ENVIRONMENTAL INNOVATIONS INOTEC

Electro-Biochemical Reactor (EBR) Technology for Treatment of Leach Pad Waters at the Landusky Mine

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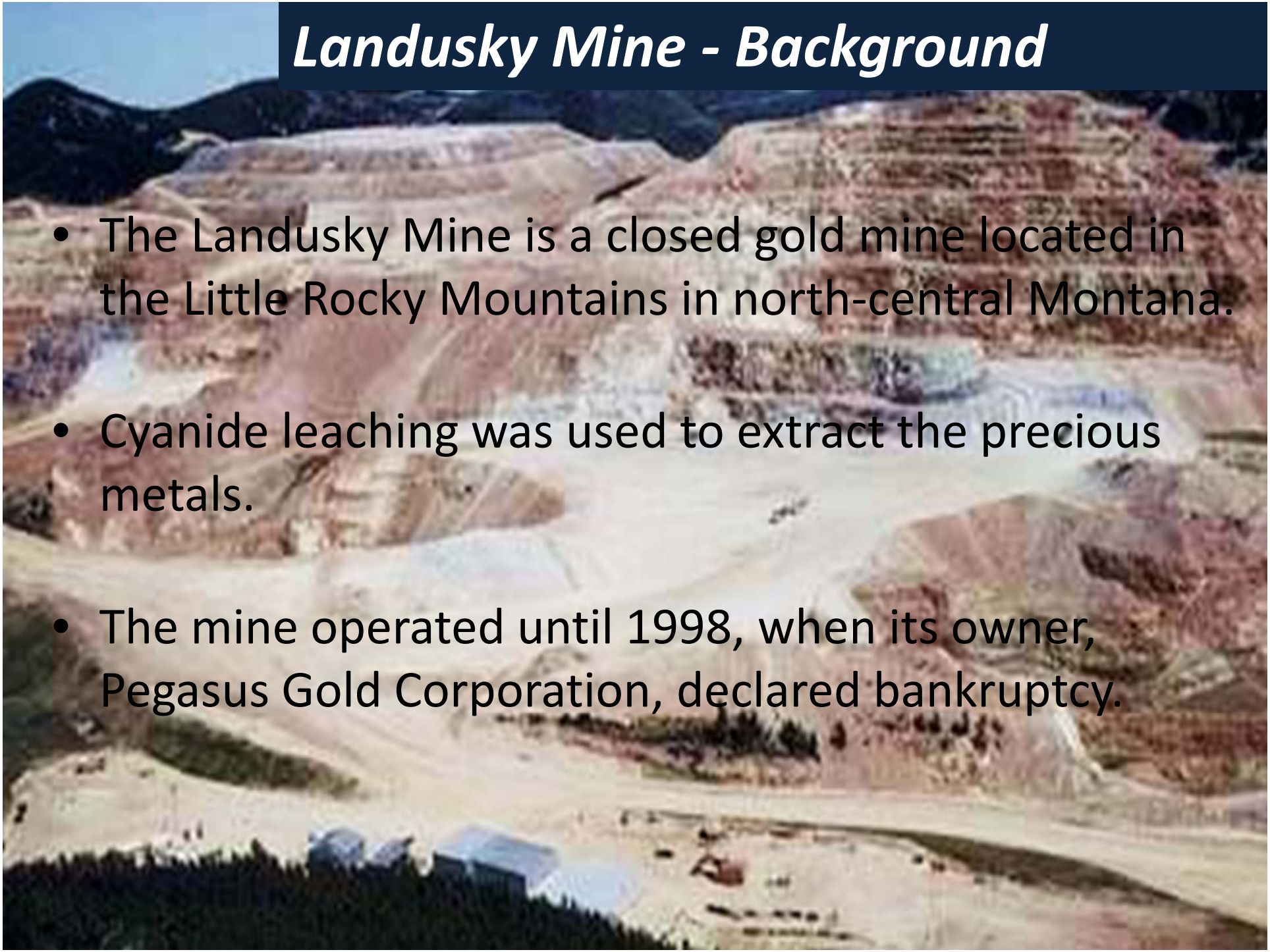
Mine Design, Operations & Closure Conference 2014

Landusky Mine - Background



- The Landusky Mine is a closed gold mine located in the Little Rocky Mountains in north-central Montana.
- Cyanide leaching was used to extract the precious metals.
- The mine operated until 1998, when its owner, Pegasus Gold Corporation, declared bankruptcy.

Landusky Mine - Background

- Spectrum Engineering of Billing, MT, performed the reclamation and is currently managing the site and its water treatment plants, including the Landusky Biotreatment System (LBS).

- The LBS system was comissioned in 2002; based on a patented advanced biological wastewater treatment process to treat contaminants not readily treatable by chemical precipitation.
  - nitrate-N at 100-350 mg/L
  - selenium at 0.8-1.5 mg/L

