State of Desalination Research in the United States

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Research Questions in the U.S.

- Does it work?
- How much does it cost?
- What is desalination and why innovate?
- Who is working to expand the water supply?
- What are some of the lessons learned?
- Where is there research funding?
- What are some of the successful research projects?

What is desalination?

- Processes that remove salt and other difficult to remove dissolved and suspended materials
- Conventional treatment described as early as 2000 BC; municipal treatment early 1800's; chemical treatment late 1800's early 1900's; comprehensive regulations and standards in 1970's
  - Includes screening, slow sand filtration, coagulation/flocculation, chlorination, etc.
- 21st century technologies and science – treatment to better than drinking water quality
  - MF, UF, RO, MBR, EDR, thermal, adsorption, ion exchange, advanced oxidation….; FO, DCMD, CDI, PRO, RED

Why is innovation needed?

Nation faces increasing water resource challenges

- Need for certainty, sustainability, resiliency
- Aging infrastructure, population growth, depletion of groundwater resources
- Impaired water quality associated with particular land uses and land cover
- New water needed for human and environmental uses
- Response to climate variability and change

Water shortage and water-use conflicts more commonplace, even in normal water years

Bureau of Reclamation

The mission of the Bureau of Reclamation is to manage, develop, and protect water and related resources in an environmentally and economically sound manner in the interest of the American public.

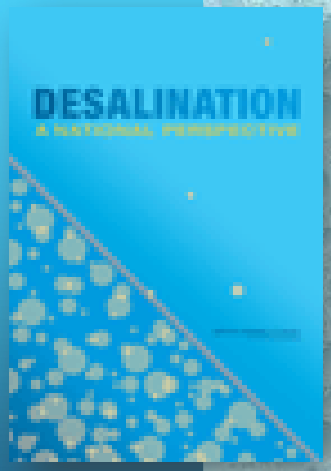
Informational Activities

- Previous workshops, NGTs, etc.; 1989 at YDP
- 2003 Desal and Water Purification Roadmap
- 2004 NAS review of roadmap
- 2006 Implementation of roadmap
- 2008 NAS – Desalination, A National Perspective
- 2009 WRRF Research Needs Workshop
- 2010 CHIWAWA Concentrate Workshop
- 2011 New Water New Energy Conference
- 2012 NAS – Water Reuse, Expanding Water Supplies
- 2012 EPA, USAID, USDA, CDM – Reuse Guidelines
- 2012 Desal Dialog, Concentrate, Direct Potable Reuse

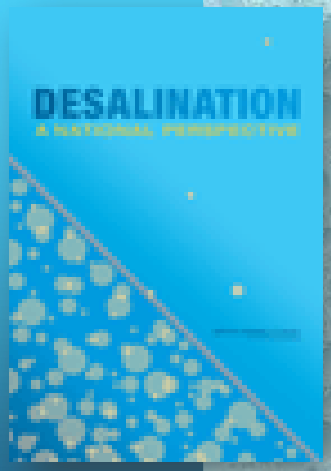
NAS Desalination: A National Perspective, 2008

Recommended Goals

- Understand the environmental impacts of desal and develop approaches to minimize these impacts relative to other water supply alternatives
- Develop approaches to lower the financial costs of desal so that it is an attractive option relative to other alternatives in locations where traditional sources of water are inadequate.



NAS Desalination: A National Perspective, 2008



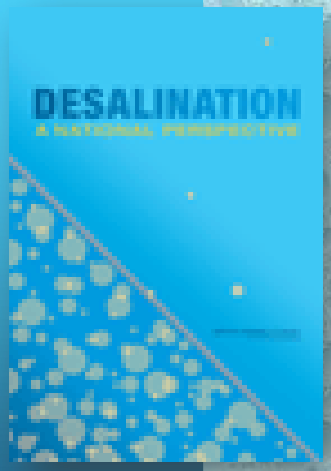
Recommended Research

- Environmental: assess potential impacts, develop methods to minimize impacts, assess brackish water resources
- Reduce Costs: improve pretreatment, improve membrane system performance, improve existing processes and develop novel approaches to reduce primary energy use
- Cross-cutting: concentrate management

