BIOLOGICAL TREATMENT OF METALS AND INORGANICS IN MINING WATERS

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METAL AND INORGANIC BIOTREATMENT

- Cost effective technology to transform and remove metals and inorganics from large water volumes

- Biological metal and inorganic transformation/removal methods, in general, produce 1,000's to 10,000 times less sludge than conventional chemical precipitation technologies

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BIOTREATMENT APPROACH

- Site evaluation - understand site chemistry and environmental parameter interactions
- Select appropriate microorganisms for optimal performance in site waters and site conditions and conduct biotreatability testing in site waters
- Design / Engineer a bioreactor system to provide desired contaminant removals and conduct on-site pilot-scale testing

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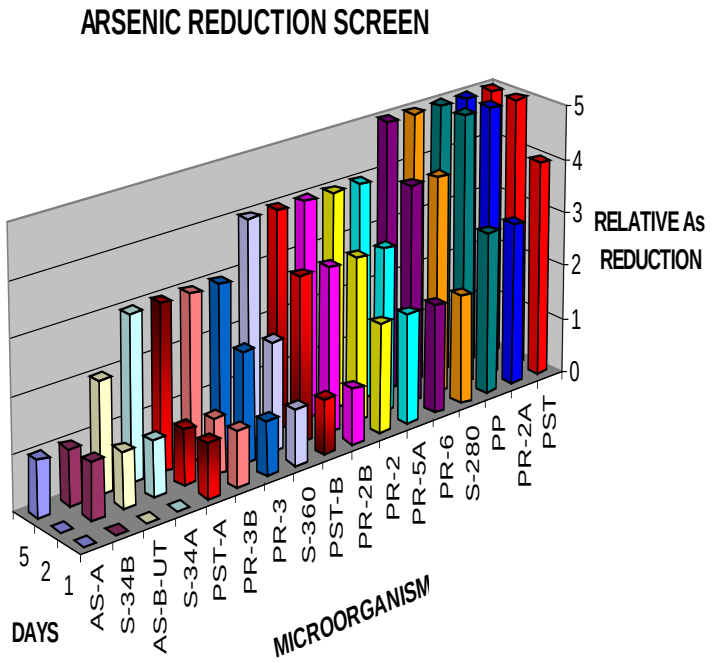
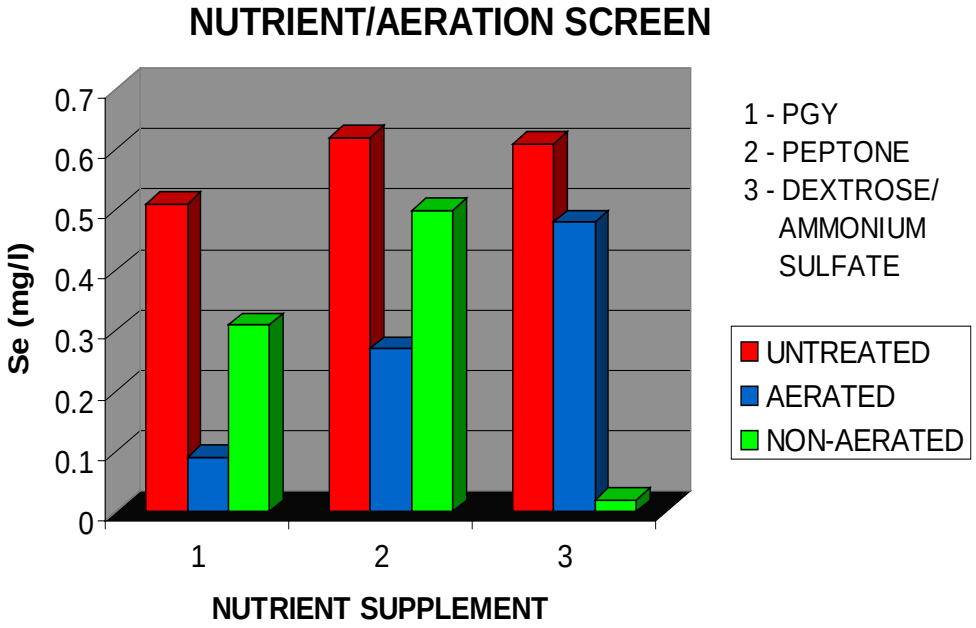
SITE EVALUATION

