Adsorption Technologies

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Presented at the 2005 Arsenic Training Sessions
Sponsored by the USEPA

Agenda

- Adsorption Technology
- Application
- System Design
- System Operation

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- **Adsorption Technology**
- Application
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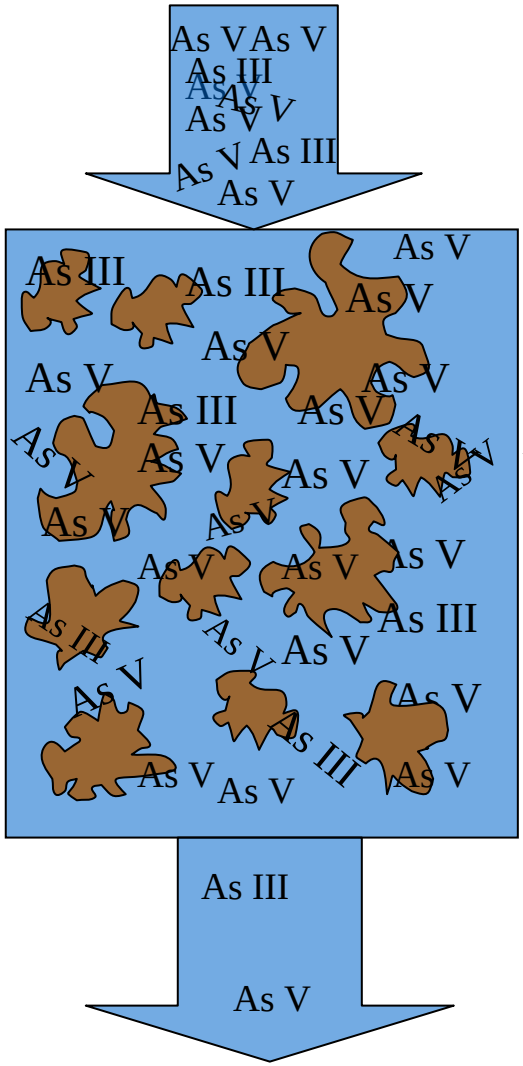
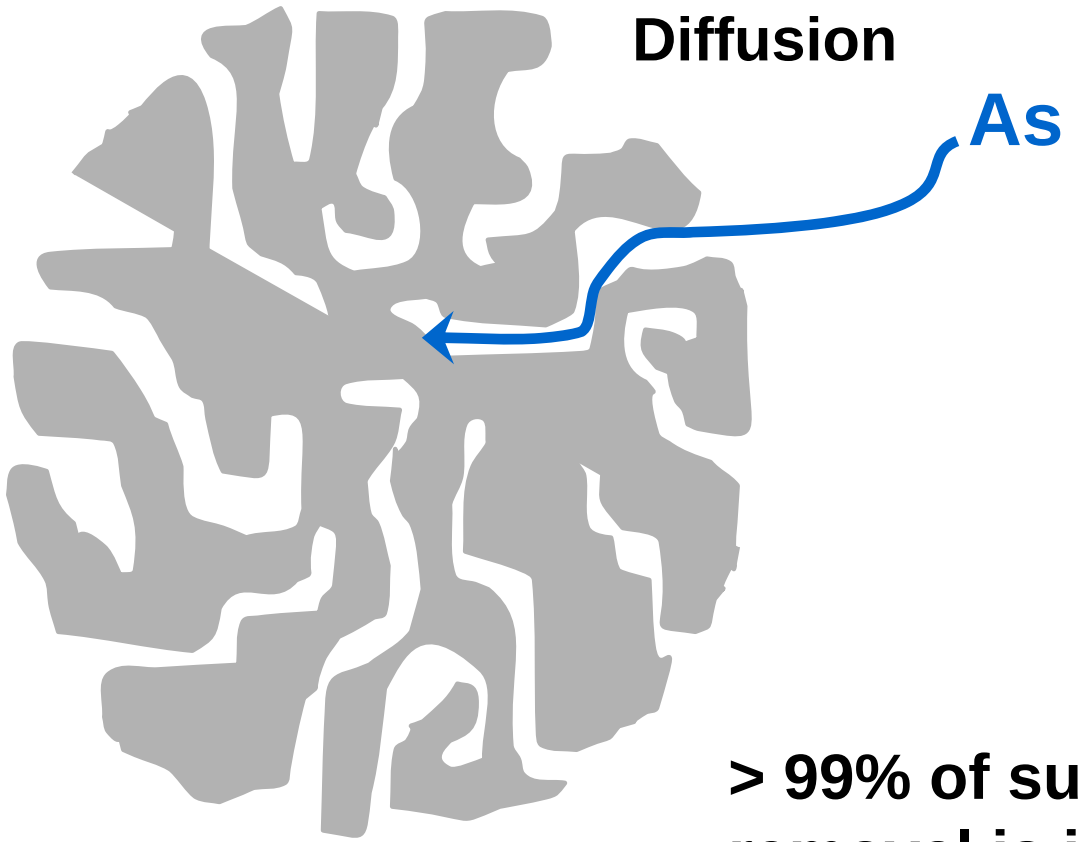
Adsorption Technology



Accessible Area of Granular Media



> 99% of surface for removal is internal

Source: M. Edwards, June 2003

Examples of Adsorbent Media

GFO Bayoxide E33

Modified activated alumina


04066

Agenda

- Adsorption Technology
- **Application—Why/Where?**
- System Design
- System Operation

Application – Why?