NAS Desalination: A National Perspective, 2008

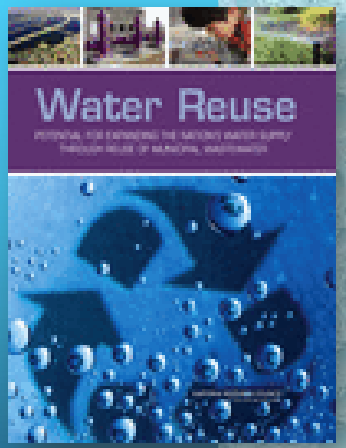
Investments in Research

- No integrated, strategic direction to Federal research, typically earmarks, observed 60% decline in FY07 ($24M to $10M)
- Private sector appeared to fund majority of research, about twice that of other sources
- States have made sizeable investments (TX, CA, FL)
- Estimated $25M federal funds necessary to make good progress



NAS Water Reuse: Potential for Expanding the Nation's Water Supply, 2012

Findings



- 32 billion gallons wastewater discharged per day, 12 billion to ocean or estuary
- De facto reuse is common, 'we all live downstream'
- Many engineered and managed natural treatments can be tailored to meet specific quality objectives
- It cannot be demonstrated that natural barriers provide any protection that is not provided by engineered processes
- 14 research priorities in health, social, environmental issues, and performance and quality assurance

Reclamation's Strategic Direction

Program Objectives

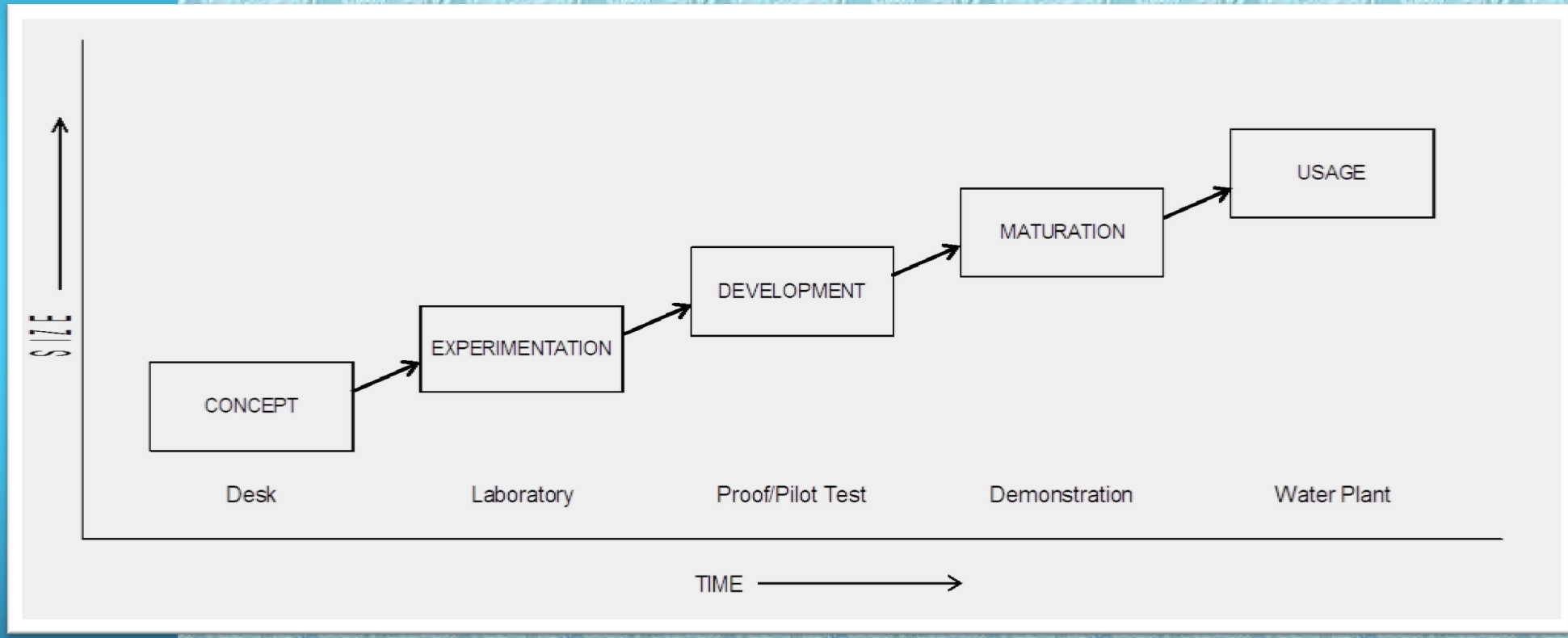
- Increase water supply from unconventional sources to meet water supply imbalances
- Rapidly move new technology from ideas to industry use
- Be a respected, independent advisor to others on testing and or use of new technologies

