COLUMN STUDY FOR EVALUATION OF IN-SITU IRON FOULING… A CAUTIONARY TALE OF AQUIFER BLOCKAGE

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October 28, 2015

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INTRODUCTION

Who here has spent time and money installing a remediation system only to see it underperform or even fail?

- Geochemistry
- Hydrogeology
- Microbiology
- Infrastructure

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PROBLEM STATEMENT

- Many remedial technologies work by changing the reduction-oxidation (red-ox) conditions within an aquifer.
  - Changing red-ox conditions has the potential to mobilize or precipitate red-ox sensitive metals.
    - Mobilization or precipitation of metals has the potential to reduce effectiveness of a remedial action, or create a new environmental condition.

RED-OX SENSITIVE METALS

Metal	Solubility under oxidizing (aerobic) conditions	Solubility under reducing (anaerobic) conditions
Arsenic	Low	High
Chromium	High	Low
Copper	Low	High
Iron	**Low**	**High**
Manganese	Low	High
Mercury	Low	High
Selenium	High	Low
Uranium	High	Low

Note: This represents only a partial list of the most common or most toxic redox sensitive metals

CASE STUDY – BASELINE CONDITIONS

Geology

- 0-6 ft bgs: Unsaturated fill soil
- 6-8 ft bgs: Saturated peat/organics
- **8-20 ft bgs: Fluvial sand aquifer**
- 20+ ft bgs: Marine clay

Groundwater

- Chlorinated VOCs
- Petroleum hydrocarbons
- Dissolved and total iron **1 to 36 mg/L**
- Dissolved and total manganese <1 mg/L

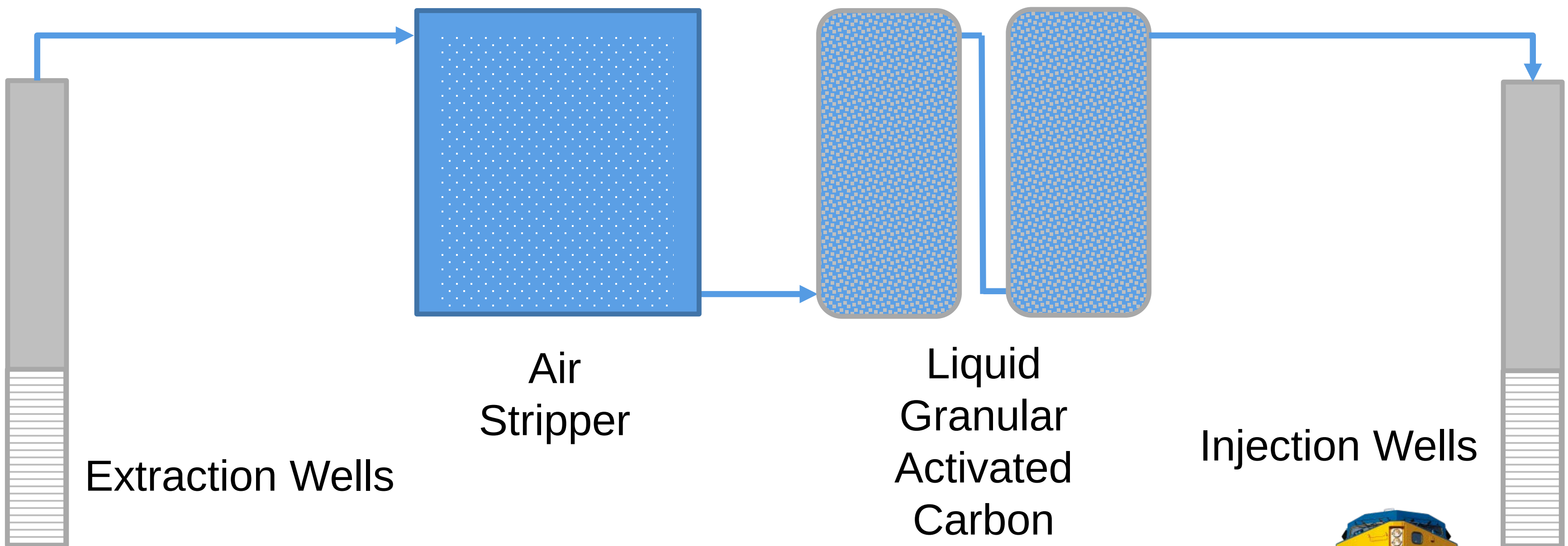
Geochemistry

- pH near neutral
- **Moderately to Strongly Reducing**
  - Dissolved oxygen <1 mg/L
  - Detectable dissolved methane
  - Elevated organic carbon in sand aquifer

PROPOSED REMEDY AND CONCEPTUAL SYSTEM DESIGN

Directed Groundwater Recirculation

- Effectiveness of remedy relies on large volumes of clean water being transported through impacted aquifer.