Number One Reason:

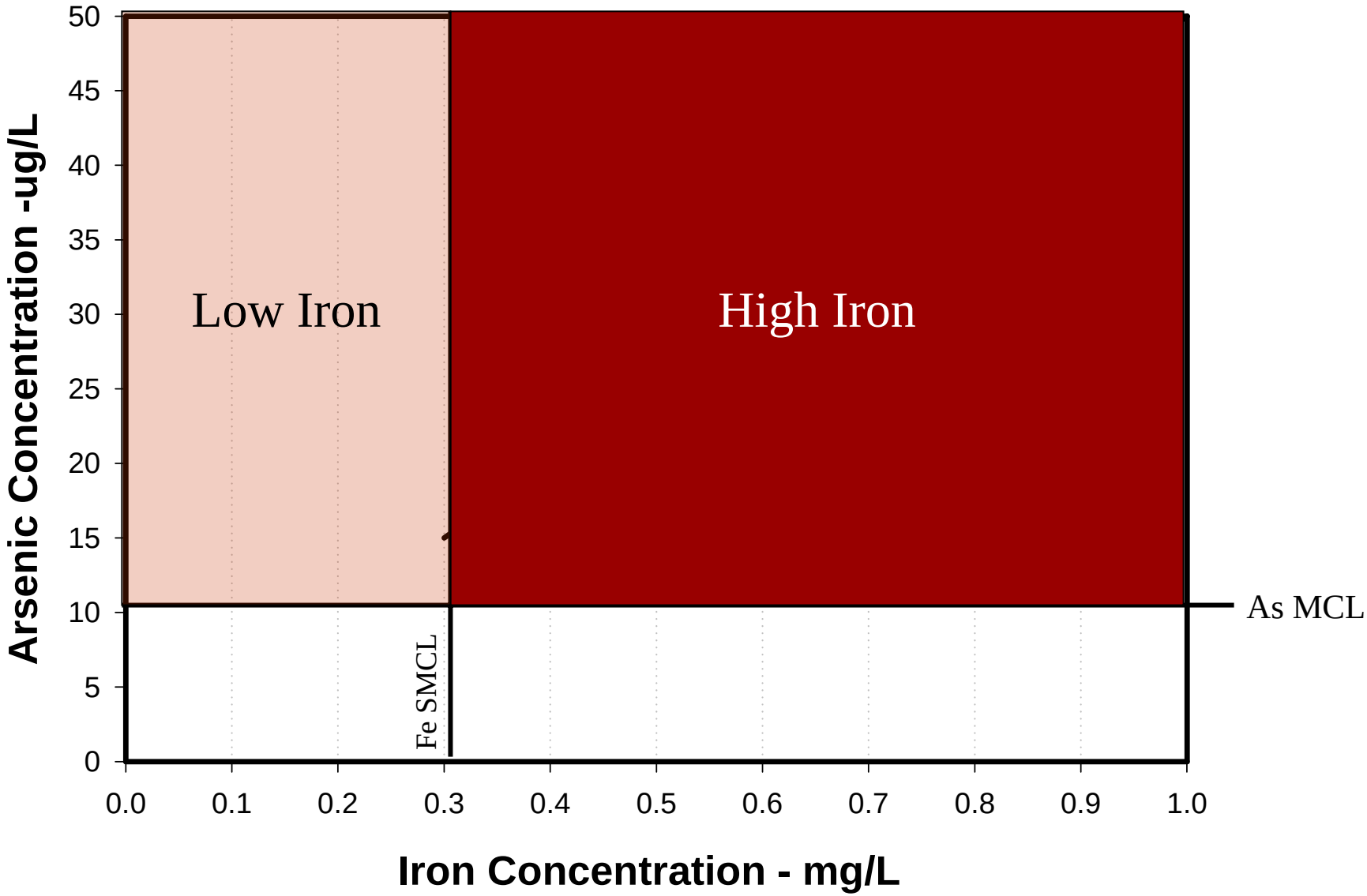
Simple to operate!

Application – Why?

Other Reasons

- Low arsenic in treated water 2-3 ug/L
- Reasonable capital and operating cost
- Small footprint
- Flexibility – use of different media products
- Residual disposal usually not a major issue

Application – Where?



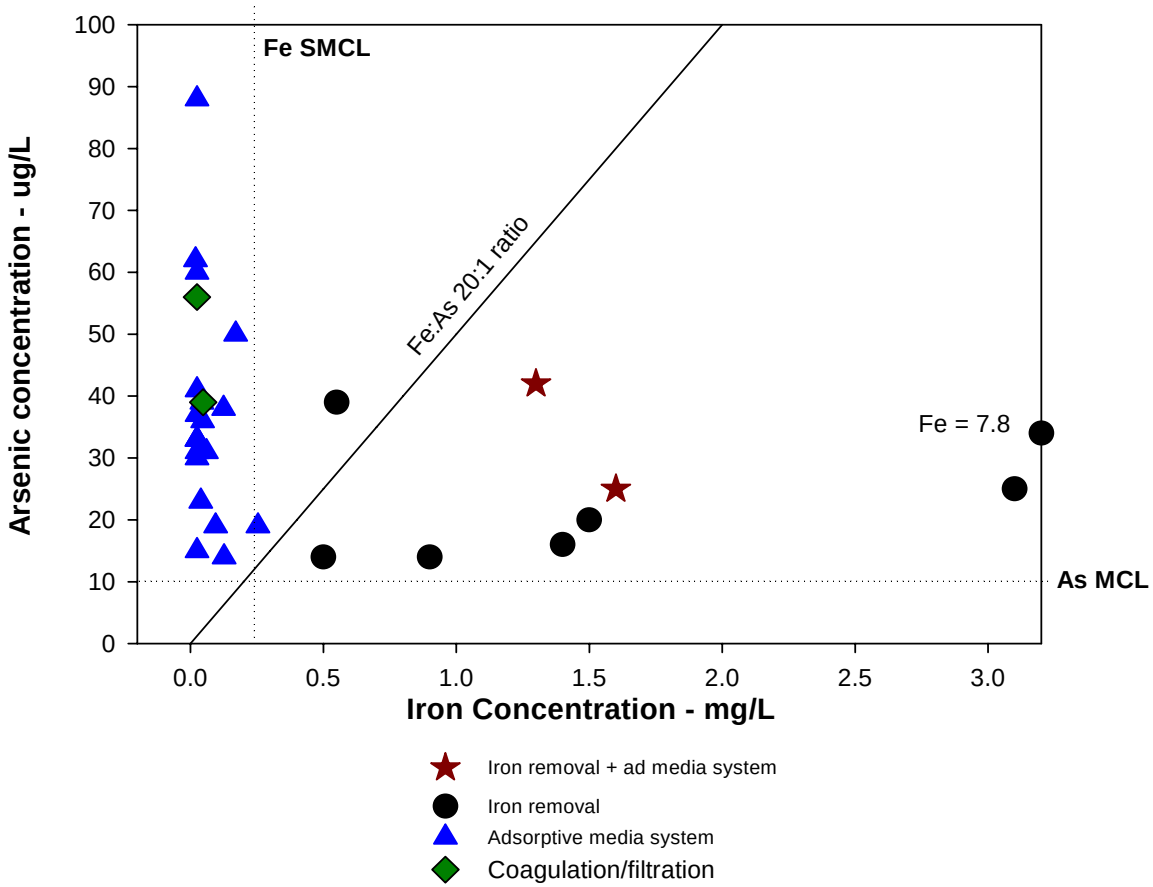
Application – Where?