- Seasonal or year round treatment
  - Volume to be treated & treatment system size
- Current and seasonal water chemistry
  - pH, temperature, suspended solids, etc.
  - Contaminants
  - Co-contaminants
- Expected changes in water chemistry

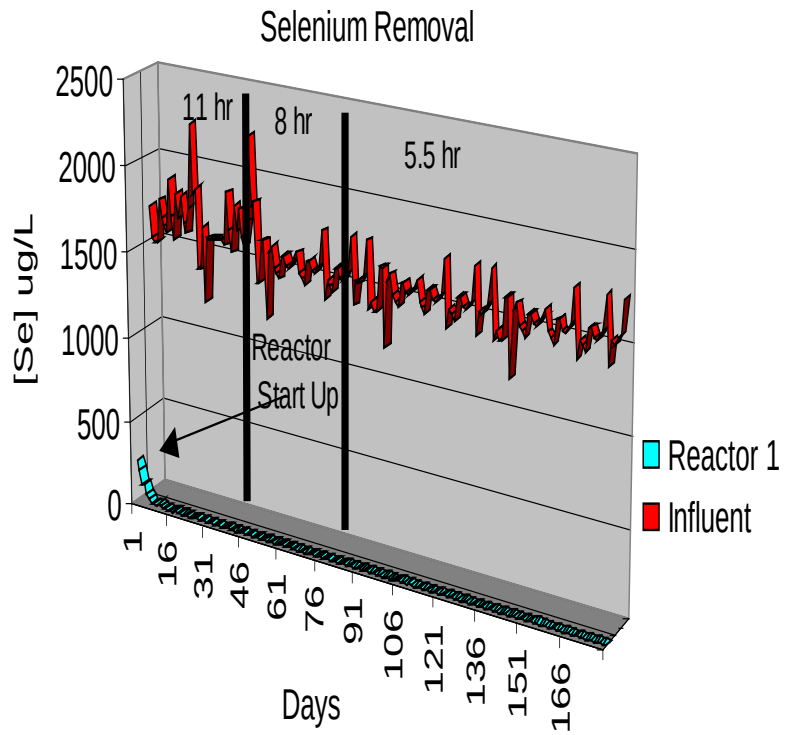
