Application of Immersed Ultrafiltration Membranes for Arsenic Reduction

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Presentation Outline

1- Zenon: Our Company
2- ZeeWeed™-1000
3- Arsenic Removal with UF Membranes
4- Pilot Results

1- Zenon: Our Company

ZENON – Our Company

- Founded: 1980
- Financially sound (no debt)
- TSX Listed: ZEN
- Customer-focused
- International presence
- Production: Canada, Hungary
- Focus: Membrane filtration of water, wastewater

Global Market Leader in Membrane Filtration

For Water, Wastewater Treatment

Water for the World

ZENON Headquarters - Oakville

- Situated on 150 acres of unserviced land
- Over 500 technicians, engineers & scientists
- Self contained drinking water and wastewater
- State of the art offices, testing and assembly

ZMP – ZENON Membrane Products

ZME – ZENON Membrane Products

- 52,500 m^2 land, only half is used initially.
- First plant covers over 105,000 ft^2.
- First plant has a membrane mfg area equivalent to ZMP.

2- ZeeWeed™-1000

ZeeWeed 1000

ZeeWeed® 1000 – Our Membrane

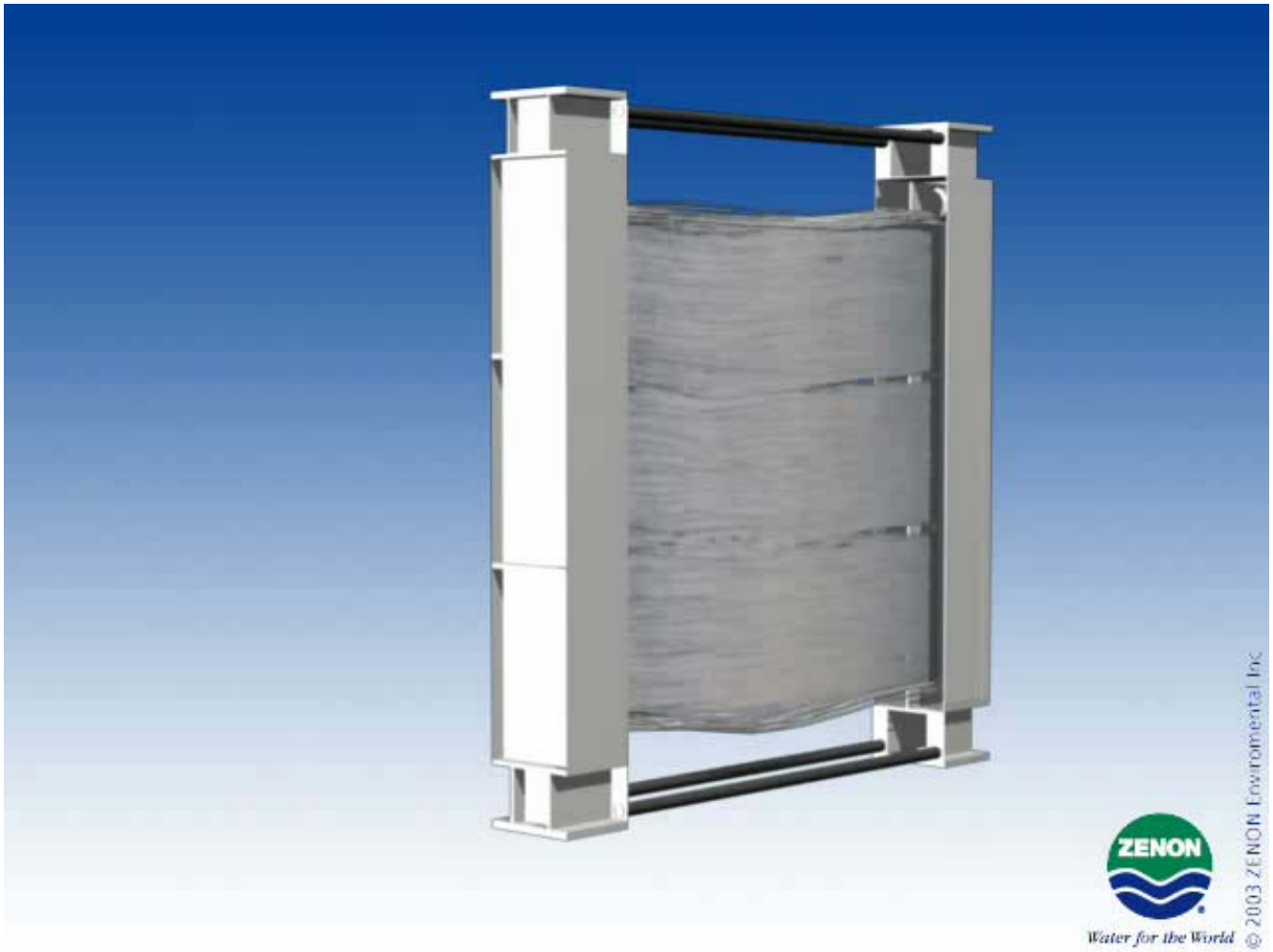
- Ultrafiltration (UF)
- Outside-in Flow
- Non-Reinforced Hollow Fiber
- Immersed, shell-less module

ZeeWeed® 1000 – Backpulse Cycle

- Removes Solids From Membrane Surface
- Typical Cycle – 15 to 60 minutes
- Air Scour Accompanies Backpulse

ZeeWeed® 1000

- Fiber
- Module
- Cassette
- Train



ZeeWeed! Everywhere!