Low Iron Source Water – Why?

High iron sites normally require pre-treatment

Application – Where?

Arsenic Demonstration Technologies: Round 1 & 2 Sites



Agenda

- Adsorption Technology
- Application
- **System Design**
- System Operation

System Design

- System configuration - parallel vs series
- Vessel design – size, materials of construction
- Media selection – performance, EBCT, cost
- Pre-treatment - oxidation, pH Adjustment
- System controls – manual vs automatic
- Residual disposal – backwash water, media
- Costs – capital and operational

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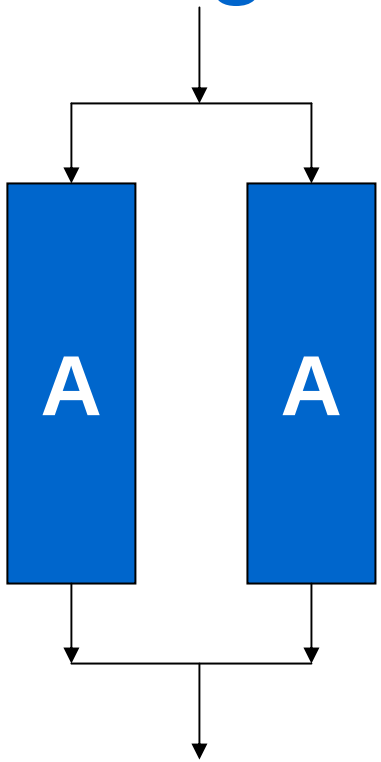
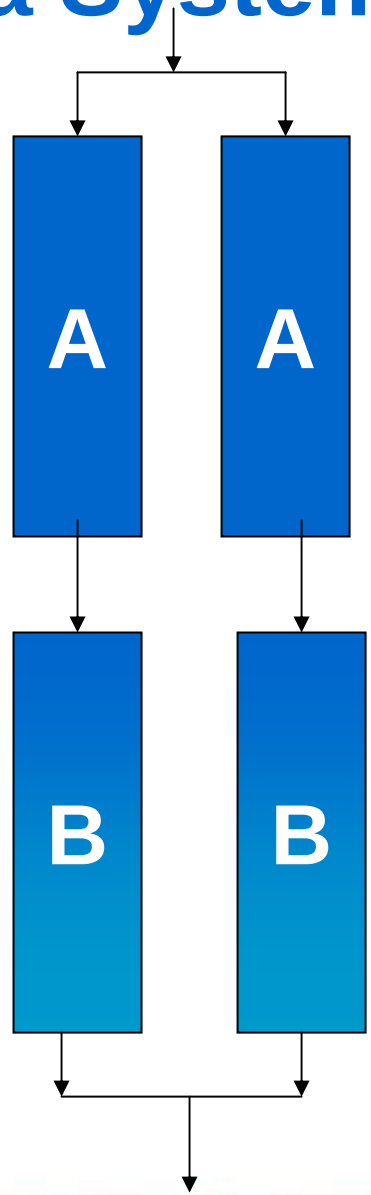
Adsorptive Media System Configuration



Simple Parallel Design



Roughing filters

Polishing filters

Series Design

System Configuration

Series - Advantages

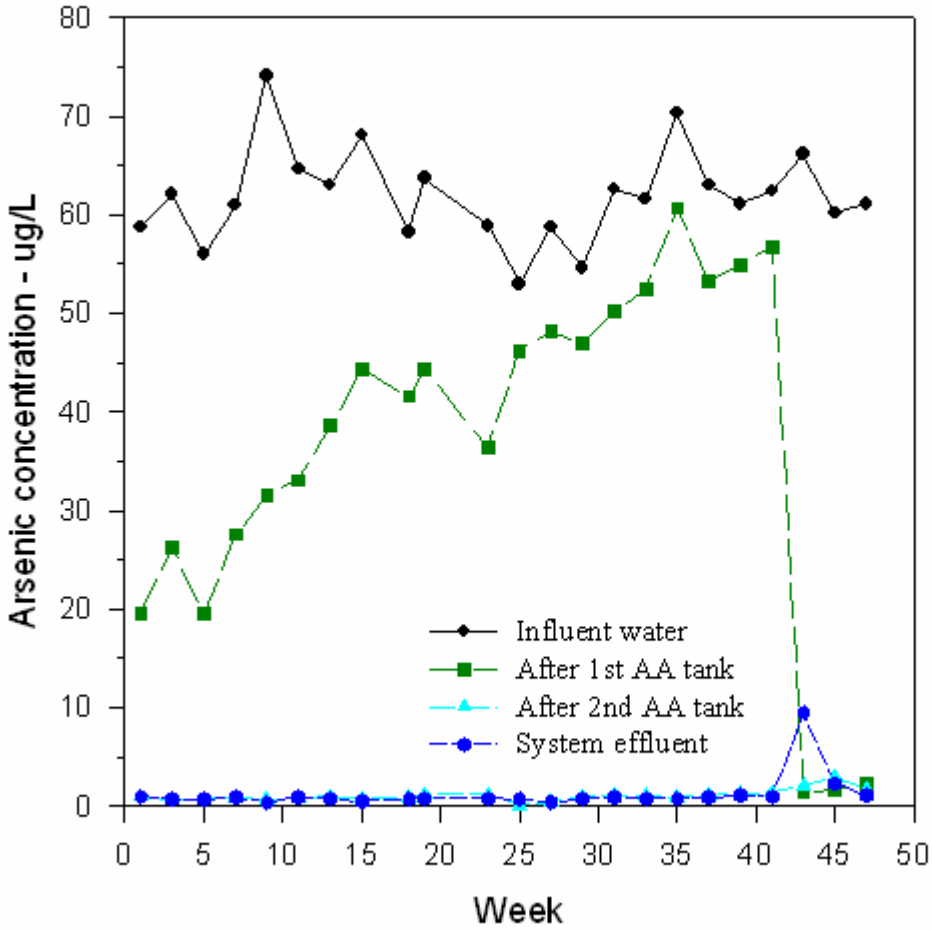
- More conservative – added safety
- Maximum use of media – lower operating cost
- More flexible change out schedule

