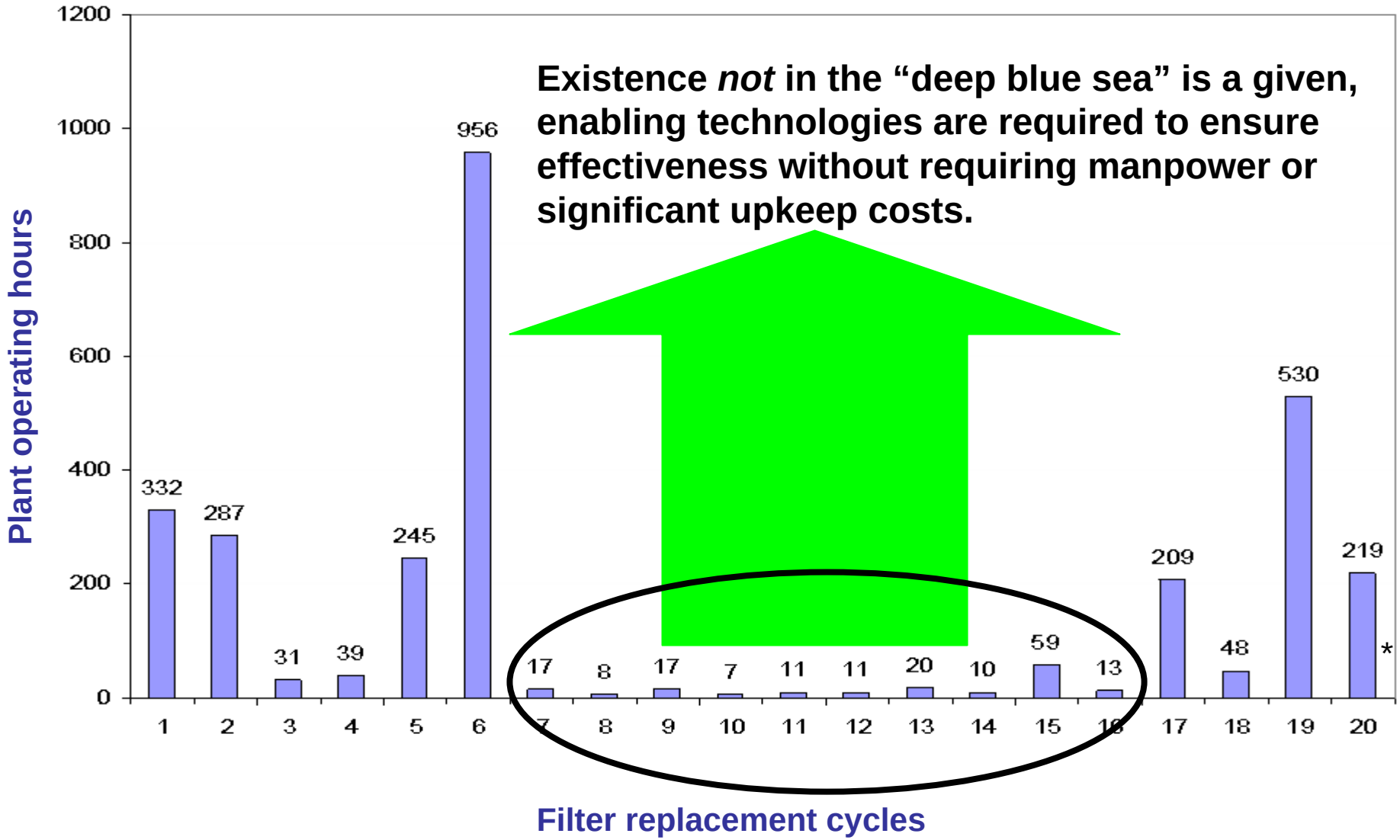
Littoral, Turbid Environment







Effectiveness in All Conditions



*Deployment ended

Ship Application

- Variety of classes, existing and future, require advanced desalination capability
- Capacities range from 2K-125K gpd
- Modular, serviceable equipment is key, with low manpower requirement and reduced logistics

NSRO is the design basis to be used going forward – for all platforms. Enhanced capabilities, coupled with friendlier equipment and more robust operation will yield savings and enable high quality of life under all mission scenarios.

Plant Sizes

RO Plants Aboard US Navy Ships

Ship Class	RO Plant Capacity (gal/day)	Number In-Service/Planned
MCM 1	3,000	28
SSN/SSBN	4,000/6,000	38/100+
FFG 7 Class	6,800	42/20
DDG 51 Class	12,000	106/18
DDG 1000	12,000	0/TBD
CG 21	TBD	0/TBD
SC 21	TBD	0/TBD
CG 47 Class	12,000	24/20
LCS	2,000	0/TBD
LHA 1 Class	12,000	12/0
LPD 17 Class	24,000	12/15
LHD 8	50,000	2/--
CVN 65	12,000	4/--
CVN 21 Class	125,000	--/4+

Three main targets:

- 4-12K gpd for potable/pure water, *pressurized brine release*
- 12K gpd for potable water (i.e., the NSRO)
- >50K gpd for potable/pure water

What Makes Equipment "Militarized"?

- Generally:
  - Removal/enclosure of all plastic parts
  - Removal of pipe threaded parts
  - Capable of meeting necessary specifications, standards and rules, as appropriate for components and system
    - e.g. shock, vibration, EMI/EMP, etc.

Design Constraints

- Key Designs:
  - Metal construction for long-life
  - Minimized hazmat and replacement/PM parts
  - Operational at 45° angles
  - Low fire toxicity
  - Low Noise (OSHA + Platform Requirement)
  - Dimensions (per BAA – account for ship install)
  - Cost per gallon of water (energy and acquisition)

- Key standards:
  - Shock/Vibration (MIL-S-901C, MIL-STD-167)
  - EMI/EMP (MIL-STD-461E)
  - Water quality (NAVMED P-5010-6; BUMED 6420.10A)
  - Environmental protection of electrical components (MIL-STD-810F)
  - Safety (MIL-STD-882)
  - Fire toxicity (MIL-STD-2031; NAVSEA DDS-078-1)
  - Liquid level equipment (MIL-L-23886C, as applicable)
  - ABS NVR as applicable

FNC Areas

- Five Key Areas
  - Advanced Pretreatment
  - Advanced Chemical Pretreatment Enhancements
  - Advanced Reverse Osmosis Membranes
  - Advanced Energy Recovery Systems
  - Alternative Approaches, Miscellaneous Enhancements

Advanced Pretreatment

- Capability to operate in the littorals, without high-maintenance requirements
- Filtration to <3um, regenerable or inherently rejecting
- High capacity, high efficiency
- Resistant to biofouling, chemical attack
- Mechanically capable of forward and backward-flow

Advanced Chemical Pretreatment Enhancements

- Coagulant agents that minimize HAZMAT risk
- Minimal quantities
- In-situ generation
- Low energy requirement
- Environmentally acceptable discharge

Contained environment with costly logistics and strong safety requirements. Advanced technologies must be considered from the savings as well as the hazard standpoint.

Advanced Reverse Osmosis Membranes

- Enhanced yield
- Chemical and fouling-resistant
- Long-life
- High mechanical strength
- Scalable production
- Reasonable cost
- Capable of producing “superior quality” product in a single pass

Advanced Energy Recovery Systems

- High recovery levels at low flow rates
- 10-15kWh/kgal target energy use @12k gpd
- Quiet, simple and reliable, with minimal moving parts
- Upward and *downward* scalability
- Low wear, long-life

Alternative Approaches, Miscellaneous Enhancements

- Any enabling technologies to assist in the previous sections, keeping in mind:
  - HAZMAT
  - Simplicity/serviceability
  - Exotic materials/processes
  - Efficiency
  - Noise
  - Weight/volume

Final Thoughts

- Navy has unique operational scenarios and an ever-changing list of requirements
- Considering energy efficiency in all processes is critical
- Acquisition, support, logistics and manpower drive lifecycle costs

A family of products, providing superior performance with reduced footprint and costs,
applicable for all current and future applications.

Office of Naval Research

Future Naval Capabilities Program: Advanced Shipboard Desalination

BAA 09-013: Component Development for Advanced Shipboard Desalination Systems

FNC Program and the BAA

Paul Armistead

Office of Naval Research

Industry/ Applied Researchers' Day

February 25, 2009 Asilomar Conference Center, Pacific Grove, CA

Future Naval Capability Programs

- Advanced Shipboard Desalination FNC is a 5 year program to develop TRL 6 level prototype desalination systems targeted to specific ship classes.

  - 2 years of maturing promising ‘component’ level technologies to nearly mature prototypes (minimal risk with making a fully mature prototype)

  - 3 years to assemble components in to robust mature prototype desalination systems, and extensively test them

- BAA 09-013 Component Development for Advanced Shipboard Desalination Systems is for the first 2 years of the FNC program.