ZENON
Water for the World

www.zenon.com

3- Arsenic removal with UF Membranes

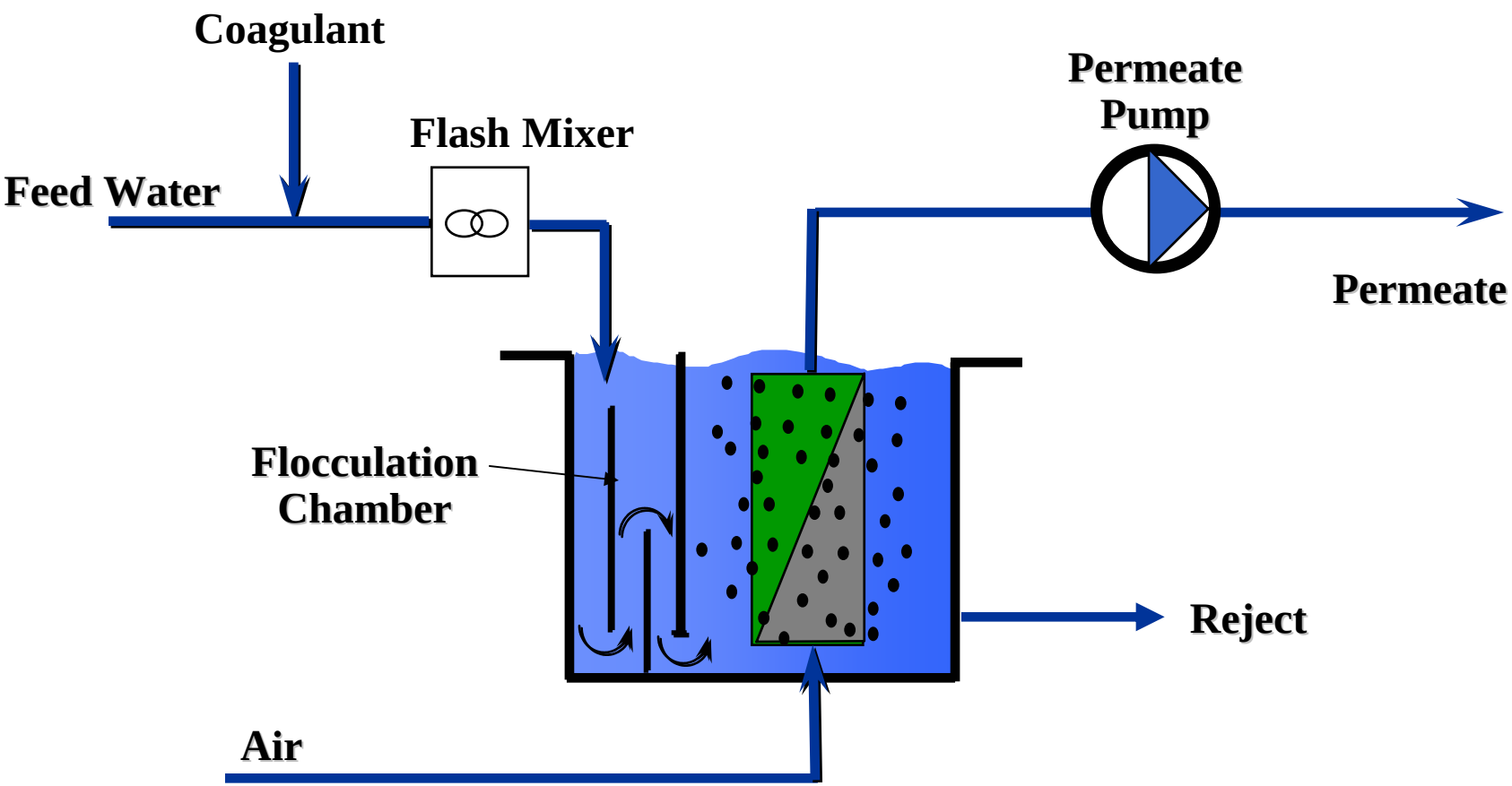
Arsenic Regulations

- Long-term exposure effects:
  - cancer, cardiovascular disease, diabetes, neurological effects
- Short-term acute effects
  - unlikely at concentrations found in drinking water
- MCL reduced from 50 to 10 μg/L

Arsenic removal with UF Membranes

- Particulate As will be removed by UF membranes without any pretreatment
- Dissolved As is smaller than the pore size of a UF membrane and will pass through
- To remove dissolved As, coagulants need to be added prior to membrane filtration

Immersed Ultrafiltration Enhanced Coagulation for Arsenic Removal



Arsenic Chemistry

- As (V), arsenate, or As (III), arsenite
- Removal by coagulation depends on the ratio of As (V) to As (III) because As (V) is easier to remove by coagulation
- As (V) predominant in surface waters, As (III) predominant in groundwaters

Arsenic Removal with UF Membranes

- As (III) more difficult to coagulate than As (V)
- As (III) easily be oxidized to As(V) by pre-oxidation using chlorine or potassium permanganate

Membranes should be compatible with pre-oxidation chemicals

Arsenic Removal with UF Membranes

- As (V) can easily be removed using commonly available coagulants such as ferric chloride

Membranes should be compatible with coagulants

Arsenic Removal with Membranes

For high DOC waters, As and DOC can compete for adsorption onto floc → higher coagulant doses required to achieve same removal