Series – Disadvantages

- Higher capital cost – more tanks
- Larger foot print
- Higher pressure drop

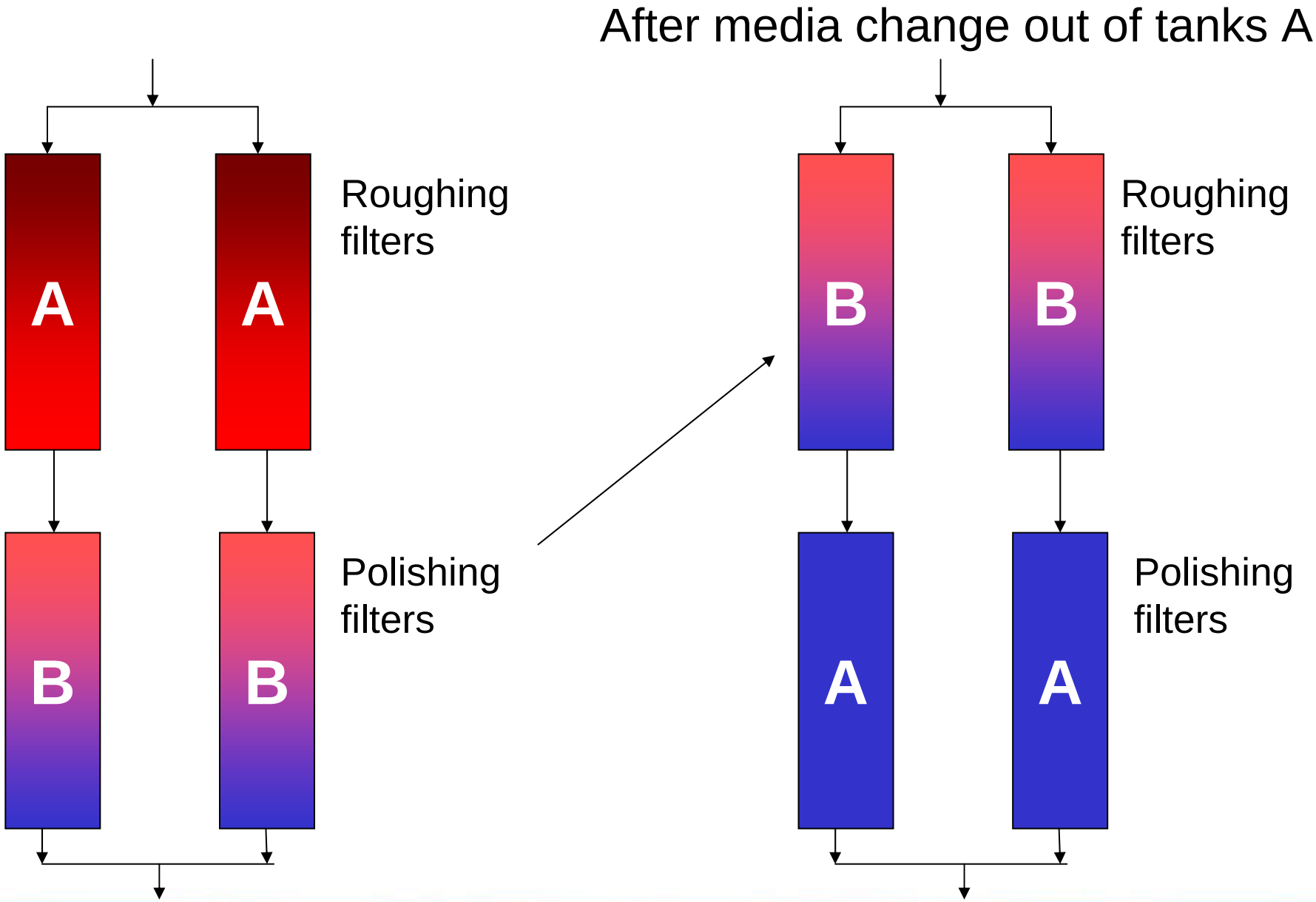
Arsenic Removal

Activated Alumina System (CS), NH—1998-1999



Influent water: pH 8.2, alk 58 mg/L ($CaCO_3$), Fe <0.03 mg/L

Adsorptive Media System Configuration



Series Design

System Design

- System configuration - parallel vs series
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- Media selection – performance, EBCT, cost
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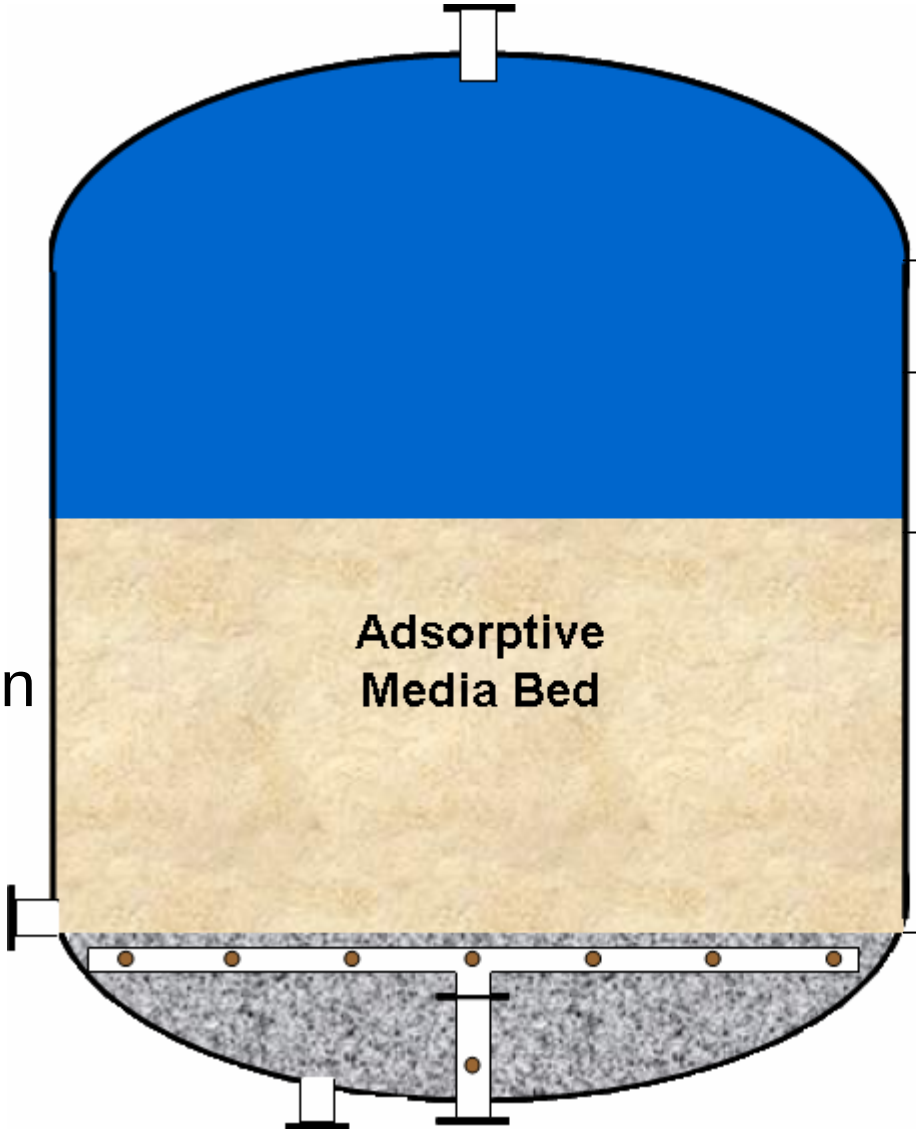
Adsorptive Media Pressure Tank

