



Rapid Small-Scale Column Tests in support of the Arsenic Water Technology Partnership's Pilot Demonstration Project

Alicia Aragon
araraq@sandia.gov
505-284-5066

Malynda Aragon, Malcolm Siegel, Randy Everett, Bill Holub, Brian Dwyer
Sandia National Laboratories



What is the Arsenic Water Technology Partnership?

DOE-funded, peer-reviewed, cost-shared research program to develop and demonstrate innovative technologies for removal and disposal of arsenic from drinking water

- **SNL**
 - Pilot Demonstrations
 - RSSCTs
- **AwwaRF**
 - Bench-scale studies
 - Material evaluation
 - Residual stability
- **WERC**
 - Economic analysis
 - Educational outreach





The Problem

- New MCL for Arsenic – **as of YESTERDAY!**
- Naturally occurring As > MCL
- Adsorption – common treatment technology
- Comparing adsorption technologies is time consuming and costly



Economy of Scale



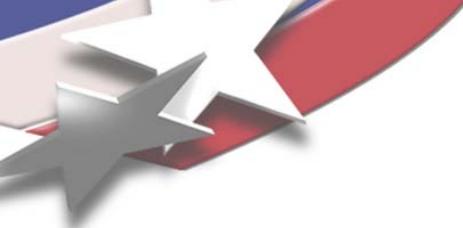
Full scale treatment



Pilot Demonstration



RSSCTs



Objective of RSSCTs

- **Significantly reduce time and costs associated with pilot studies**
- **Quickly and inexpensively determine the most effective treatment technology and design for small systems and/or for a variety of water qualities**
- **Apply RSSCTs to site specific waters to aid in the design of future pilot studies and full-scale treatment systems**



RSSCT Theory

- **DFPSDM - Dispersed flow pore and surface diffusion [mass transfer] model**
- **Incorporates:**
 - Advective flow
 - Liquid phase (film) mass transfer resistance
 - Local adsorption equilibrium at exterior surface
 - Surface and pore diffusion
 - Dispersive axial transport
 - Competitive adsorption of multiple solutes
 - Used in determining scaling relationships



RSSCT Design and Practice

- **Dimensional analysis and similitude**
 - Attention to dimensionless parameters
- **Crush media to much smaller sizes**
 - Smaller media, faster kinetics
- **Apply a higher hydraulic loading rate**
 - Faster HLR, smaller boundary layer, faster kinetics
 - Reduces external mass transfer resistance
- **Reduce column diameter**
 - Smaller column, higher HLR
- **Shorter EBCT**



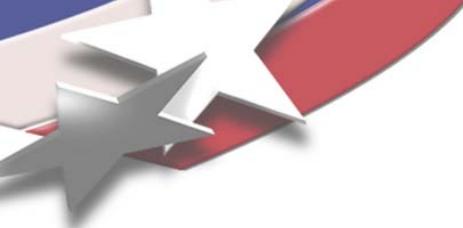
Theoretical Scaling Relationships

Diffusivity factor (x) Relationship between D_s and particle size	$\frac{D_{s,RSSCT}}{D_{s,pilot}} = \left[\frac{R_{RSSCT}}{R_{pilot}} \right]^x$
Non-constant D_s (x = ?)	$\frac{EBCT_{RSSCT}}{EBCT_{pilot}} = \left[\frac{R_{RSSCT}}{R_{pilot}} \right]^{2-x}$
Proportional D_s (x = 1)	$\frac{EBCT_{RSSCT}}{EBCT_{pilot}} = \left[\frac{R_{RSSCT}}{R_{pilot}} \right]$
Constant D_s (x = 0)	$\frac{EBCT_{RSSCT}}{EBCT_{pilot}} = \left[\frac{R_{RSSCT}}{R_{pilot}} \right]^2$