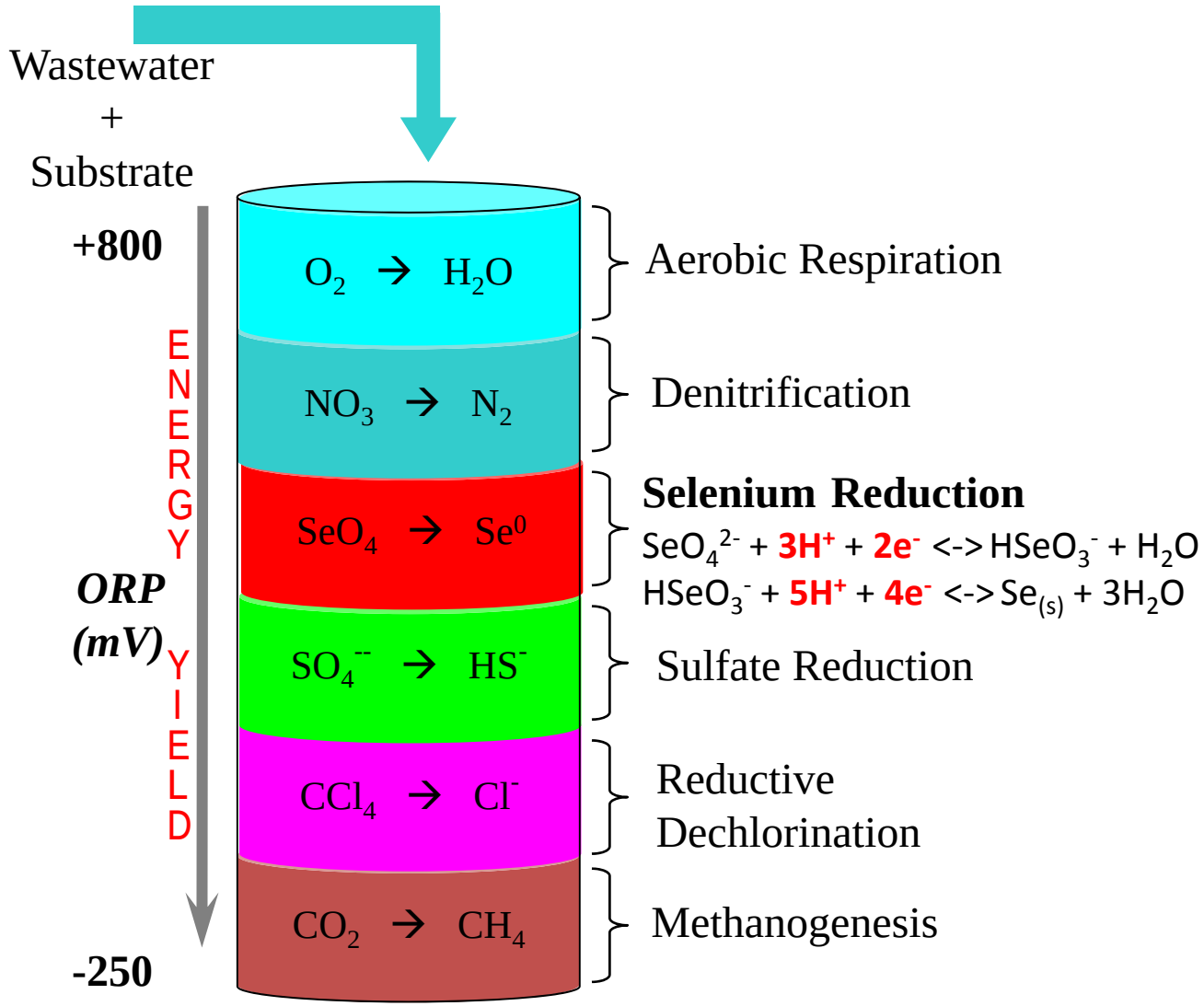
Landusky Conventional Biotreatment

Treatment Conditions

- Water temp. <2 - 12° C
- pH~4.0 adjusted to ~6.5
- NO_3-N - 100 to 340 mg/L
- Hardness >2,100 mg/L
- Broad spectrum of metals

(Se, Cd, Cu, Fe, Mn, Ni, Zn)

EBR – ORP Fundamental Concepts
(Electron Availability)

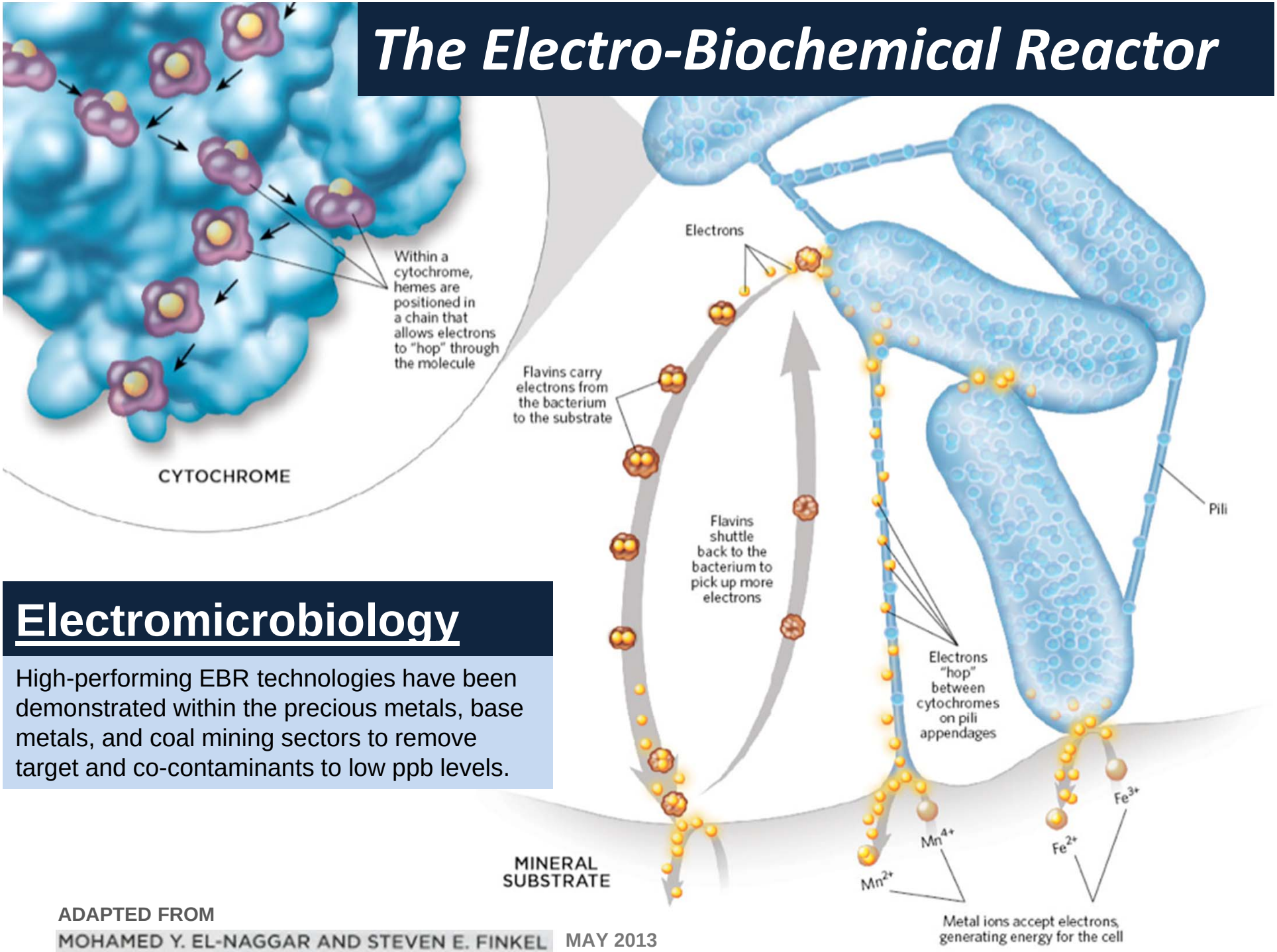


EBR Technology

- EBR technology utilizes nutrients to provide required component for cell growth
- Low voltage (1-3 Volts potential) provides:
  1. Electrons and electron acceptor environments for controlled contaminant removal environment
  2. Compensation for inefficient and fluctuating electron availability through nutrient metabolism

- 1 mA provides ~6.24 x 10^{15} electrons/second
- to the EBR system.
  - Replaces excess nutrients
  - Better contaminant removal
  - Produces less TSS (bio-solids)

The Electro-Biochemical Reactor



Electromicrobiology

High-performing EBR technologies have been demonstrated within the precious metals, base metals, and coal mining sectors to remove target and co-contaminants to low ppb levels.