BIOTREATABILITY TESTING

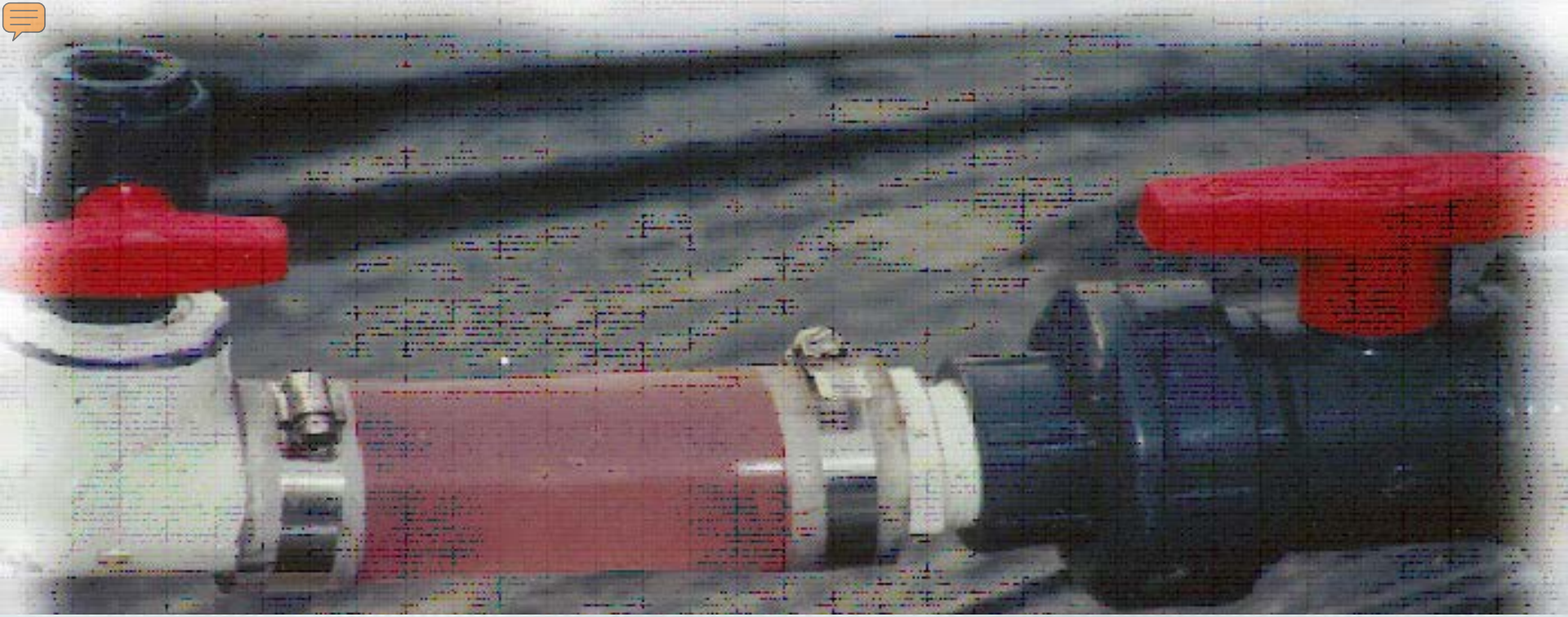


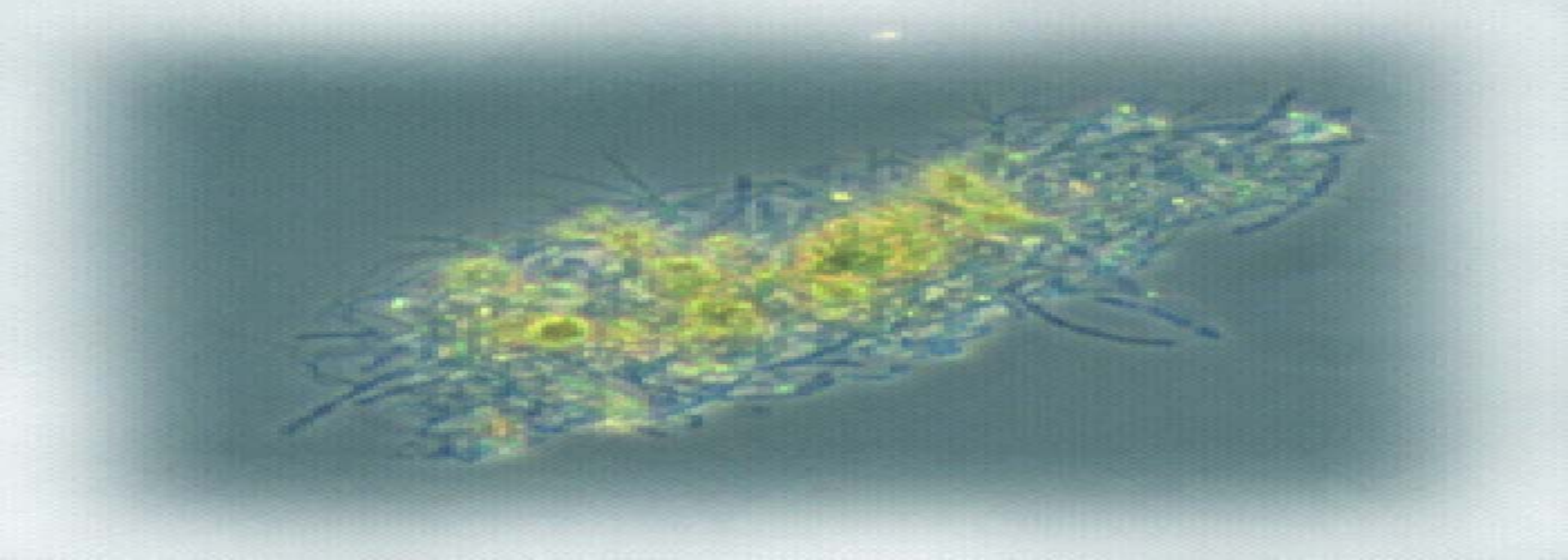


EPA MINE WASTE TECHNOLOGY PROGRAM VALIDATION

- Se ~2.0 mg/L with low levels of Cu and As
- pH ~7.0
- Flow Rate - 2 gpm
- Retention Time 5.5 hr to 11 hr
- Over 9 months testing