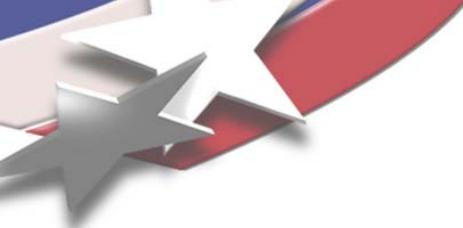
Scaling and Dimensionless Parameters

Hydraulic Loading Rate	$\frac{HLR_{RSSCT}}{HLR_{pilot}} = \frac{R_{pilot}}{R_{RSSCT}} * \frac{(Re Sc)_{min}}{Re Sc_{pilot}}$
Reynolds Number	$Re = \frac{\rho(HLR) * 2R_{particle}}{\mu \varepsilon}$
Schmidt Number	$Sc = \frac{\mu}{\rho D_l}$
Peclet Number	$Pe = \frac{2R_{particle}}{h}$



RSSCT Design Example

Parameter	Pilot	PD RSSCT	CD RSSCT
Mesh	10x35	100x200	200x325
Particle Diameter (mm)	1.00	0.106	0.058
Column Diameter (cm)	7.62	0.70	0.46
EBCT (min)	3.00	0.32	0.01
Bed Height (cm)	74	7.8	4.3
Q (mL/min)	1136	9.4	70
HLR (cm/min)	25	25	421
Duration	7 mos	22 days	17 hrs