Media

EBCT
3 – 10 min



Freeboard

Bed expansion
15 -50 %

Bed depth
3-6 ft

EBCT

EBCT—3 to 10 minutes

The lower the EBCT

- The higher the unit flow rate
- The smaller the size of the vessels

Vessel Materials

Pressure and Cost Issues

- Fiberglass (FRP)
- Carbon Steel
- Stainless Steel


FRP Tanks


SS Tanks
2004 6 30

System Design

- System configuration - parallel vs series
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- **Media selection – performance, EBCT, cost**
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Media Selection Criteria

- Performance – water quality dependent
  - Arsenic form – As III, As V
  - pH, silica, phosphate, vanadium
- EBCT
- Cost of media
- Regeneration of media vs one time use
- Residual Disposal (BW Water and Media) – hazardous vs non- hazardous

Adsorptive Media Listed in NSF/ANSI STD 61

Company	Base Material	Name	Material
Alcan (4)	Aluminium	AAFS - 50	Mod AA
Alcoa (2)	Aluminium	CPN	AA
Apyron	Aluminium	Aqua-Bind	Mod AA
Engelhard	Aluminium	ARM 100	AA
Engelhard	Iron	ARM 200	Iron Oxide
ADI	Iron	G2	Iron based
SMI	Iron	SMI III	Iron/sulfur
US Filter	Iron	GFH	Iron Hydroxide
Bayer AG	Iron	E 33	Iron Oxide
WRT	Zeolite	Z – 33	Mod Zeolite
Magnesium Elektron	Zirconium	Isolux	Zirconium Hydroxide

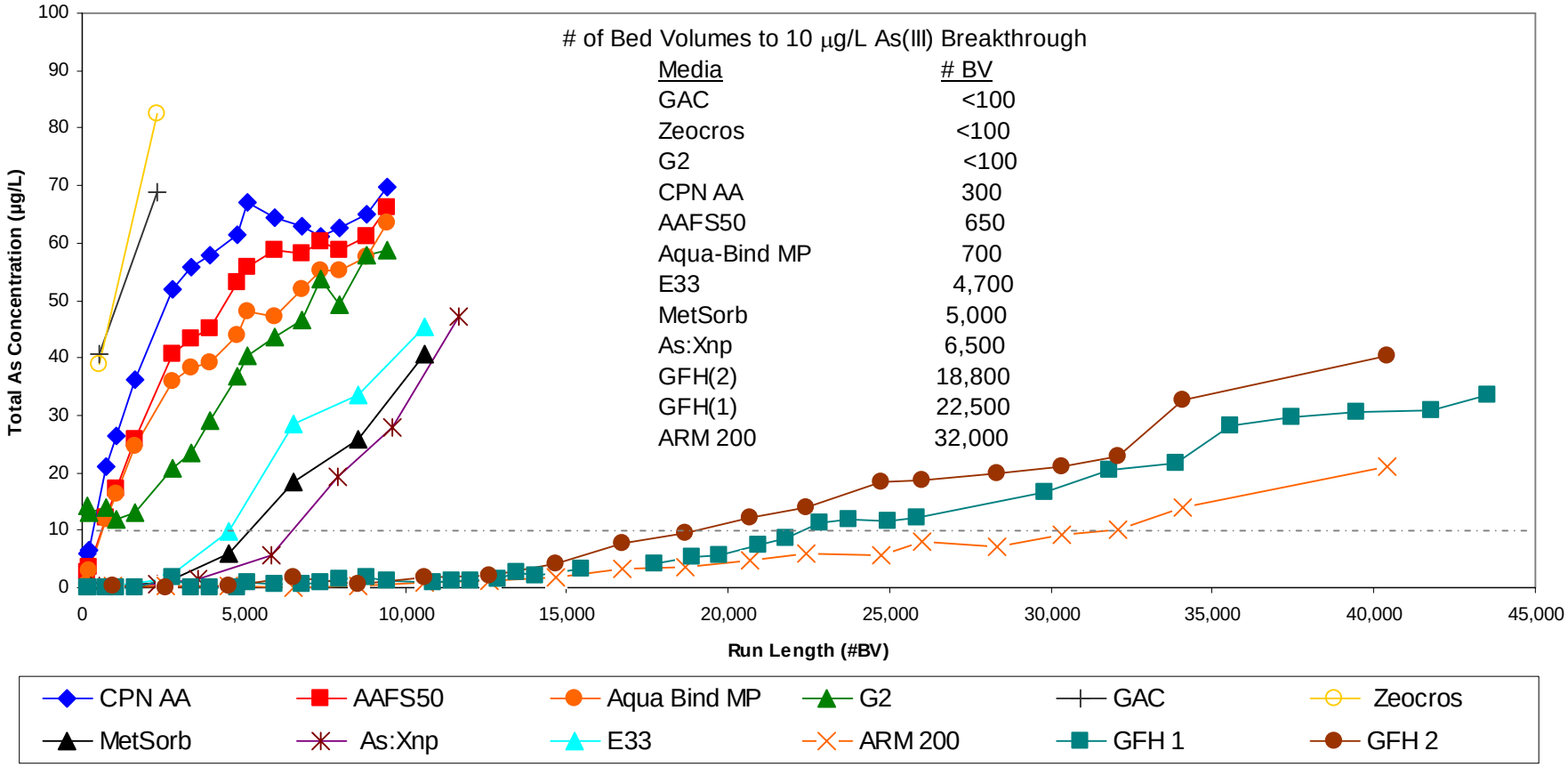
Adsorptive Media Listed in NSF/ANSI STD 61