TEST SUMMARY*

- Applied Biosciences' Biological Selenium Removal process was the only technology, including ferrihydrite adsorption, to remove selenium to below discharge criteria (50 ppb) under site testing
  - The Applied Biosciences' metal removal bioprocess removed selenate and selenite to below detection
  - During the nine months of testing, the bioprocess also consistently removed low levels of copper and arsenic to below detection

*EPA Mine Waste Technology Program
Final Report - Selenium

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EPA ECONOMIC ANALYSIS*

(Metal Removal)

Cost	Ferrihydrite Adsorption	Catalyzed Cementation	Bioprocess
Capital	$1,026,835	$1,083,285	$603,999
Annual O&M	$2,084,559	$1,165,358	$135,029
Capital and Operational Costs over 10 years	$18,017,962	$10,582,608	$1,704,681
Total treatment costs per (1,000 gal)	$13.90	$8.17	**$1.32**

***EPA Mine Waste Technology Program**
Final Report - Selenium
(Based on 2mg/L selenium @ 300 gpm – over 10 yrs)

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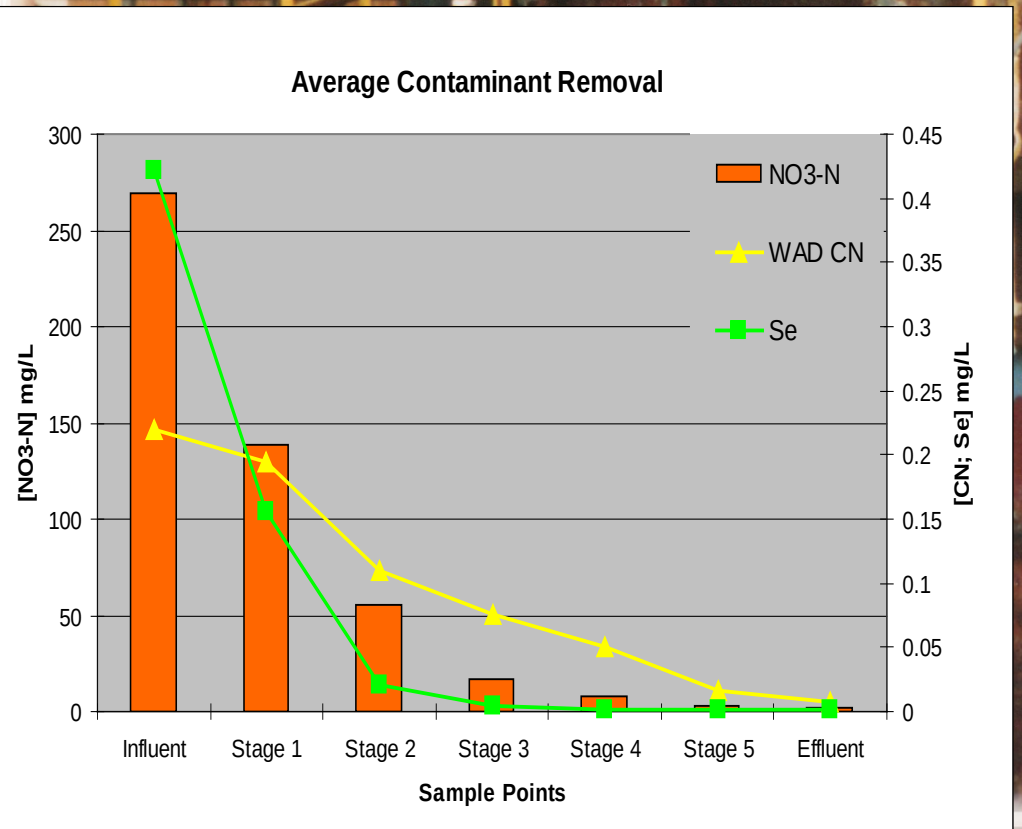
LANDUSKY SITE

- Nitrate ~240 mg/L
- Selenium ~0.8 mg/L
- Cyanide ~0.7 mg/L
- 108 Millions tons spent ore
- 150 Million gallons require treatment annually
- Geochemistry – changing
- pH ~5.0 => ~7.0
- Other contaminants
  Al, Mg, Mn, Zn, SO4-2, Na, Ni, Cu, As

