



Pilot and Bench-scale Studies of Arsenic Adsorptive Media

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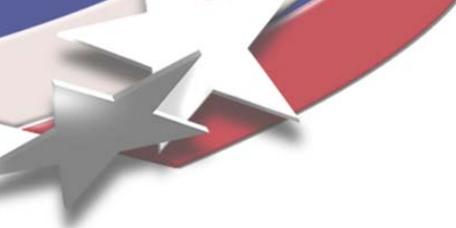
March 14, 2007
**2007 Nevada Rural Water Association
Conference**





Take Home Message

1. Don't panic! – the water won't kill you right away.
2. Don't make hasty decisions about water treatment system for arsenic removal.
3. The right system for your community depends on:
 - Available (non-treatment) options
 - Financing options
 - Operator training
 - Existing infrastructure
 - **Water chemistry**
4. There's no magic bullet!



For More Information:

Arsenic Partnership Website

<http://www.arsenicpartners.org/>

Sandia Website

<http://www.sandia.gov/water/arsenic>

→ Papers, Presentations, Vendor Information, Pilot Results

WERC CoAsT Website

<http://www.werc.net>

→ Click on Outreach tab, then CoAsT





Outline of Talk

- **Background – why we have a new As MCL.**
- **Arsenic Water Technology Partnership**
 - Screening of technologies for pilot studies
 - Sandia Labs Pilot Test program
- **Frontiers of Science**
 - What things can be improved
 - Rapid testing techniques
 - New adsorptive media
- **What this all means in the real world-**
 - Helping communities deal with the new Standard
 - Sandia arsenic website





Sandia Labs Arsenic Team Members

- Malynda Aragon – lead engineer
- Alicia Aragon – RSSCT studies
- Melody Nocon, Hongting Zhao – lab studies
- Randy Everett, William Holub Jr., Brian Dwyer,
- Jerome Wright, Justin Marbury, Emily Wright, Michelle Shedd, Carolyn Kirby, Paul McConnell, Linnah Neidel, Nik Rael, Andres Sanchez, David Stromberg, Zac Satterfield
- Pat Brady, Richard Kottenstette
- Prof. Shuguang Deng, New Mexico State



Questions about the New Arsenic Standard





Background

- **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.**



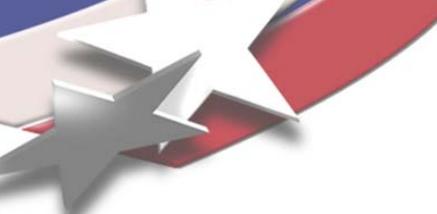


Health Effects of Concern

- **Skin Cancer**
- **Bladder Cancer**
- **Lung Cancer**
- **Cardiovascular Disease**
- **Blackfoot Disease**

These are result of exposure to relatively high doses over extended period of time.

Other effects of concern include diabetes, cancers of liver and kidney, birth defects



Studies of Human Populations are Ambiguous

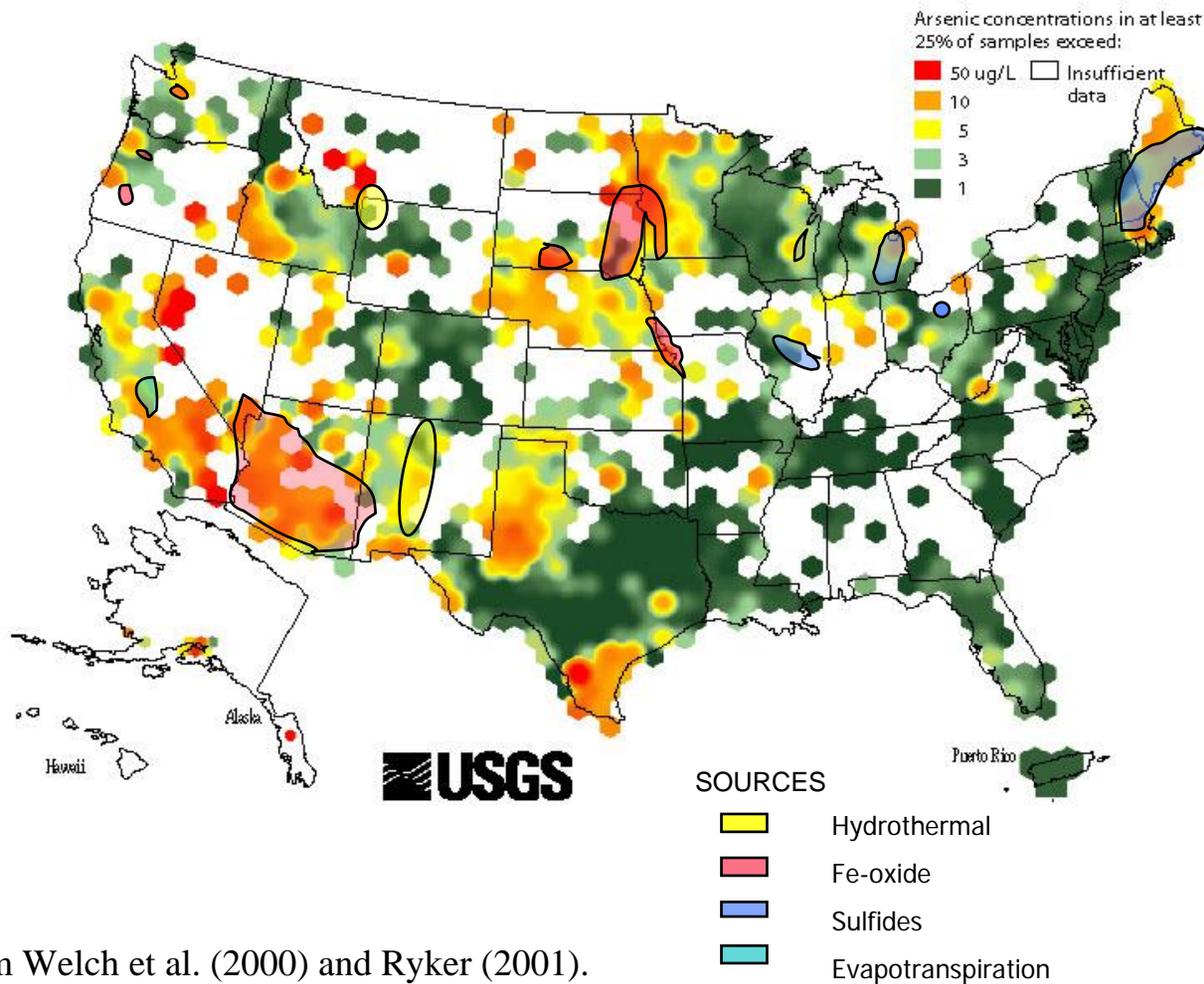
- **Studies prior to 2001 Standard**

- Some studies carried out in populations in Taiwan, South America show elevated bladder cancer risks. (“relative risk” = 5 –11).
- As concentrations were generally above 50 $\mu\text{g/L}$.
- Results of studies of US and European populations at lower As concentrations show no increased risk or are ambiguous.

- **Post-2001 studies**

- Results: *do not* suggest that chronic exposures to arsenic at low levels (50 – 100 $\mu\text{g/L}$) lead to increased mortality risk for bladder or lung cancer for the majority of populations studied.
- Some studies suggest interaction between smoking and exposure to arsenic may lead to increased risk for bladder and lung cancers;
- Smokers may experience a higher risk at levels below 100 $\mu\text{g/L}$
- Elevated incidence in New Mexico (>10 ppb) reported recently
- Potential role of arsenic in endocrine disruption

Arsenic Sources and Occurrences



Adapted from Welch et al. (2000) and Ryker (2001).





Volcanic Sources of Arsenic

- **Strongly enriched in volcanic gases compared to magma**
 - sublimation of As_2O_3 (193°C) and As_2S_5 (500° C)
 - enrichment factor = 1000 - 1000000
- **Abundant in silicic volcanics**
 - derived volcaniclastic sediments
 - associated hydrothermal systems
 - As is a pathfinder elements in prospecting for hydrothermal gold deposits



Increase of Arsenic in Natural Waters

- **Reductive dissolution of iron oxides**
 - co-release of adsorbed and structural As
- **Reductive desorption of As(V)**
 - strongly sorbed As(V) -> weakly sorbed As(III)
- **Competitive desorption**
 - phosphate, bicarbonate, silicate, dissolved organics
- **pH changes**
 - increased pH leads to As(V) desorption

Arsenic Water Technology Partnership Background

- Congressional Appropriation - \$13M FY03 – FY06
- DOE- funded peer-reviewed, cost-shared research program to develop and demonstrate innovative technologies for removal and disposal of arsenic from drinking water
- Partner Roles
 - 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



Can advances in water treatment technology significantly reduce costs?



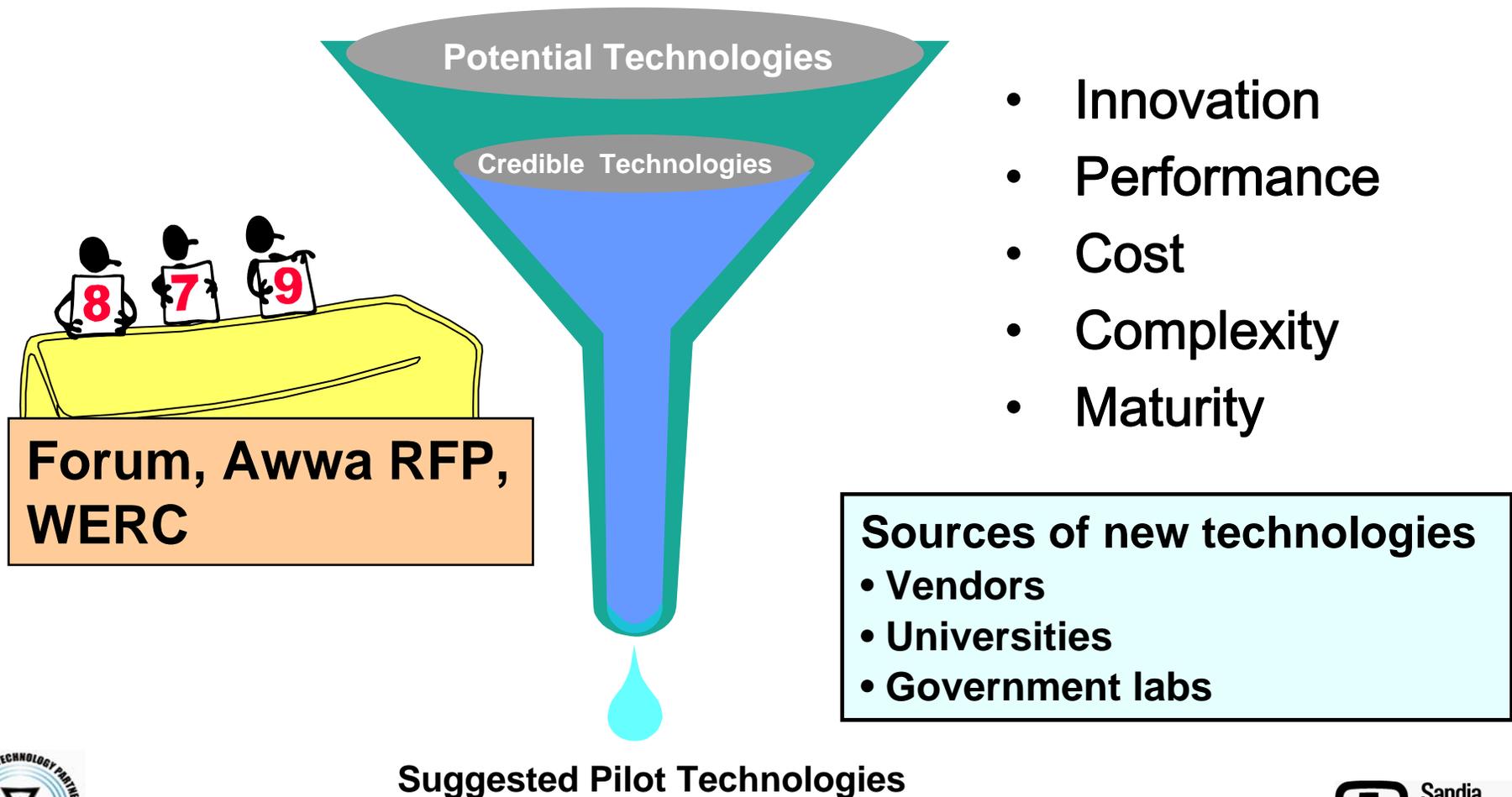


AWTP Technology Screening Programs

- **Sandia Arsenic Treatment Vendors Forum**
 - Open session allows Vendors to present product descriptions
 - Closed session review by Technical Evaluation Teams
- **Awwa Research Foundation**
 - Technical Review Committee defines research objectives
 - Grants are awarded through competitive, peer-reviewed RFP process
- **WERC Design Contest**
 - WERC utilizes its existing Design Contest in order to obtain innovative arsenic removal technologies.