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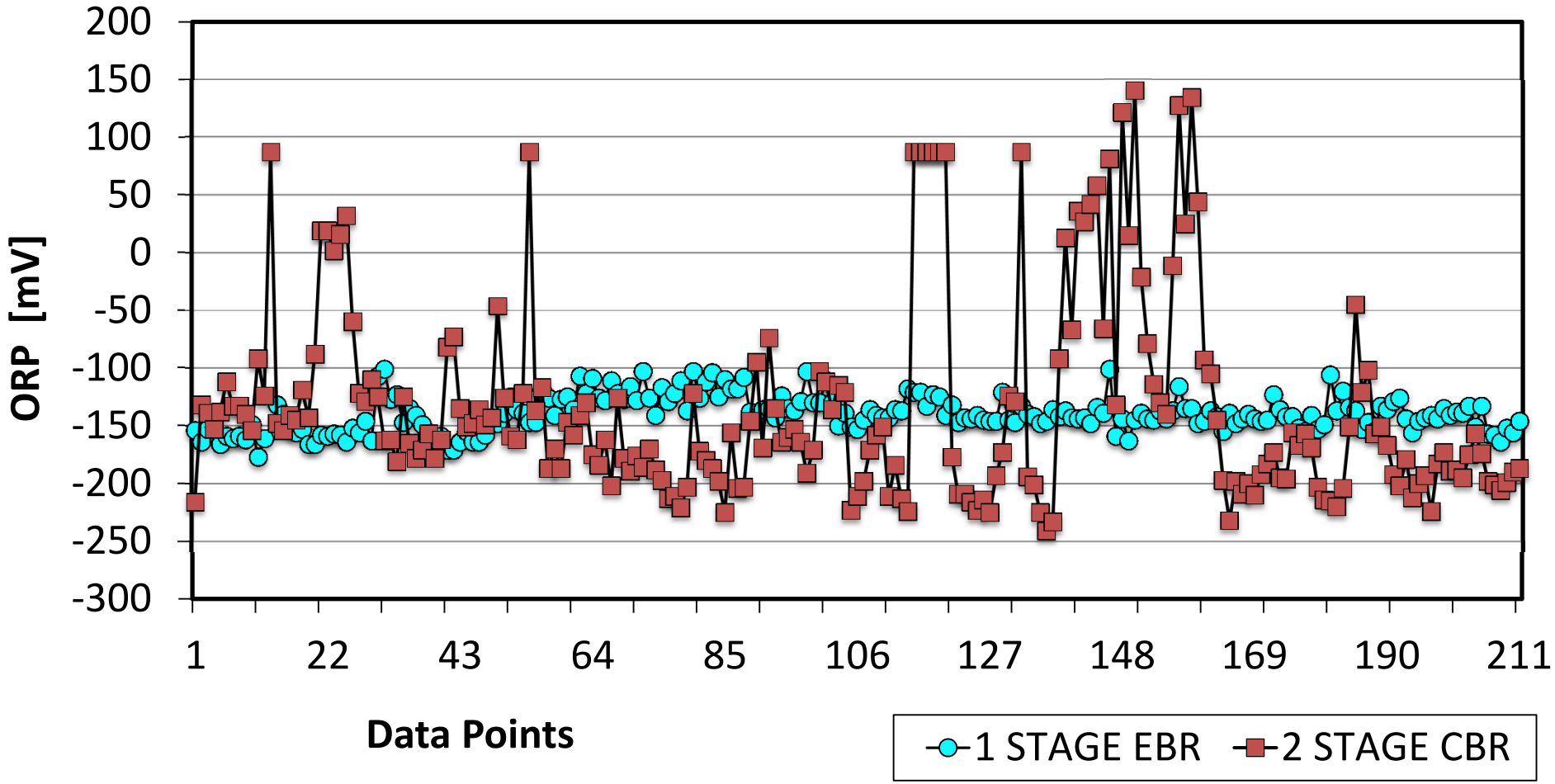
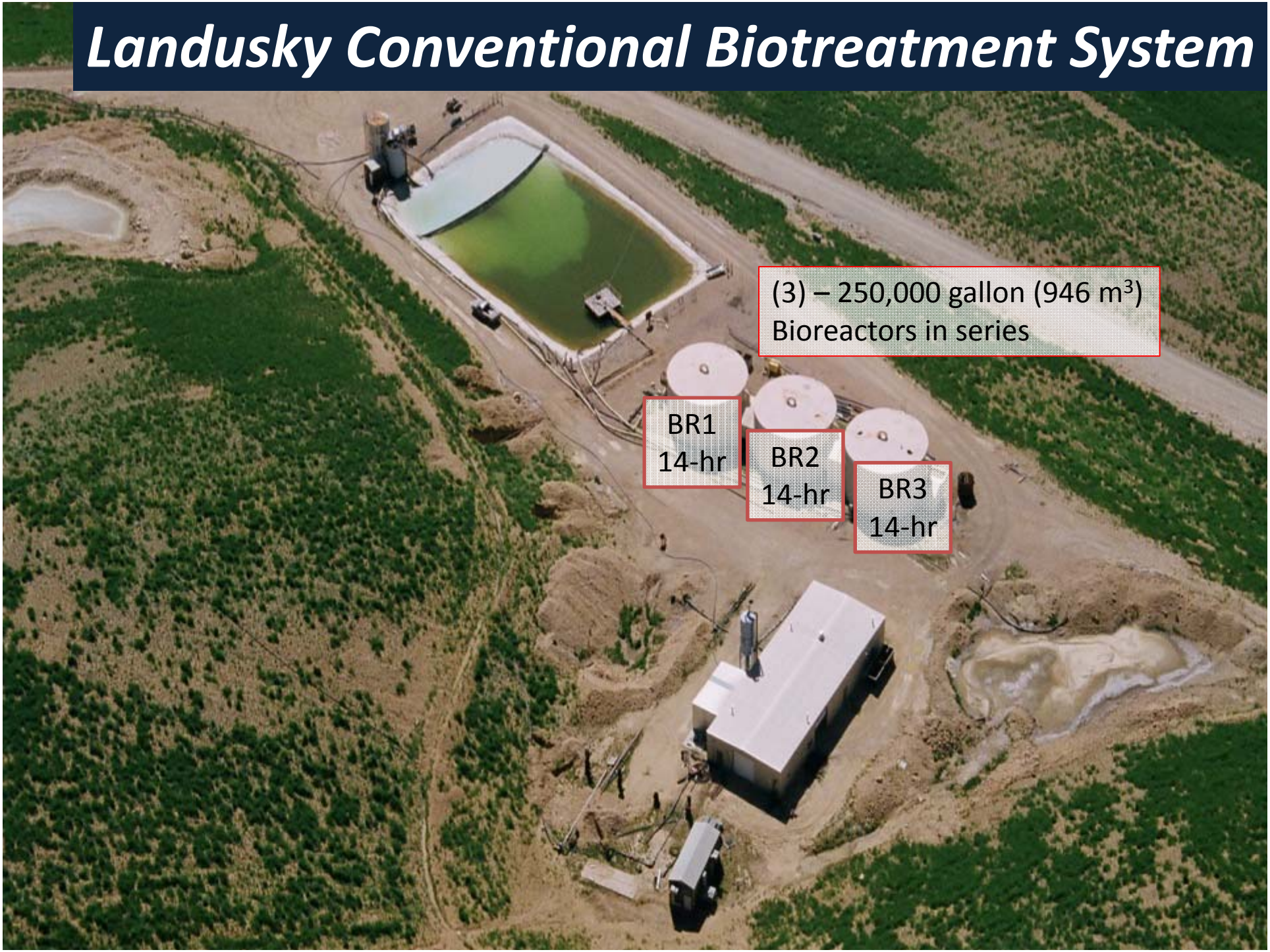
Electro-Biochemical Reactor Technology

Providing electrons directly has numerous benefits including better ORP control and stability.