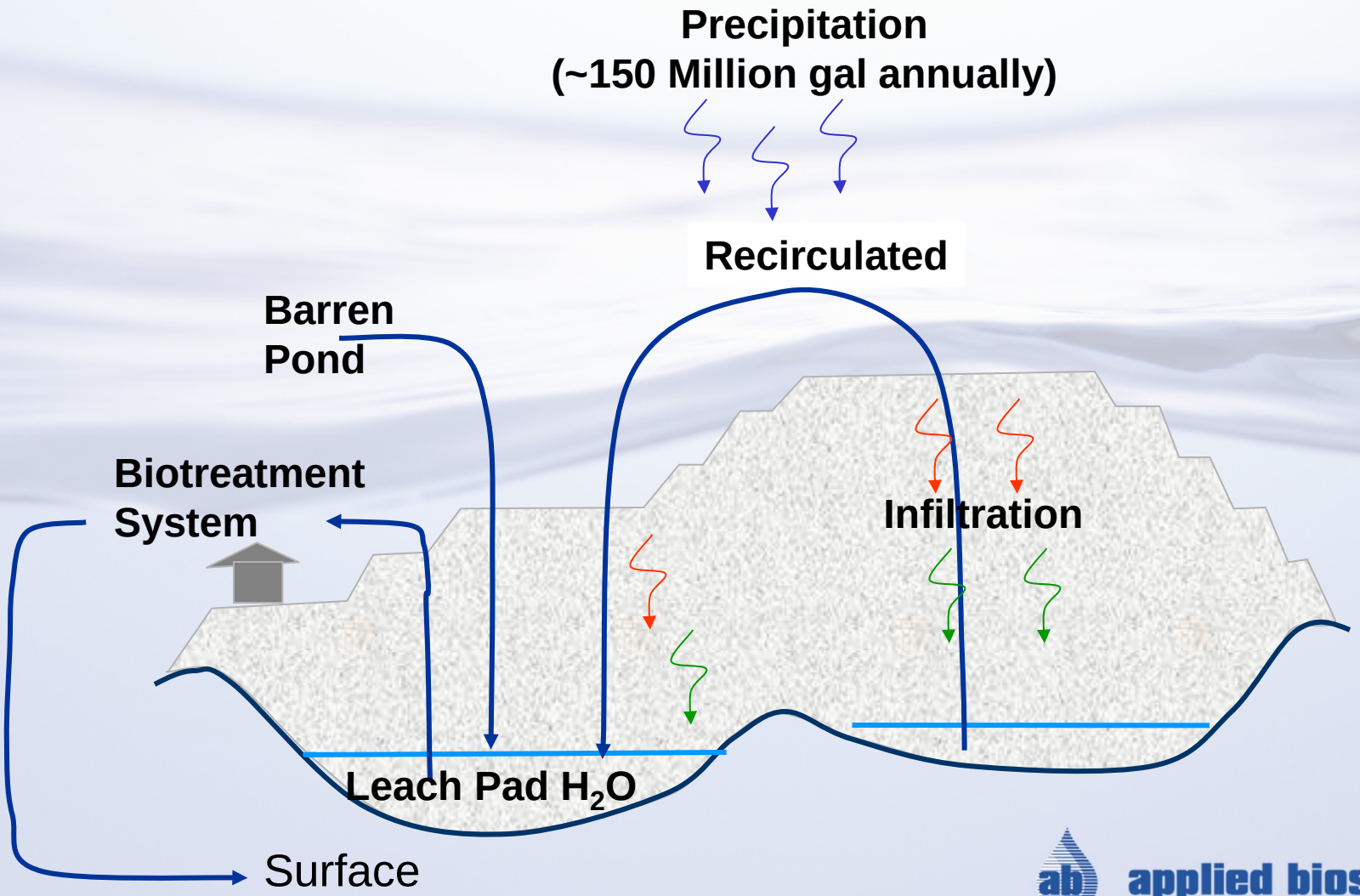
PILOT-SCALE BIOTREATMENT SYSTEM

Treatment Criteria

- Ambient water temp. ~8° C
- NO_3-N ~240mg/L to <10 mg/L
- Se ~ 0.8 mg/L to <50 ppb
- WAD CN ~0.7 mg/L to<20 ppb
- Treatment costs under $1.00/1,000 gal treated



CURRENT PAD WATER MANAGEMENT



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LANDUSKY SITE
(FULL-SCALE)