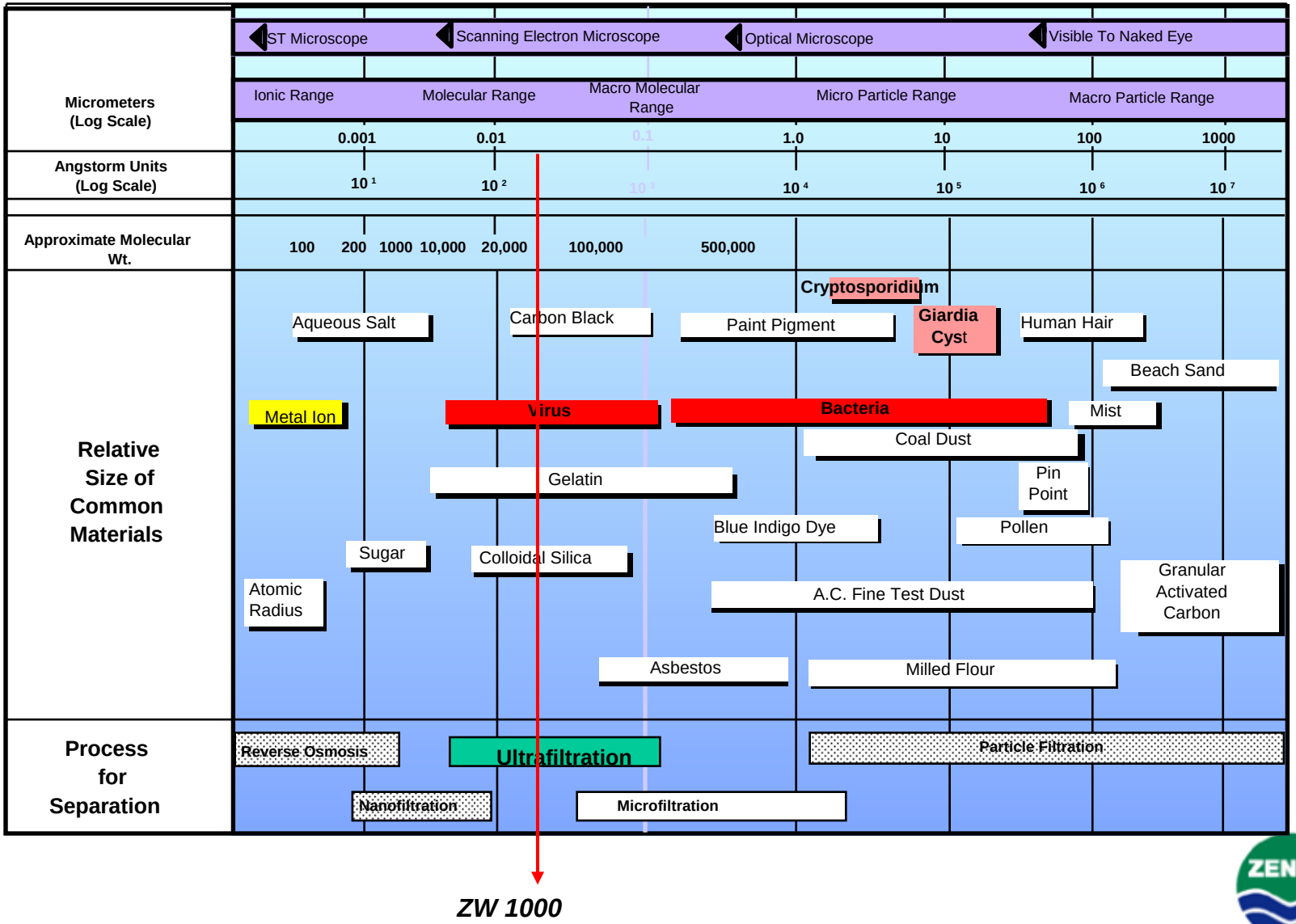
Membranes should be able to handle high coagulant dosages

Arsenic Removal with Membranes

Presence of fine colloidal arsenic

Tighter membrane pore size may achieve better removals

How small is 0.02 microns?



