Pilot Demonstrations of Arsenic Removal Technologies

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Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy’s National Nuclear Security Administration under contract DE-AC04-94AL85000.
Team Members

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The New Standard for Arsenic

- Recent reduction of drinking water Maximum Concentration Level (MCL) for arsenic from 50 ppb to 10 ppb was intended to reduce incidence of bladder cancer and other cancers in US.
- Southwestern United States is characterized by high and variable background levels for arsenic.
- Estimated national annual costs of implementing 10 ppb MCL range from $165M to $605M to save 7 – 33 lives.
  - $5M – $23.9M /life saved
  - $1.3M – $6.6M/ year of life saved
    - About 1 life/500,000 exposed persons per year
- New MCL is controversial due to high costs and uncertain health benefits.

Can advances in water treatment technology significantly reduce costs?
Arsenic Water Technology Partnership

• Congressional Appropriation - $10M
• DOE-funded peer-reviewed, cost-shared research program to develop and demonstrate innovative technologies for removal and disposal of arsenic from drinking water
• Partners
  – Bench-Scale Studies (AwwaRF)
  – Demonstration Studies (Sandia)
  – Economic Analysis/Outreach (WERC)
• Focus on small systems
  – 40% of resources directed to rural and Native American utility needs
  – Minimize costs - capital, operating, maintenance
  – Minimize residual quantities & disposal costs
Activities (FY2003 – 2005)

• Initial technology deployment at Kirtland AFB
• Sponsored activities at New Mexico Environ. Health Conference (October 2003)
  – Theme session to introduce program
  – Vendors Forum to evaluate commercial technologies
  – Website: http://www.sandia.gov/water/arsenic.htm

• 2nd Vendors Forum at 9th New Mexico Environmental Health Conference (Oct. 19 - 20)

• Start pilot test deployment at Socorro, NM, Jemez Pueblo, and Desert Sands, NM
• Concepts for Pilot Demonstration Tests
  • Site selection
  • Technology selection process
  • Examples of Innovative Technologies
  • Initial Tests in New Mexico
Sandia Pilot Test Concepts

- Side-by-side demonstrations of technologies tested by AwwaRF bench-scale program, WERC design contest or commercial technologies vetted through Vendor Forums
  - Test duration: 3 – 9 months
  - Test size: 0.3 – 10 gpm
  - Different technology classes: adsorptive media, Coagulation/Filtration, membranes, electrochemical
- Cooperative effort between Sandia, Technology Owner and Site Owner
- Test Protocols developed with help from NSF International, academia, industry during 2004
Pilot Test Configurations

- Pump house
- Skid Mount or container
- Mobile unit
Roles and Responsibilities

- Technology Owner
  - Provides material or technology
- Sandia National Laboratories
  - Funds and oversees test
- Site Owner
  - Assists with test
- WERC
  - Economic analysis and tech transfer
• Concepts for Pilot Demonstration Tests
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National Scope of Program: Consider all Arsenic source types

Adapted from Welch et al. (2000) and Ryker (2001).
Things we look for in a pilot site

• As concentration (>10 ppb)
• Example ground water composition that will help other communities
  – pH, TDS, foulants such as Fe, Mn, silica, and organics
  – As(III)/As(V)
  – Competing ions (V, SO₄, etc.)
  – Other contaminants of concern/benefit (e.g, Ra, U, ClO₄, F)
• Small size of system to be treated (< 10,000 users)
• Community support facilitates rapid deployment
  – Water utility
  – Municipal government
• Ability to deal with residuals/treated effluent
• Rural and Native American communities that would benefit from assistance
High Arsenic in New Mexico’s Waters

• Abundant in silicic volcanics
  – derived volcaniclastic sediments and associated hydrothermal systems

• Arsenic enrichment by Potassium Metasomatism
  - low temperature alteration common in closed hydrographic basins in arid climates

Mixing of deep geothermal waters and shallower surface influenced waters
Hydrothermal Waters in Jemez Silicic Volcanic Field

- Thermal springs plume extends along Jemez fault zone (San Diego Canyon).
- Composition similar to deep thermal waters.