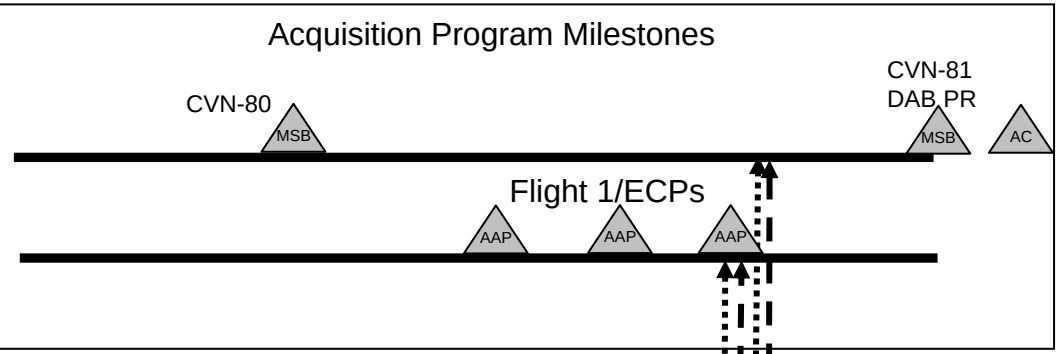
Advanced Shipboard Desalination System

Possible Transition Alignment

POM-10 FNC Process

Transition Targets

- CVN 81
- LCS follow-on ships



Technology Products

	09	10	11	12	13	14	15	16
1. Pre-filtration and Membranes	◆			◆		●		
2. Advanced Desalination System	◆			◆		●		

TRL-6

◆ Demo
▲ Transition
● Demo and Transition

AAP: Award Advanced Procurement
AC: Award Contract
SF: Start Fabrication
MSA: Milestone A
MSB: Milestone B

Objectives of the FNC

- **Develop an advanced shipboard desalination system that *costs the same or less* than NSRO, that occupies 40% less volume, has 40% less weight, uses 65% less energy, and has 50% lower total ownership costs.**
- **The desalination system will be able to operate in littoral environments at >95% operational availability, eliminating the need for costly and risky water barging and enabling in port humanitarian missions.**

Metrics - Shipboard Potable Water Production Products 1 & 2

	Navy Standard RO*	Same Capacity**
	CVN 21 RO	FNC-EC-100gpd
▪ Water Production Rate (4 RO units) (gal/day)	500,000	500,000
▪ Water Design Production Rate (gal/person/day)	50	50
▪ Consumables (per deployment)	15,000 filters	2880 lbs SHMP
▪ Storage Space (L' x W' x H'/cu-ft)	16 x 20 x 8 / 3264	8 x 5.4 x 8 / 346
▪ Maintenance + Consumable Costs ($K)	180	20
▪ Sp Energy Consumption (kw-hrs / K-gals) ***	129	26.4
▪ Energy Cost ($ / K-gal) – Potable Water***	8.28	1.70
▪ Operational Availability (A_o) – Open Ocean	>99%	>99%
▪ Operational Availability (A_o) – Littoral	>50%	>95%
▪ Mean Time Between Failures (hours)	>2,000	> 2,000

Total Desalination System Metrics

▪ Acquisition Cost ($M)	8.3	6.1
▪ Weight (lbs)	214,000	133,000
▪ Volume (cu-ft)	16,428	6,300
▪ Water Production/Unit Volume (gal/cu-ft/day)	34.6	79

* Production costs, ** Design goals, *** Assumes diesel generator power conversion and diesel fuel at $ 2.60 / gal

The Advanced Shipboard Desalination Systems will have capability to make water in the littoral zones at lower power, maintenance, and manning cost. Similar percentage gains should exist for 12k and 50k gpd units.

Future Naval Capability Programs: The Vision

- We plan to have mature, robust, ship ready prototypes complete in less than four years from the FNC program start in October 2009.
- Our state-of-the-art, starting point, or fall back position are the EUWP demonstrators, which already significantly outperform NSRO. They merely need hardening for shipboard application.
- Our plan is to spend two years on the component level (pumps, energy recovery devices, membranes, prefiltration approaches, etc…):
  - evaluating new/current technologies in the background at the government test sites, consistent with shipboard constraints.
  - **under this BAA**, maturing promising new, improved, or alternative technologies that are applicable to shipboard desalination to TRL 5,6 (minimal risk with making a fully mature prototype)

Technical Readiness Levels, TRL

In this BAA we are starting at TRL 4, 5 and going to TRL 5, 6

6.1

1. Basic principles observed and reported.

   Lowest level of technology readiness. Scientific research begins to be translated into applied research and development.

2. Technology concept and/or application formulated Invention begins.

   Once basic principles are observed, practical applications can be invented. Applications are speculative and there may be no proof to support the assumptions.

6.2

3. Analytical and experimental critical function and/or characteristic proof of concept.

   Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology.

4. Component and/or breadboard validation in laboratory environment.

   Basic technological components are integrated to establish that they will work together. This is relatively "low fidelity" compared to the eventual system.

6.3

5. Component and/or breadboard validation in relevant environment.

   Fidelity of breadboard technology increases significantly. The basic technological components are integrated so that device can be tested in a simulated environment.

6. System/subsystem model or prototype demonstration in a relevant environment.

   Representative model or prototype system, which is well simulated operational environment.

Advanced Shipboard Desalination
Future Naval Capability 2010-14

Program Schedule

FY2009 BAA Component Development for Advanced Shipboard Desalination

FY2010 Initiate 24 month efforts to develop novel component prototypes

FY2011 Last 6 months of awards will be gov't testing and down selection of components

BAA 09-013: Major areas of focus:

1. • Advanced pretreatment
2. • Advanced Chemical Pretreatment Enhancements
3. • Advanced Reverse Osmosis Membranes
4. • Advanced Energy Recovery Systems
5. • Alternative Approaches to desalination, pretreatment

FY2012 Select target ship classes for prototypes

Cover small system, large system, potable only system, potable and ultrapure system

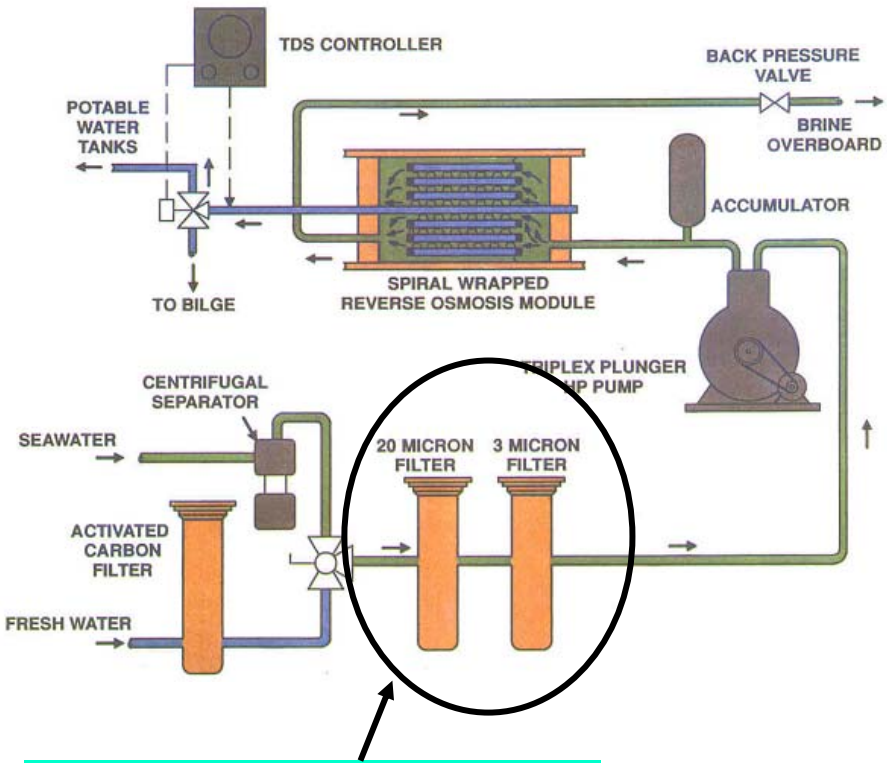
Gain support from two ship classes, build robust prototypes under BAA, RFP

FY2013 Rigorous land-based testing of prototypes

FY2014 Potential shipboard testing

Advanced Shipboard Desalination Industry / Applied Researcher Day

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems



(1) Pretreatment: Membrane-based filtration in near shore areas should result in less maintenance and increased reliability.

BAA topic 6.1:
Advanced Pretreatment

Requirements:
15 min SDI < 3.0
Turbidity < 1.0 NTU

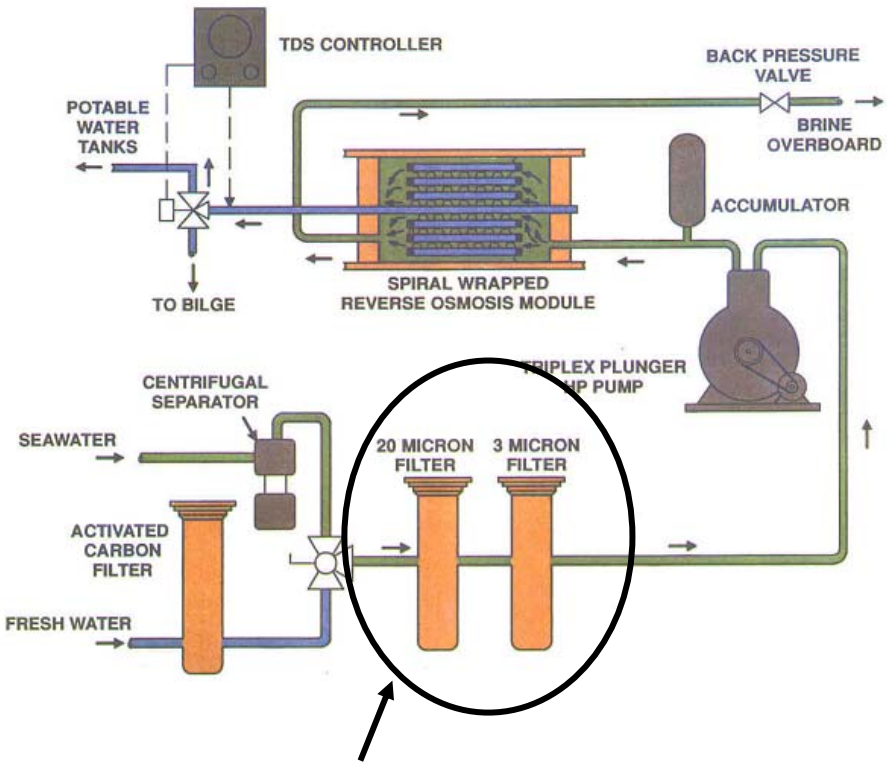
Current solutions:

NSRO	cartridge filters
TWPS	MF, polypropylene hollow fiber
LWP	UF, polysulfone hollow fiber
EUWP Gen 1	UF, polysulfone, hollow fiber
EUWP Gen 2	MF, PVDF, hollow fiber

Various strategies for automated backflushing to maximize cleaning intervals

Advanced Shipboard Desalination Industry / Applied Researcher Day

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems



(2) Enhanced Pretreatment: It may be possible to increase the interval between membrane cleaning with in situ produced coagulants or enhanced backwashes.