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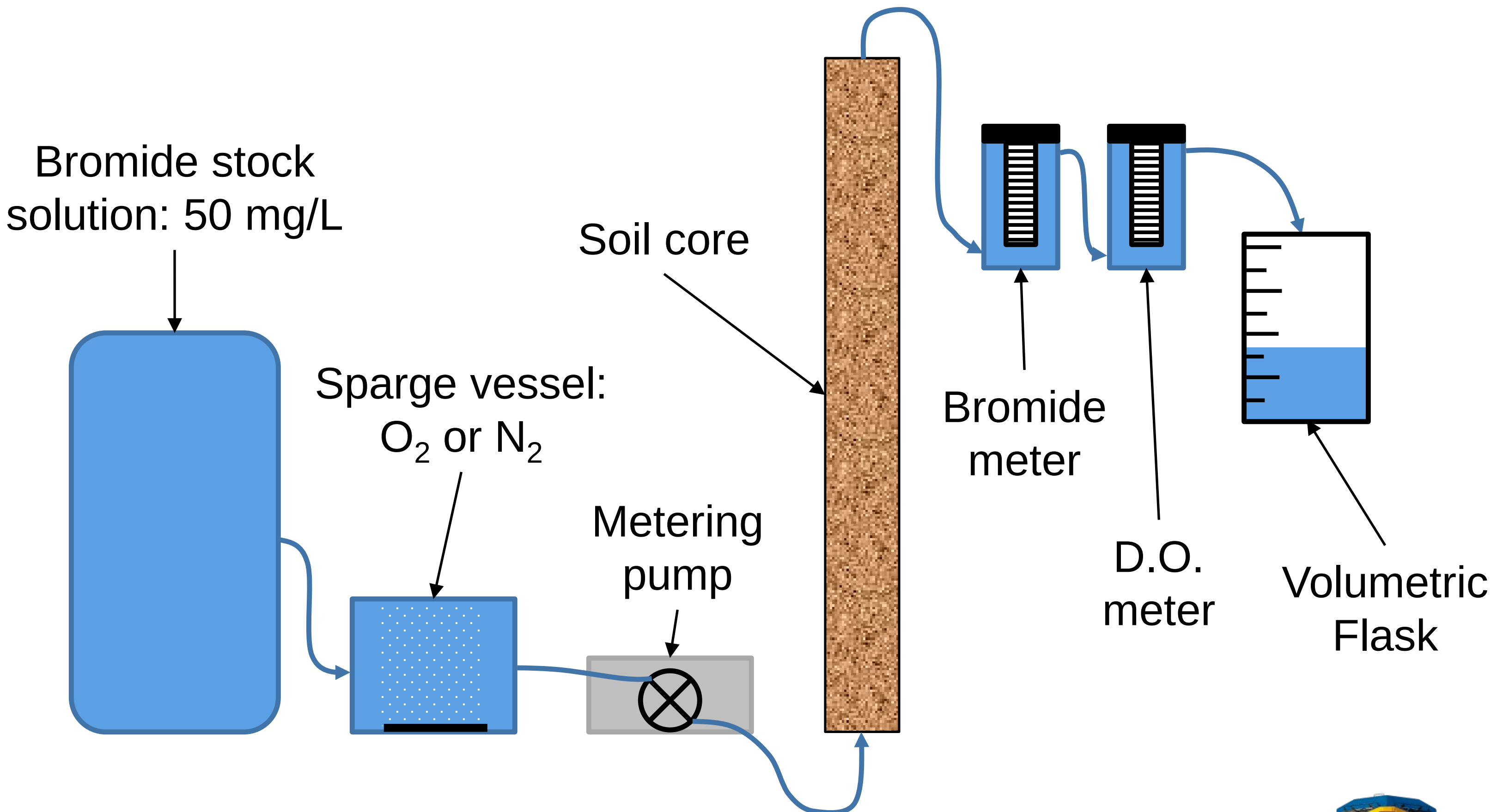
BENCH SCALE TESTING – EXPERIMENTAL SET-UP