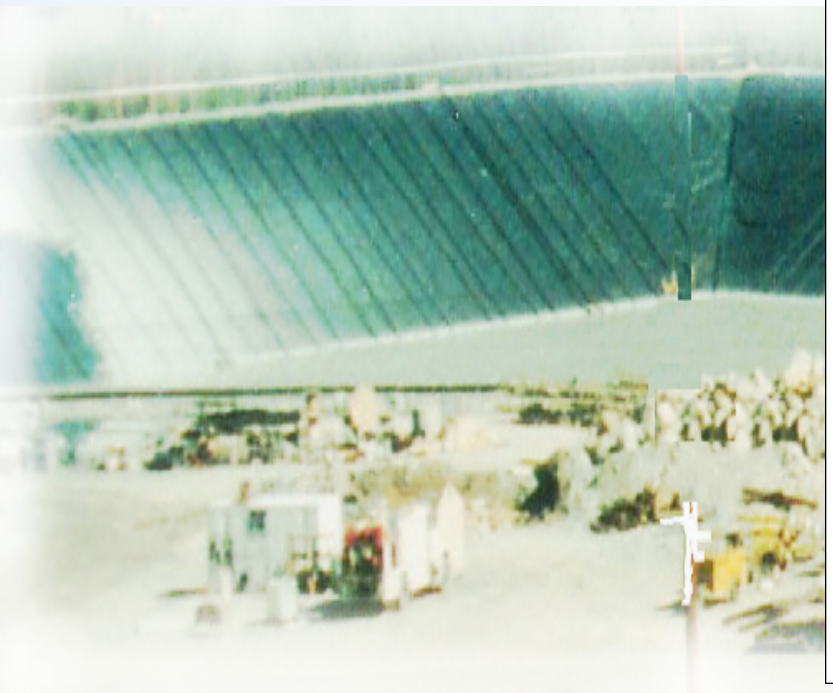
An integrated process system using biological denitrification, biological selenium removal and biological cyanide biooxidation has been constructed to remove these contaminants at ~8° C