AWTP Technology Screening Process





Sandia Vendor Forum Description

- **Held at *New Mexico Environmental Health Conferences* in Albuquerque, 2003-2005.**
- **Format**
 - Public presentations by vendors.
 - Vendors privately interviewed by *Technology Evaluation Teams*
 - Four five-person teams of water treatment experts at each Forum.
 - Each vendor interviewed by at least two teams.
- **Twenty-seven different vendors evaluated at the three Forums.**
 - Nine vendors in 2003, twelve in 2004, ten in 2005.
 - Four of the 27 vendors attended two Forums.
 - Two universities were among the 27 vendors.





Vendors Forum Evaluation

- **Each vendor was scored based upon six criteria:**
 - Performance
 - Maturity
 - Cost
 - Implementability
 - Effect [on communities]
 - Innovation
- **Highest scores generally given for Performance and lowest for Maturity, but numerous exceptions**
- **Overall Total score given to each vendor based upon a *weighted* value of each criterion.**
- **Most” of the vendors deemed viable candidates for Pilot testing.**



General Treatment Innovations

- **Sorption treatment processes**
 - Regenerable, higher capacity and selectivity
 - 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
 - Recycle systems to minimize chemical addition

2003, 2004, 2005 Vendor Forums led to recommendation of innovative technologies for initial pilots and others for additional bench-scale studies





Top Five Ranked Vendors at Forums

2003	2004	2005
Hydroglobe – TiO ₂	Purolite – Hybrid resin	Purolite
MEI - ZrO ₂	BASF- GFO	ResinTech
<i>Kinetico</i>	<i>Filtronics</i>	EaglePicher – La-coated DE
AdEdge – GFO (Severn Trent)	DOW – TiO ₂	ADA – Coated silicate
<i>Filtronics</i>	ResinTech – Hybrid resin	Virotec – mixed oxides from Bauxite



Sandia Pilot Test Concepts

- **Side-by-side demonstrations of technologies tested by AwwaRF bench-scale program, WERC design contest, University programs, or commercial technologies vetted through Vendor Forums**
 - Test duration: 3 – 9 months; longer, if multiple pilots at same site
 - 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 2004-2005**

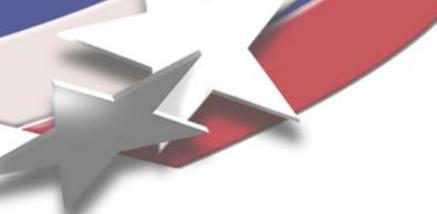




Roles and Responsibilities

- **Technology Owner**
 - Provides material or technology
- **Sandia National Laboratories**
 - Funds and oversees test
- **Site Owner**
 - Assists with test
- **WERC**
 - Economic analysis and tech transfer

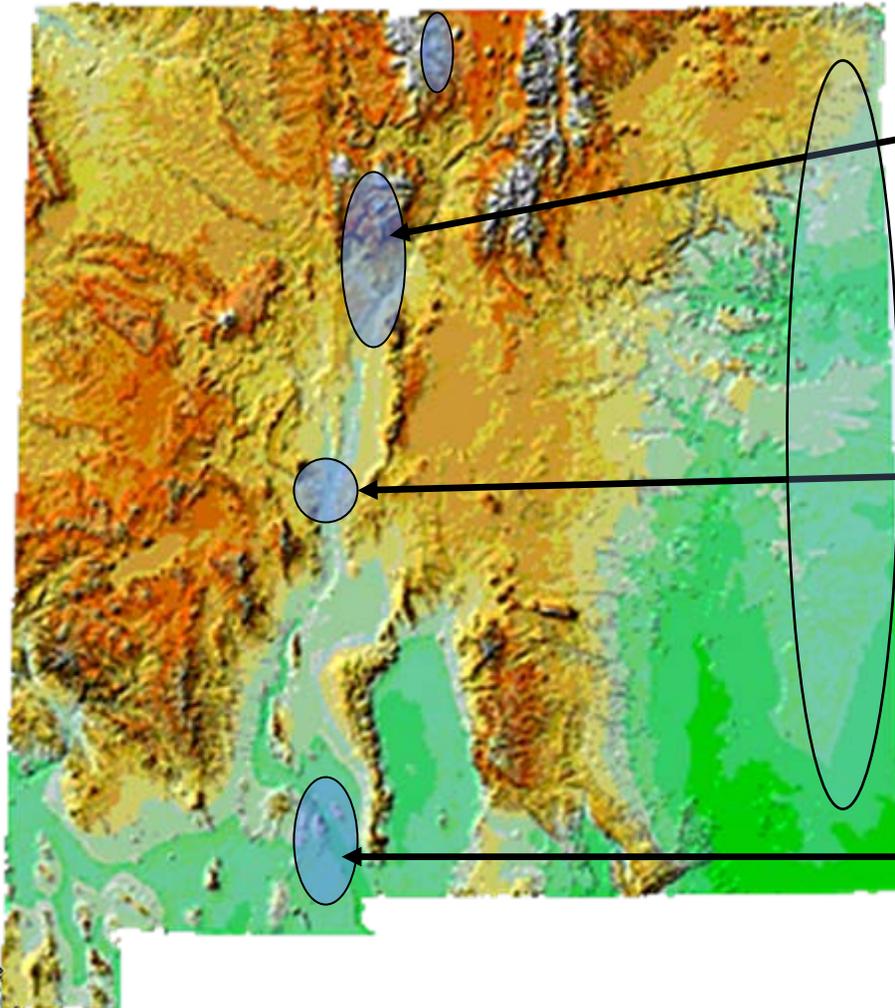




Things we look for in a pilot site

- **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**

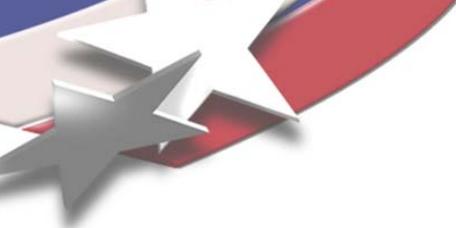
High Arsenic in New Mexico's Waters



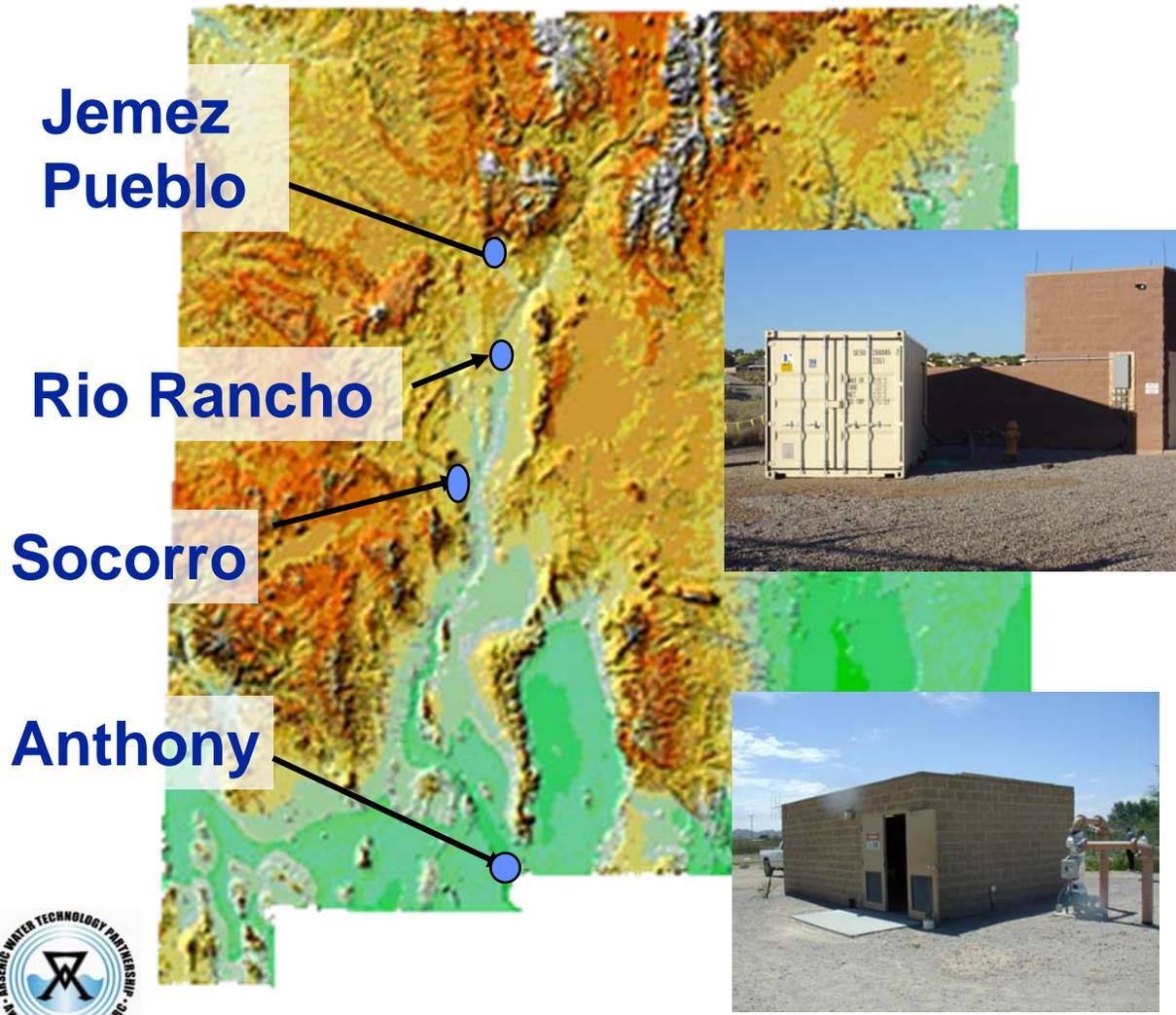
• **Abundant in silicic volcanics**
– derived volcaniclastic sediments and associated hydrothermal systems