BAA topic 6.2:

Advanced Chemical Pretreatment Enhancements

Requirements:

Strategies to reduce or eliminate the need for periodic acid (or hazmat) cleanings and are consistent with shipboard operation wherein logistics supported chemicals are discouraged relative to generate in place options:

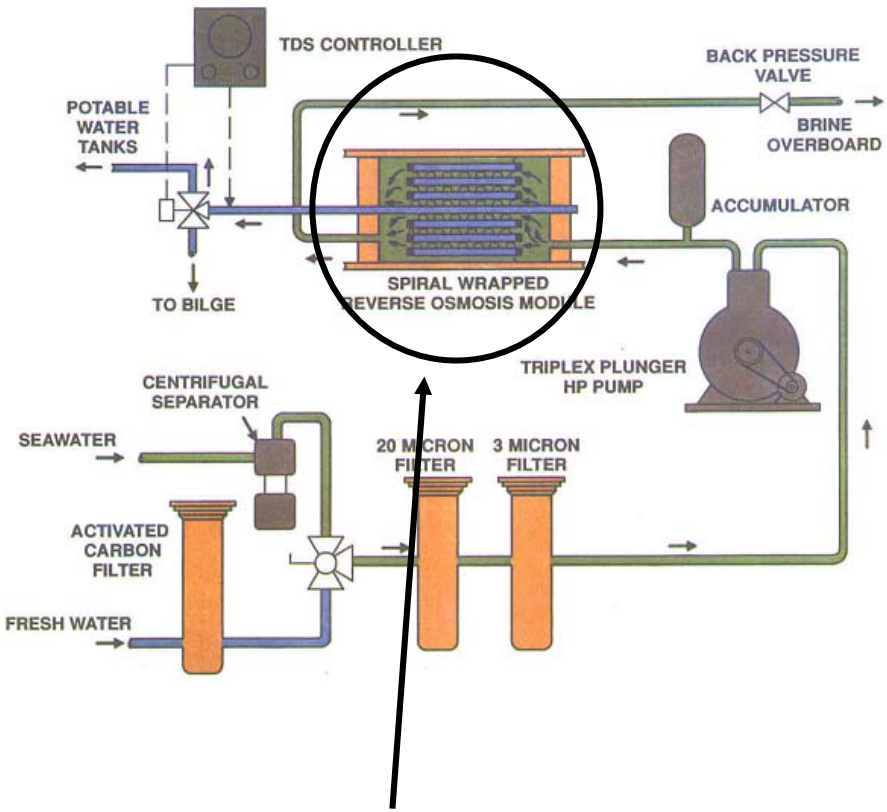
Current solutions:

NSRO	cartridge filters only
TWPS	none
LWP	ferric sulfate
EUWP Gen 1	UF with ferric chloride
EUWP Gen 2	MF with chlorinated water backwash

Electrocoagulation, ozone, chlorine backwashes

Advanced Shipboard Desalination Industry / Applied Researcher Day

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems



(3) Desalination: Advanced high flux, RO membranes and hybrid configurations can reduce space, weight, and energy requirements

BAA topic 6.3:
Advanced Reverse Osmosis Membranes

Goals:

Longer membrane lifetime, reduced cleaning, reduced system size, reduced energy

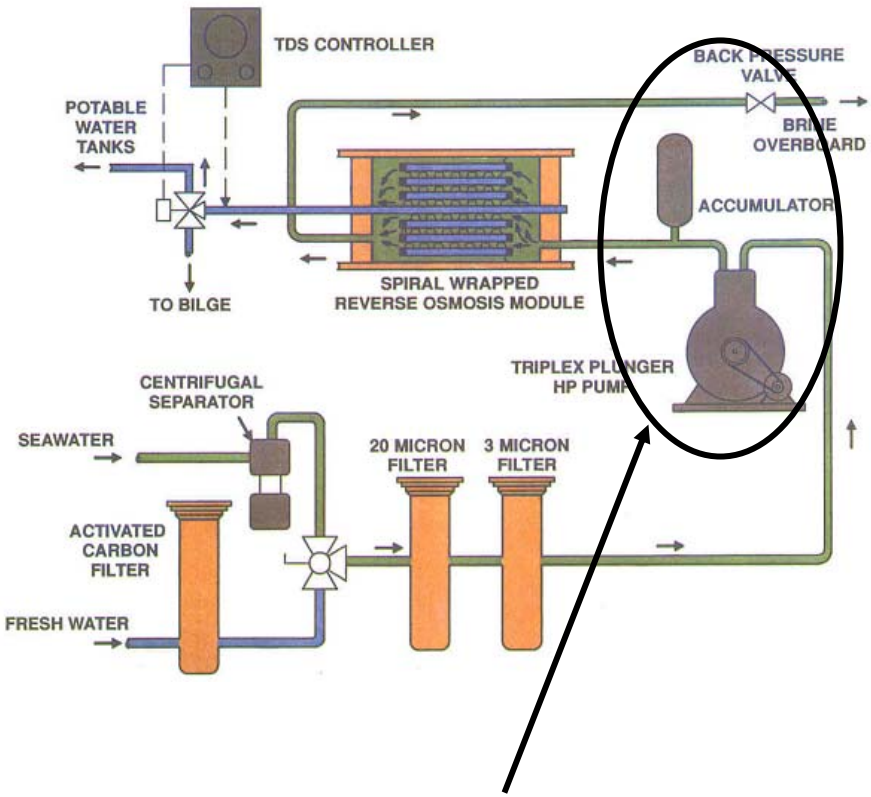
Oxidant resistance, reduced fouling, higher flux

Current solutions:

NSRO	commercial seawater RO
TWPS	commercial seawater RO
LWP	commercial seawater RO
EUWP Gen 1	commercial & experimental seawater RO
EUWP Gen 2	commercial & experimental seawater RO

Advanced Shipboard Desalination Industry / Applied Researcher Day

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems



(4) Energy Reduction: Energy recovery device can reduce energy, size, noise, and maintenance requirements.

BAA topic 6.4:
Advanced Energy Recovery Systems

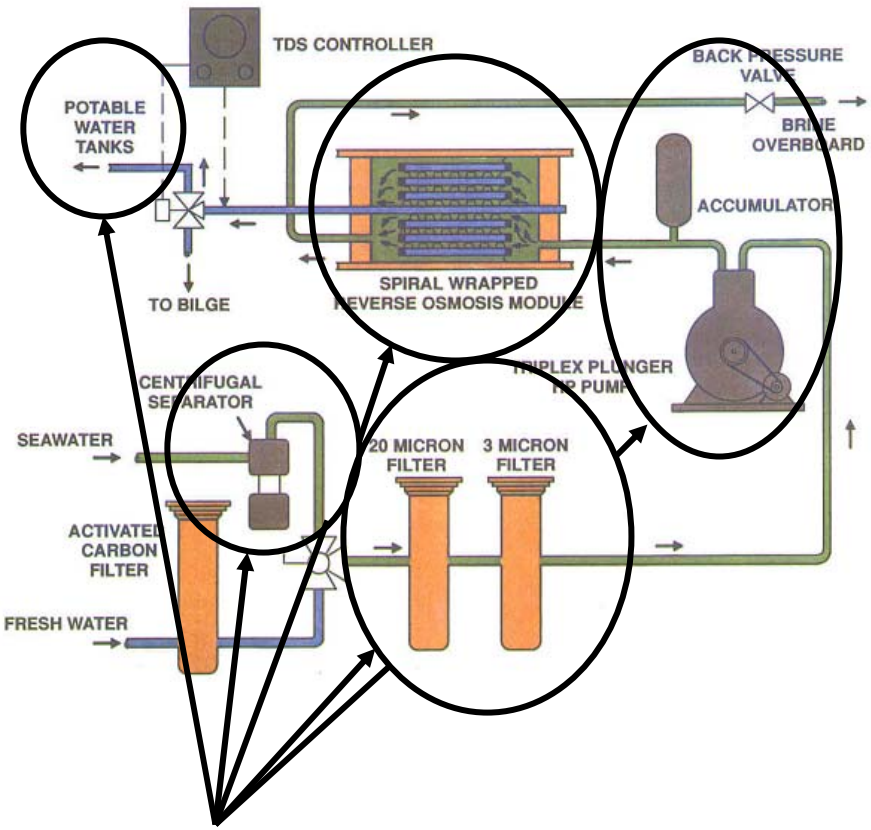
Goals:
Enable use of this technology for smaller systems, 12,000 gallons per day

Current solutions:

NSRO	none
TWPS	turbocharger ER device
LWP	none
EUWP Gen 1	commercial ER device
EUWP Gen 2	commercial ER device

Advanced Shipboard Desalination Industry / Applied Researcher Day

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems



(5) Anything else?