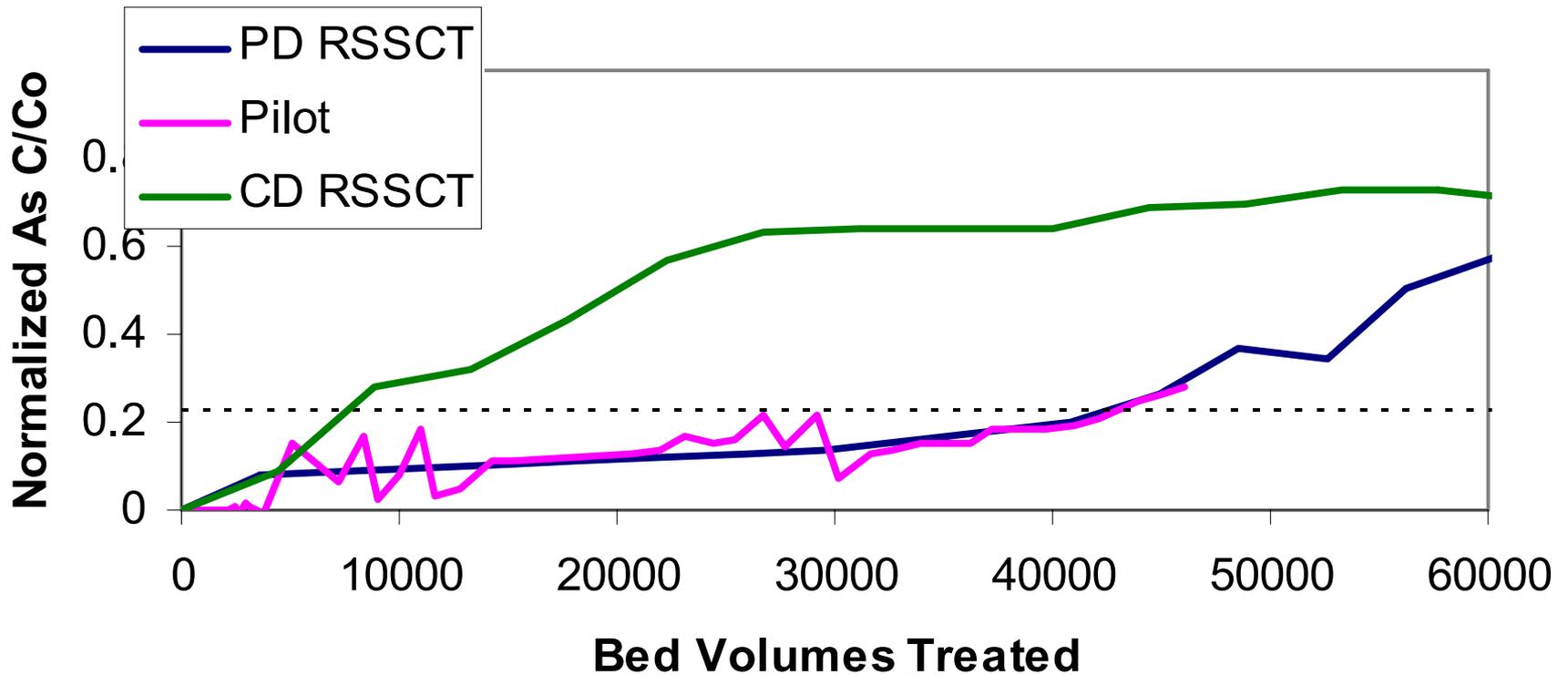


What are we looking for?

- Which is the better predictor of media performance, CD or PD?
- RSSCT breakthrough curve should be identical to breakthrough curve of pilot.
- Arsenic breakthrough curves from PD and CD RSSCTs tend to bracket the breakthrough curves of pilot columns