• **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



Sites in New Mexico



New Mexico Pilot Sites – Water Quality

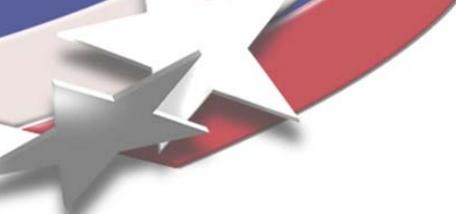
Site	Total As/As(III)	V (ppb)	SO ₄ (ppm)	Fe (ppm)	pH
Socorro	42 ppb / 0 ppb	11	29	0.4	8.0
Anthony	20 ppb / 18 ppb	2	180	0.15	7.7
Rio Rancho	19 ppb / < 1 ppb	15	100	<0.10	7.7
Jemez Pueblo	20 ppb / 19 ppb	<1	24	1.2	7.5

Site	Cond. (μS/cm)	TOC (ppm)	Ca Hard (ppm CaCO ₃)	Alkalinity (ppm CaCO ₃)	SiO ₂ (ppm)
Socorro	360	0.5	44	120	25
Anthony	1380	0.8	66	180	37
Rio Rancho	630	ND	62.5	184	22
Jemez Pueblo	770	2.0	155	290	50

First Community Pilot: Socorro, NM

- 100% groundwater source for drinking water
- 2 warm springs (90°F) provide 500 gpm, 35 – 55 ppb As(V) by gravity flow.
- Formerly site of tap for bottled water company;
- Optimal F for oral health
- Phase 1: Feb-Oct 2005
 - Tested
 - Fe oxides: ED33, ARM200
 - Resin - AsX^{np}
 - Ti-oxide - Metsorb
 - Zr-oxide - Isolux
 - EBCT study of E33
 - 2,4,5 min

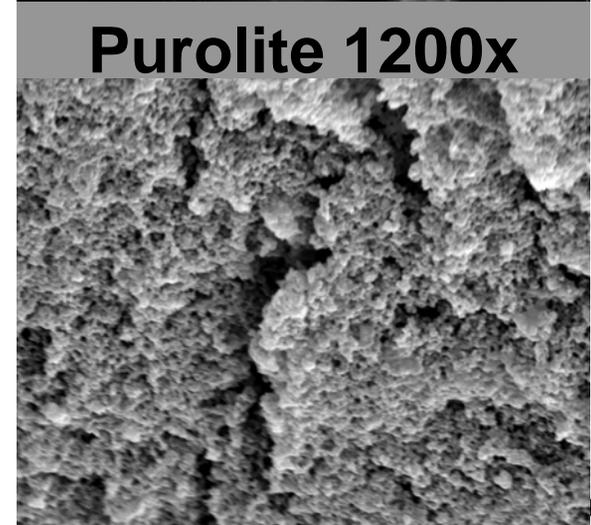
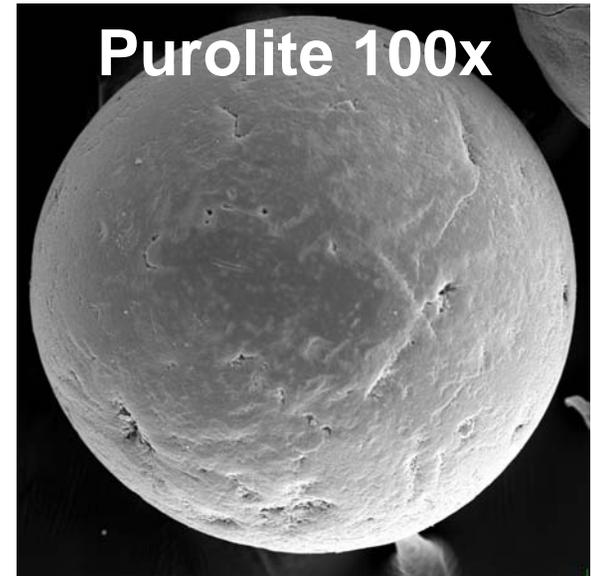
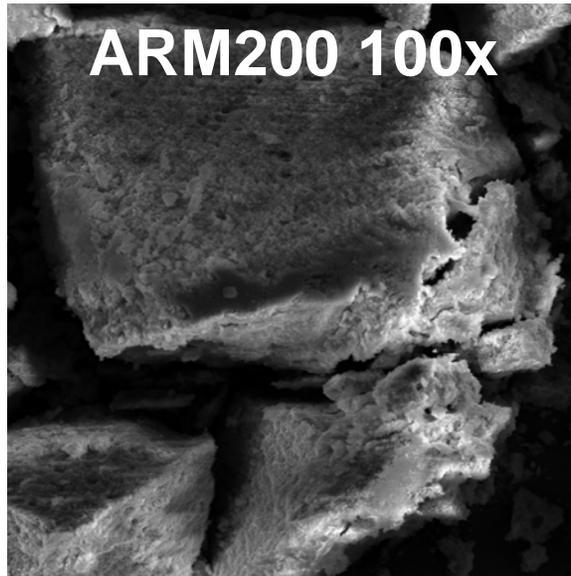
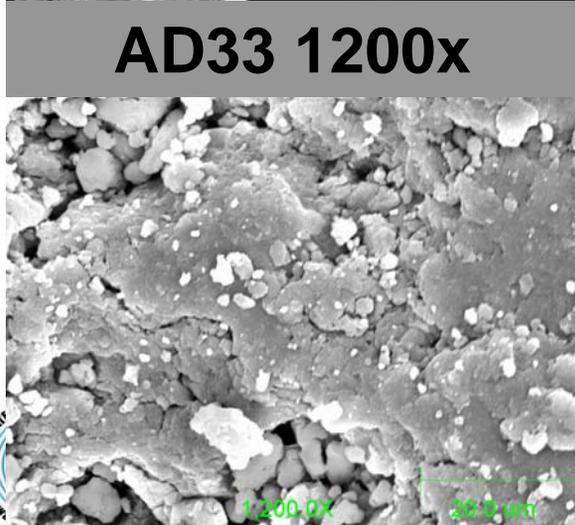
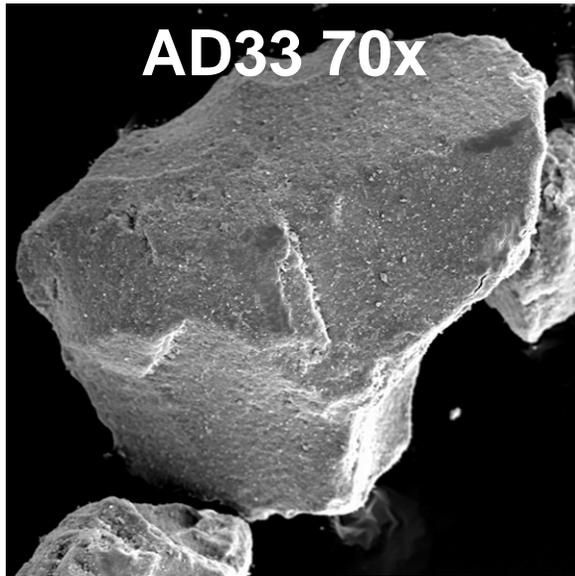




Chemical Compositions of Media

Media	Constituents (XRD)	Dominant Elements (EDS)
Isolux 302M	Amorphous zirconium oxide/hydroxide	Zr, O
Metsorb	Crystalline TiO ₂ (<i>Anatase</i>)	Ti, O
ARM200	Amorphous Iron oxide/hydroxide (or very poorly crystalline <i>Hematite</i>)	Fe, O
ArsenX ^{np}	Amorphous iron oxide/hydroxide Resin impregnation	Fe, O, C
E33	Iron oxide/hydroxide (<i>Goethite</i>)	Fe, O

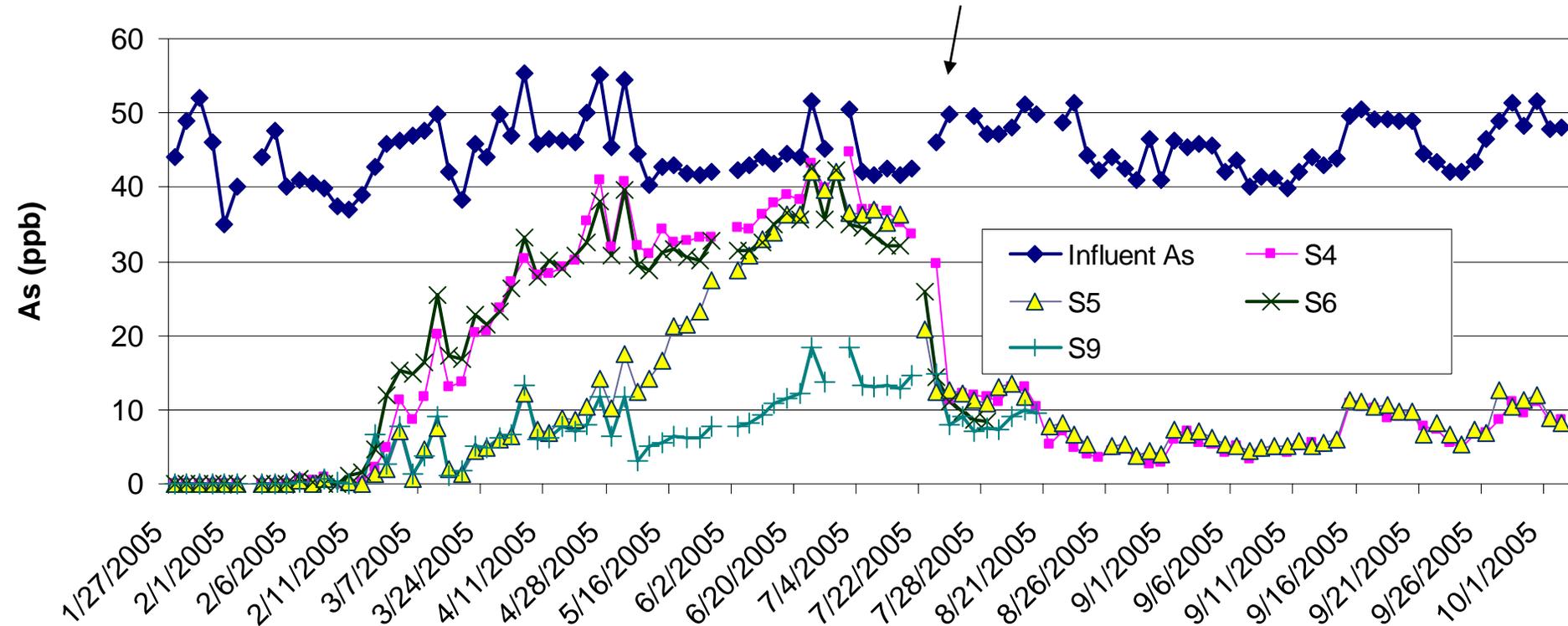
SEM Photos of Adsorptive Media



Socorro Pilot Phase I and IIa Events

S4 = ARM200 (FeOx); S5 = AsXnp (resin); S6 = Metsorb (TiOx);
S9 = E33 (FeOx)