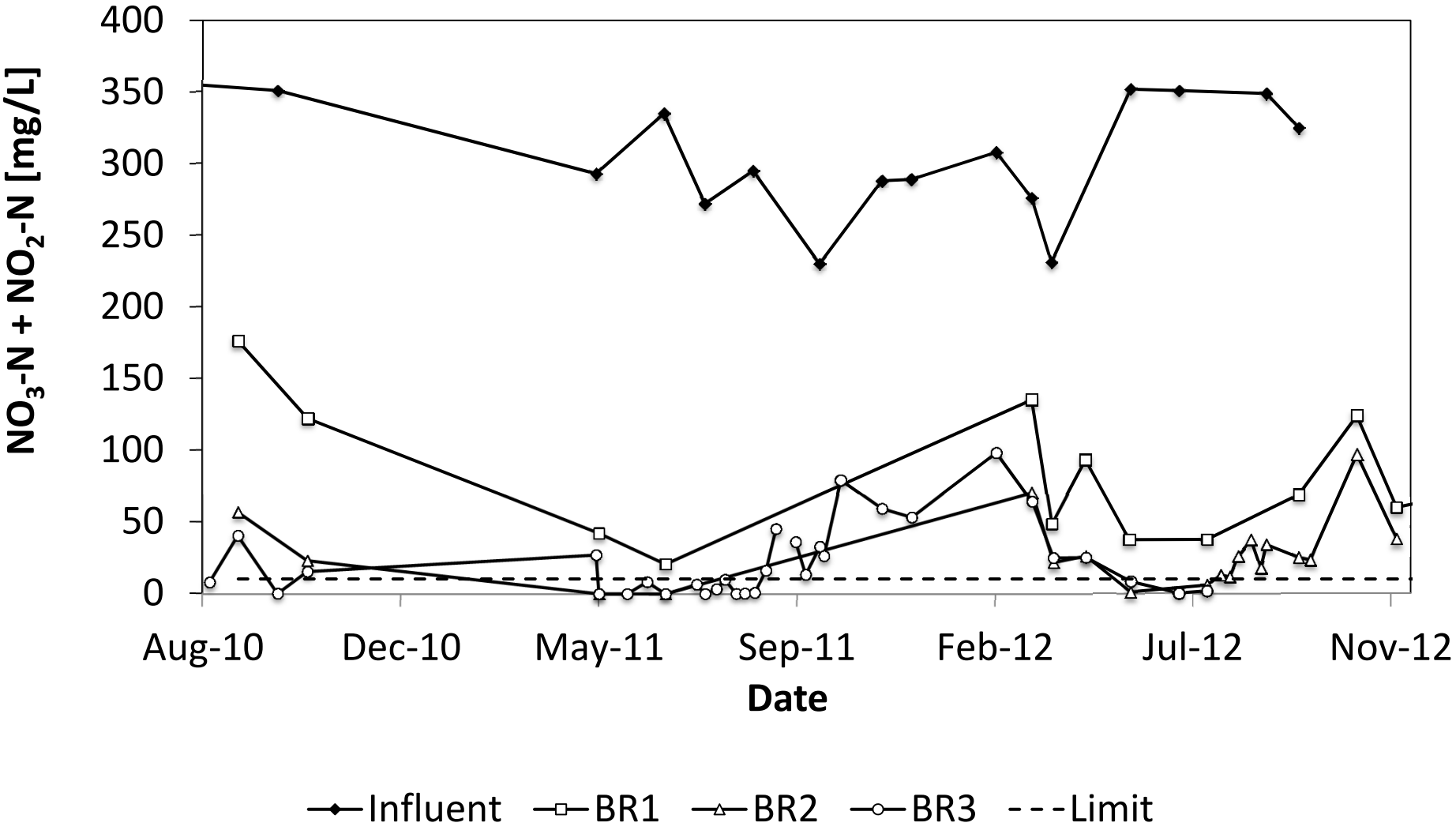


Landusky Conventional Biotreatment System

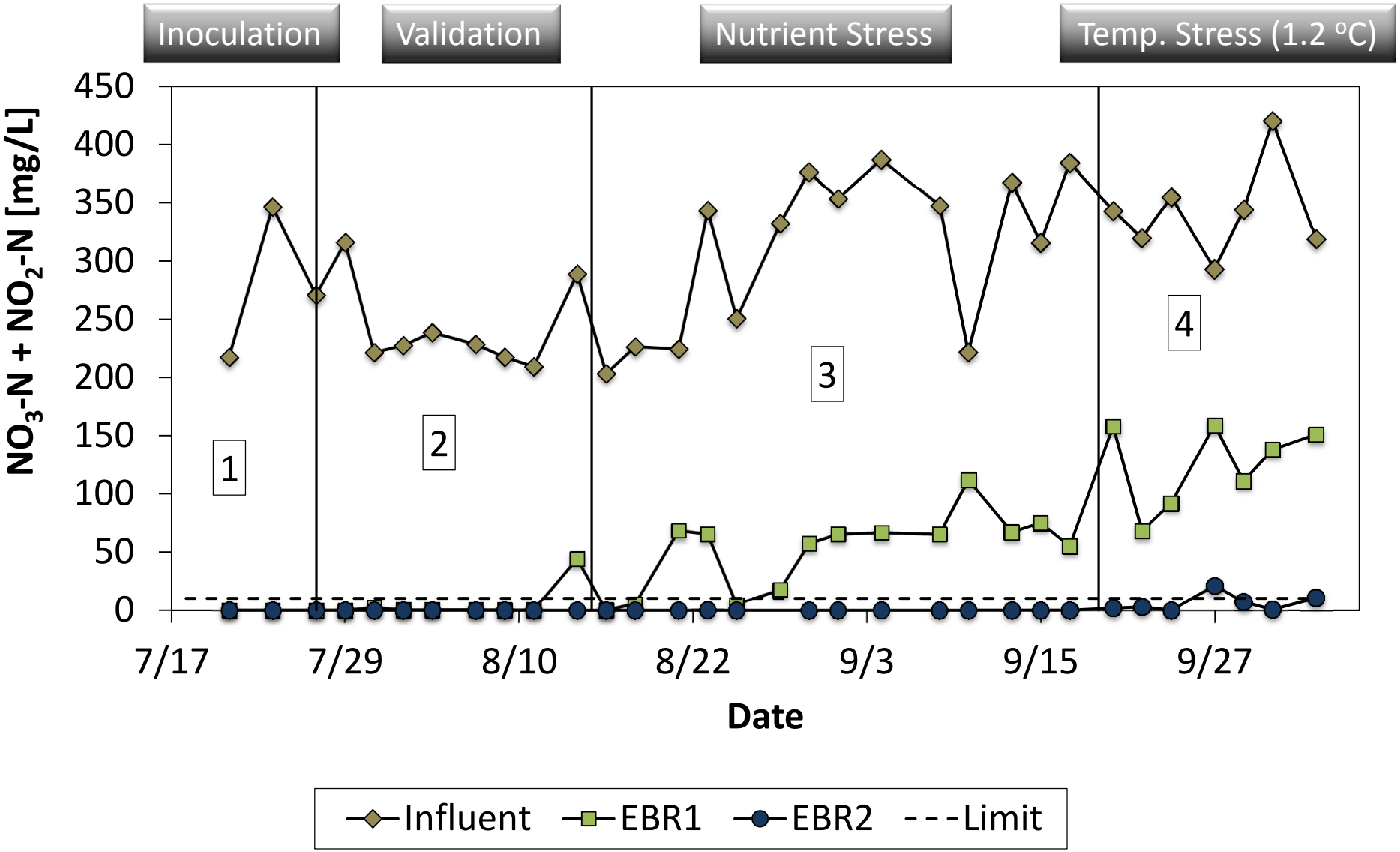


Landusky EBR Pilot System

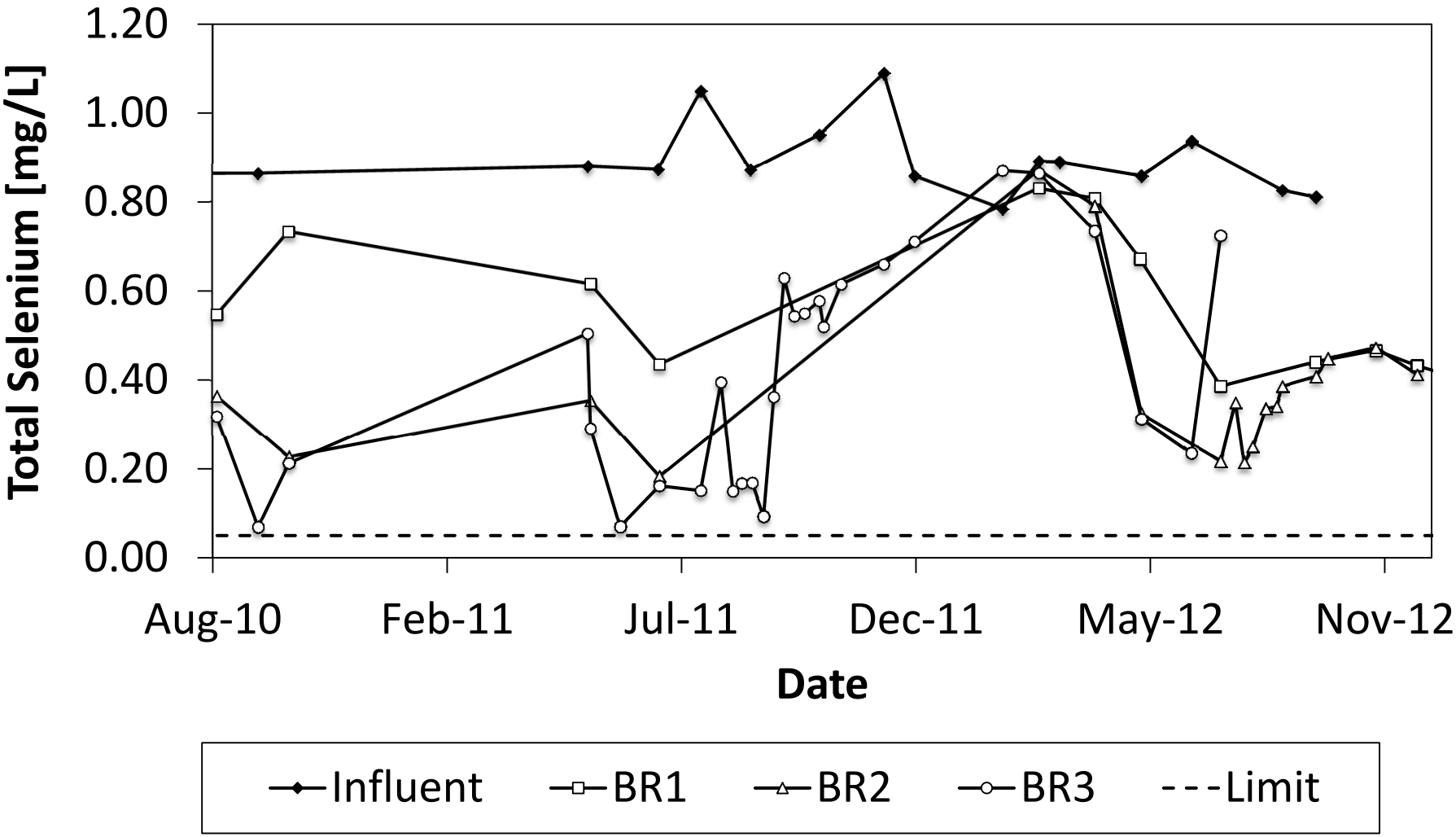
Nitrate/Nitrite - LBS



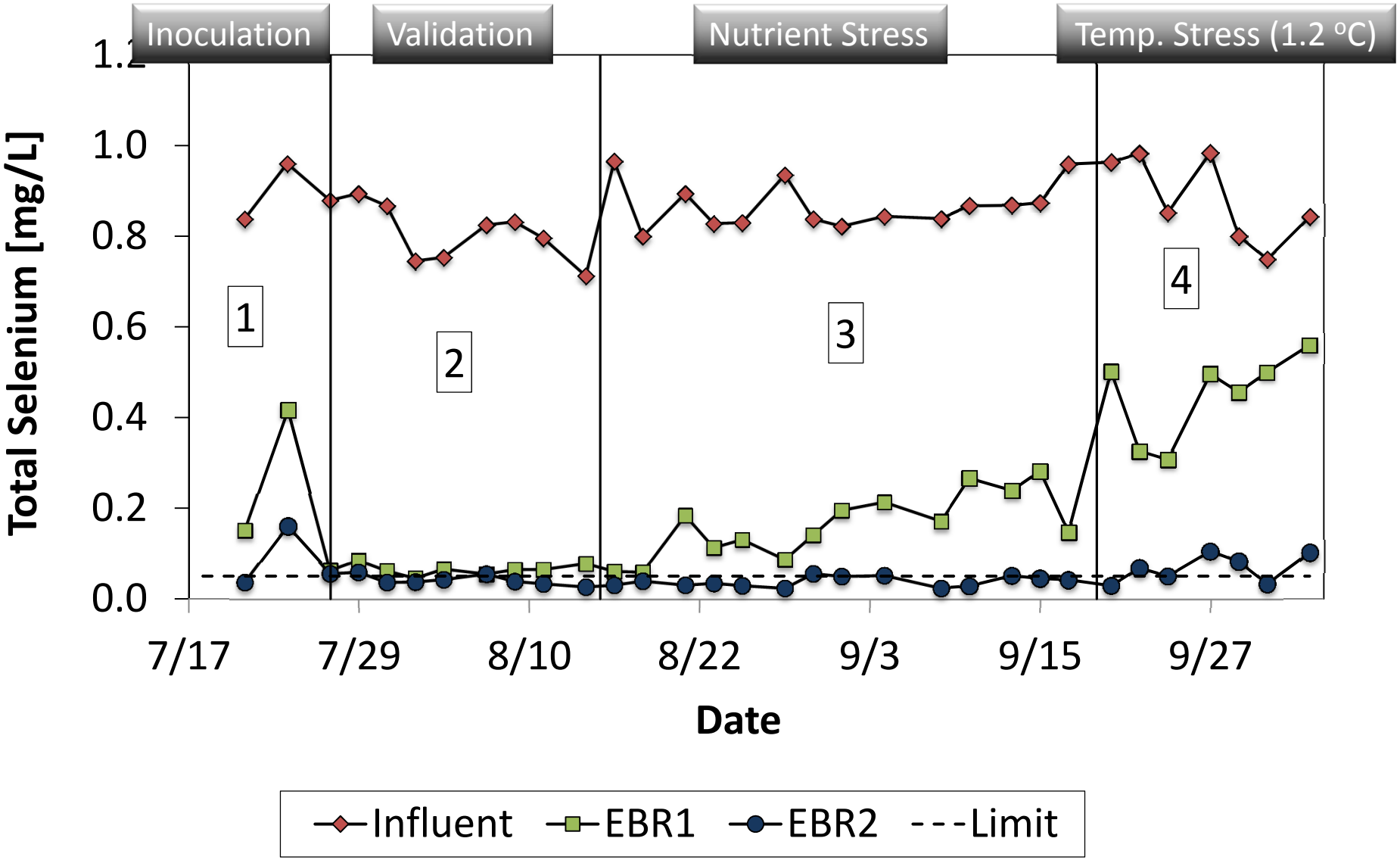
Results: Nitrate/Nitrite - EBR