BENCH SCALE TESTING – RESULTS

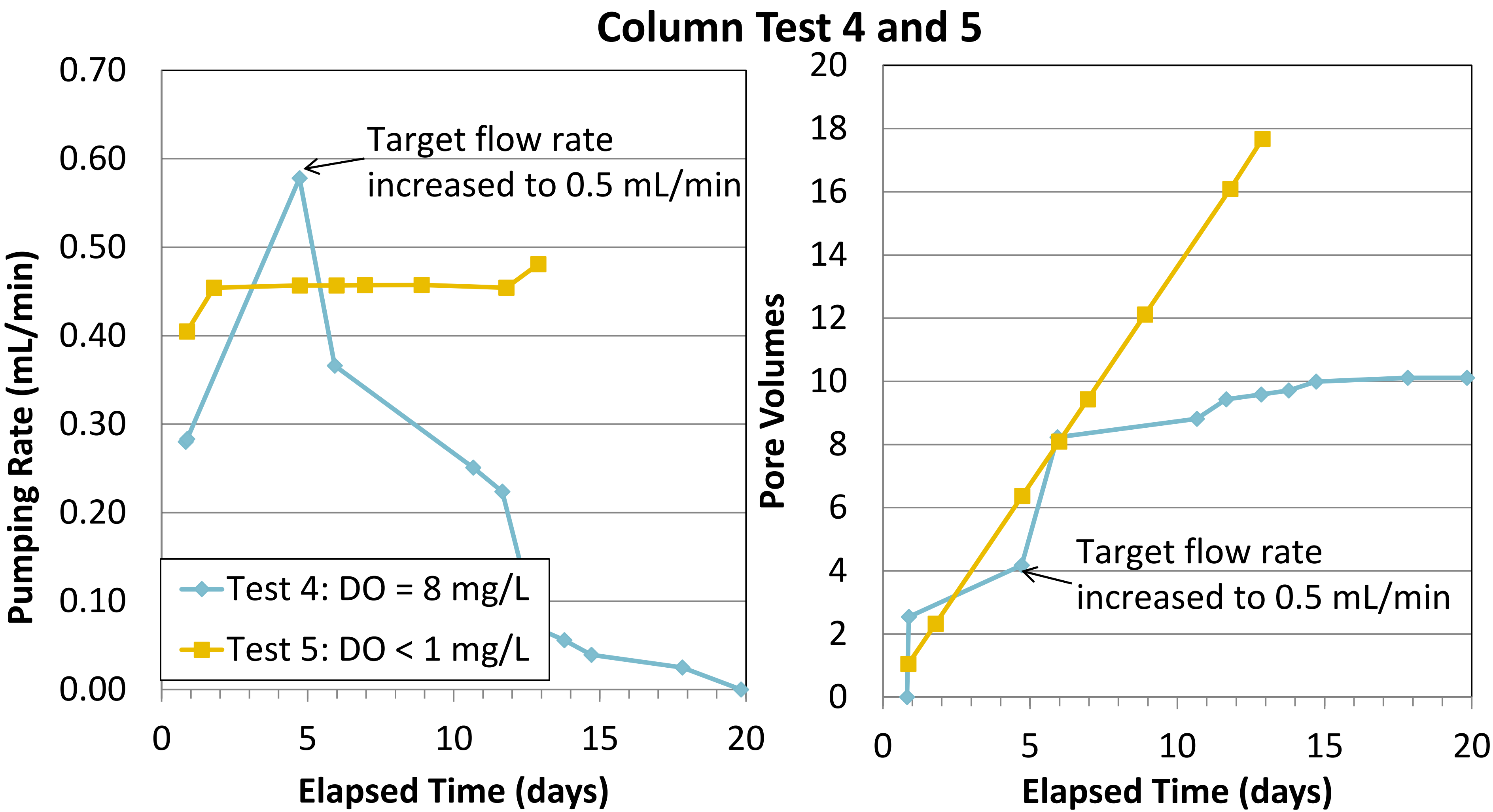
Column Test No.	Sparge Gas	Total Diss. Metals Conc. (mg/L)	D.O. Conc (mg/L)
1	O2 - Aerobic	23.2	8 mg/L
2	N2 > O2, Anaerobic > Aerobic	23.2	1 mg/L > 8 mg/L
3	O2 - Aerobic	3.6	8 mg/L
4	O2 - Aerobic	10.3	8 mg/L
5	N2 - Anaerobic	10.3	< 1 mg/L