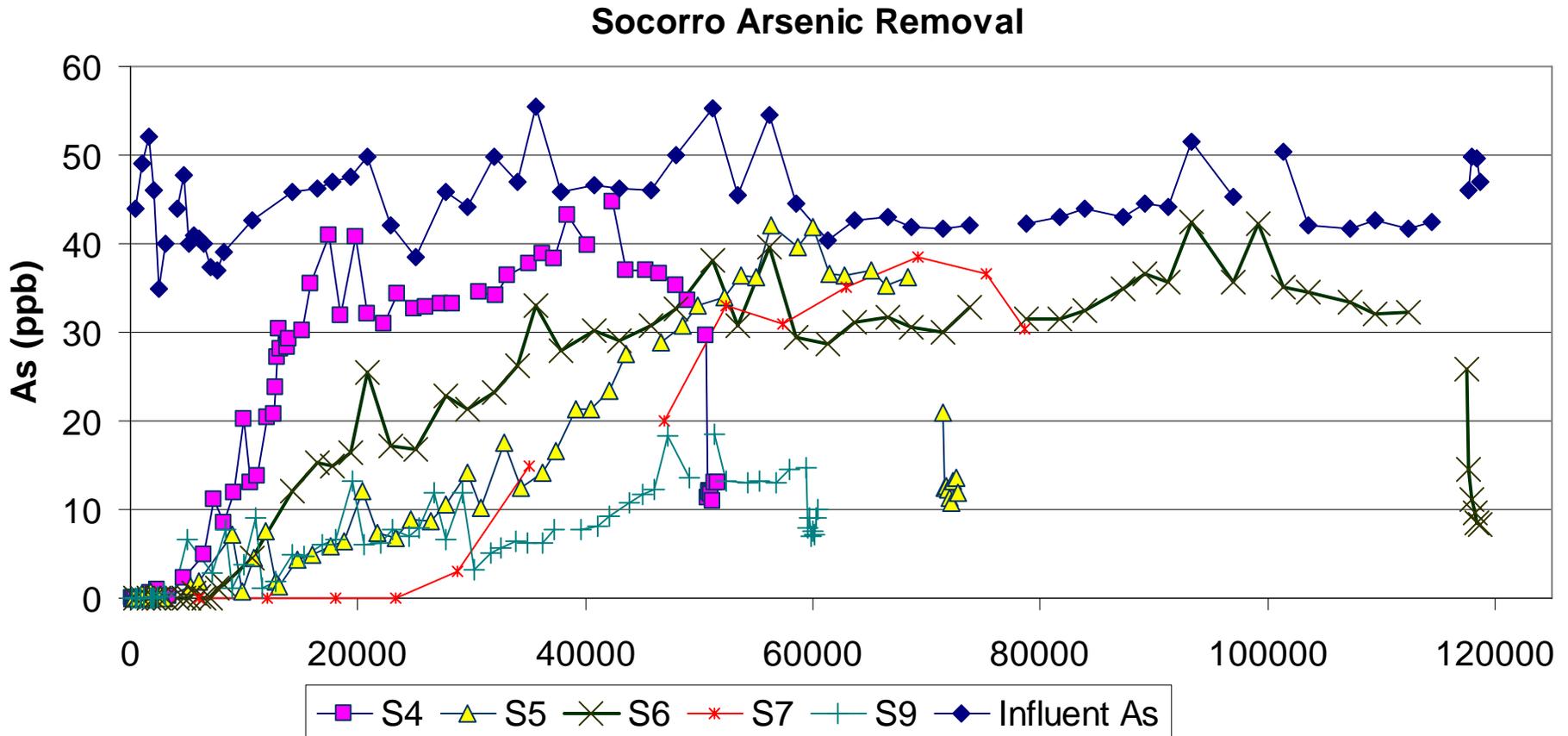
Phase IIa, pH adjust begins S4,S5,S6,S9 (7/26/05)



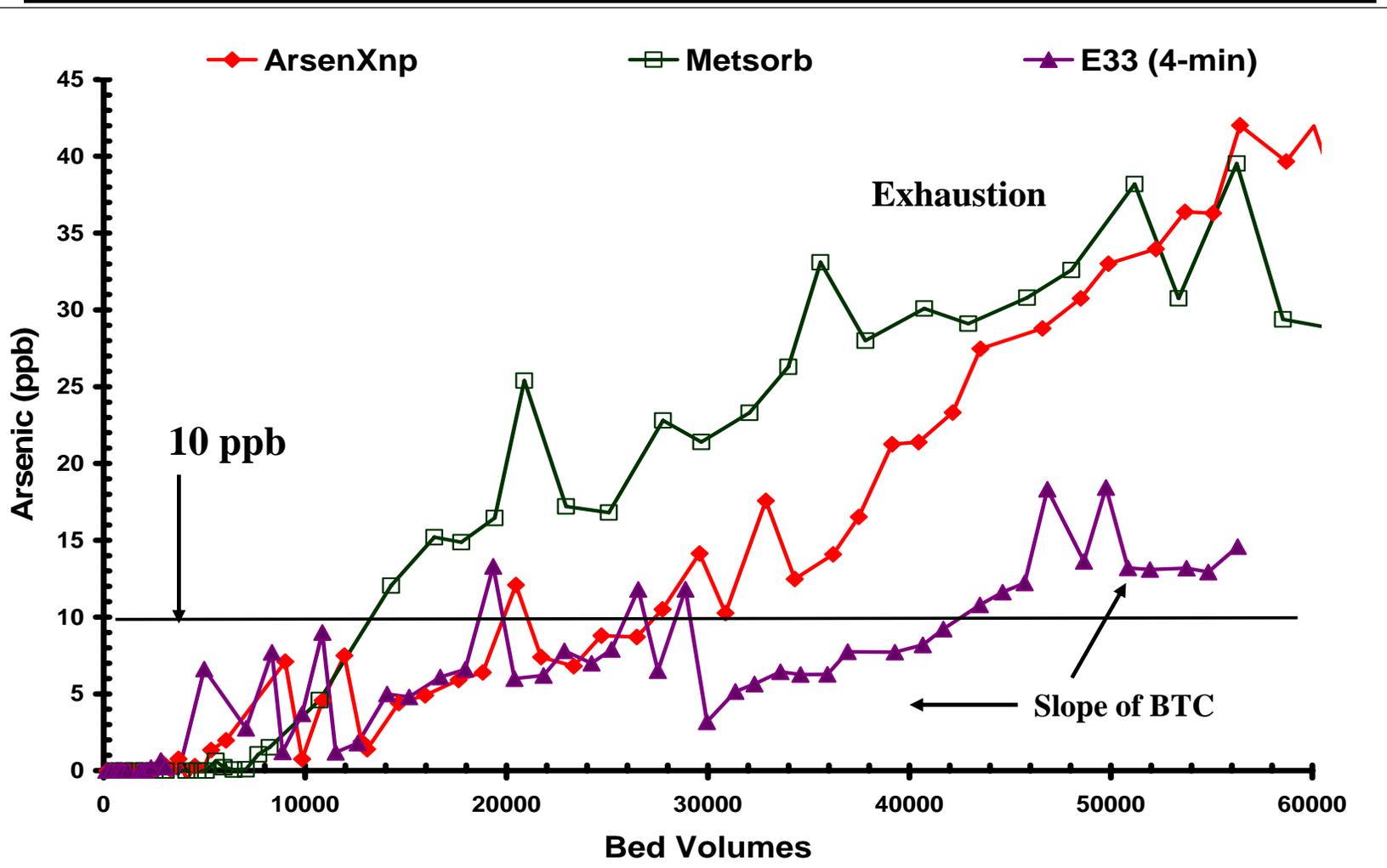
Not a linear scale!

Media Performance Socorro, NM

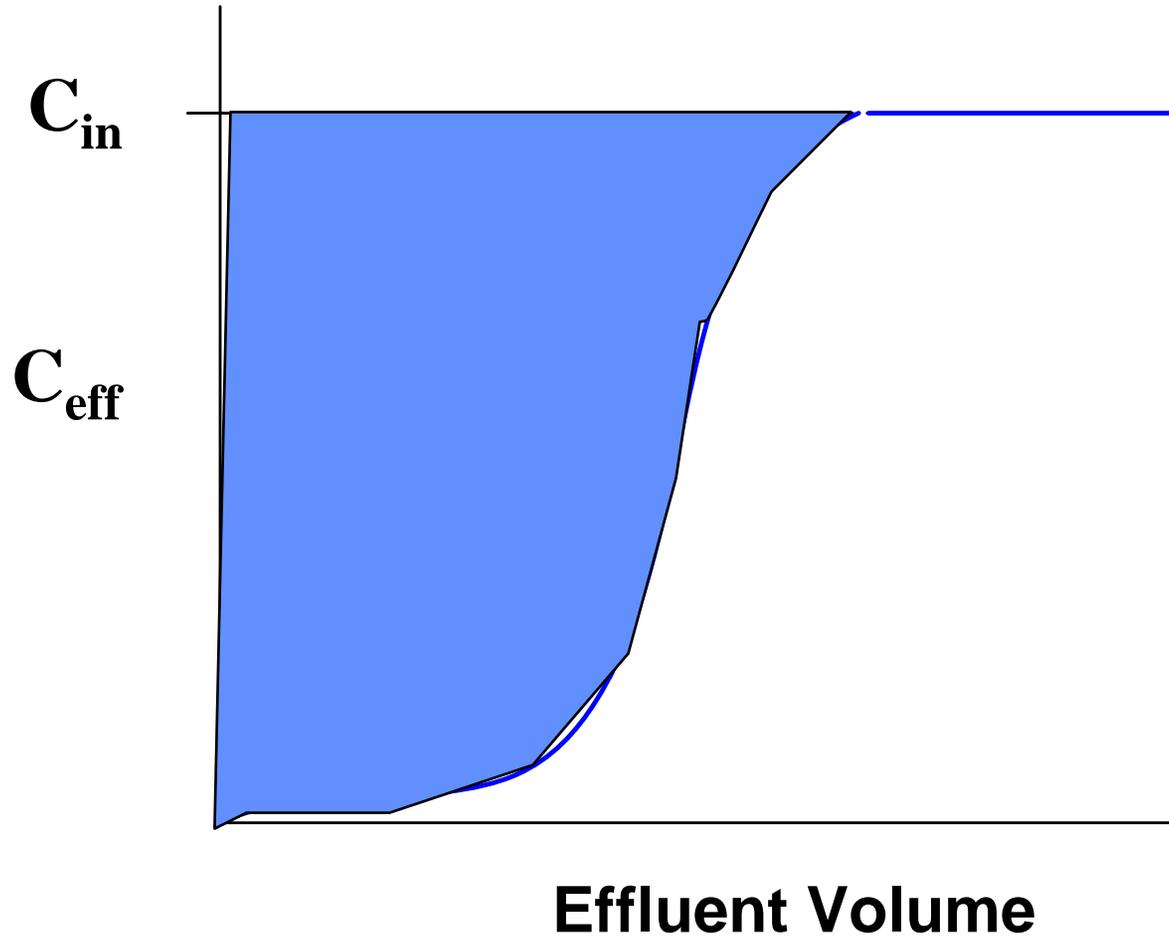
S4 = ARM200 (FeOx); S5 = AsXnp (resin); S6 = Metsorb (TiOx);
S7 = Isolux (ZrOx); S9 = E33 (FeOx)



Different ways to describe performance



Calculation of Column Arsenic Loading Capacity



Media Performance in Socorro, NM

- **Arsenic Removal Capacity**

Parameter	*ARM200 FeOx	Metsorb - TiOx	*AsX ^{np}	Isolux ZrOx	E33 (FeOx)
BV to 10 ppb	8,600	13,000	27,000	32,000	43,000
Capacity at 10 ppb, mg/g	0.60	0.70	1.38	1.67	3.56
Capacity at 35K BV, mg/g	1.17	1.39	1.75	1.67	3.01
Depletion - C/Co at 35K BV	0.88	0.60	0.35	0.38	0.15
BV at C/Co = 0.8	33,000	87,000	53,000	63,000	>63,000
Capacity at C/Co = 0.8	1.15	2.26	2.10	2.23	> 4.62

*AsX^{np} batch was defective, ARM200 was pre-production batch





Media Performance in Socorro, NM Phase 2b (Ambient pH vs. pH 6.8)

Phase 2b:

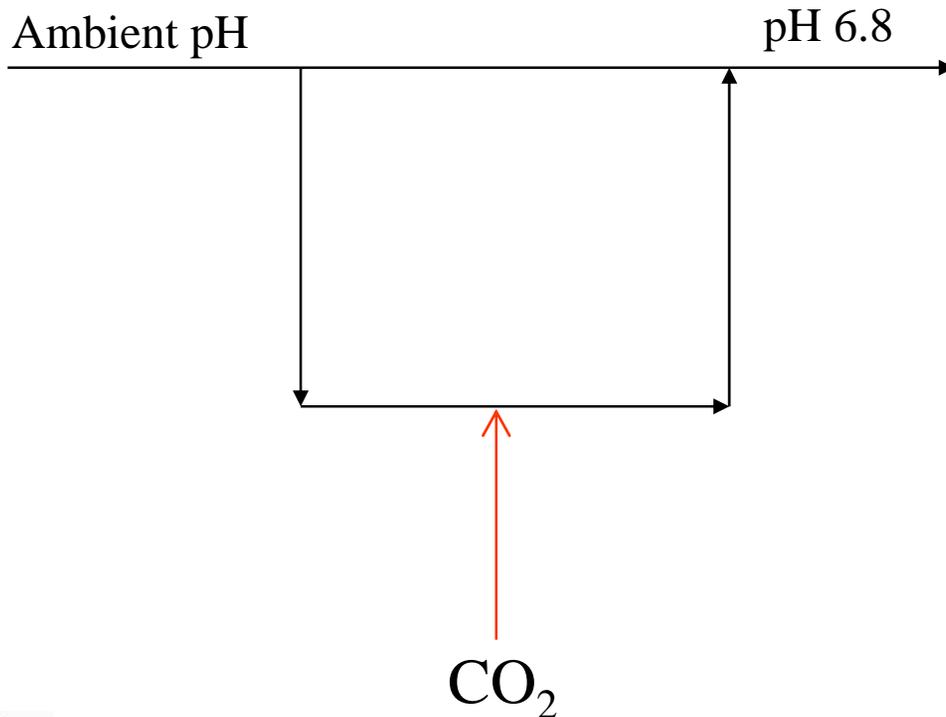
- **Side-by side comparisons of 5 media at 2 pH levels (ambient and pH 6.8)**
 - ArsenX^{np} – New, QC'd batches
 - Isolux – larger cartridge
 - Kemiron – FeOx media—CFH-12
 - SANS – Sandia proprietary media
 - Metsorb – TiOx media
- **Evaluate inadvertent effects of treatment**
 - Loss of pH control
 - Loss of flow
- **Evaluate AwwaRF & University media (pH 6.8)**
 - AwwaRF: Auburn University, ASU
 - University Media: NMSU, NMT

Media Performance in Socorro, NM

Phase 2b (Ambient pH vs. pH 6.8)

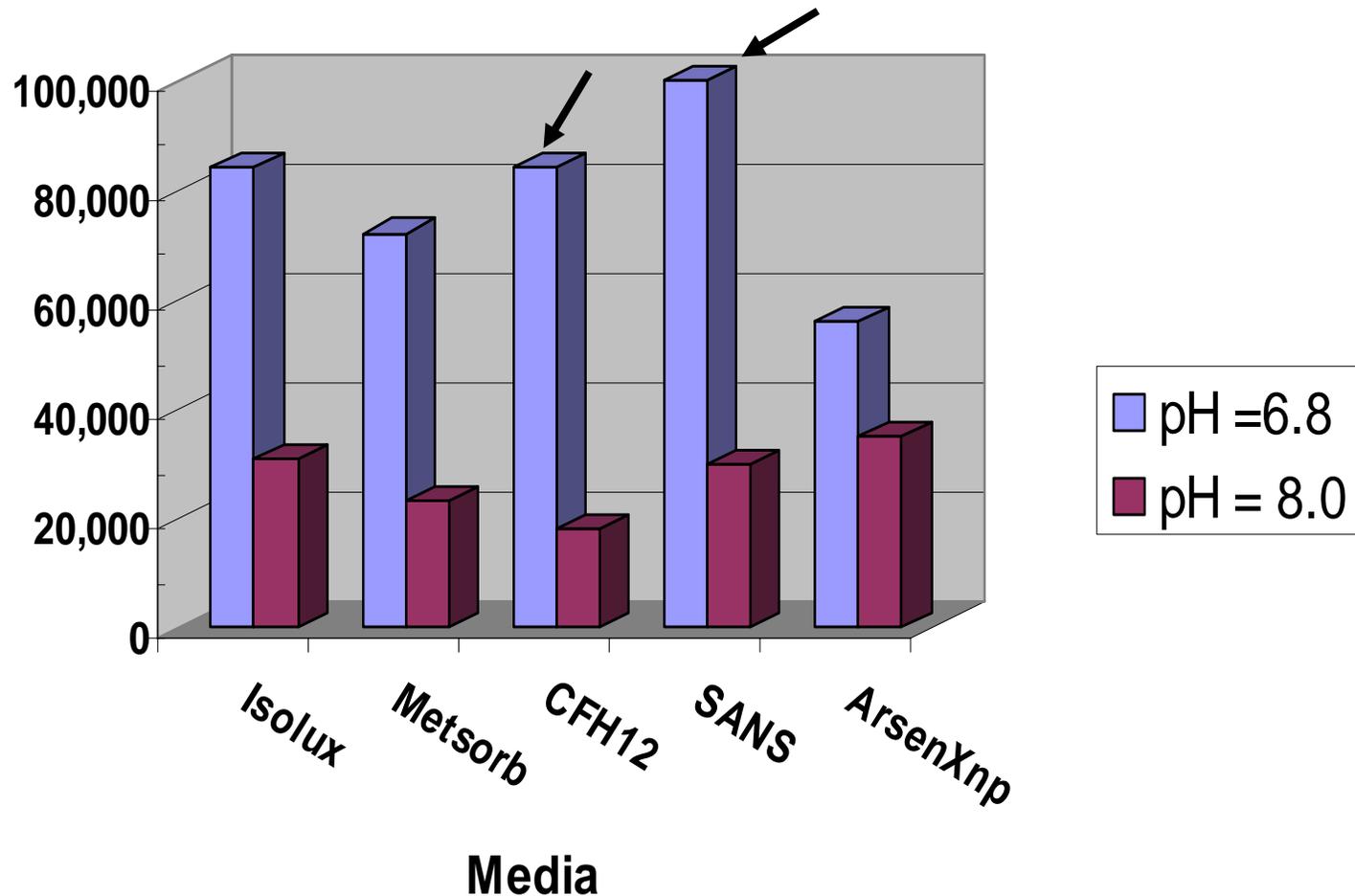
Phase 2b:

- pH Adjustment using CO₂ gas



Media Performance in Socorro, NM Phase 2 (pH = 6.8 vs. 8)

Bed volumes to
10 ppb



Second Community Pilot: Anthony, NM

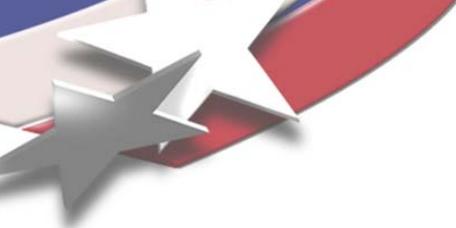
- 100% groundwater source for drinking water
- Warm springs (~85°F) provide 240-270 gpm, 20 ppb As - mainly As(III).
- High sulfates, TDS
- Intermittent Flow Operation
- Phase 1: August 2005
 - 3 FeOx, 1 ZrOx, 2 TiOx, resin
- Phase 2: Coated media December 2005
 - La-coated diatomaceous earth
 - Oxide-Coated GAC
 - Fe-coated silicate
 - Fe-coated SBA resin



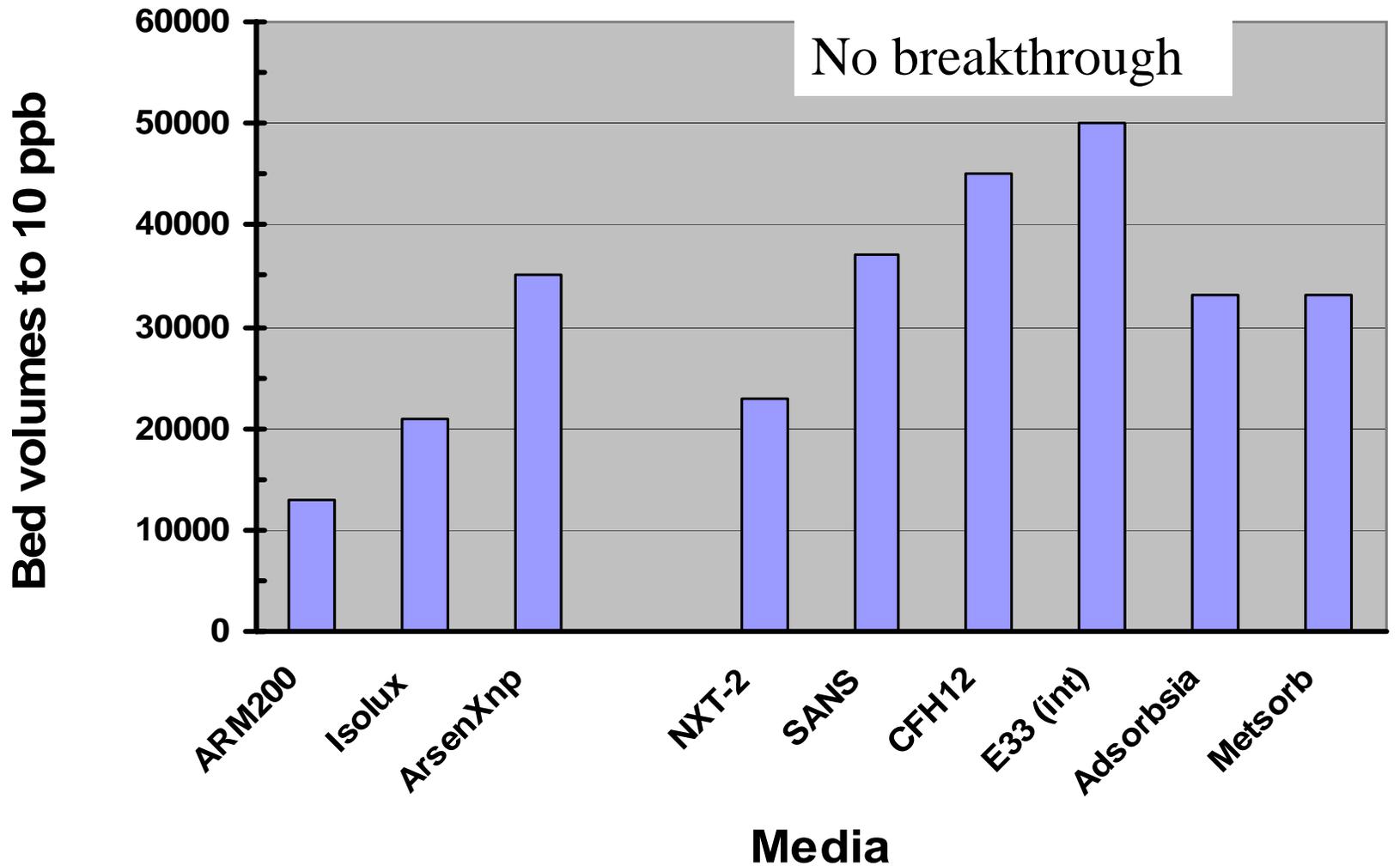


Second Community Pilot: Anthony, NM (Desert Sands MDWCA)