Reclamation's Strategic Direction

Goals

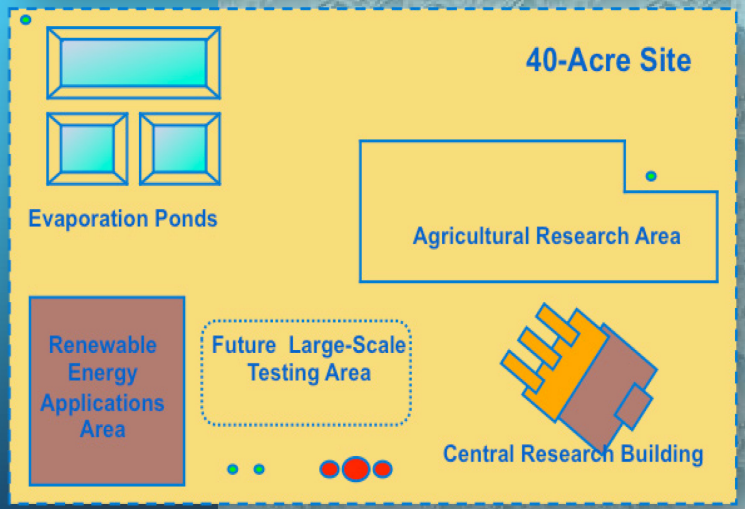
- Increase water supply
- Reduce cost
- Reduce environmental impacts
- Identify institutional barriers
  - e.g. design specifications vs. performance standards
- Demonstrate new technology
- Maintain expertise

Lessons Learned



Taking a Solution from Idea to Commercial Adoption

Brackish Groundwater National Desalination Research Facility - NM



- Desalination of brackish groundwater
- Renewable energy sources for desalination
- Concentrate management
- Small-scale rural systems
- Treatment of produced waters
- Public information and education
- Major partners – NMSU, ReNUWit

Water Quality Improvement Center - Yuma, AZ

- Evaluates technology for possible use at the Yuma Desalting Plant; year long YDP pilot run with MWD, CAWCD, SNWA
- In-house and partnered research programs

- Agricultural tail water, brackish groundwater, Colorado River water
- Only bench-to-demonstration-scale water research facility on the Colorado River
- A desalination R&D laboratory facility

Other Lessons Learned

- An unsolicited program generates unexpected ideas
- Low levels of consistent funding are better than higher levels of inconsistent funding
- Risk taking requires strong initial and periodic technical reviews so that additional resources can be added
- Research requires the support of the highest levels of an organization in order to compete with day-to-day crises
- New processes: will be simple, fast, high recovery, and reliable (Jim Birkett, *Desalination at a Glance*, International Desalination Association)

Research Funding

- WateReuse Research Foundation
- Water Research Foundation
- Various state programs (TX, CA, FL)
- Federal Agencies: DOD/ONR/DARPA/Army/Navy, DOE (ARPA-E), EPA, NSF, NASA
- Reclamation
  - Internal – partner with Area Offices ($1.3M/yr)
  - External – Funding Opportunity Announcement R13SF80007 ($1M/yr), proposals due April 18, 2013