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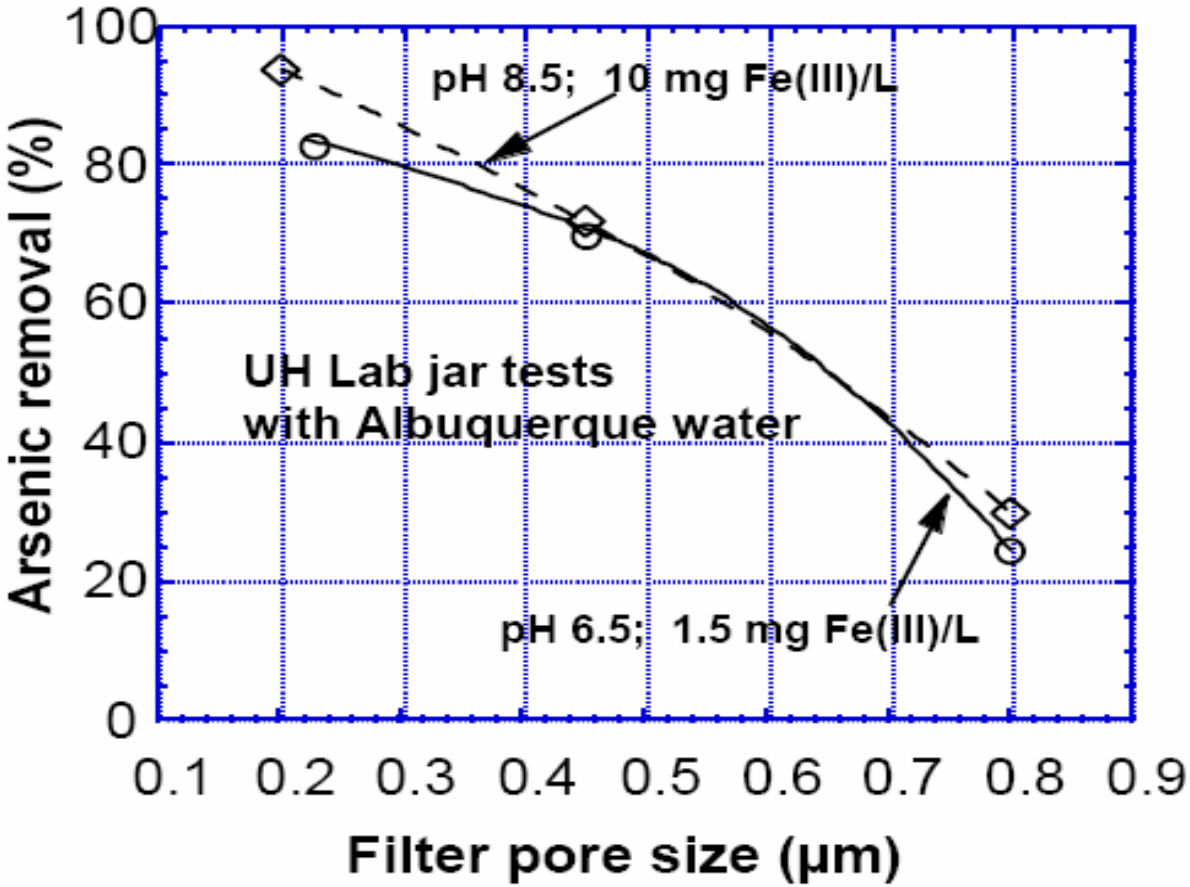
NMEHC 2003

Dennis Clifford, University of Houston



4- PILOT RESULTS

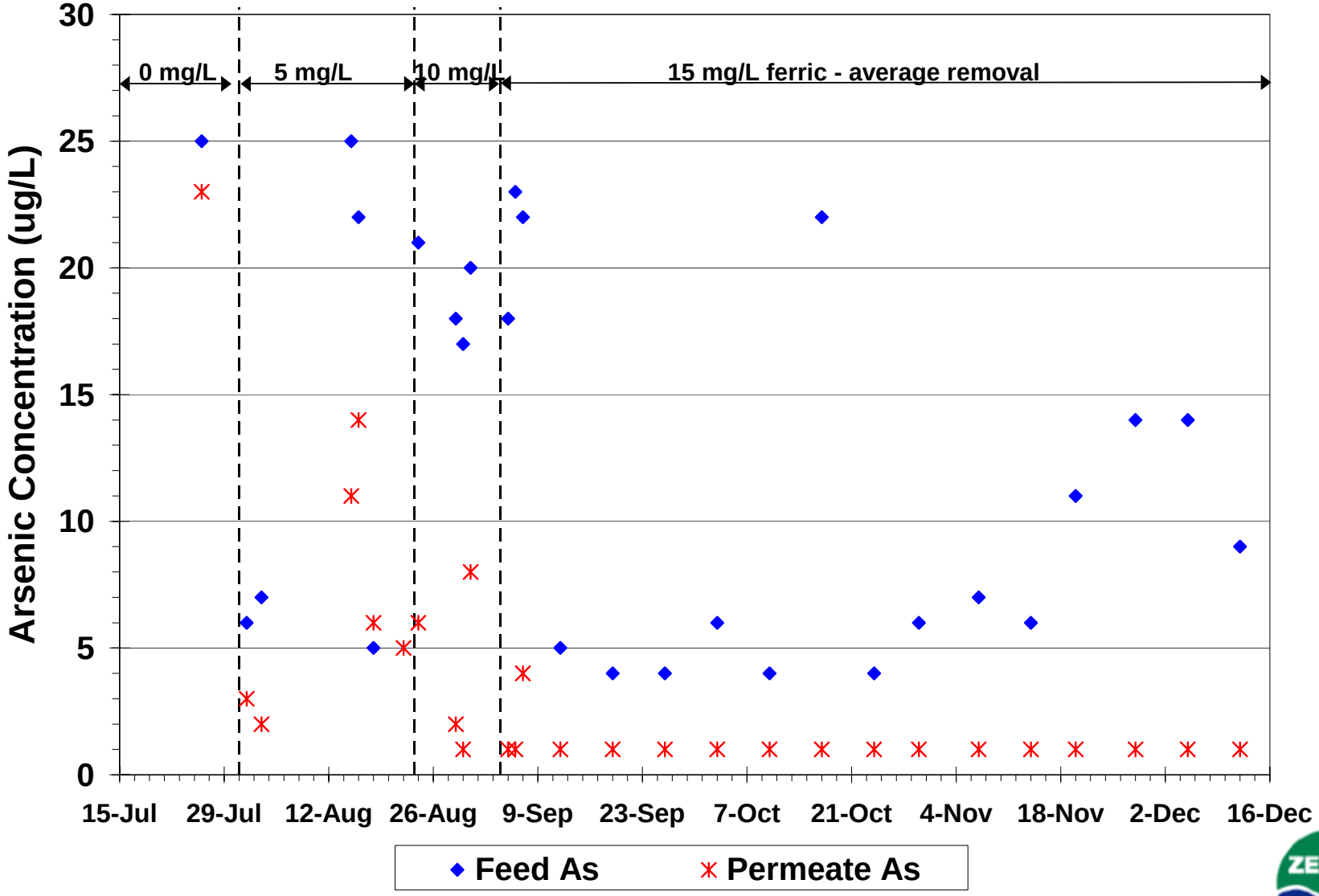
Arizona Pilot

- Six month study
- Primary Objective: < 3 ug/L arsenic
- Coagulant used: ferric sulfate
- Study divided into two phases:
  - Coagulant Optimization Phase
  - Demonstration Phase
- Arsenic spiked in the feed