- **Phase 1: August 2005**
 - FeOx: E33, ARM200, CFH12
 - ZrOx: Isolux
 - TiOx: Metsorb, Adsorbsia
 - SANS: mixed oxides
 - Resins: ASM-10HP, ArsenX^{np}
 - La, Fe, Mg-coated diatomaceous earth: NXT-2
- **Phase 2: December 2005**
 - FeOx-Coated GAC
 - Fe-coated silicate
 - Also: re-loaded ArsenX^{np} column
- **Phase 3: June 2006**
 - La, Fe, Mg-coated diatomaceous earth: NXT-2
 - Modified zeolite: Redisorb
 - New batch ARM200
- **Phase 4: October 2006**
24/7 flow operation comparing:
 - E33 with 5 μ m pre-filter
 - vs
 - AD26 Fe/Mn/As removal media



Results of Desert Sands Study

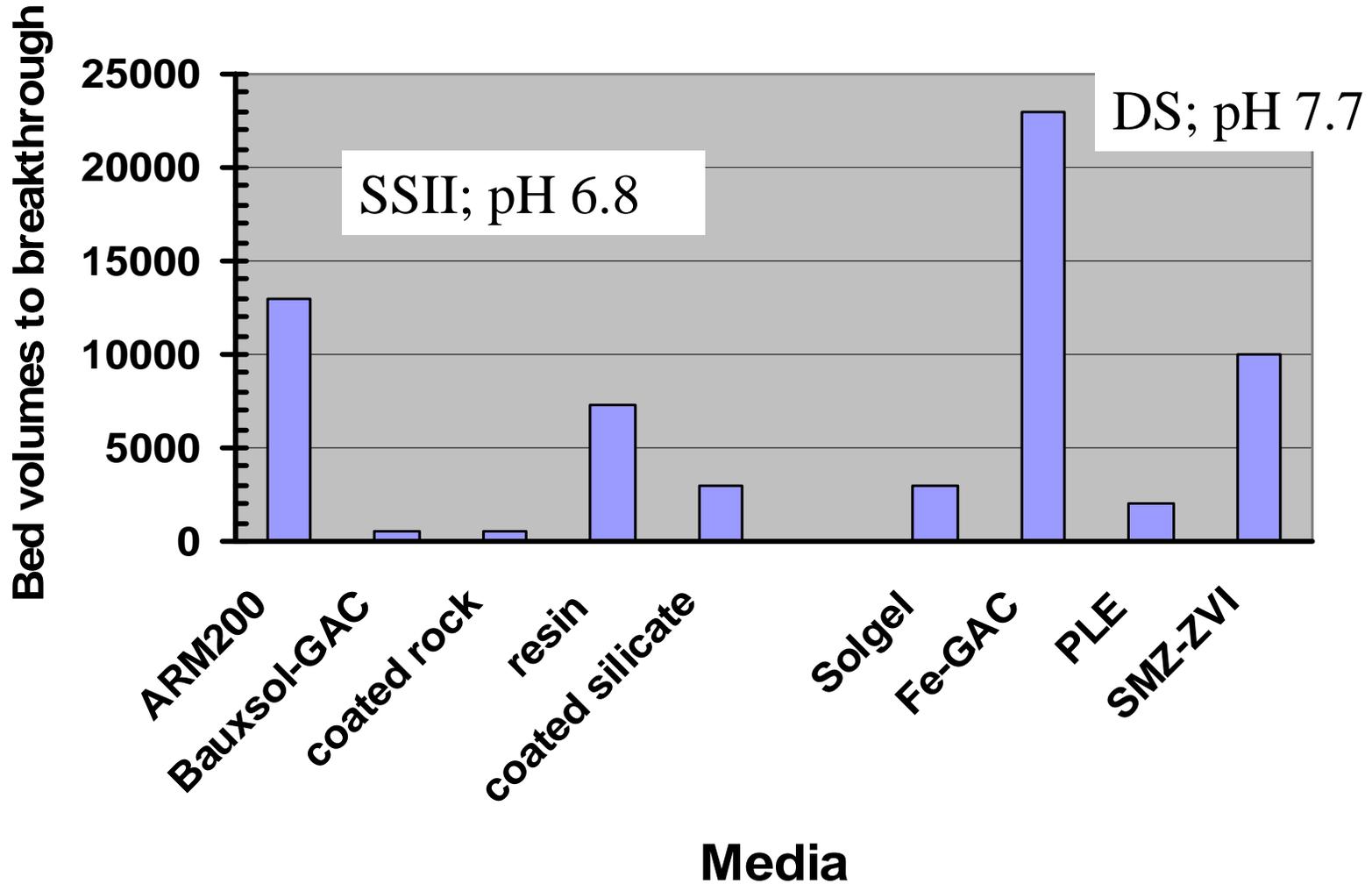




Sorption Treatment Innovations

- **Fe, Ti, Cu, Zr or mixed metal oxides in granules formed by chemical precipitation or nanoparticle agglomeration. (e.g. AdEdge, Kemiron, Argonide, Graver)**
- **Coating granular activated carbon (GAC), strong base anion exchangers resin or polymeric ligand exchangers with nanoparticulate metal oxides. (e.g. Purolite, Resintech, Auburn University, Arizona State)**
- **Coating inexpensive natural media or waste products with metal oxides or other functional groups. (e.g. ADA, Virotec, Lawrence Berkeley Labs)**
- **Increased surface area and chemical selectivity based on fibrous or gel substrates coated by metal oxides or materials with sulfhydryl functional groups. (e.g. NMSU, Weber State, Drexel University)**

“Experimental” Media





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 - Screening of technologies for pilot studies
 - Sandia Labs Pilot Test program
- **Frontiers of Science**
 - Understanding media performance
 - Rapid testing techniques
 - New adsorptive media
- What this all means in the real world-
 - Helping communities deal with the new Standard
 - Sandia arsenic website



Research Program - Overall Objective



Full scale treatment
12-24 months

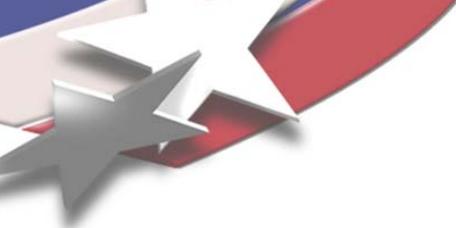
Develop rapid testing methods to reduce time and costs required to determine the most effective adsorptive treatment technology for small systems.



Pilot scale
6-12 months



RSSCT &
isotherm
Days-weeks

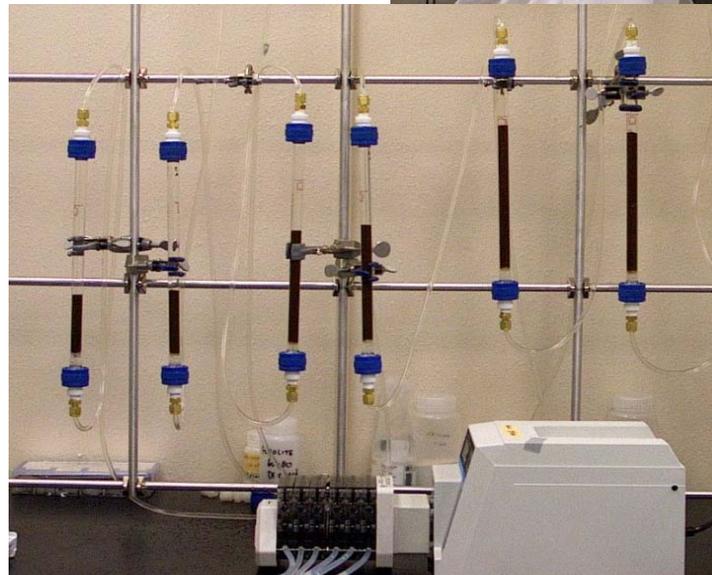
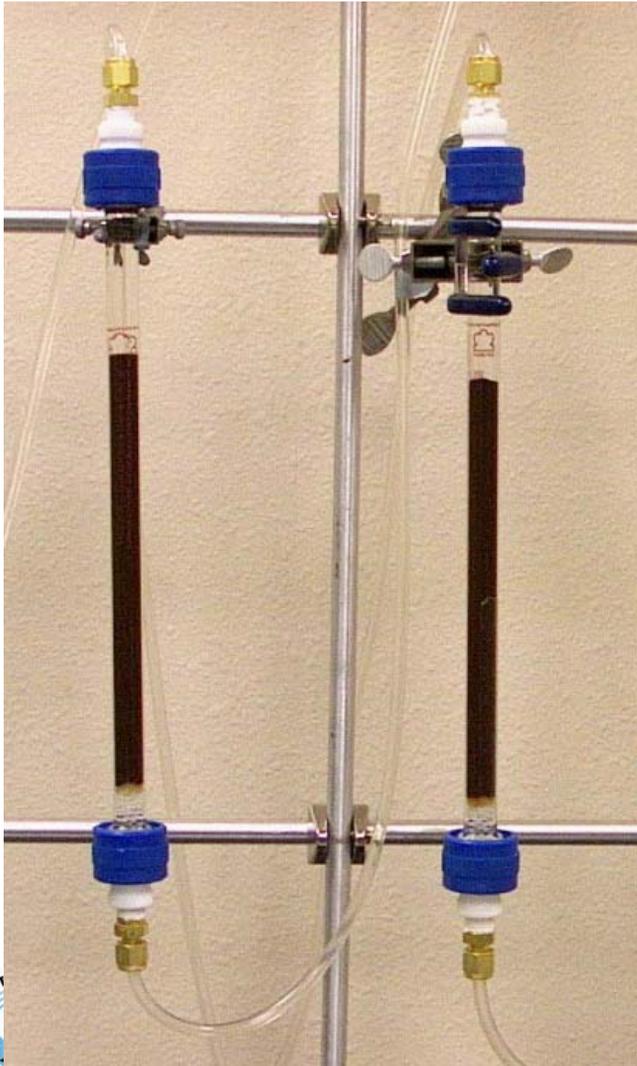