BAA topic 6.5:

Alternative Approaches, Miscellaneous Enhancements

Goals:

Evaluate, mature alternatives to UF/RO or processes to enhance UF/RO consistent with compact, robust, low maintenance shipboard desalination requirements

- forward osmosis
- direct contact membrane distillation
- non-membrane particle separation
- in situ oxidant generation
- membrane cleaning approaches
- other ideas

Anticipated Award Information

BAA Topic Area	Totals	Expected Awards
6.1 Advanced Pretreatment	**1,000**	**2 to 4**
6.2 Advanced Chemical Pretreatment Enhancements	**800**	**1 to 3**
6.3 Advanced Reverse Osmosis Membranes	**1,000**	**2 to 4**
6.4 Advanced Energy Recovery Systems	**800**	**1 to 3**
6.5 Alternative Approaches, Miscellaneous Enhancements	**800**	**1 to 3**

It is anticipated that there will be 10 to 16 awards.

Though not explicitly stated, it is anticipated that award values will be between $200k and $500k for the two year period.

Future Naval Capability Programs: The Vision

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems

- **Under this BAA**, the primary goal is to develop, evaluate, mature promising new, improved, or alternative technologies to nearly mature prototypes (minimal risk with making a fully mature prototype)
  - Awards are for 24 months
  - Offerors are expected to deliver a component to a government test site prior to the 19th month of the award for government testing.
  - Offerors must be reachable for consultation during testing.
  - Offerors retain ownership of their prototypes.
  - Offerors must submit a report based on government results by the end of the 24th month.

Future Naval Capability Programs: The Vision

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems

- Scale of component prototypes
  - Not specified, but large enough to show technology is ready for incorporation into 6000 to 12000 gpd potable water system.
- Robustness of prototype
  - Will be operated with minimal shelter and oversight near a surface water source.
- Weight, volume, energy restrictions per gallon of potable water
  - Dimensions of NSRO are given in BAA, page 3
  - Goal is 40% weight, volume decrease, 65% energy decrease, though no component level restrictions are stated.

Future Naval Capability Programs: The Vision

ONR BAA 09-013: Component Development for Advanced Shipboard Desalination Systems

- pay attention to **Technical Concept** and **Operation Utility Assessment Plan** on pages 11,12 of BAA
  - state available power, compressed air, etc…
  - ask if there are any toxic chemicals coming out of your system, or required to operate your system
  - tell you to supply your own computer and spare parts
  - ask you for permission to modify your equipment to help it work

Future Naval Capability Programs: The Vision

We Want What You Want…

We want to know whether various technologies will enhance or are superior to UF/RO for shipboard desalination.

We want to know if the awardees can deliver what they propose and can work with their equipment (after month 19) to quickly optimize performance for the stated application with various source waters.

As we provide these answers to ourselves, we will also be providing to you a realistic assessment of the maturity of your technology, or it applicability to seawater desalination (in a shipboard environment).

Future Naval Capability Programs: The Vision

We will be testing a limited number of commercial products throughout FY2009 and 2010.

Awardees are encouraged to work with the government test sites prior to the start of the 19th month and as soon as 6 months from the award dates.

Future Naval Capability Programs: The Vision

Technical Point of Contact:

Paul.armistead@navy.mil

Contracting Specialist:

Brenda.burke@navy.mil

White papers are required.

Available for questions up until 1 week before white papers or full proposals are due.

Advanced Shipboard Desalination
Future Naval Capability 2010-14

Advanced Shipboard Desalination IPT

Paul Armistead	Office of Naval Research
Dave Nordham	NSWCCD-SSES, Philadelphia
Larry Johnson	Fulcrum
John Heinzel	NSWCCD-SSES, Philadelphia
Ian Peek	NSWCCD-SSES, Philadelphia
Jim Higgins	NSWCCD-Carderock
Bill Varnava	US Navy NFESC
Bob Shalewitz	US Army TARDEC
Jay Dusenbury	US Army TARDEC
Mark Miller	US Army TARDEC c/o NFESC
Michelle Chapman	US Bureau of Reclamation

Details, Dates, and Procedures

for BAA 09-013 "Component Development for Advanced Shipboard Desalination Systems"

Ian Peek

NSWCCD-SSES

25 February 2009

Anticipated Award Information

BAA Topic Area	Totals	Expected Awards
6.1 Advanced Pretreatment	1,000	2 to 4
6.2 Advanced Chemical Pretreatment Enhancements	800	1 to 3
6.3 Advanced Reverse Osmosis Membranes	1,000	2 to 4
6.4 Advanced Energy Recovery Systems	800	1 to 3
6.5 Alternative Approaches, Miscellaneous Enhancements	800	1 to 3

Five areas for opportunity

$4.4M

Up to 17 awards expected

The Application and Submission Processes

POM-10 FNC Process

WHITE PAPER

Deadline: 2PM, 3 April 2009

WHITE PAPERS REQUIRED FOR ALL SUBMISSIONS

NAVY REVIEW

Notification on or about 24 April 2009

FULL PROPOSALS

Deadline: 2PM, 1 June 2009

Initial selections on or about 29 June 2009

NAVY REVIEW, SELECTION, & NOTIFICATION

White Paper Format

➢ Format:

- ❖ 8.5 x 11 inch paper
- ❖ 1 inch Margins
- ❖ Single or Double Spacing
- ❖ Font: Times New Roman, 12pt
- ❖ Length: No more than 6-single sided pages (excluding cover page & resumes)
- ❖ ELECTRONIC SUBMISSION
  - MS WORD or MS EXCEL or PDF files EMAILED by 2PM, 3 April 2009 to paul.armistead@navy.mil

Submissions exceeding length may not be evaluated, and hard copy submissions will not be accepted!

White Paper Content

➢ Content

- ❖ **Cover page**
  - BAA number, proposal title, relevant topic area in BAA, administrative & technical points of contact, with all contact information, signed by authorized officer
- ❖ **Technical Concept (3 Pages)**
  - Objectives, technical issues, approach, assessment, comparison, and references
- ❖ **Deliverables (1 Page)**
- ❖ **Programmatic Section (1 Page, Milestones and Timetable)**
- ❖ **Cost (1 Page, Segregated by Tasks)**
- ❖ **Resumes (Single page for PI & other key personnel)**

Technical Concept Section should address the Technical Concept and Operational Utility Assessment from the Full Proposal Section

Full Proposal Format

➢ Format:

- ❖ 8.5 x 11 inch paper, 1 inch Margins, Single or Double Spacing
- ❖ Font: Times New Roman, 12pt
- ❖ Length:
  - Technical Proposal: No more than 20-single sided pages (excluding cover page, table of contents, management approach, and other agencies)
  - Cost Proposal: No page limitations
- ❖ Electronic Submission for CONTRACTS ONLY
  - MS WORD or MS EXCEL or PDF files EMAILED by 2PM, 1 June 2009 to paul.armistead@navy.mil
  - One ORIGINAL and one COPY (hardcopies) to Dr. Paul Armistead via Express Mail (USPS) or UPS.

Submissions exceeding length may not be evaluated.
Contracts emailed to Dr. Paul Armistead followed by 2 hardcopies.
GRANT applicants submit PDFs via www.grants.gov

Full Proposal Content

- Cover Page
- Table of Contents
- Statement of Work
- Technical Concept
- Operational Utility Assessment Plan
- Project Schedule & Milestones
- Assertion of Data Rights and/or Rights in Computer Software
- Deliverables
- Management Approach
- Other Agencies

Additional and specific information listed in BAA 09-013 Announcement

Cost Proposal Content for Contracts and Grants

- Contracts
  - Cover Page
  - Part I – Contract Costs
    - Direct Labor
    - Indirect Costs
    - Travel
    - Subcontracts
    - Consultants
    - Materials & Supplies
    - Contractor Acquired Equipment or Facilities
    - Other Direct Costs
    - Options
    - Fee / Profit
  - Part II – Cost breakdown by task / subtask in Statement of Work

- Grants
  - Cover Page
  - Part I – Contract Costs
    - Direct Labor
    - Indirect Costs
    - Travel
    - Subawards
    - Consultants
    - Materials & Supplies
    - Recipient Acquired Equipment or Facilities
    - Other Direct Costs
    - Options
    - Fee / Profit (**UNALLOWABLE!**)
  - Part II – Cost breakdown by task / subtask in Statement of Work

Reminder: Contracts are for companies, Grants are for Universities & Non-Profit Organizations. Grants are submitted in PDF format via www.grants.gov

Grant Submissions (not applicable to Contracts)

- All White Papers sent directly to Dr. Paul Armistead at paul.armistead@navy.mil
- Grant Full Proposals must be submitted in PDF form through www.grants.gov
- Contract Full Proposals submitted electronically with 2 hardcopies by post
- Directions at http://www.onr.navy.mil/02/how_to.asp
- Organization Registration Checklist at http://www.grants.gov/applicants/register_your_organization.jsp

Special Notice for Grant Submissions: Please read BAA 09-013 Section IV – "Application and Submission Information" **CAREFULLY**!