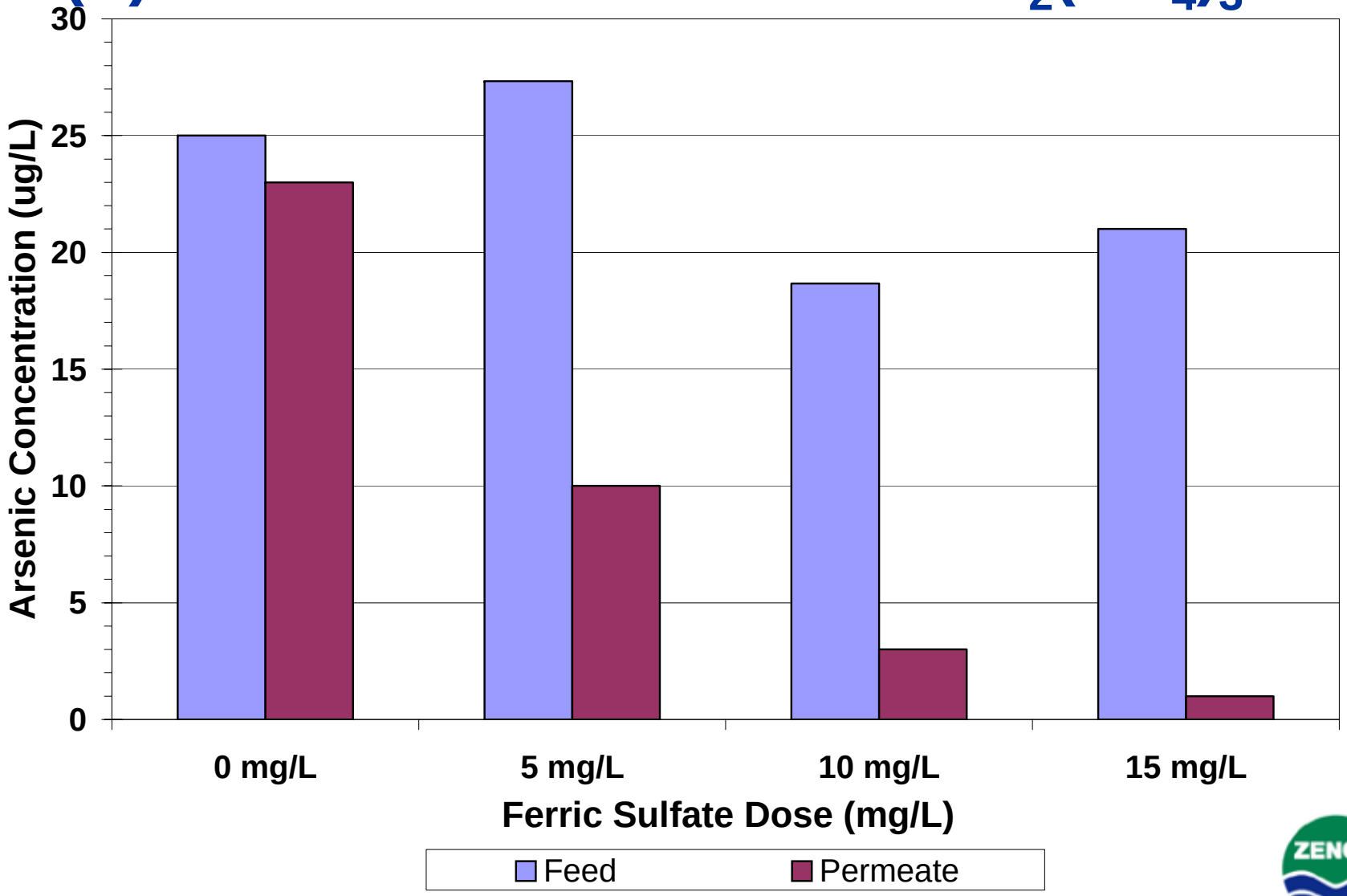
Arizona Pilot: Water Quality

- Temperature: 12 – 30°C
- Arsenic: 3 - 35 μg/L (after spiking)
- Turbidity: 2 - 20 NTU with spikes up to 65 NTU
- TOC: 2 - 3 mg/L
- pH: 6 - 8.1
- Hardness: 180 - 280 mg/L as $CaCO_3$
- Alkalinity: 120 - 200 mg/L as $CaCO_3$