Research Program - Components

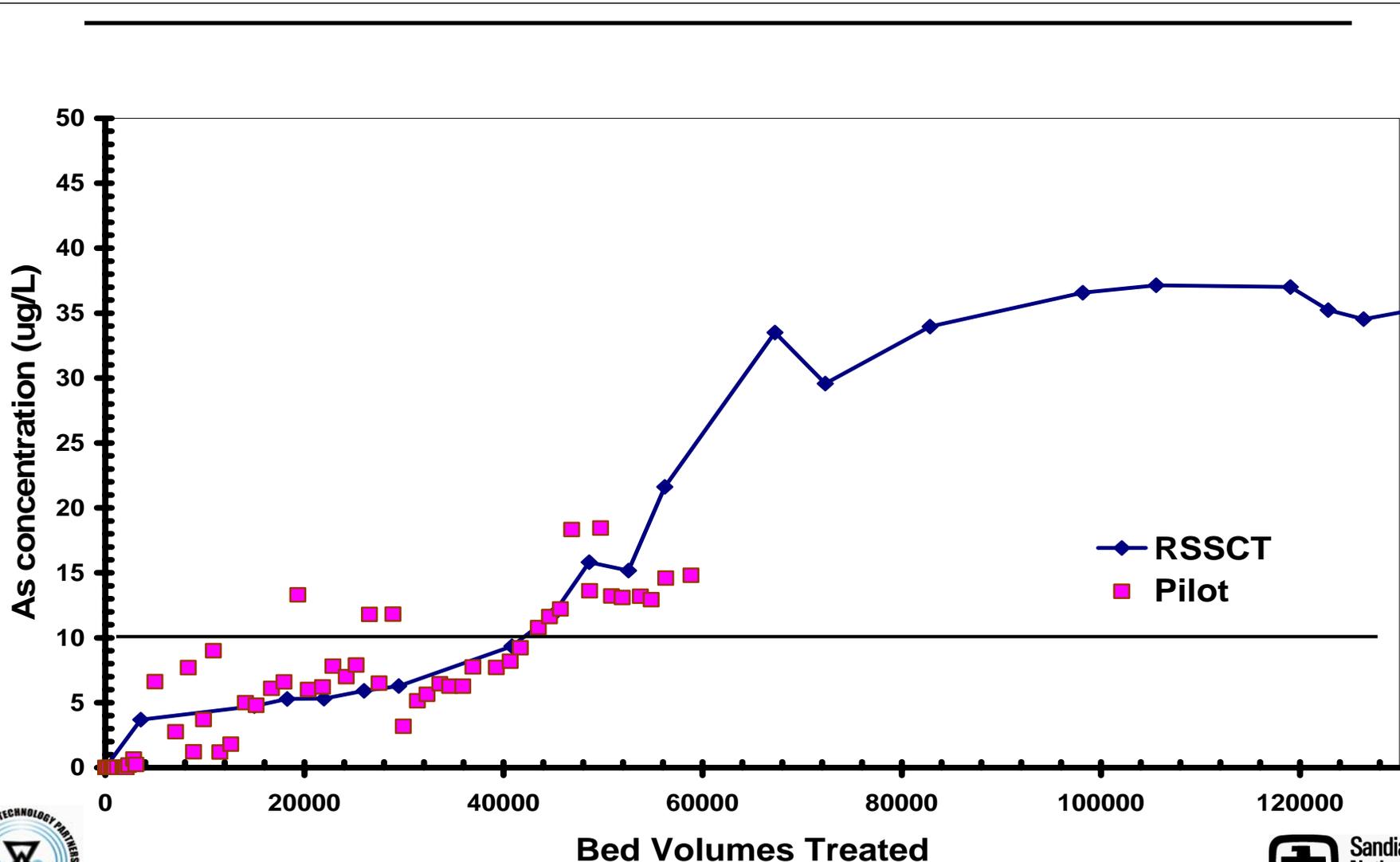
- **Materials characterization**
 - Pre-test and post studies, temperature-ageing studies
 - XRD, Surface area (BET), pore size distribution
 - Particle morphology and surface chemistry
 - Attrition loss
 - Post-mortem pore fluids and solids
- **Batch sorption studies**
 - Kinetic (15°C and 40°C)
 - Isotherms (linear, Freundlich, Langmuir)
- **Rapid small scale column tests (RSSCTS)**
- **Develop simple model that could predict media performance from Lab tests**



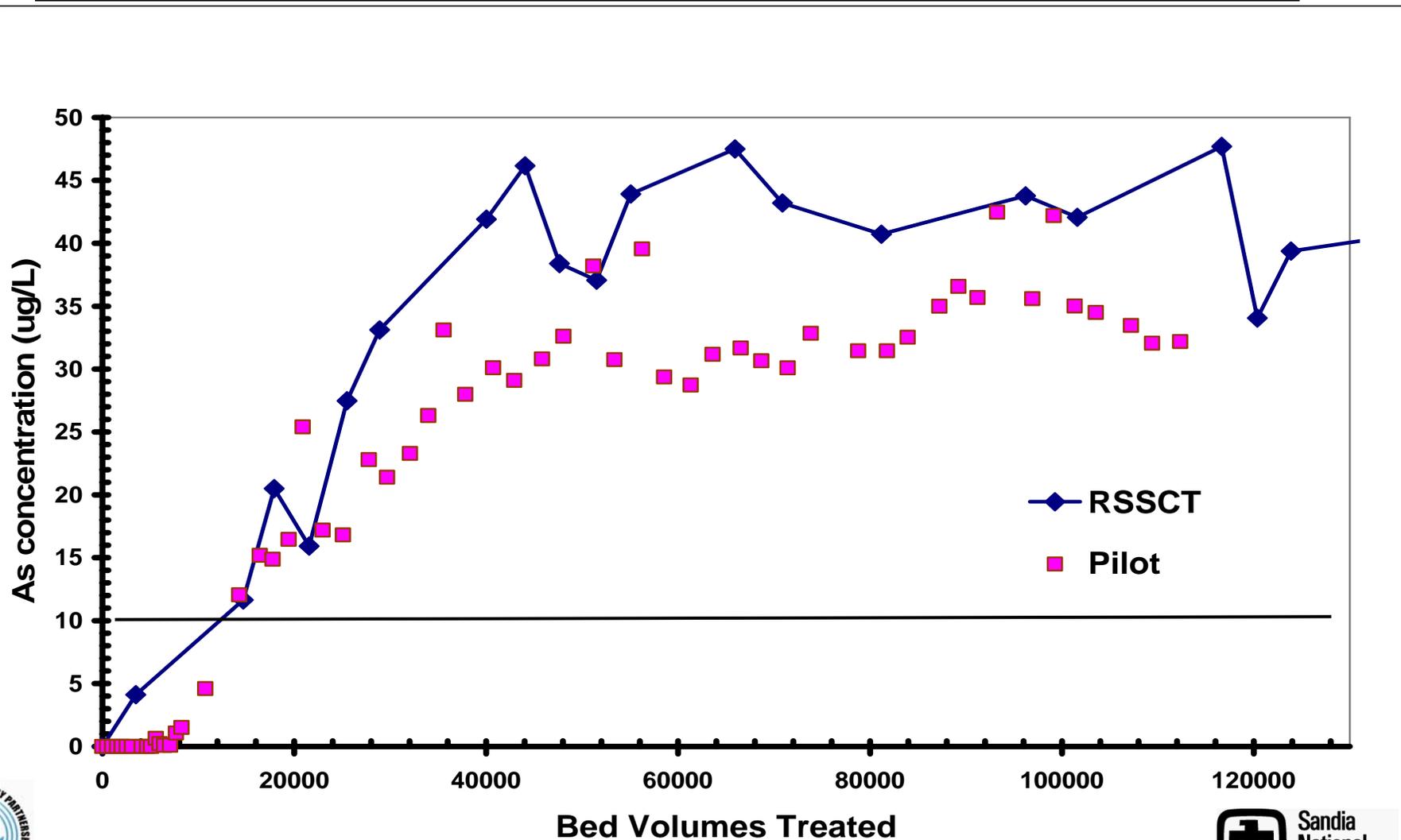
Socorro PD RSSCTs



Socorro I Pilot and RSSCT Breakthrough Curves for E33 (4 min. EBCT)



Pilot and RSSCT Breakthrough Curves for Metsorb Media



Estimates of Arsenic Sorption Capacity from Different Tests

	E33	ARM200	Metsorb
BV to 10ppb (pilot)	43,000	8,600	13,000
<u>As</u> at 10ppb (pilot)	3.56 mg/g	0.6 mg/g	0.7 mg/g
BV to 10ppb (RSSCT)	43,000 (PD)	6000 (CD)	12,800 (PD)
<u>As</u> at 10 ppb (RSSCT)	3.39 mg/g (PD)	0.42 mg/g (CD)	0.69 mg/g (PD)
<u>As</u> at 10 ppb (Freundlich)	5.0 mg/g	3.6 mg/g	1.2 mg/g

BV = bed volumes, **PD** = proportional diffusivity, **CD** = constant diffusivity

As = capacity calculated from loading or batch test





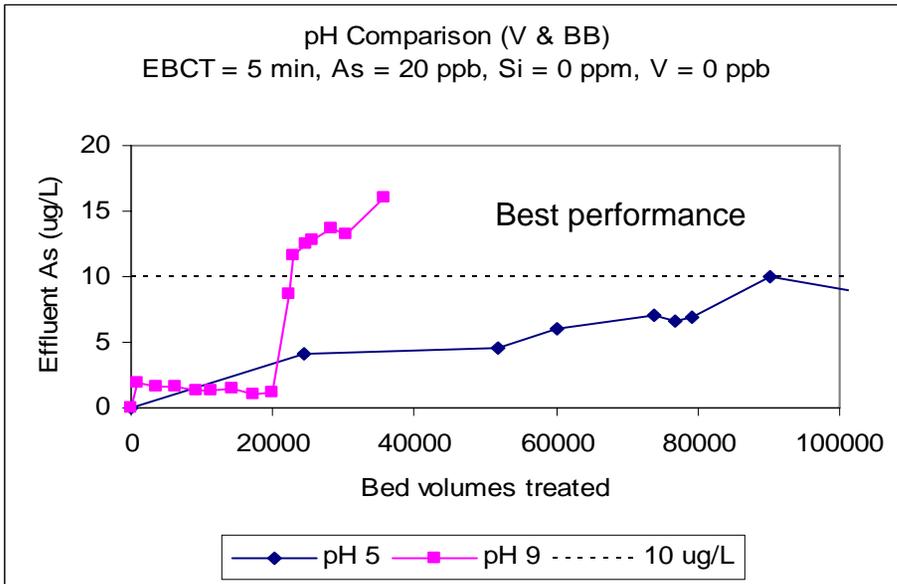
Parametric RSSCT studies with E33: Rapid tests of effects of water chemistry

Parameter	“High” Value	“Low” Value
Arsenic*	100 ug/L	20 ug/L
Vanadium*	60 ug/L	0
Silica*	60 mg/L	0
pH*	9.0	5.0
EBCT (simulated)	5 min	3 min

* Nationwide groundwater concentration ranges for these constituents are taken from the USGS NAWQA Data Warehouse for Groundwater

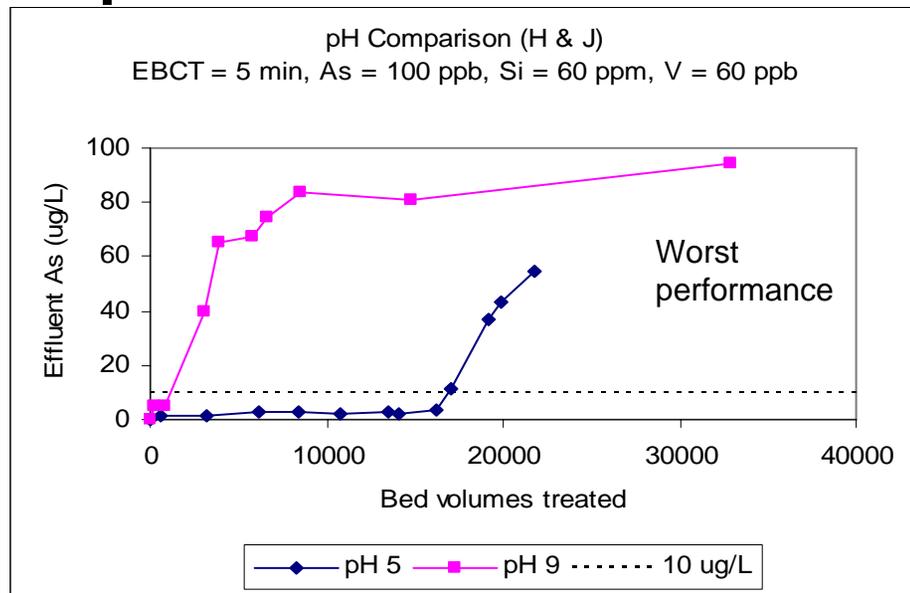


Arsenic Breakthrough - pH Comparison



Increase in performance of
at least 3x (up to 18x)

E33 consistently performs MUCH better at pH 5 (vs. pH 9) regardless of other water chemistry parameters