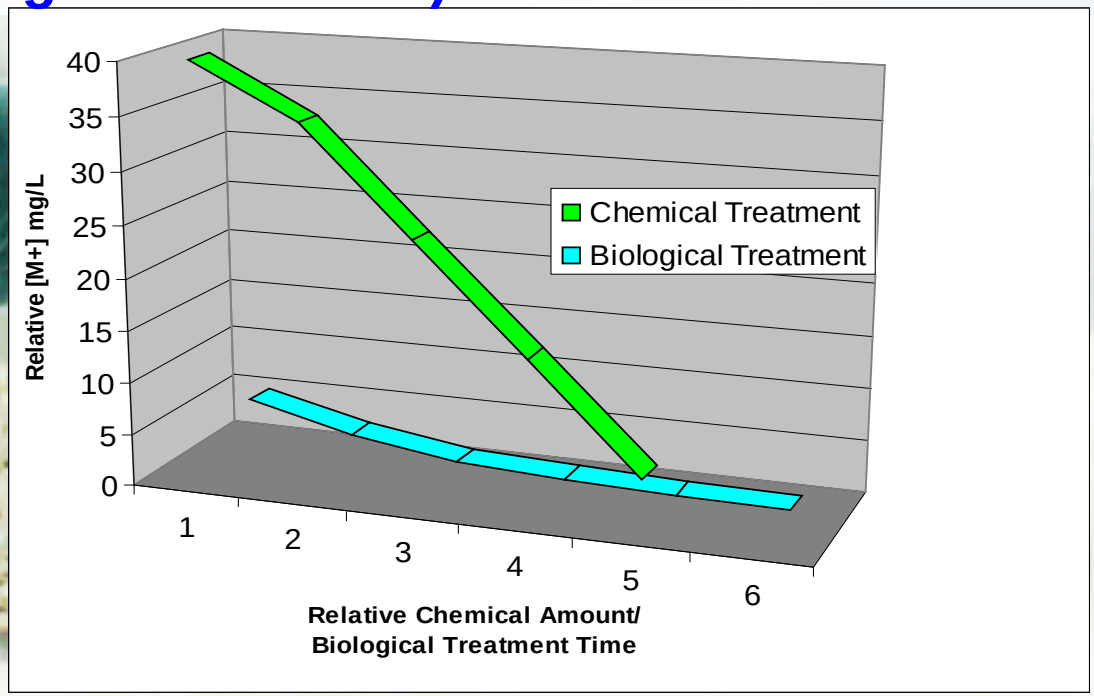
LANDUSKY OPERATION

- System inoculated and on line in August 2002
  - Operational checkout September / October 2002
  - Currently finalizing system optimization
    - Removing nitrate and selenium to below discharge criteria – since August 2002
      - NO_3 – from ~ 240 mg/L to <5 mg/L
      - Se - from ~ 0.8 mg/L to <0.002 mg/L
      - CN - from ~0.3 mg/L to 0.03 mg/L
    - Currently balancing the nutrient feed - more complete CN removal and lower costs
  - System inoculated to remove other metals – As, Zn, Cu, Ni, Mn, Al, Au

WASTEWATER POND

(~10 M gal - Full-scale)





Initial Values (mg/L)	Chemical/Biological Treatment - Pond (mg/L)	Post Bioreactor (mg/L)
2.11 As	0.16	Below detection (5 ppb)
11.7 Cu	0.204	0.05
1.7 Se	Below (50 ppb)	Below detection (2 ppb)