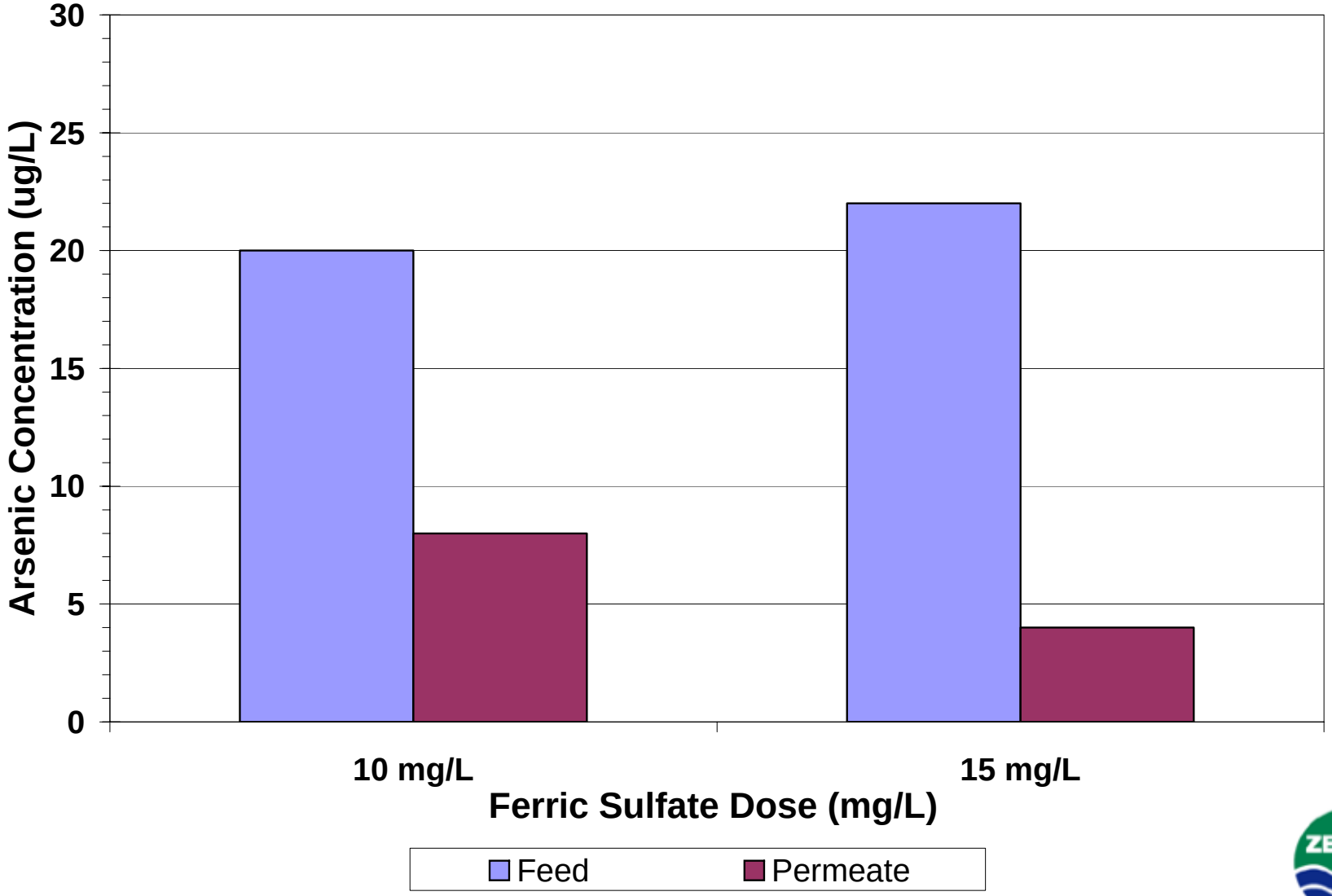
Arizona Pilot:
Arsenic Concentration in Feed and Permeate



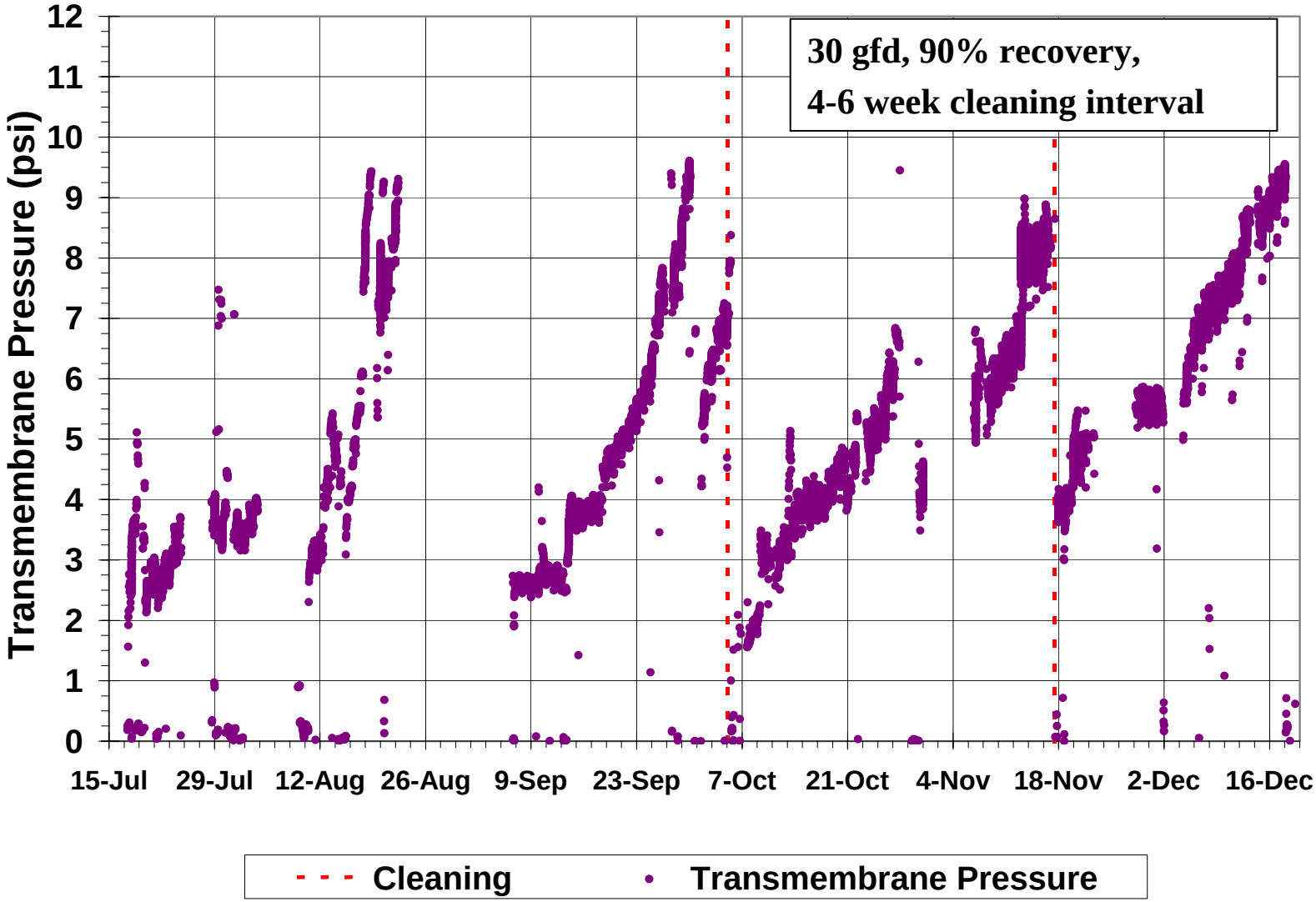
Arizona Pilot:
As (V) removal as a function of $Fe_2(SO_4)_3$ Dose