Late Proposals

- **Proposals received AFTER the published submission deadline will be considered "late", and will not be considered UNLESS**
  - **It is received before award is made AND the Contracting Officer determines that it will not unduly affect the acquisition**
- **Late modification of an otherwise timely proposal with terms MORE FAVORABLE to the Government will be accepted.**
- **Time and Receipt established by time/date stamp**
- **Contracting Officer will notify offeror if proposal was late and whether proposal will be evaluated**

Best results when proposals are submitted on time!

Evaluation Criteria

1. **Overall scientific and technical merits of proposal**

2. **Potential of proposed effort and product of development to meet Navy's mission as described in this BAA**
   (i.e., 40% weight & volume reduction, 65% energy savings, etc.)

3. **Potential of proposed product of development to be production-ready and available for shipboard application in Calendar Year 2012**

4. **Potential for proposed product of development to be militarized to meet applicable Navy qualification testing**

Evaluation Criteria (Continued)

5. Offeror's capabilities, related experience, facilities, techniques & combinations thereof for achieving the proposal objectives and bringing product of development to production (route to development)

6. Qualifications, capabilities, and experience of proposed principal investigator, team leader and other key personnel who are critical to achieving the proposed objectives

7. Proposed costs and realism of those costs to meet the proposed objectives

Evaluation Panel

- **Proposal Evaluation Panel composed of**
  - **Program Officer**
  - **Government Scientific Experts**
  - **Support Contractors as technical consultants (subject matter experts)**
  - **Support Contractors for cost proposal evaluation**

ALL PROPOSALS are protected by unauthorized disclosure in accordance with FAR 3.104-4 & 15.207. Further, any support contractor reviewing the technical and cost proposals will sign NON-DISCLOSURE AGREEMENTS (NDAs).

Reporting

- **Data Deliverables:**
  - **Technical & Financial Progress Reports**
  - **Presentation Materials**
  - **Final Report**
- **Deliverables (typical for Contracts):**
  - **Software**
  - **Prototypes for testing**
  - **Other Hardware Deliverables**

Additional deliverables may be proposed and finalized during negotiations.

Other Useful Information

- **Please read Section VI – "*Award Administration Information*" CAREFULLY for unique classification, certification, and registration information**
- **Government Property / Government Furnished Equipment**
- **Project Meetings & Reviews**
  - **60% at Offerors, 40% at or near ONR, Arlington, VA**
  - **Other reviews as necessary via teleconference, video teleconference, or web-based collaboration tools**
- **Submission of Questions**
  - **By electronic mail (email) to Points of Contact in this BAA (Brenda Burke, Business POC / Contracting Officer & Dr. Paul Armistead, Technology Point of Contact**
  - **Questions on WHITE PAPER up to 2PM, 27 March 2009**
  - **Questions on FULL PROPOSAL up to 2 PM, 22 May 2009**
  - **Deadlines posted in released BAA will NOT be extended.**

Summary

- **BAA 09-013 "Component Development for Advanced Shipboard Desalination Systems" seeking advanced techniques for fresh water production from seawater**
- **Critical Dates for White Paper & Proposal Submissions (3 April 2009 & 1 June 2009, respectively)**
- **Unique Submission requirements for Contracts and Grants**
- **Questions about *Details, Dates and Procedures*?**

Naval Facilities Engineering Command
ENGINEERING SERVICE CENTER

OVERVIEW OF GOVERNMENT TESTING CAPABILITIES for EVALUATION OF DELIVERED BAA PRODUCTS in support of ONR BAA 09-013

SEAWATER DESALINATION TEST FACILITY PORT HUENEME, CA

PRESENTED to:

ONR Industry and Applied Researchers Day , Pacific Grove, CA

February 25, 2009

BACKGROUND – Seawater Desalination Test Facility (SDTF)

The SDTF provides research, development, test and evaluation, and training support for water purification equipment. It is located at the entrance to the port at Port Hueneme, CA providing direct access to natural Pacific Ocean water using an open-ocean intake.

The SDTF is managed by the Amphibious and Expeditionary Department of the NAVFAC Engineering Service Center, Naval Base Ventura County.

Naval Base Ventura County
Port Hueneme, CA

BACKGROUND – Origins and Mission

- Origins: The SDTF was originally established in 1983 at the Naval Civil Engineering Laboratory (NCEL), a predecessor to NAVFAC ESC. In January 2000, the SDTF was relocated to the harbor entrance at Naval Base Ventura County, Port Hueneme, CA.

- Mission: The mission of the SDTF is to provide a real world test environment for long term evaluation of desalination equipment and other water purification components including pumps, pretreatment filters, and energy recovery devices. The test data collected provides DoD and private sector developers with real world feedback on the reliability and durability of key system components.

SDTF FACILITY SPECIFICATIONS

- **Location: Adjacent to entrance of Port Hueneme Harbor with direct access to seawater**
- **Area: Occupies approximately 0.75 acres along waterfront (approx. 125 ft wide x 260 ft long).**
- **Tent: Covered 3000 ft^2 concrete pad, trenches, electricity (208/460 V) instrument room, shop tools**
- **Outdoor Pad: 1800 ft^2 concrete test pad with 460 V/3 phase power**
- **Intake pier: provide access to harbor (8 ft wide x 65 ft. long)**
- **Intake pump house: (12 ft x 12 ft), 2 pumps up to 350 gpm flow**
- **Storage tanks: 5000 gallon raw seawater, 2500 gallon product, 20K gallon fresh water bladder**
- **Power: 3 phase, 460 V, 1000 A / 208 V, 800 A, 750KW transformer**
- **Compressed Air: 2 compressors available**
- **Discharge piping: 2 outfalls/sumps, 24 in. diameter, brine/product recombined**

SDTF TEST EQUIPMENT

- **Lightweight Water Purifier (LWP): (UF/RO skids, 75 GPH)**
- **Tactical Water Purification System (TWPS): (2 units) (MF/RO, 1200 GPH)**
- **EUWP GEN 1: (100K GPD, UF and RO skid)**
- **EUWP GEN 2 :(300K GPD, MF and RO skid)**
- **MICROFILTER PILOT UNIT: (MEMCOR XP3 MF, 20 gpm)**
- **RO ELEMENT TEST STAND: (4 in dia, up to 10 elements, 20 gpm)**
- **MULTIMEDIA FILTER: (36 in dia x 72 in high, 70 gpm flow)**
- **CARTRIDGE FILTER: (8 cartridges, 40 in long)**
- **ASSORTED PUMPS, FILTER HOUSINGS, TANKS, HOSES**

SDTF INSTRUMENTATION

- Turbidity meters
- pH meter
- Conductivity meter
- ORP meter
- Fluorescence meter
- Dissolved Oxygen meter
- Temperature sensor
- Particle counts (> 2 micron)
- Silt Density Index (SDI)
- Resistivity meter
- Deionized Water system
- Hand held chemical analyzer (chlorine, iron, multi ion)
- Flow Totalizers

ANALYTICAL CAPABILITIES

- **Can conduct following water quality analyses in house through ESC chemist:**

- **Chloride (Cl-)**
- **Total Carbon Dioxide (TCO2)**
- **Total Suspended Solids (TSS)**
- **Total Dissolved Solids (TDS)**
- **Silica (SiO2)**
- **Chlorine – Free and Total (Cl2)**
- **Titrations, filtration and various wet chemistry techniques**

Instrumentation:

- **We have the following major instrumentation for analysis of materials:**
- **FTIR – identification of organic (and some inorganic) solids, liquids, and gases**
- **UV-VIS – colorimetric analysis of liquids and solids, reaction studies**
- **ICP – emission spectroscopy technique for analyzing elements in solution**
- **DMA – mechanical flexural modulus information of solids**
- **SEM – microscopic analysis of material structure**
- **Instron/Baldwin – tensile and compression properties of solids (e.g. concrete, steel)**

SDTF – Raw Water Characteristics

- NPDES Permit: The SDTF is permitted by State of California to pump and discharge approximately 1,000,000 gallons of seawater per day. Brine/product recombined.
- Raw Water Quality: The SDTF utilizes an open ocean intake to draw in raw water to the facility.

Raw Seawater Parameter	Measured Values
Turbidity	0.5 - 3 NTU (1.0 NTU)
Total suspended solids (TSS)	0.5 - 15 mg/L (5mg/L)
Total dissolved solids (TDS)	35,000 - 38,000 mg/L
Temperature	53 - 70 °F
Total Carbon Dioxide, TCO_2	110-120 mg/L
pH	7.8-8.0
Total organic carbon (TOC)	0.0 – 2.0 mg/L
Silica	0.6 -1.5 mg/L
Chloride concentration (Cl^-)	19,680 mg/L

SDTF Programs – Research & Development Efforts

- USMC Lightweight Water Purification System
  - Design, development and evaluation
- EUWP Gen1
  - Preliminary design
  - Hybrid RO configuration pilot testing
  - Ultrafiltration system pilot testing
  - System evaluation
  - Verification testing
- EUWP Gen2
  - Microfiltration comparison and pilot testing
  - High range chlorine meter evaluation
  - System evaluation

SDTF Programs – Technology Evaluation & Endurance Testing

- Technology Evaluation
  - Ceramic microfiltration membranes
  - Continuous Electrodeionization (CEDI) system
  - Micro/Ultrafiltration (MF/UF) technologies
  - Membrane Distillation Systems

- Endurance Testing
  - LPD 17: 24,000 gpd, 90-day test
  - SSN688: 6,000 gpd, 45-day test
  - NSRO 1,200 gpd: 45-day test

SDTF Programs – Private Sector Testing

- SDTF is unique government testing facility which can be utilized by private sector under certain conditions:
- Affordable Desalination Coalition (ADC):
  - State project to demonstrate low energy desalination
- Energy Recovery Inc (ERI)
  - Testing of energy saving components for desalination.
- Hydranautics:
  - Submerged MF membrane testing
- Pall Corporation:
  - Seawater testing of pressurized MF membranes
- Arkal:
  - Fine strainer/MF evaluation
- Koch/Fluid Systems:
  - RO membrane testing for new product line.