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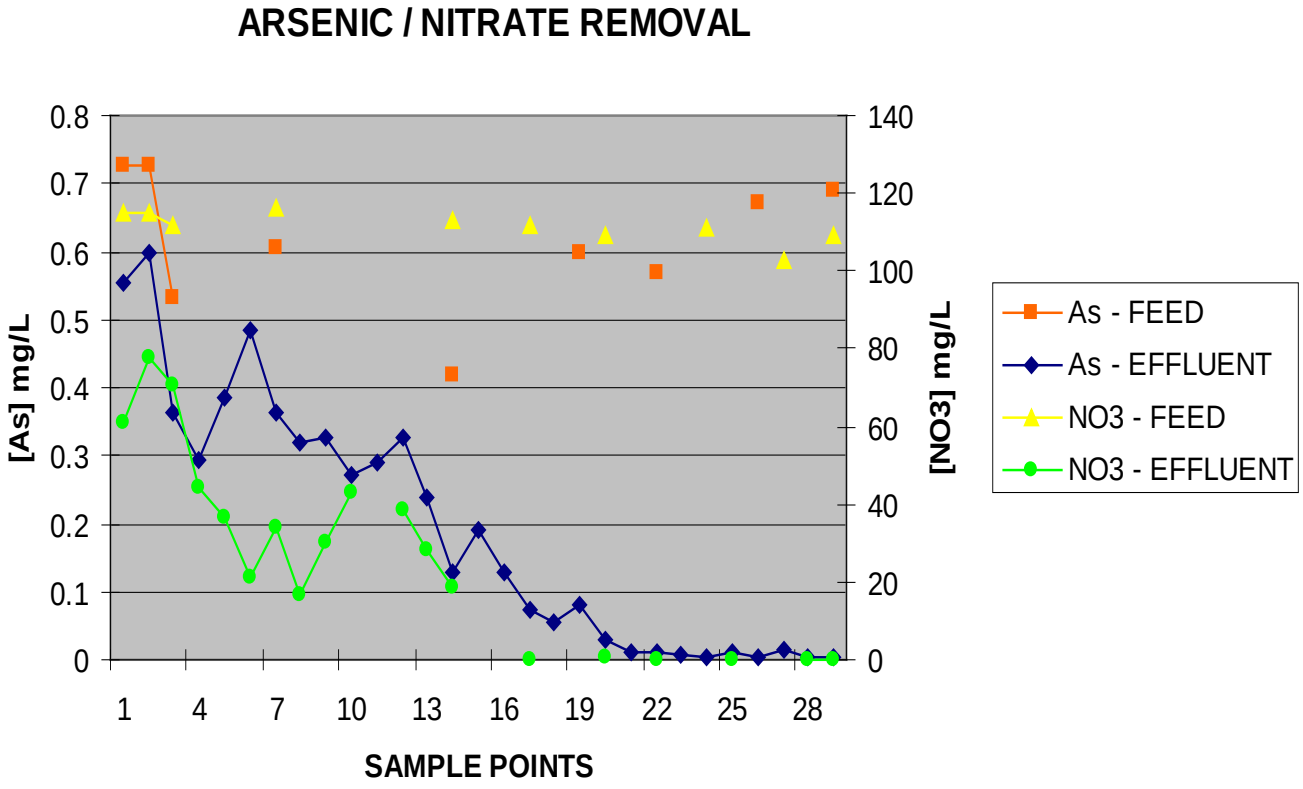
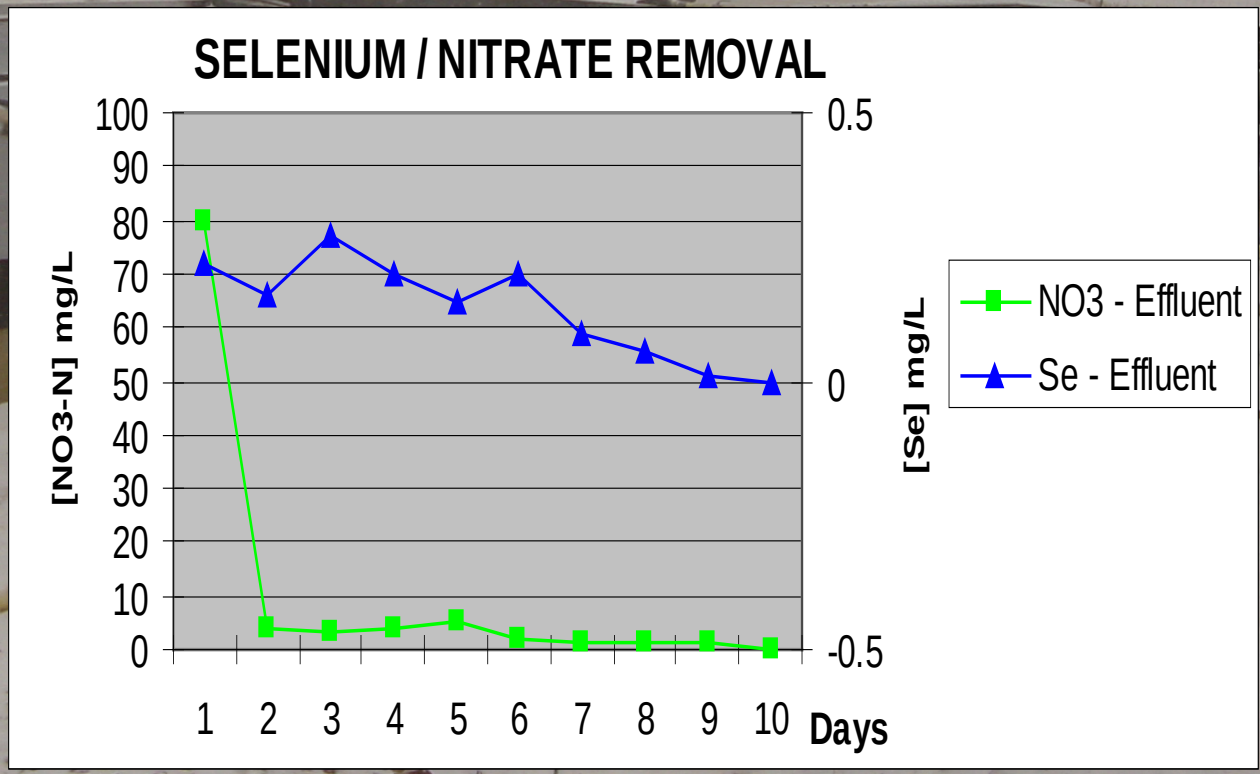
PILOT-SCALE TESTING

Arsenic – 0.6 mg/L
Nitrate – 70 to 120 mg/L
pH ~ 7.0
Flow Rate ~1.0 gpm
Temperature ~8° C to 16° C



FULL-SCALE TREATMENT

- Treatment costs <$0.25/1,000 gallons
- Retention time ~ 7 hr
- pH ~7.0
- Flow Rate - 70 to 150 gpm
- Temp. ~8º C to 16º C



SUMMARY

The Applied Biosciences metal and inorganic removal process technology has been validated through the EPA's Mine Waste Technology Program and various full-scale implementations.

- Simple "pump & treat" bioreactor design
- Low nutrient costs - $0.19 to $0.45 / 1,000 gallons
- Metal removal to below detection
- Can be configured to simultaneously remove various metal and inorganic contaminants, e.g., Se, NO_3, Cu, CN, NH_3, Ni, As, Te, Cd, Zn

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