Arizona Pilot:
As(III) Removal as a Function of $Fe_2(SO_4)_3$ Dose



Arizona Pilot: Membrane Performance



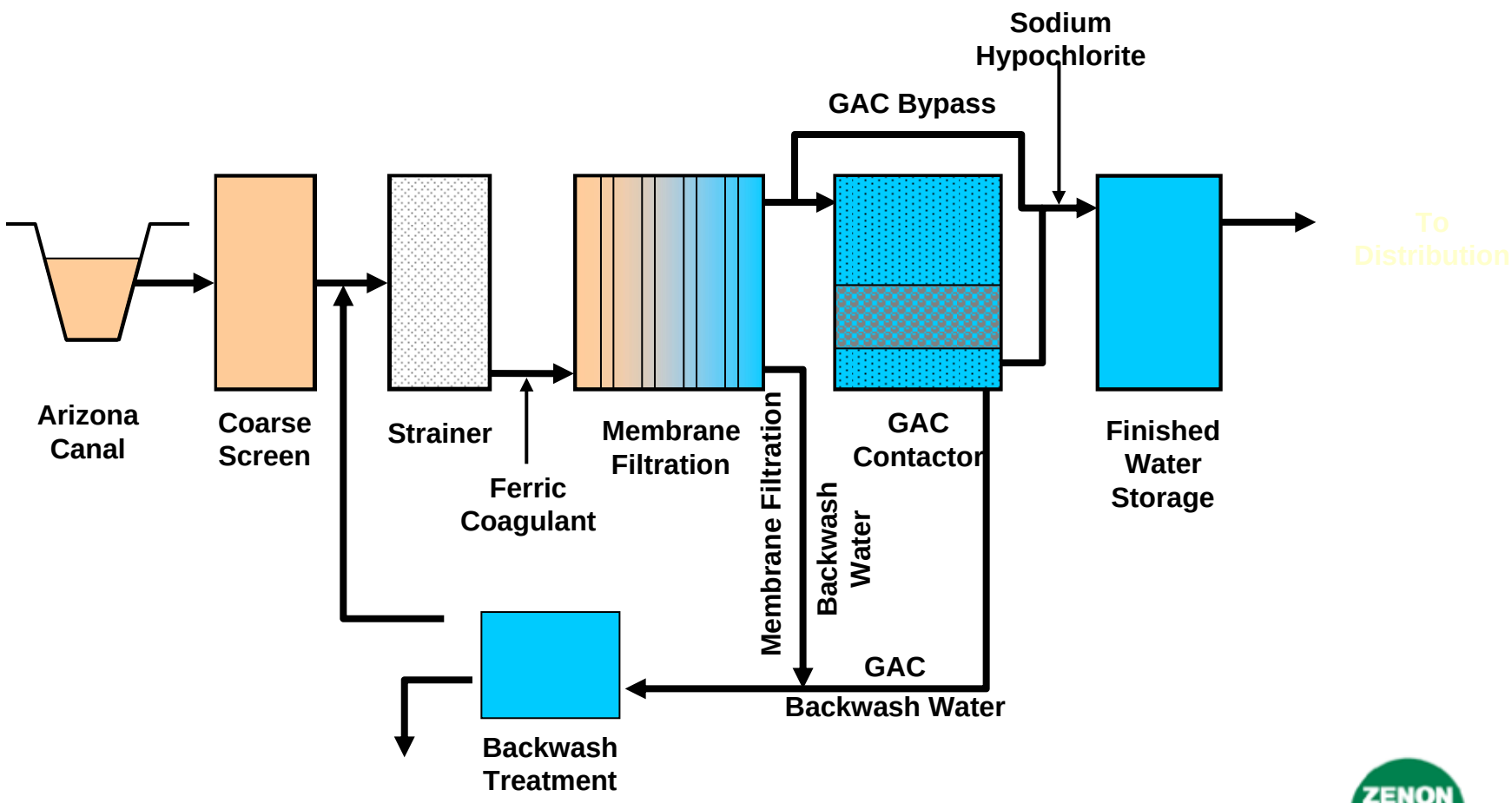
Chaparral WTP

Scottsdale, AZ

Viewed from the northwest

Viewed from the southwest (park)