Desalination and Water Purification Research and Development Program

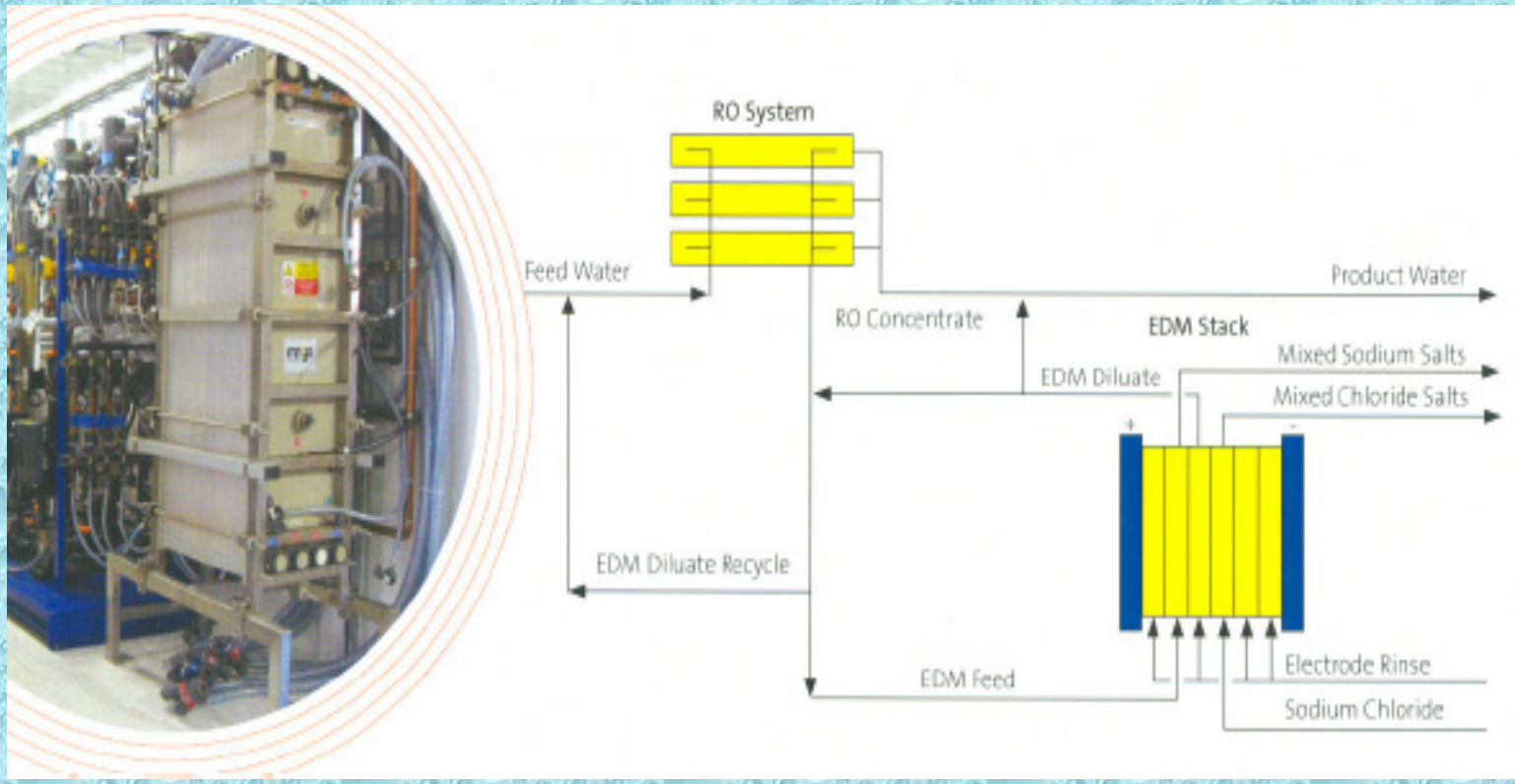
- Funding started FY98, approximately 130 projects, $12M federal, $17M cost-share, reauthorization needed for FY14
  - Water reuse research - funding started FY00, 133 projects, $17M federal, $25M cost-share
- Successes: chlorine resistant membranes, 16-inch diameter membranes, zero discharge desalination, highly efficient high pressure pumps, testing of seawater slant wells, understanding membrane fouling, evaluation of membrane bioreactor systems, spray cleaning, selenium bioreactors, membrane distillation, dewvaporation