POINTS OF CONTACT

U.S. Navy / NAVFAC ESC - SDTF

Bill Varnava
NAVFAC ESC
Phone: 805-982-6640
william.varnava @ navy.mil

Micah Ing
NAVFAC ESC
Phone: 805-982-1357
micah.ing @ navy.mil
micah.ing @ us.army.mil

U.S. Army / TARDEC - SDTF

Mark Silbernagel
TARDEC
Phone: 805-982-1632
mark.silbernagel @ navy.mil
mark.silbernagel @ us.army.mil

Mark Miller
TARDEC
Phone: 805-982-1315
mark.c.miller @ navy.mil
mark.c.miller1 @ us.army.mil

NAVFAC
Naval Facilities Engineering Command
ENGINEERING SERVICE CENTER

Seawater Desalination Test Facility

What is it?

The Seawater Desalination Test Facility (SDTF) provides research, development, test and evaluation, and training support for water purification equipment. The SDTF is the test laboratory for the water purification team within EX32, Amphibious and Expeditionary Department at NAVFAC Engineering Service Center in Port Hueneme, CA. It is located at the entrance to the harbor of Naval Base Ventura County (NBVC) providing direct access to natural Pacific Ocean Seawater.

Origin

The SDTF was originally established in 1983 at the Naval Civil Engineering Laboratory (NCEL) which was one of the predecessor organizations to NAVFAC ESC. In January 2000, the SDTF was relocated to a new facility on NBVC.

RDT & E Mission

The mission of the SDTF is to conduct RDT & E and to provide a real world test environment for long term evaluation of desalination equipment and other water purification components including reverse osmosis membranes, pumps, and energy recovery devices. The test data collected provides the customer with real world feedback on the performance, reliability, and durability of key system components.

Support to the Warfighter

The SDTF has provided key technical and testing support in the development of military field water purification equipment used by the U.S. Army and U.S. Marine Corps. NAVFAC ESC has teamed and partnered with the US Army TARDEC for the development, testing, and evaluation of water purification. Examples of equipment are:

- Tactical Water Purification System (TWPS) (Army/Marine Corps)
- Lightweight Water Purifier (LWP) (Army/Marine Corps)
- Water Packaging (Army/Marine Corps)
- Maintenance/Training/Technical Support 600 GPH/3,000 GPH/ROWPU
- 45-90 Day Shipboard RO Certifications (SSN688/LPD17)

The SDTF also conducts pilot and demonstration studies on new water purification technologies for use on future military systems. The SDTF has been designated as an approved test site for shipboard RO endurance testing by NAVSEA. Additionally, several product improvement and research studies aimed at lowering the operational cost and improving system reliability of these units have been demonstrated at our facility.

Examples of technology include:

- Ceramic Low Pressure Membranes
- Membrane distillation
- Energy recovery devices
- Long term testing of micro and ultra filtration systems

SDTF Facility

Facility

- State discharge permit for 1MGD
- Pump house (12 x 12 ft), 2 intake pumps 350 gpm
- Intake Pier (65 ft x 8 ft wide)
- 1 Outfall 12 inch diameter
- Sanitary sewer connection
- 12,500 ft^2 Office trailer, phone/fax lines
- 3,000 ft^2 covered facility
- 1,800 ft^2 outdoor test pad
- Facility occupies area 250 ft x 125 ft (3/4 acre)
- Uncovered test area (15,000 ft^2)

Power

- 750 KVA 460 V, 3 phase
- 225 KVA 208 V, 3 phase

Test Equipment

- Test Beds
  - UF Skid 6.4 gpm
  - RO Skid 3.25 gpm
  - MF Skid 70 gpm
  - RO Skid 20 gpm
  - 100K GPD UF/RO 2 pass
  - 300K GPD MF/RO 2 pass
  - MF Skid - 20 gpm
  - Media/Cartridge Filter Skid - 70 gpm

Instrumentation

- Incandescent turbidimeter
- Laser turbidimeter
- Dissolved oxygen meter
- pH
- Conductivity/resistivity
- Particle size analyzer
- Fluorescence meter
- Auto silt density index (SDI) meter
- Temperature

Past Customers Supported

- U.S. Navy
- U.S. Army
- U.S. Marine Corps
- Bureau of Reclamation
- Multiple Private Sector Companies

Points of Contact

U.S. Navy/NAVFAC ESC-SDTF:

Mr. Bill Varnava
NAVFAC ESC
Phone: (805) 982-6640

Mr. Micah Ing
NAVFAC ESC
Phone: (805) 982-1357

U.S. Army/TARDEC-SDTF:

Mr. Mark Silbernagel
TARDEC
Phone: (805) 982-1632

Mr. Mark Miller
TARDEC
Phone: (805) 982-1315

RECLAMATION

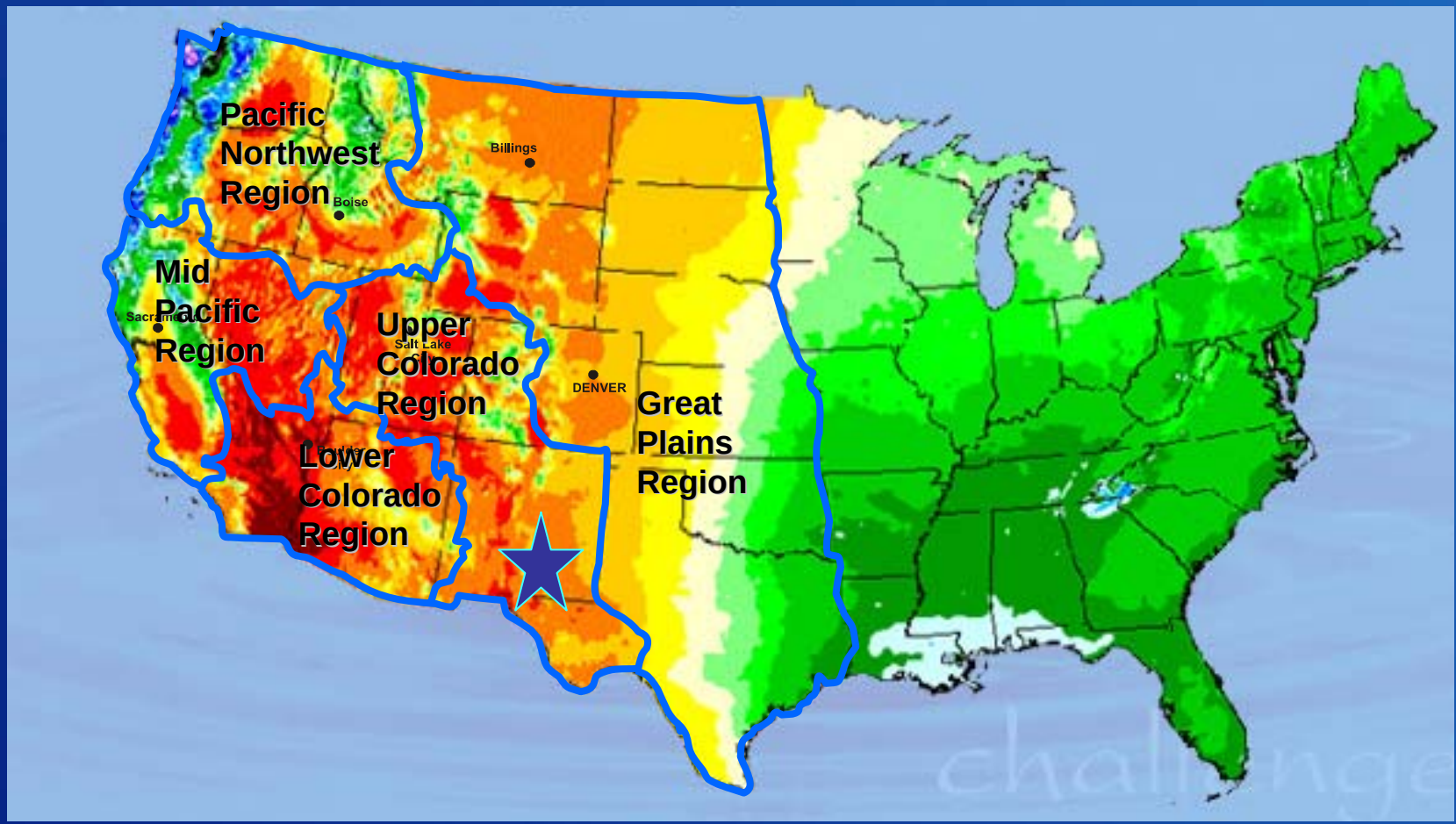
Managing Water in the West

Testing Capabilities: Brackish Groundwater National Desalination Research Facility