Company	Base Material	Name	Material
ATS (MA)		A/I Complex 2000	
Hydroglobe, Inc	Titanium	MetSorb	Titanium Oxide
Dow Chemical	Titanium	ADSORBSIA	Titanium Oxide
Purolite	Resin	ArsenX	Mod w/Fe
ResinTech	Resin	ASM-10HP	Mod w/Fe

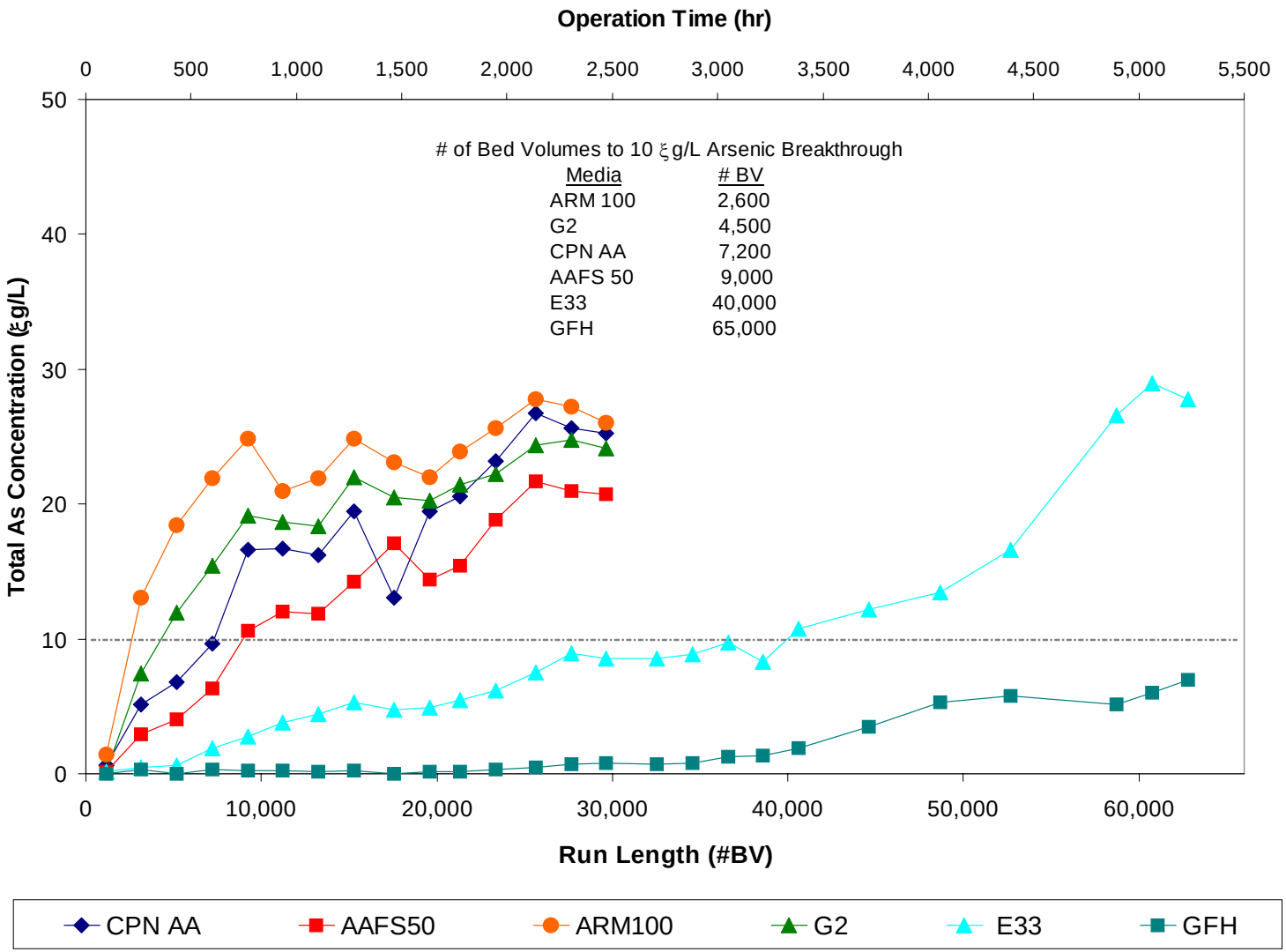
EPA Pilot Columns Studies

Licking Valley High School (LVHS)

LVHS Pilot Plant Tests - As III



LVHS Pilot Plant Tests - As V



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Pre-Treatment Needs

- Oxidation of As III to As V

- pH Adjustment – pre and post (pH > 8)