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Helping Communities

- Information gathered at Vendors Forum and Pilots available on Sandia Pilot project website:
 - <http://www.sandia.gov/water/arsenic.htm>
- WERC regional training courses
- WERC developed Comprehensive Arsenic Tool (CoAsT)
 - to be available at: <http://www.arsenicpartners.org>
 - Summaries of BATs
 - Several cost models
 - Decision tree
 - Beta-version of rate structure tool
- Sandia Rural Outreach Program
 - Outreach to individual communities in New Mexico





Arsenic Water Technology Partnership Pilot Demonstration Project



- [Pilot Demo Project Home](#)
- [Technology Evaluation](#)
- [Pilot Demonstrations](#)
- [Outreach](#)
- [Publications](#)
- [Partners](#)
- [Contacts](#)

The **Arsenic Water Technology Partnership** is supported with a \$13 million Congressional appropriation through the U.S. Department of Energy. The program is a multi-year effort designed to move innovative technologies from the bench-scale to pilot scale demonstration. This program will enable water utilities, particularly those serving small, rural communities and Indian tribes, to implement the most cost-effective solutions to their arsenic treatment needs. This goal is being met by carrying out three activities:

- **conducting research to develop innovative, arsenic removal technologies with a focus on reducing energy costs, minimizing operating costs, and minimizing quantities of waste;**
- **demonstrating the applicability of innovative technologies to a range of water chemistries, geographic locales, and system sizes; and**
- **evaluating the cost effectiveness of these technologies and providing education, training, and technology transfer assistance to user communities.**

The Awwa Research Foundation (AwwaRF) has managed the bench-scale research programs. WERC (A Consortium for Environmental Education and Technology Development) is evaluating the economic feasibility of the technologies investigated and conducting community education/technology transfer activities. Sandia National Laboratories (SNL) manages the pilot-scale demonstration program. During the period 2004-2006, Sandia National Laboratories has conducted pilot treatment demonstrations at six sites. Pilot communities and technologies were matched to examine a wide range of alternative technologies and site conditions. The classes of technologies tested include 1) Continuous Flow Systems (ion exchange, metal oxyhydroxides sorbents), 2) Batch Systems (Coagulation/Microfiltration), and 3) Reverse Osmosis. This website serves as a gateway to the activities supported by Sandia National Laboratories as part of the Arsenic Water Technology Partnership. Links are provided to:

- **Evaluation of innovative commercial arsenic treatment technologies**
- **Educational [Short Courses](#) and [Vendors Forums](#) held as part of the New Mexico Environmental Health Conferences in 2003 - 2005.**
- **Results of Pilot Demonstrations**
- **Project publications**
- **Activities of other [members](#) of the Arsenic Water Technology Partnership**



Arsenic Water Technology Partnership

Pilot Demonstration Project

Pilot Demonstrations



[Demo Project Home](#)

[Technology Evaluation](#)

[Pilot Demonstrations](#)

[Socorro](#)

[Anthony](#)

[Rio Rancho](#)

[Jemez Pueblo](#)

[Pine Hill](#)

[Weatherford](#)

[Outreach](#)

[Publications](#)

[Partners](#)

[Contacts](#)

Overview of Pilot Demonstrations

Siegel, M.D., Dwyer, B., Aragon, A. and Everett, R. 2005. *Pilot Demonstrations of Arsenic Treatment Technologies in the U.S. Department of Energy, Arsenic Water Technology Partnership Program* [pdf 800kb]

SAND2005-1909C, Sandia National Laboratories, Albuquerque, NM.

Malynda Aragon, 2006. *Pilot Demonstrations of Arsenic Removal Technologies - Sandia National Laboratories* [pdf 612kb]

SAND2006-7639P, Sandia National Laboratories, Albuquerque, NM.

Sandia National Laboratories Arsenic Treatment Technology Demonstration Program [pdf 1.4mb]

Presented at the American Water Works Association Inorganics Contaminants Conference, January 31, 2006.

Pilot Tests of Adsorptive Media Arsenic Treatment Technologies in the Arsenic Water Technology Partnership 2006-0372C [pdf 811kb]

Presented at the National Groundwater Association Meeting on Naturally Occurring Contaminants, Albuquerque, NM, February 6, 2006.

Pilot Test Sites News Releases

- [Socorro, New Mexico](#)
- [Anthony \(Desert Sands\), New Mexico](#)
- [Rio Rancho, New Mexico](#)
- [Jemez Pueblo, New Mexico](#)
- [Pine Hill, Ramah Navajo Reservation \(New Mexico\)](#)
- [Weatherford, Oklahoma](#)

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Sandia Water Initiative





Arsenic Water Technology Partnership Pilot Demonstration Project Technology Evaluation



[Pilot Demo Project](#)

[Home](#)

[Technology Evaluation](#)

[Pilot Demonstrations](#)

[Outreach](#)

[Publications](#)

[Partners](#)

[Contacts](#)

Introduction

The decrease of the drinking water standard (MCL) for arsenic from 50 μL to 10 μL in January 2006 could lead to significant increases in the cost of water for many rural systems throughout the United States. The Arsenic Water Technology Partnership (AWTP), a collaborative effort of Sandia National Laboratories, the Awwa Research Foundation (AwwaRF) and WERC: A Consortium for Environmental Education and Technology Development was formed to address this problem by developing and testing novel treatment technologies that could potentially reduce the costs of arsenic treatment. Each of the Partners develops or evaluates new technologies in their respective programs: AwwaRF manages a bench-scale research program through a series of competitive grants; WERC hosts an annual contest in which university students compete to provide the best solution to a design challenge involving arsenic treatment; Sandia National Labs has sponsored educational [Short Courses](#) on arsenic removal technology and evaluated cutting-edge commercial products in three annual [Vendors Forums](#) held during the annual New Mexico Environmental Health Conferences (NMEHC) in 2003, 2004 and 2005. The most promising of the technologies from these three programs are pilot tested at several field sites in collaboration with local water utilities.

This website describes the efforts of Sandia National Laboratories to evaluate commercial technologies for the pilot test program from 2003 to 2006. The educational [Short Courses](#) held at the NMEHC included invited talks on aspects of arsenic occurrence, health effects and treatment technologies. The [Vendors Forums](#) were designed to allow vendors of commercial technologies to present product descriptions to the conference participants and to allow objective evaluation by technical experts. During a closed session, the technologies were reviewed by teams of recognized experts in water treatment and related fields and were assigned numerical scores based on expected performance and costs. [Table 1](#) lists all the companies that participated in the Forums, identifies their products and provides electronic links to points of contacts or company websites. Table 2 describes the rankings of technologies for each of the 3 Vendors Forums and identifies those being pilot tested at the field scale by Sandia National Laboratories.

Other technologies were evaluated through other methods such as by independent review of product performance and cost by Sandia staff, technical review by the Technical Advisory Committee and the Partnership Management Committee of the AWTP. Several of these technologies were chosen for pilot scale demonstrations; [Table 3](#) provides descriptions of these products. A list of the technologies being tested at each of the 5 pilot sites is given in [Table 4](#).

[Table 1. Vendor Forum Participants](#)

[Table 2. Vendor Rankings for each Forum](#)

[Table 1. Vendor Forum Participants](#)

[Table 2. Vendor Rankings for each Forum](#)

[Table 3. Vendors Not Participating in Forum but Currently or Potentially Involved in Pilot Studies](#)

[Table 4. Vendor Participation in Pilot Tests](#)

All of the technologies that were reviewed are described in this website. Treatment methods are categorized as [adsorptive media](#), [coagulation/filtration/membranes](#) or [other technologies](#). An [alphabetical index](#) to all technologies is also provided. Other information about the technologies and related topics can be found in two summary reports and the websites for each of the [Short Courses](#) and [Vendors Forums](#), which include links to the presentations given at these events.

Treatment Methods

Category Listing

[Adsorptive media](#)

[Coagulation/Filtration/Membranes](#)

[Other Technologies](#)

[Alphabetical Index](#)

Summary Reports

- [Development and Evaluation of Innovative Arsenic Adsorption Technologies for Drinking Water by the Arsenic Water Technology Partnership](#), SAND2006-0113C [pdf 248kb], National Groundwater Association Meeting on Naturally Occurring Contaminants, Albuquerque, NM, February 6, 2006
- Malcolm Siegel, Paul McConnell, Randy Everett, Carolyn Kirby 2006. [Arsenic Treatment Technology Vendors Forums Summary Report](#) [pdf 220kb] SAND2006-5423, Sandia National Laboratories, Albuquerque, NM.

Event Websites

- [Arsenic Treatment Technology Short Courses](#)
- [Arsenic Treatment Technology Vendors Forums](#)

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Sandia Water Initiative





Arsenic Water Technology Partnership Pilot Demonstration Project Outreach



[Demo Project Home](#)

[Technology Evaluation](#)

[Pilot Demonstrations](#)

[Outreach](#)

[Publications](#)

[Partners](#)

[Contacts](#)

James L. Krumhansl, Kathleen C. Holt, Heather Himmelberger, Susan Butler, Matt Ziegler, and Bruce Thomson, 2007. [*Summary of Resources Available to Small Water Systems for Meeting the 10 ppb Arsenic Drinking Water Limit*](#) [pdf 1mb]
SAND2006-6943, Sandia National Laboratories, Albuquerque, NM.

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From Lab to Field: Sandia Pilot Test Program Summary

- **Pilot Test Demonstration Objectives**
 - Generate cost/performance data for innovative technologies for small communities
- **Technology Selection**
 - Initial technologies chosen from participants in Vendors Forum
 - Phase II test can involve experimental technologies from other Partners
- **Pilot Studies**
 - Socorro, NM
 - Desert Sands, NM
 - Rio Rancho, NM
 - Jemez Pueblo
 - Pinehill, Ramah Navajo Reservation
 - Weatherford, OK





Cost Considerations

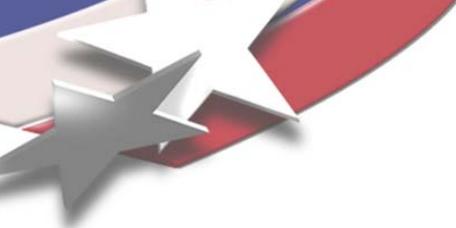
- Spend appropriately on the front end – “pay me now, or pay me later”
- Design of arsenic removal system should:
 - Remove As below MCL – Get a guaranteed \$/1000 rate or media capacity from your vendor
 - Allow for minimal maintenance
 - Allow for simple media replacement
 - Do tank(s) have a drain? Large enough access ports?
 - Does your building allow for easy access?
- Plan for annual expenses
 - Labor
 - Media Replacement
 - Chemicals

(MA, 2007)



Unanswered Questions from the Frontier

- **Can a comprehensive lab-based study of media properties replace the need to carry out site-specific field tests for predictions of media performance?**
 - Relate pore structure to performance?
 - Effect of major ions on performance?
 - Effect of hydraulic properties on performance?
 - Backwashing may create fines and decrease BVs
- **Comparison to full-scale treatment plant results?**



For More Information:

Arsenic Partnership Website

<http://www.arsenicpartners.org/>

Sandia Website

<http://www.sandia.gov/water/arsenic>

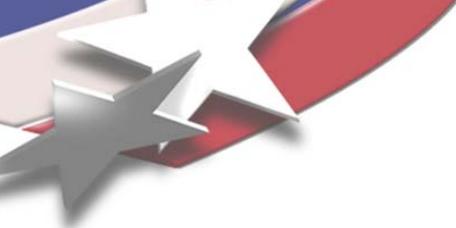
→ Papers, Presentations, Vendor Information, Pilot Results

WERC CoAsT Website

<http://www.werc.net>

→ Click on Outreach tab, then CoAsT





**Thank you for your
attention**

Questions?

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