- Soda Dam
  - Na-HCO₃-Cl water
  - pH = 6.7
  - Na = 960 ppm
  - HCO₃ = 1500 ppm
  - Cl = 1500 ppm
  - As = 1500 ppb

- Jemez Springs
  - As = 700 ppb

- Jemez River
  - As = 28 - 66 ppb

- Jemez Pueblo
  - 20 ppb As(III)
  - New standard = 10 ppb
• As levels: 20-30 ppb; optimal F level
• Treatment plant under construction (May 2005 completion?)
• Opportunities for training and outreach will be important aspects of pilot test program
Arsenic Enrichment near Socorro

– K-metasomatism near Ladron Mtn region
  • 700 sq mi x 5000 ft thick
  • As range: 3 - 10 ppm, mean 5 ppm in altered rock
  • As mean = 1 ppm in fresh rocks

– Local hydrothermal alteration
  • As contents range: 2 - 200 ppm

– Local groundwaters
  • <2 ppb - 40 ppb As

– Sources: Chapin & Dunbar, 1994; Brandvold 2001
First Community Pilot: Socorro, NM

- 100% groundwater source for drinking water
- Warm springs (90°F) provide 500 gpm, 20 – 40 ppb As by gravity flow.
- Formerly site of tap for bottled water company; optimal F
- Installation complete: 12/15/2004
- Training audit by NSF
- Full operation started Feb 2005
- 2 Phases
- Completion 10/2005
Additional Sites in New Mexico

- Chama
- Jemez Pueblo
- Placitas
- Socorro
- Desert Sands
  - EPA test site
  - 10 adsorptive media
  - Rapid small scale tests
  - As(III) vs As(V) removal
  - Full scale cost data
  - Late Spring start

NMED list 90 sites >10 ppb in state
Future Pilot Studies Under Consideration

10-15 pilot sites during program lifetime
New technologies from industry, academia and DOE labs
Public Water Systems Supervision Program under Navajo Nation EPA regulates approx. 200 public water systems (PWSs)

Water sources of 26 PWSs (13%) exceed Arsenic MCL of 10 ppb; 15 are Community Water Systems (CWSs) and 11 are Non-Transient Non-Community Water Systems (NTNCWSs)

Over 30% of Navajo residents are not connected to PWSs. Most of them haul water from unregulated water sources which contain contaminants such as arsenic, uranium, coliform and pesticides
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Pilot Technology Selection Process

Potential Technologies

Credible Technologies

• Performance
• Cost
• Complexity
• Maturity

Pool of technologies
• Vendors (currently)
• Universities (planned)
• Government labs (planned)

Suggested Pilot Technologies

Forum

Technical Evaluation Teams

8
7
9
Current Treatment Alternatives

• Sorption treatment processes
  – Ion exchange
  – Activated alumina
  – Iron-based sorbents

• Membrane treatment processes
  – Reverse-osmosis
  – Precipitation/filtration processes
    • Conventional gravity coagulation/filtration
    • Coagulation-assisted microfiltration
    • Enhanced lime softening
    • Oxidation/filtration
Proposed Treatment Innovations

• Sorption treatment processes
  – Regenerable, higher capacity and selectivity
    • Modified Fe-based sorbents
    • Ti, Zr-based sorbents
    • Resin-metal oxide hybrids
  – More stable residuals
  – ‘Tougher’ sorbents
  – Coatings on inexpensive materials (industrial waste, natural materials)

• Precipitation/filtration processes
  • Enhanced coagulation with Fe compounds or polyelectrolytes
  • Improved filtration with nanocomposite materials

Vendor Forums led to recommendation of 10 innovative technologies for initial pilots and 6 for bench-scale studies
Promising Technologies Identified at the Arsenic Treatment Vendor Forums

- **Pilot technologies from 2003 Forum**
  - Magnesium Elektron Inc. (Isolux - Zr-oxide)
  - Hydroglobe (MetSorb - nanocrystalline Ti-oxide)
  - AdEdge (Granular Fe-oxide)
  - Filtronics (Coagulation/Electromedia filtration)
  - Kinetico (Macrolite media)
- **Pilot Technologies from 2004 Forum**
  - Purolite (ArsenX\textsuperscript{np} – Fe-IX resin)
  - Engelhard (ARM-200 – GFO)
  - DOW – (Absorbsia – GTO)
  - Watts Premier and Zenon RFO membranes
  - Several others need bench scale studies before pilot
Summary

• Pilot Test Demonstration Objectives
  – Generate cost/performance data for innovative technologies for small communities

• Site Selection
  – Initial sites in New Mexico
  – Subsequent sites chosen through State and Tribal contacts and Web site applications

• Technology Selection
  – Initial technologies chosen from participants in Vendors Forum
  – Later stages include technologies vetted by university and government labs with State and Federal funding

• Initial Pilot Studies
  – Socorro, NM – February 2005 start
  – Desert Sands, NM – Spring 2005 start
  – Jemez Pueblo – Spring 2005 start