February 25, 2009

U.S. Department of the Interior
Bureau of Reclamation

Brackish Groundwater National Desalination Research Facility



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RECLAMATION

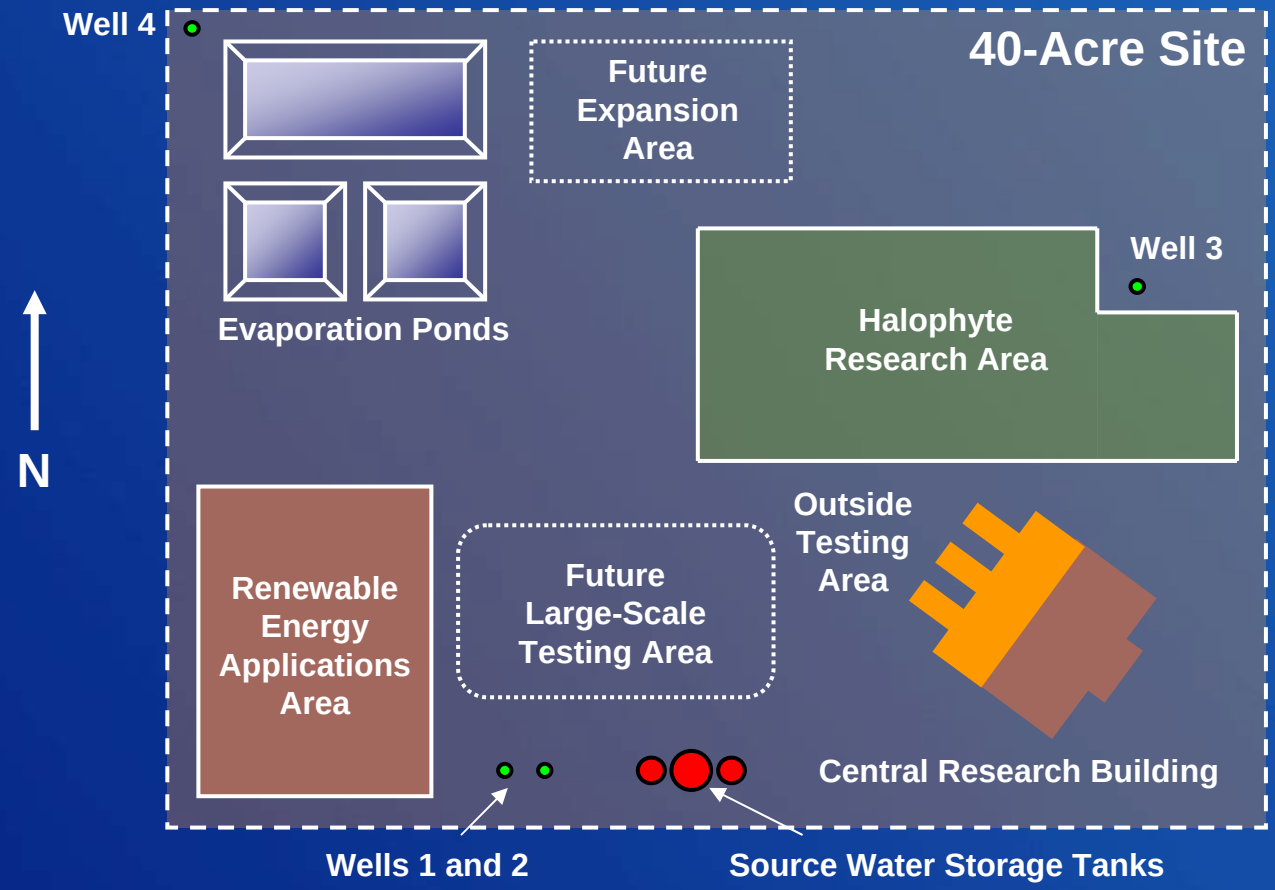
Research Program at the Facility

There are five aspects to the research program:

1) **Cooperative agreements and projects**
2) **Cooperative research and development agreements (CRADAs)**
3) **Federal partnerships**
4) **Professional and industrial research group**
5) **Student internship and work program**

The Facility

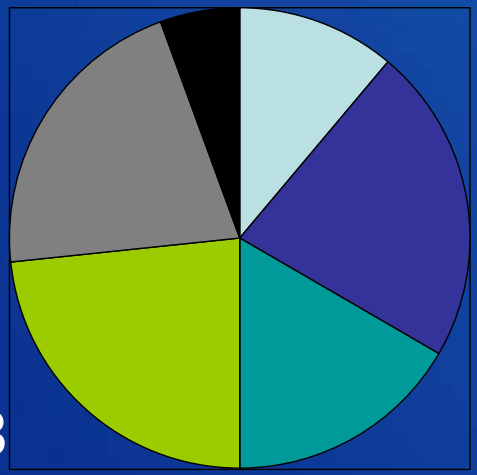
Facility Layout Permits a Wide Range of Research Projects



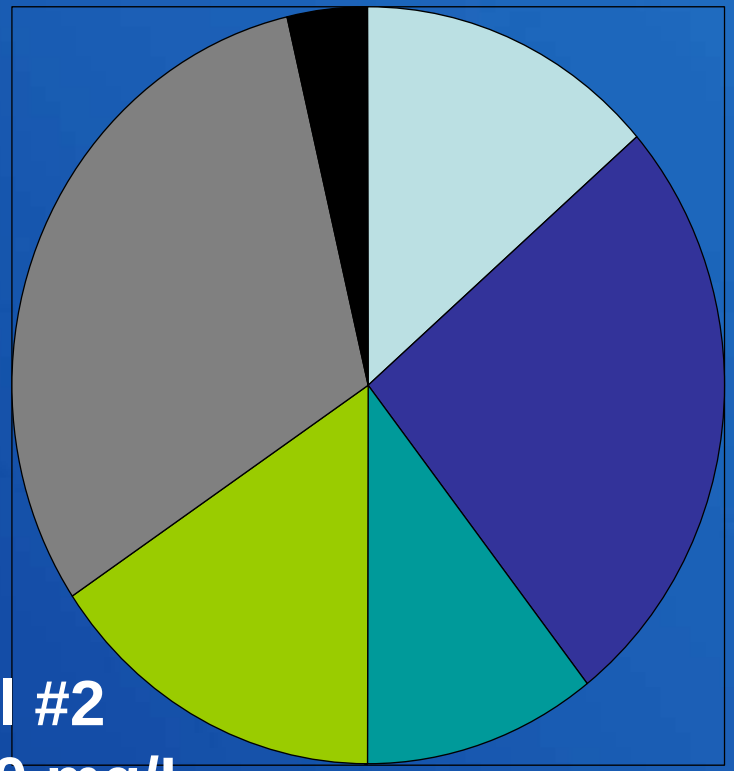
Water Qualities Available for Research

- **Low total dissolved solids (TDS) well (Well 1)**
  - **TDS: 1,000 – 1,200 mg/L**
  - **Temperature: 41 °C (cooling tower available)**
- **Mid TDS wells (Wells 2, 3 & 4)**
  - **TDS: 3,450 – 6,400 mg/L**
  - **Temperature: 21 °C**
- **High TDS source (trucked to site or prepared)**
  - **TDS: 10,000 mg/L or greater**