  Acid

  CO_2

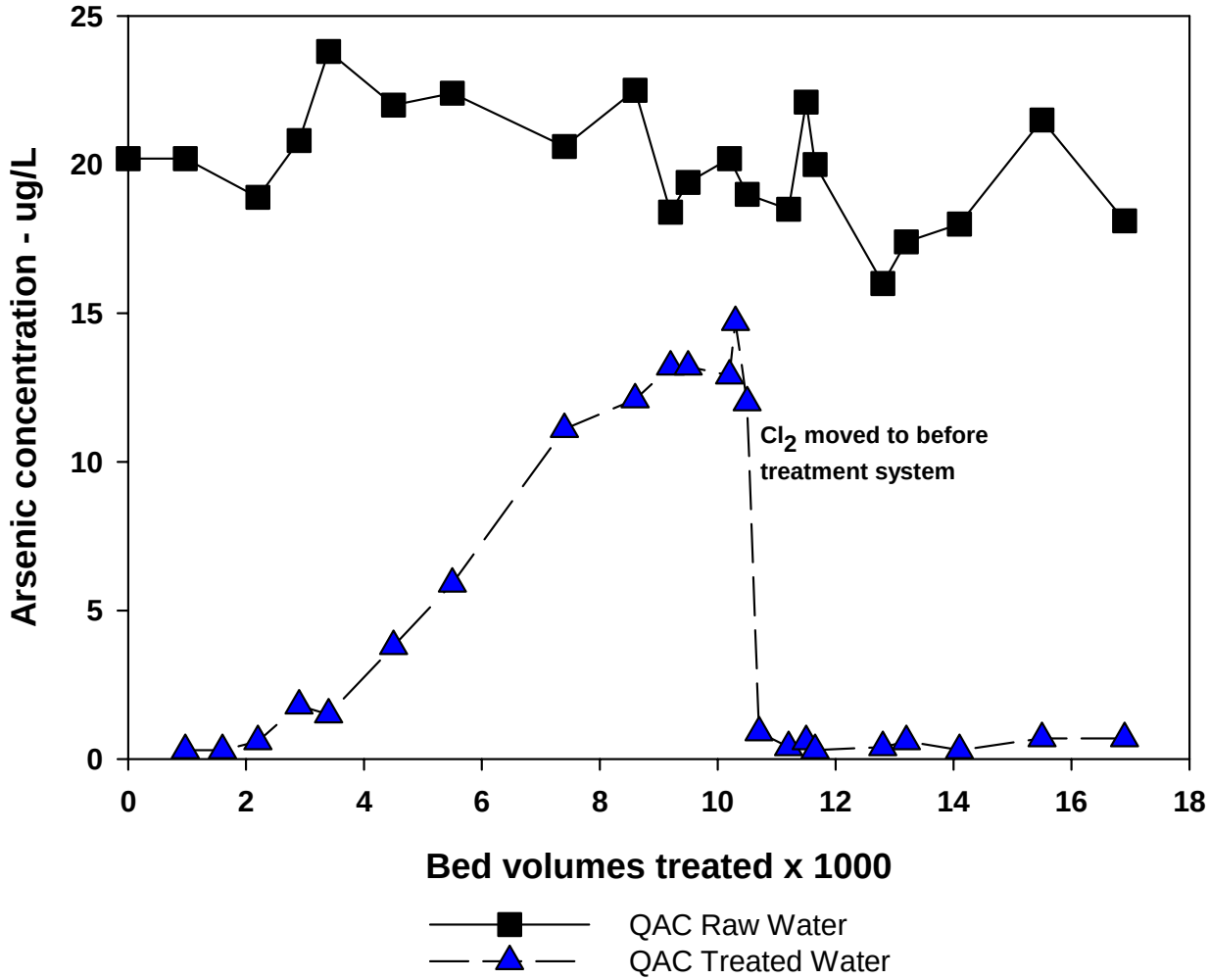
Pre-Treatment Needs

Oxidation of As III to As V

Most adsorptive media have greater removal capacity for As V than As III

Queen Anne's County

Adsorptive Media (E33) Treatment System



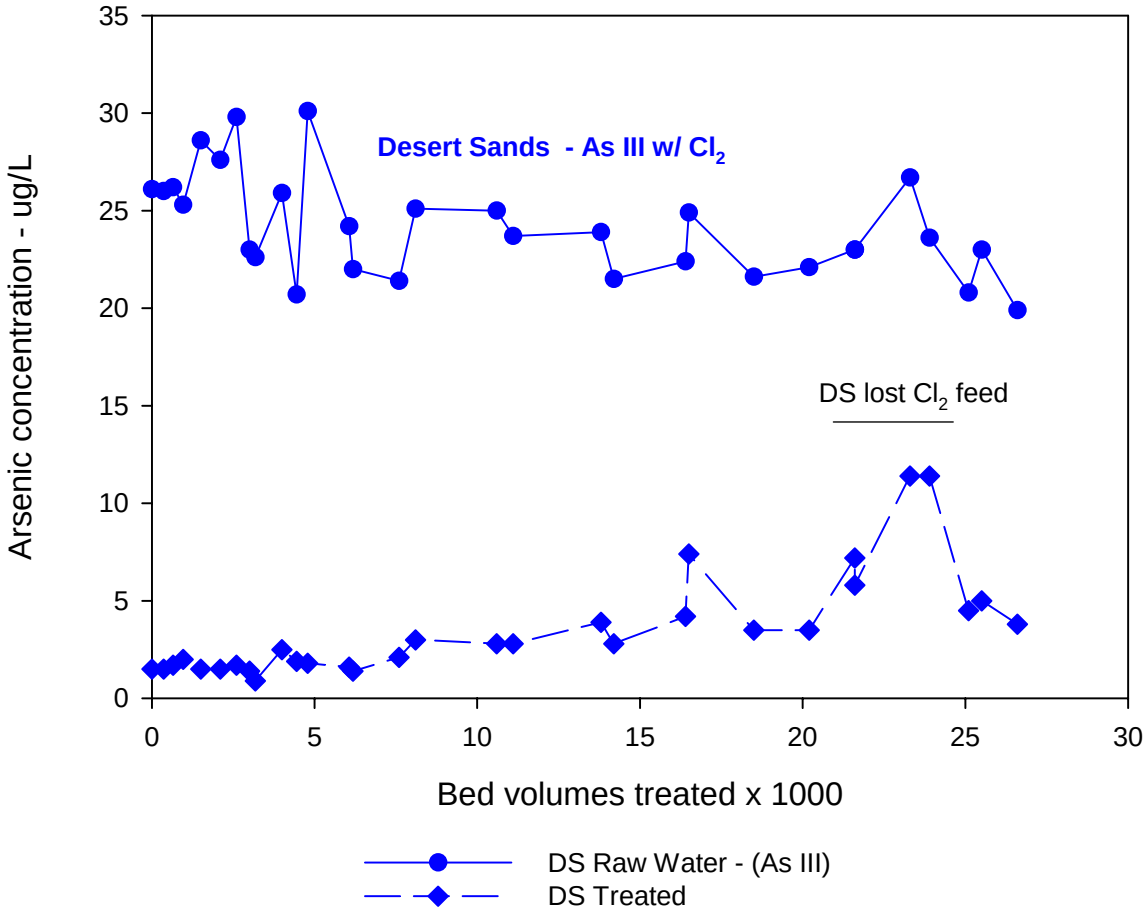
As III Oxidation

Caution!