Selenium - LBS



Results: Selenium - EBR



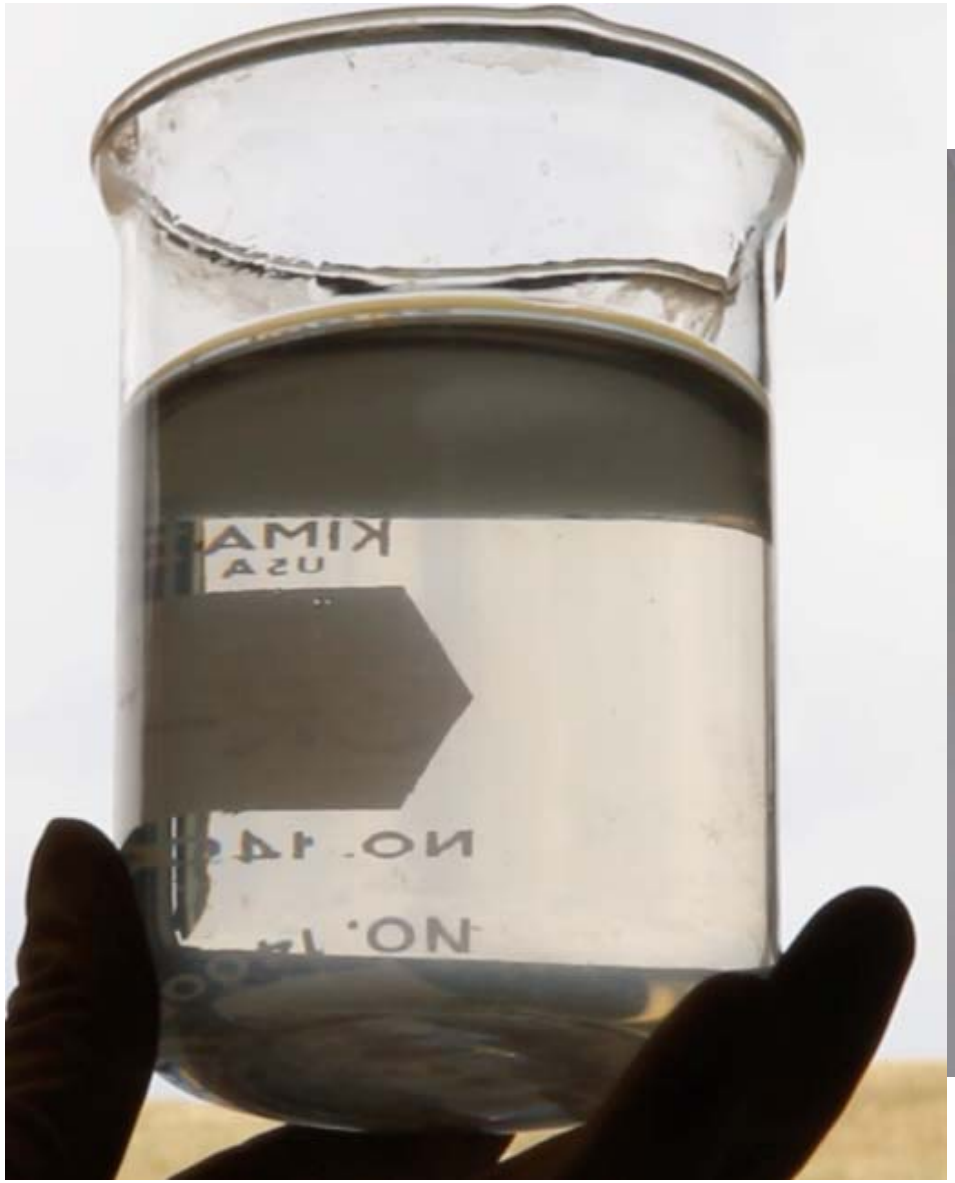
Results: Other Contaminants (Average)

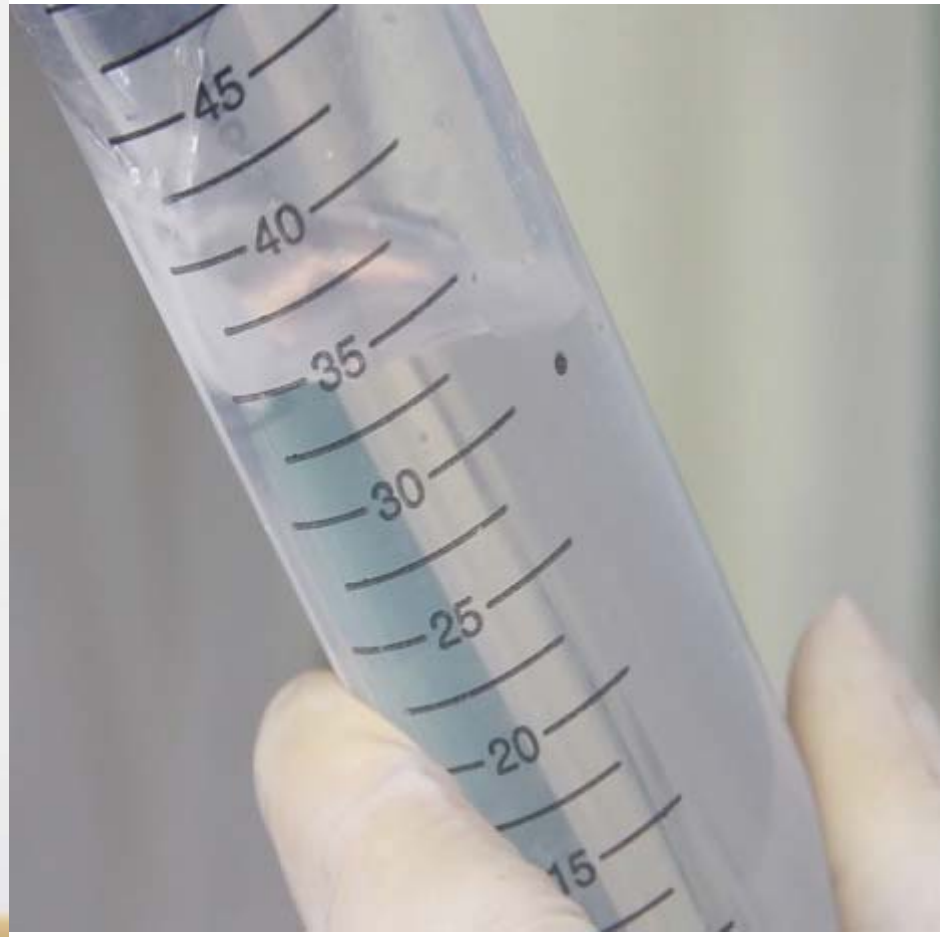
	Influent	LBS Effluent	EBR Effluent	Discharge Limit
CN^{1} (TOTAL)	0.084	NA	<0.005	0.005
CN^{1} (WAD)	0.012	0.072	<0.005	NA
Al [mg/L]	0.34	1.99	0.04	NA
Cd [mg/L]	0.135	0.125	<0.001	0.005
Cu [mg/L]	0.061	0.122	0.014	0.031
Mn [mg/L]	57	55	29	NA
Ni [mg/L]	0.832	0.893	0.007	NA
Se [mg/L]	0.858	0.417	0.039	0.050
Zn [mg/L]	2.26	2.94	0.04	0.388
TSS [mg/L]	<18	NA	<16	NA

[1]After EBR system aerobic step.