Results…

BENCH SCALE TESTING – RESULTS

Column Test No.	Sparge Gas	Total Diss. Metals Conc. (mg/L)	D.O. Conc (mg/L)	Flow Loss Due to Mineral Precipitation	No. of Pore Volumes Prior to Blockage
1	O2 - Aerobic	23.2	8 mg/L	Yes	6.8
2	N2 > O2, Anaerobic > Aerobic	23.2	1 mg/L > 8 mg/L	No	NA - 35.1 total
3	O2 - Aerobic	3.6	8 mg/L	Yes	21.6
4	O2 - Aerobic	10.3	8 mg/L	Yes	10.1
5	N2 - Anaerobic	10.3	< 1 mg/L	No	NA - 17.7 total

BENCH SCALE TESTING – RESULTS



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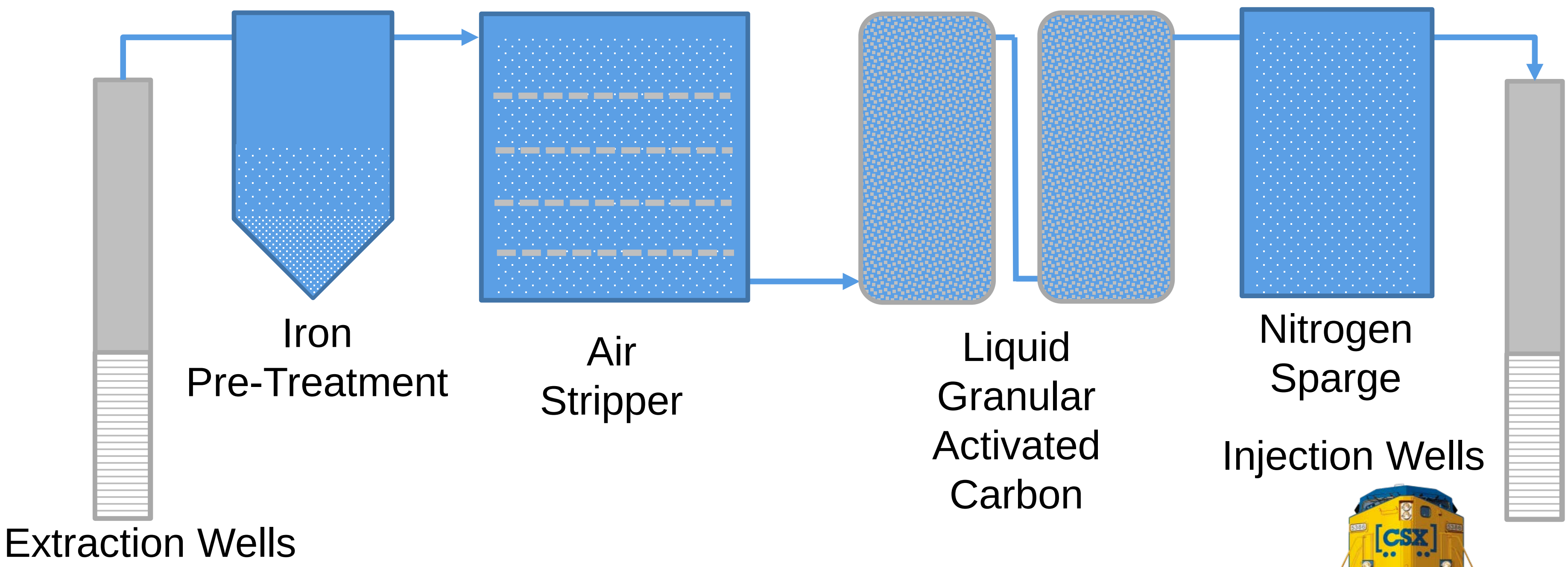
REMEDIAL SYSTEM MODIFICATIONS

- Iron removal pre-treatment prior to air stripper
- Nitrogen scrub after LGAC vessels to remove D.O. before reinjection



LESSONS LEARNED

- Understanding in-situ geochemistry is critical prior to installing a remedial system.
  - Shift to aerobic: Potential for red-ox sensitive metals to precipitate and clog aquifer.
  - Shift to anaerobic: Potential for metals mobilization and secondary plume creation.

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QUESTIONS?

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SUPPLEMENTAL SLIDES

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BENCH SCALE TESTING – EXPERIMENTAL SET-UP

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