16-inch Diameter Standard

Sorek facility, 25% capital cost savings, (D&WR September 2012)

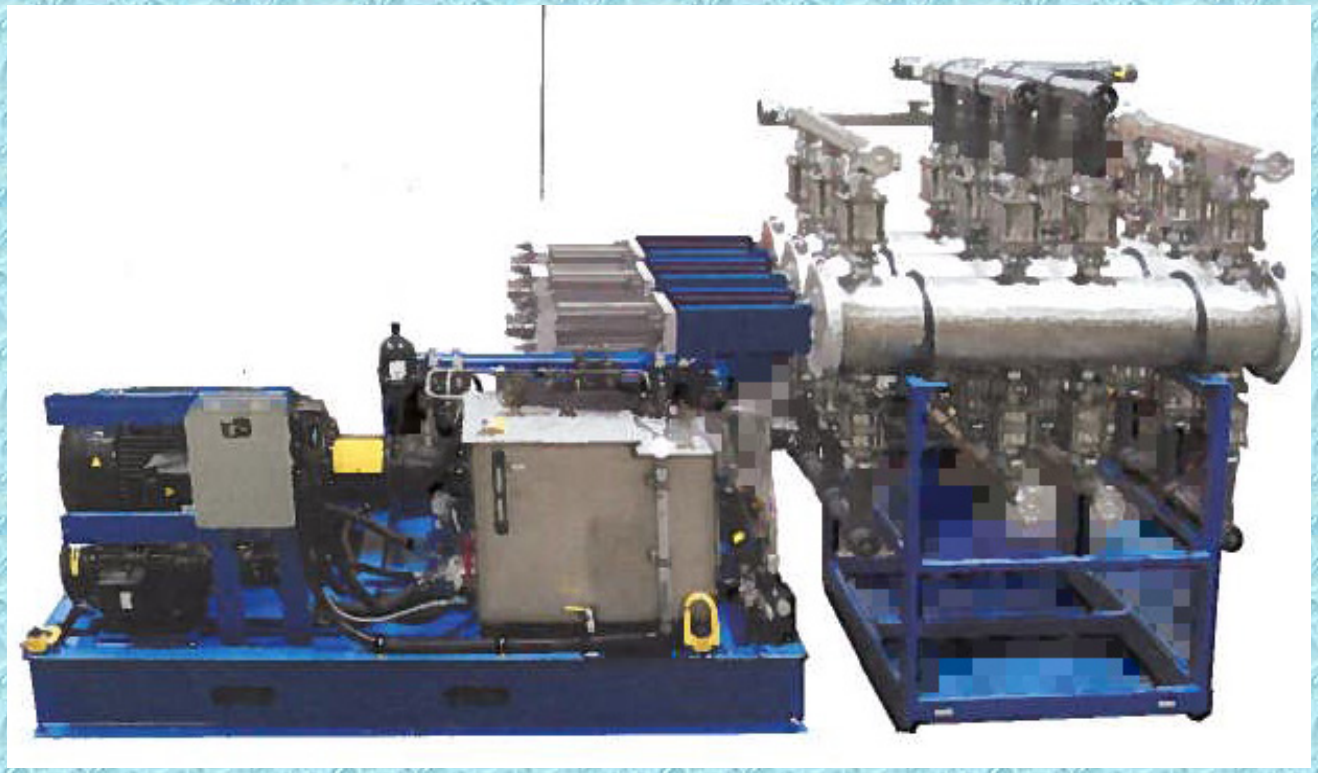
City of Scottsdale's Water Campus - Comparison of 2.4 MGD train (left), 1 MGD trains (right) with 8-inch elements. (WDR September 10, 2012)

Zero Discharge Desalination



Use of electrodialysis metathesis and nanofiltration to reach 98 to 99% recovery. Currently, being commercialized by Veolia, in the demonstration phase.

High Pressure Pump



GE's new Integrated Pump and Energy Recovery (IPER) system – A new high pressure pump for seawater desalination reducing energy demands by at least 10 percent.

(World Water: Water Reuse & Desalination / Summer 2012 p 31)