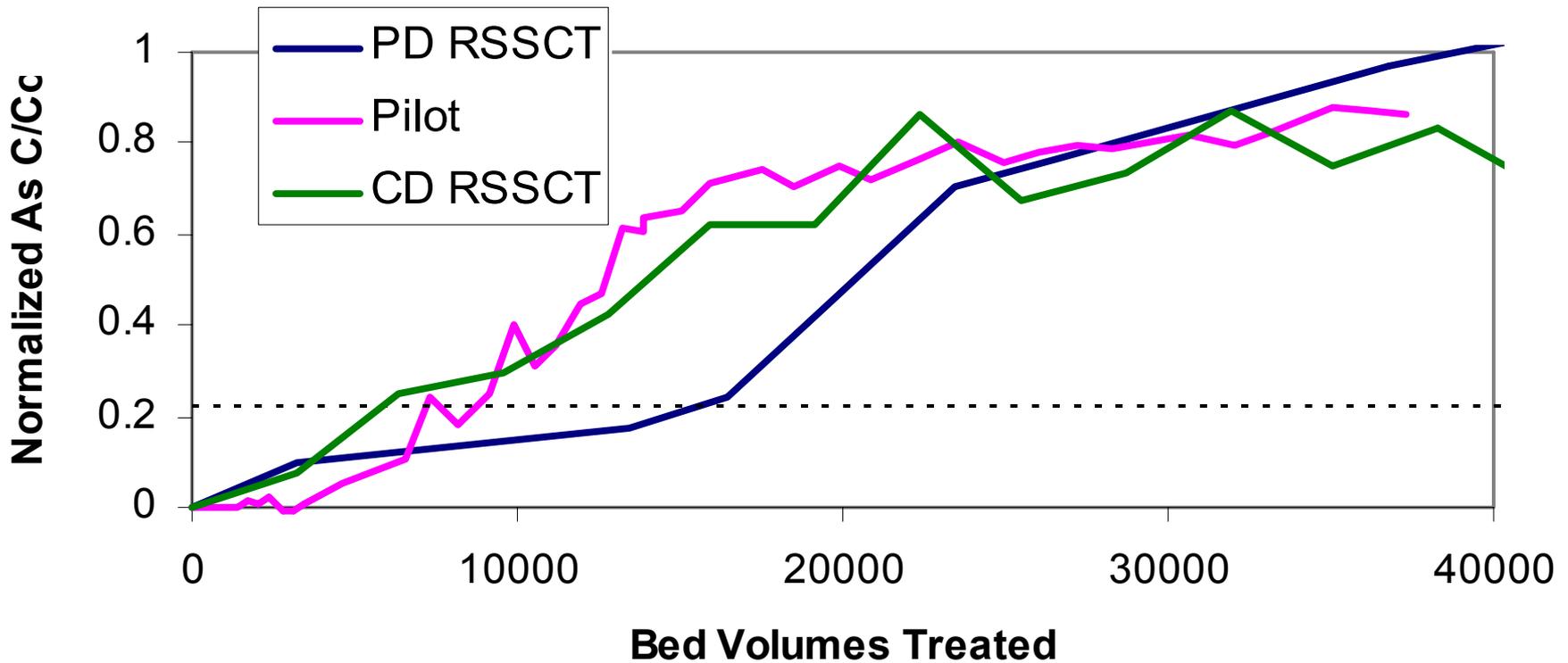
Socorro RSSCTs vs. Pilot

Iron Based Media I



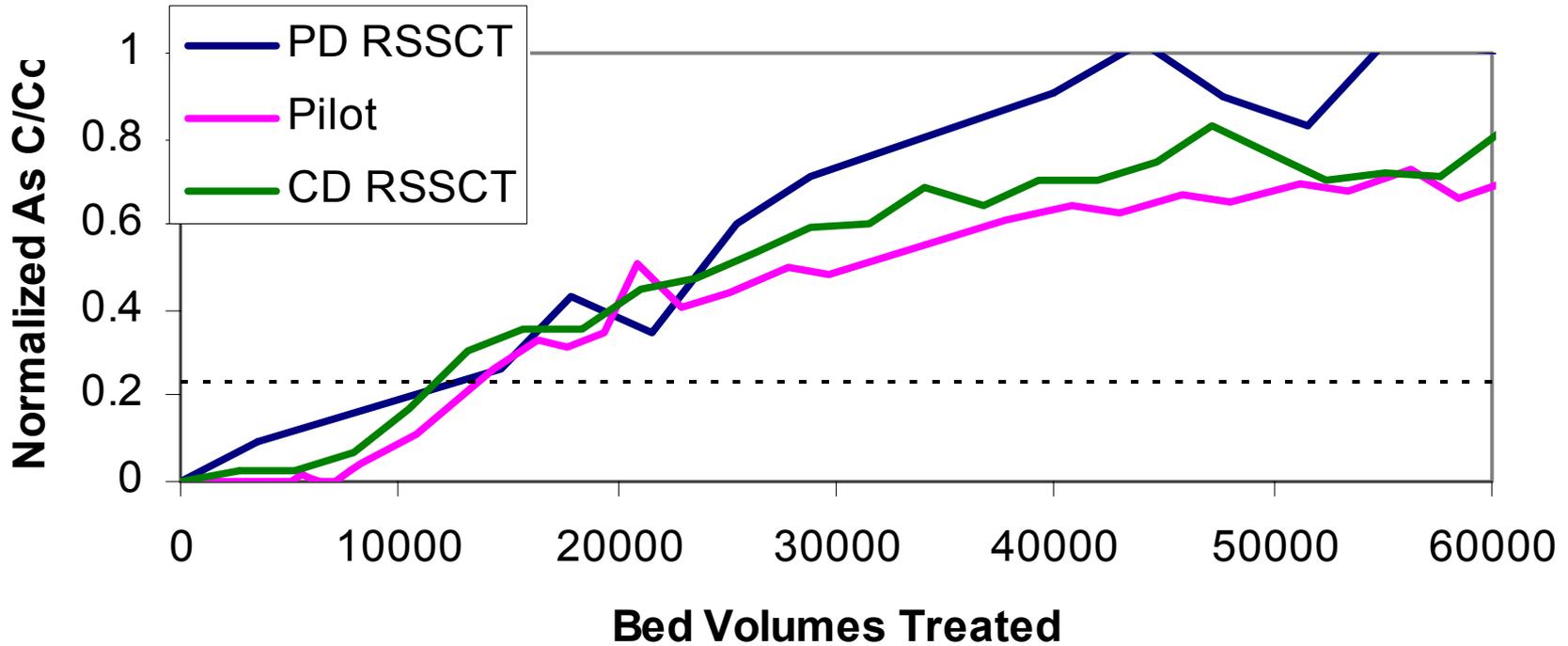
Socorro RSSCTs vs. Pilot

Iron Based Media II



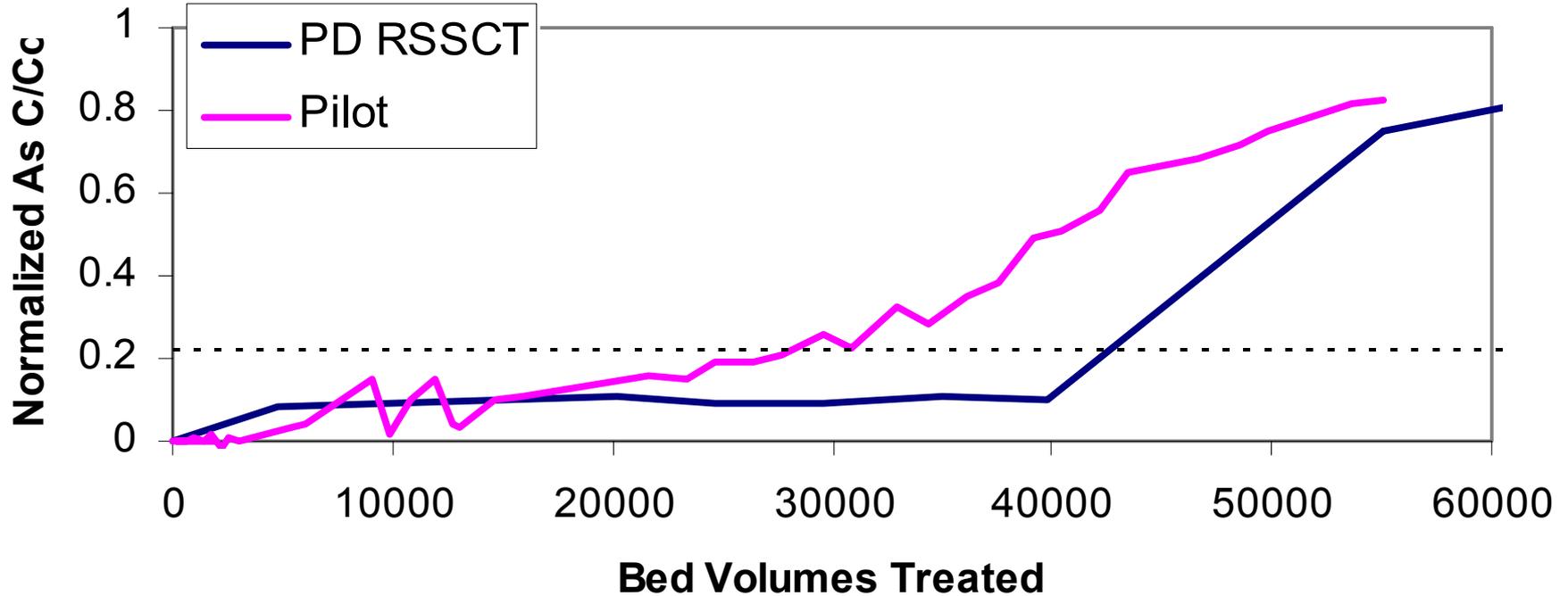
Socorro RSSCTs vs. Pilot

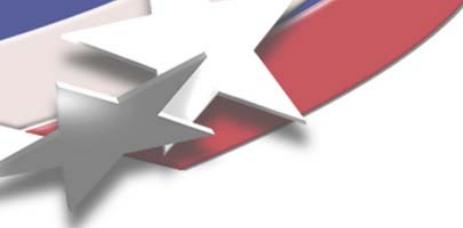
Titanium Based Media



Socorro RSSCTs vs. Pilot

Resin Based Media





To Do List

- **Determine correlation between RSSCTs and pilots under differing water chemistries**
- **Determine surface diffusion coefficients for each media in different water qualities to provide better scaling relationships**
- **Statistical analysis and design of experiments**
- **Potentially eliminate the need for time-consuming pilot studies - **RSSCTs ROAD SHOW??****