Lose oxidation, arsenic in effluent will likely increase (spike)

Desert Sands

Adsorptive Media (E33) Treatment System



Pre-Treatment Needs

pH adjustment

Removal performance for many media products (AA & iron based media) is pH dependent.

The lower the pH, the greater the removal capacity.

pH Adjustment

Valley Vista, AZ (44-46 ug/L As)

(AAFS 50 media w/acid)

pH 7.8 BVs to 10 ug/L – 8,000

pH 6.8 BVs to 10 ug/L – 25,000

pH Adjustment

Arsenic Demonstration Program

Bow, NH – Acid/Cauatic	7.5 – 6.5 – 7.8
Rollinsford, NH – CO_2	8.2 to 7.2
Valley Vista, AZ – Acid	8.4 to 6.9
Nambe Pueblo, NM – CO_2	8.3 to 7.3
Taos, NM – CO_2	9.5 -
Bunni, TX – CO_2	8.0 -
Wellman, TX – CO_2	8.2 -
Tohono O'Odhan – CO_2	8.2 -

Valley Vista, AZ – AAFS 50 media pH Adjustment w/acid

pH Adjustment

Caution!

Lose pH adjustment, arsenic in effluent will likely increase (spike)

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System Controls

Backwashing of media

Manual vs automatic

Instrumention – gages, etc

(Cost issue!)

System Design

- System configuration - parallel vs series
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- System controls – manual vs automatic
- **Residual disposal – backwash water, media**
- Costs – capital and operational

Residual Disposal

Backwash water

Disposal – sewer, pond, ground

Recycle liquid

Spent media

Landfill - hazardous vs non-hazardous


Rimrock – E33 Media
BW Water Recycle Tank

System Design

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- Residual disposal – backwash water, media
- **Costs – capital and operational**

Costs

Total costs

Capital
Operational

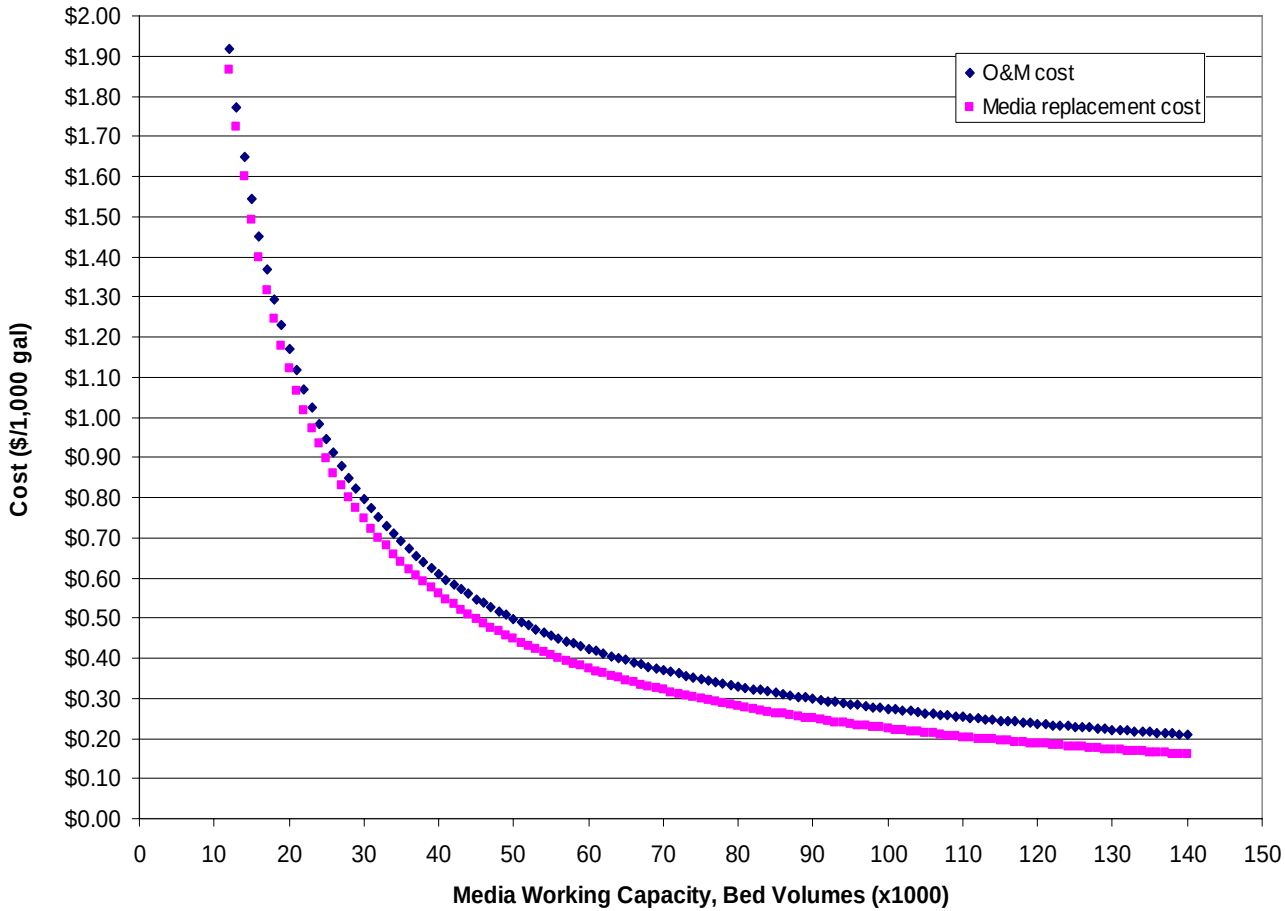
Costs

Operational costs

One time use adsorptive media system—Major cost item is media replacement (85-95 %)

Desert Sands MDWCA Arsenic Removal System

Media Replacement and O & M Costs



Media:
160 cu ft,
$150/cu ft,

Total Cost
$26, 800

Resource Material

- Design Manual: Removal of Arsenic from Drinking by Adsorptive Media EPA/600/R-03/019—March 2003

- Workshop on the Design and Operation of Adsorptive Media Process for Arsenic Removal from Drinking Water – August 2004 (CD of presentation slides available)

Thank you for your time. Are there any questions?

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Arsenic web site
http://www.epa.gov/ORD/NRMRL/arsenic/