Chaparral WTP Process Flow



Chaparral WTP Process Highlights

- 30 MGD WTP treating a challenging surface water
- 500 micron pre-screen (H.P. Kinney)
- Ferric salt for arsenic removal
- UF for microbials and particulates
- GAC for geosmin,MIB, and THM precursors
- On-site chlorine generation using salt

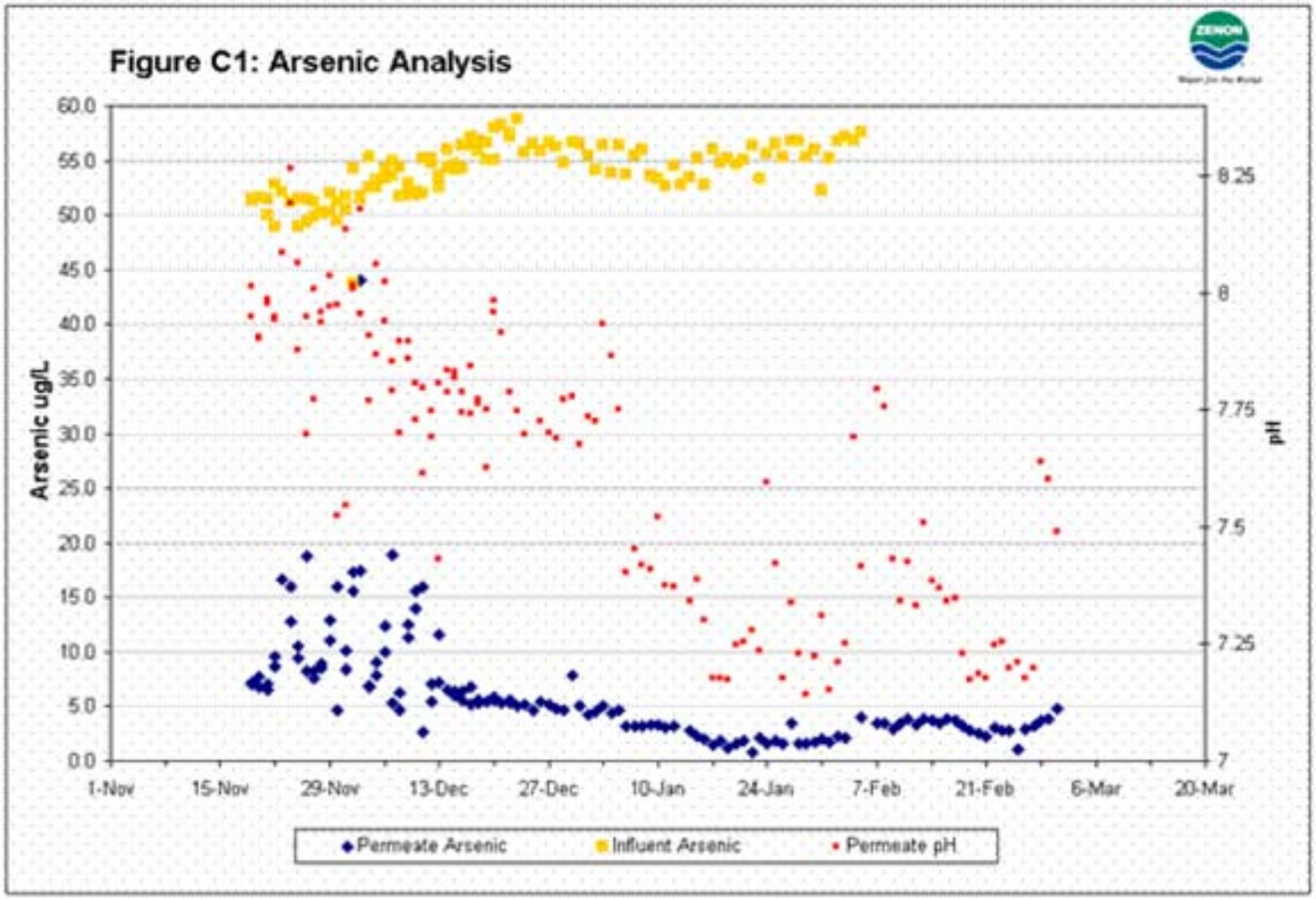
Colorado Pilot

- Ground water
- 30 mg/L of Ferric Chloride
- 3 minutes of HRT
- As (V): 45 to 90 µg/L
- Temperature: 15ºC to 27 ºC
- pH: 8.0 to 9.0
- SiO_2: 120 to 150 mg/L
- Alkalinity: 80 to 100 mg/L

Pilot performed with UF / Coagulation because:

- High silica interfered with As reduction in Granular Ferric Oxide
- Anion exchange worked well at bench test level, but larger pilot testing showed irreversible silica interference that inhibited As removal and increased headloss
- Bench testing showed poor flocc formation and settleability

Arsenic Results - As (V)



Thank You!

Questions?