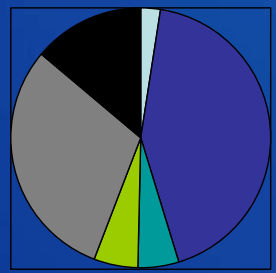
Water Composition



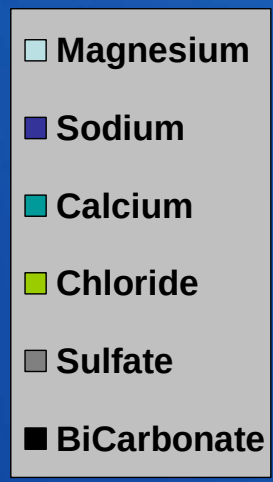
Well #3
3350 mg/L



Well #2
6400 mg/L

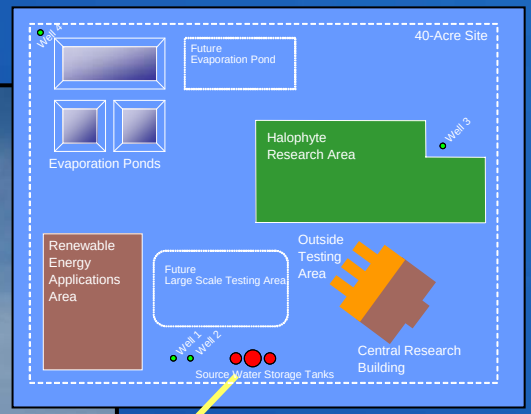


Well #1
1100 mg/L



RECLAMATION

Source Water Storage Tanks

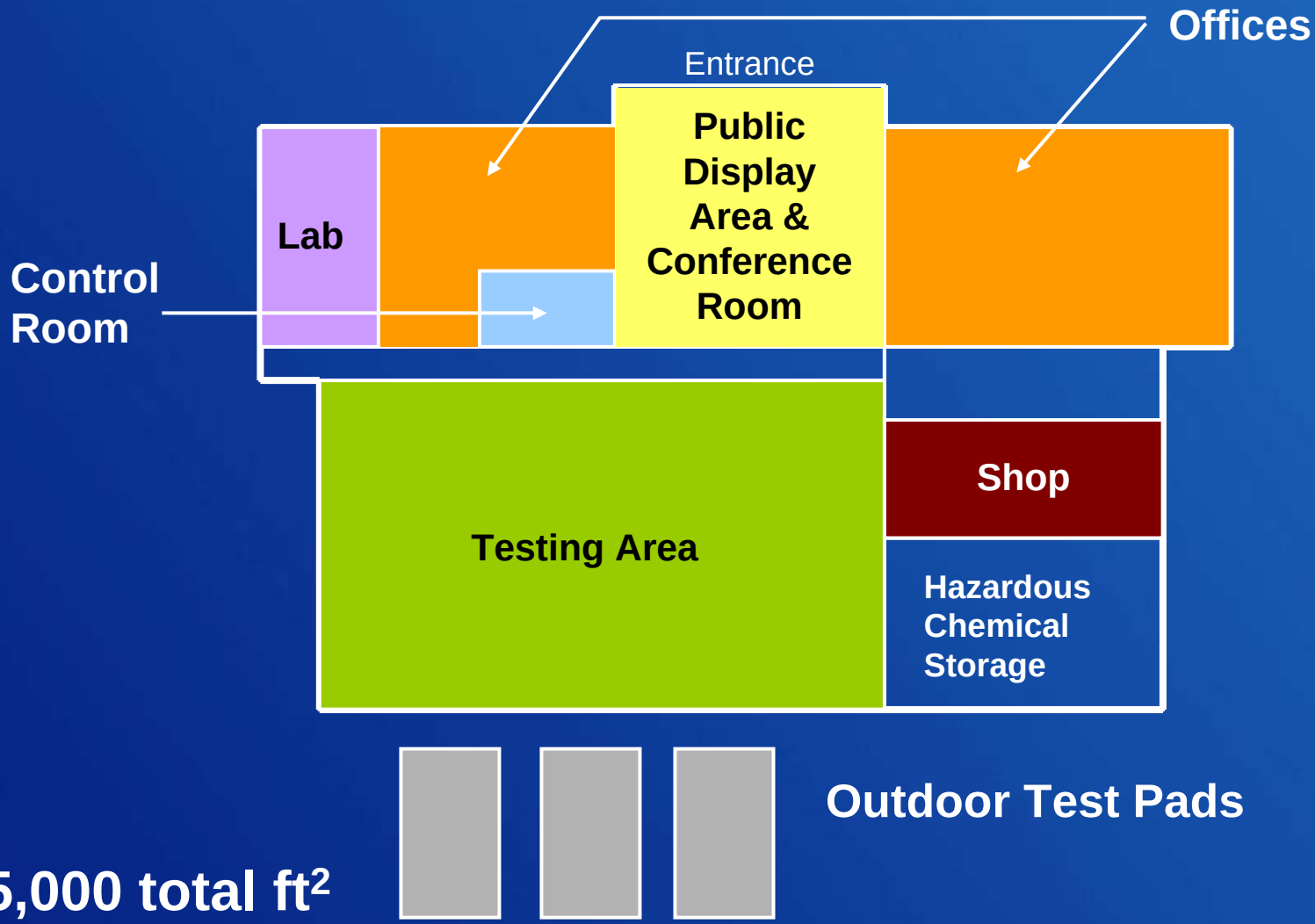


Smaller storage tanks available Inside building.

Storage tanks can be used to blend water sources

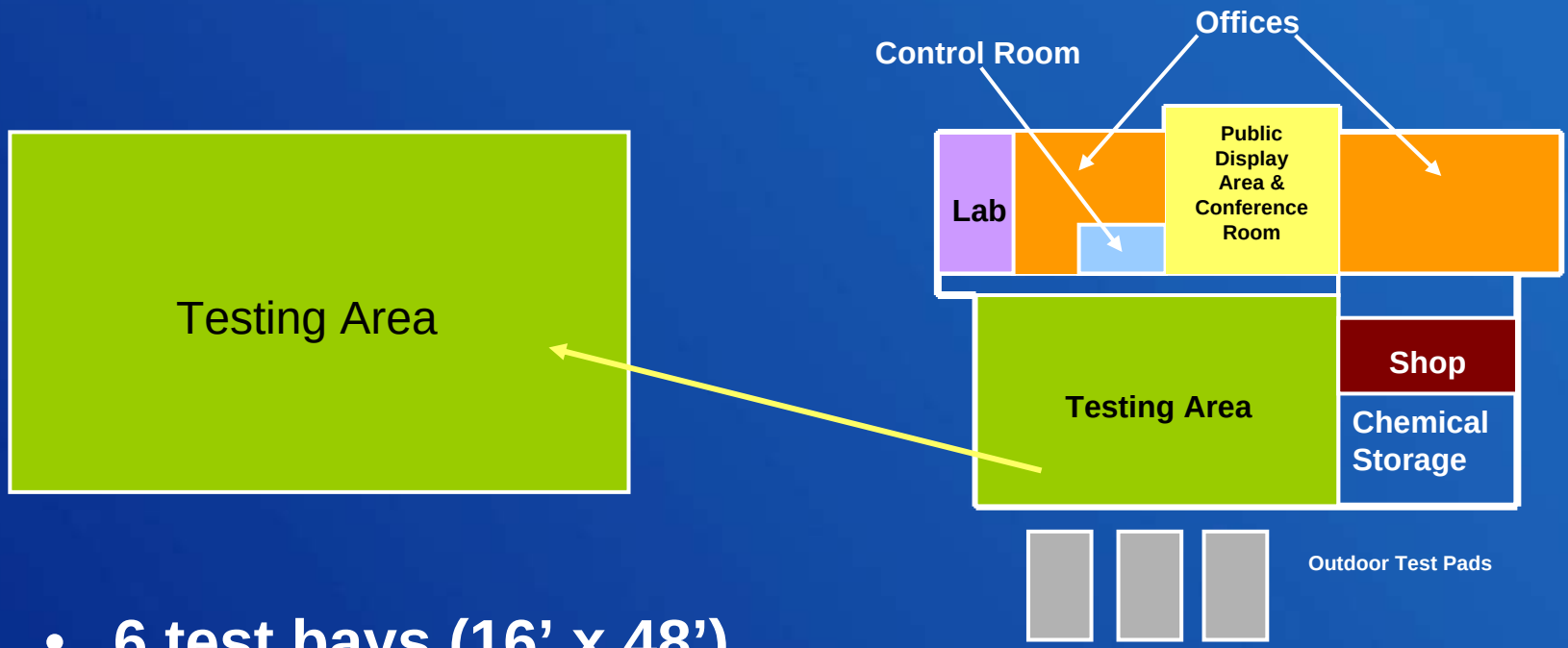
Central Research Building

Central Research Building



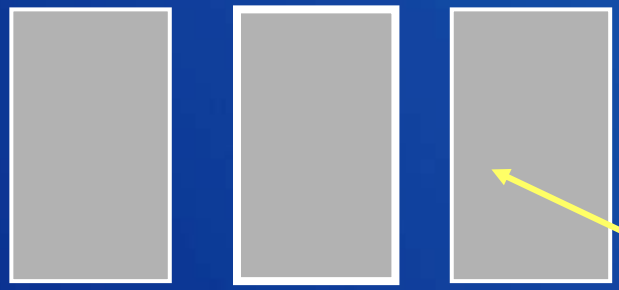
15,000 total ft²

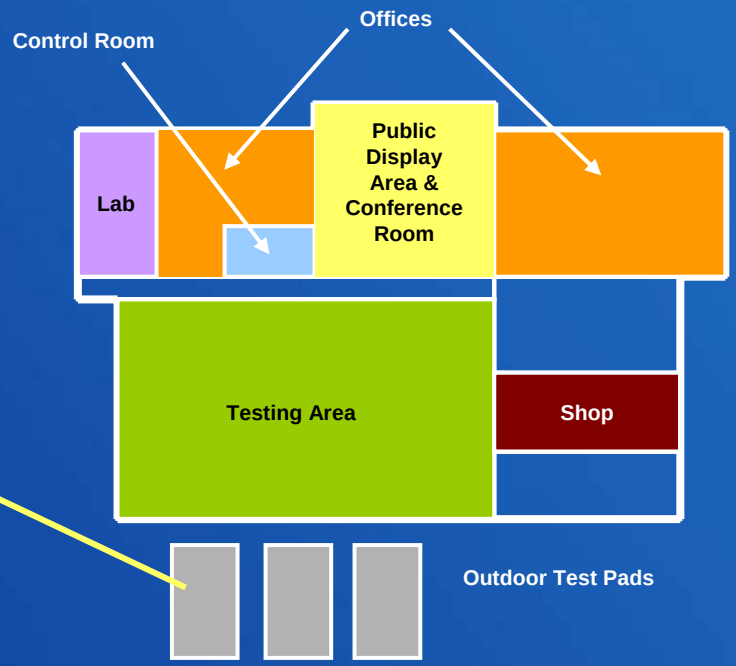
RECLAMATION



- **6 test bays (16’ x 48’)**
- **Flow available: 30 gpm per bay**
- **Each bay has dedicated power, data ports, source water, and service water**
- **Chemical feed pretreatment available**

Outdoor Test Pads





- **3 test bays (20’ x 60’)**
- **Flow available: 60 gpm per bay**
- **Each bay has dedicated power, source water, and service water**

Distribution Statement A:
Approved for public release,
distribution is unlimited

RECLAMATION