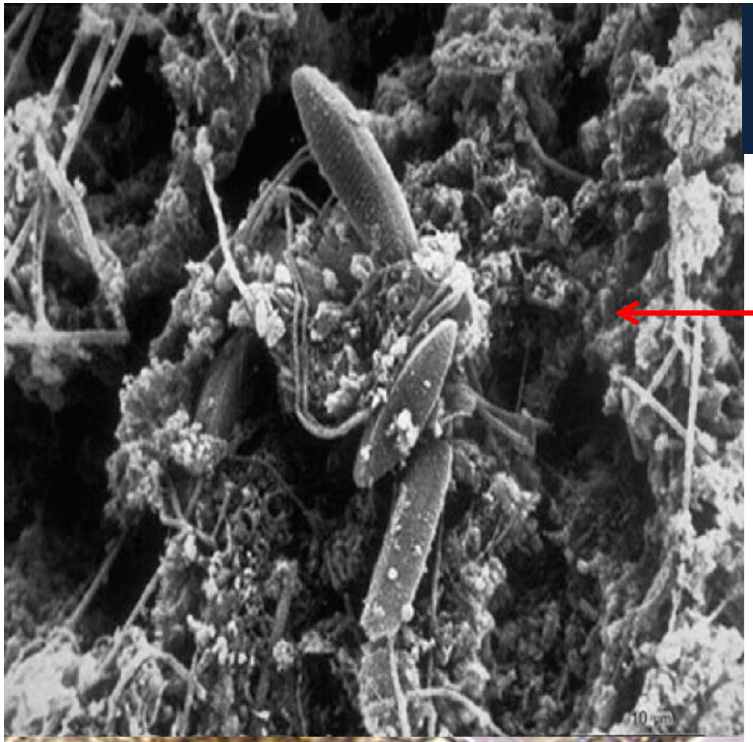
EBR Water Sampling

EBR Water Sampling

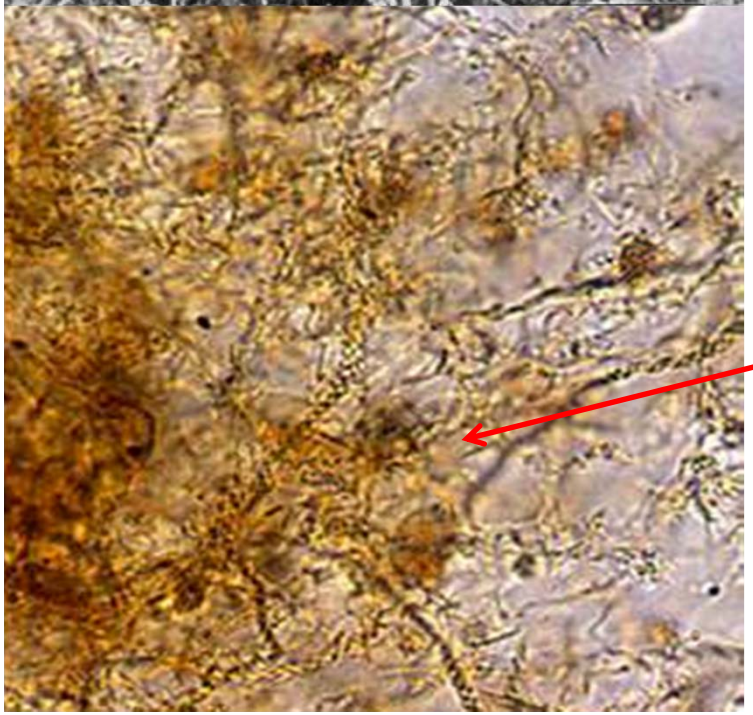




Microbial Metal Precipitates

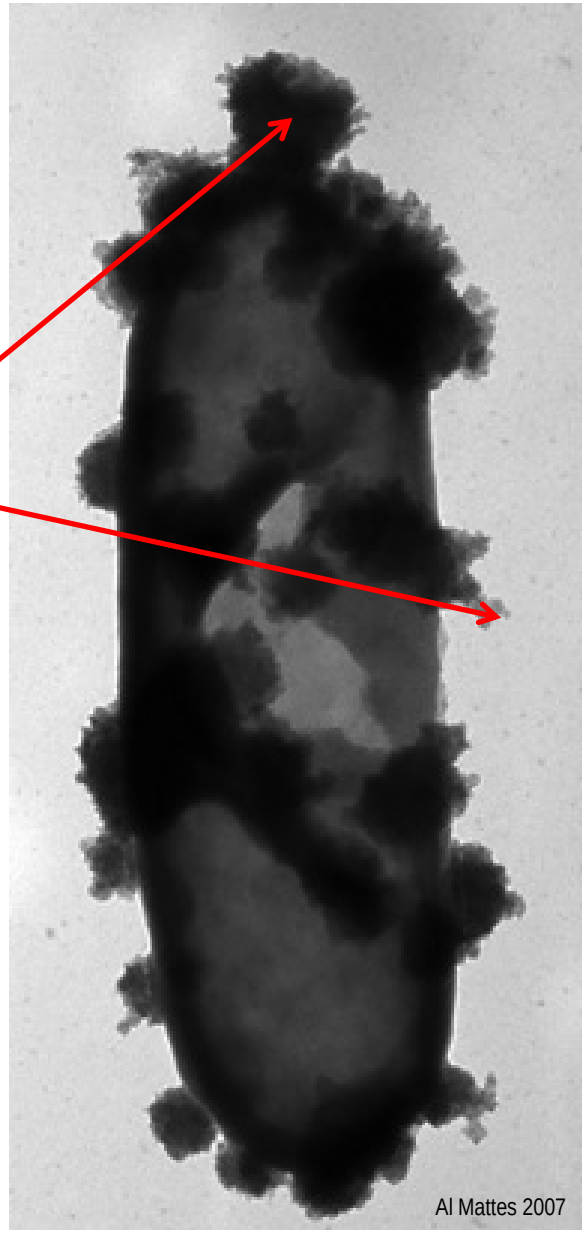


Biofilm



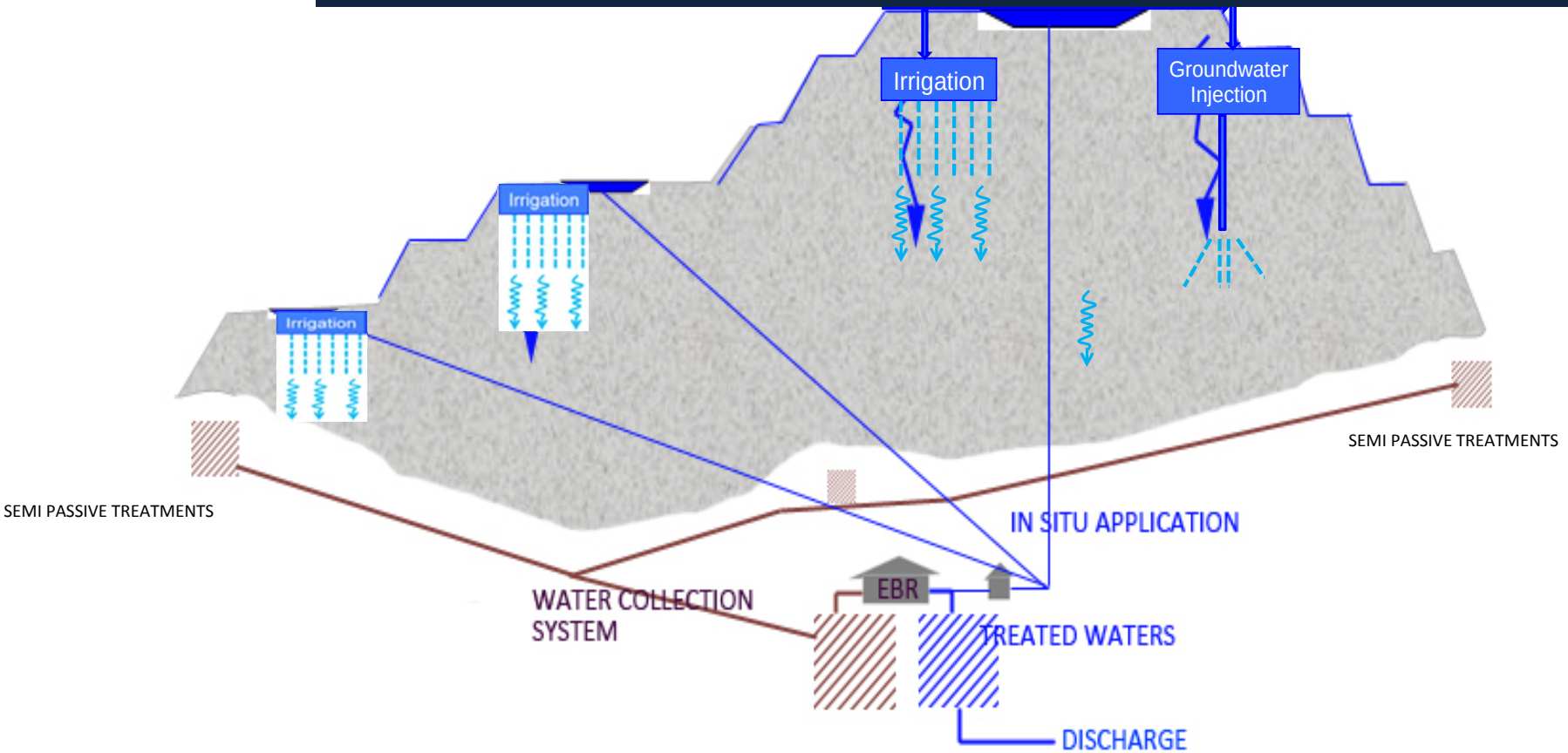
Biofilm with
Se precipitate

Metal precipitate
formation and
growth on bacteria



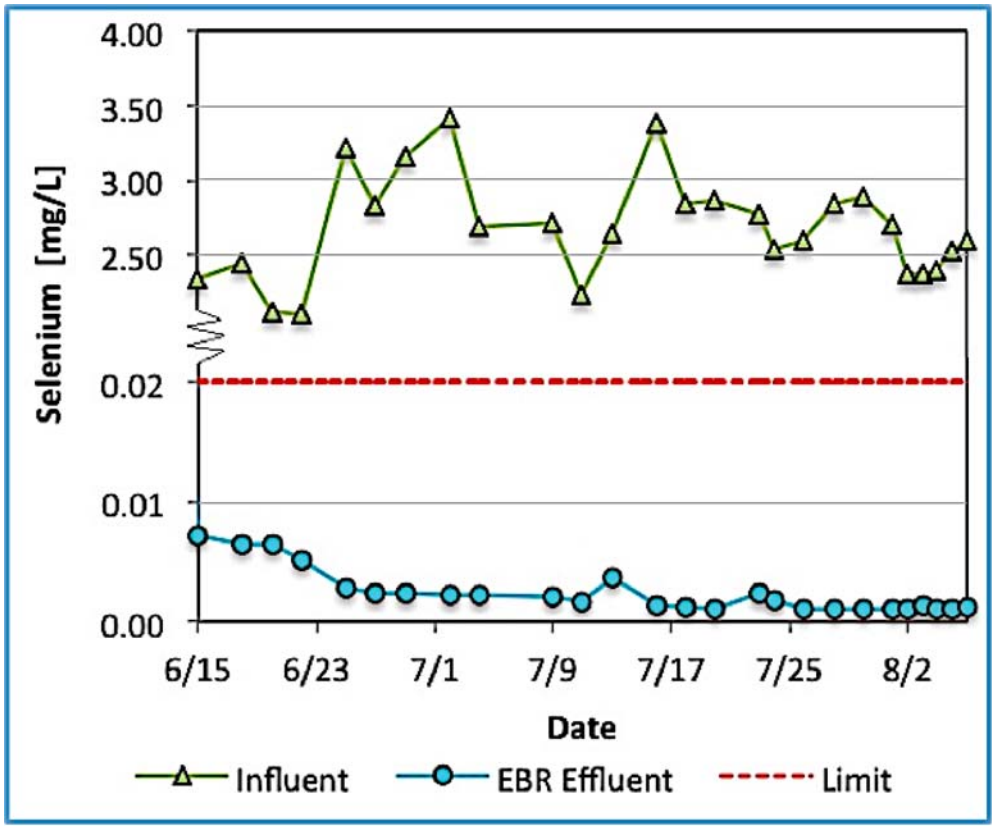
Refurbishment & Conversion of the Landusky Biotreatment System to an EBR

Combined EBR/In Situ Biotreatment



- Reconfigure water collection system for (additional amendments) and partial redistribution from the EBR active treatment system to in situ heap treatment
- Approaches have been proven in full-scale applications at several US hard rock mines at elevations >3,200 meters

EBR – Yukon Mine



Parameter [mg/L]	Average Influent	Average Discharge	% Removal
Antimony	0.15	<0.001	>99.3%
Cadmium	0.014	<0.0002	>98.0%
Copper	0.41	<0.005	>98.7%
Lead	0.30	0.0008	99.7%
Molybdenum	0.10	<0.0005	>99.5%
Selenium	2.73	0.002	99.9%
Silver	0.041	<0.0001	>99.8%
Zinc	0.46	<0.03	>93.5%
Nitrate-N	3.3	<0.1	>97.1%
Nitrite-N	0.9	<0.02	>97.8%
Cyanide $_{WAD}$	0.26	<0.005	>98.1
Cyanide $_{TOTAL}$	0.47	<0.005	>98.9

- The EBR system consistently removed selenium from an average of 2.73 mg/L to an average of 0.002 mg/L - well below the discharge requirement of 0.020 mg/L.

- An ~8 hour EBR HRT will be required to achieve the lowest levels of selenium removal at full-scale with temperatures down to <5° C at this site.

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Thank You

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