Treatment of Arsenic and Metals in Ground Water Using a Compost/ZVI PRB

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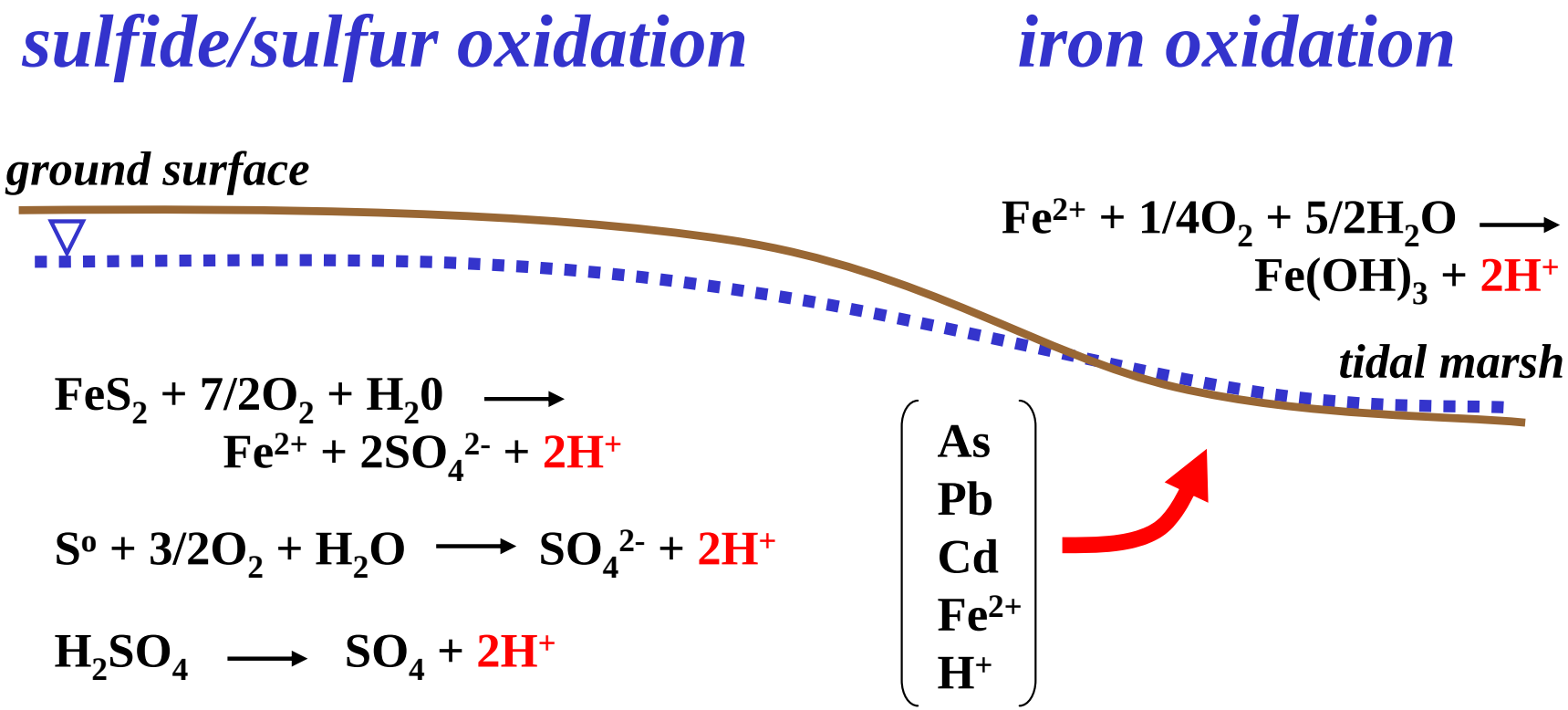
Columbia Nitrogen Site
tidal
marsh

Columbia Nitrogen Site

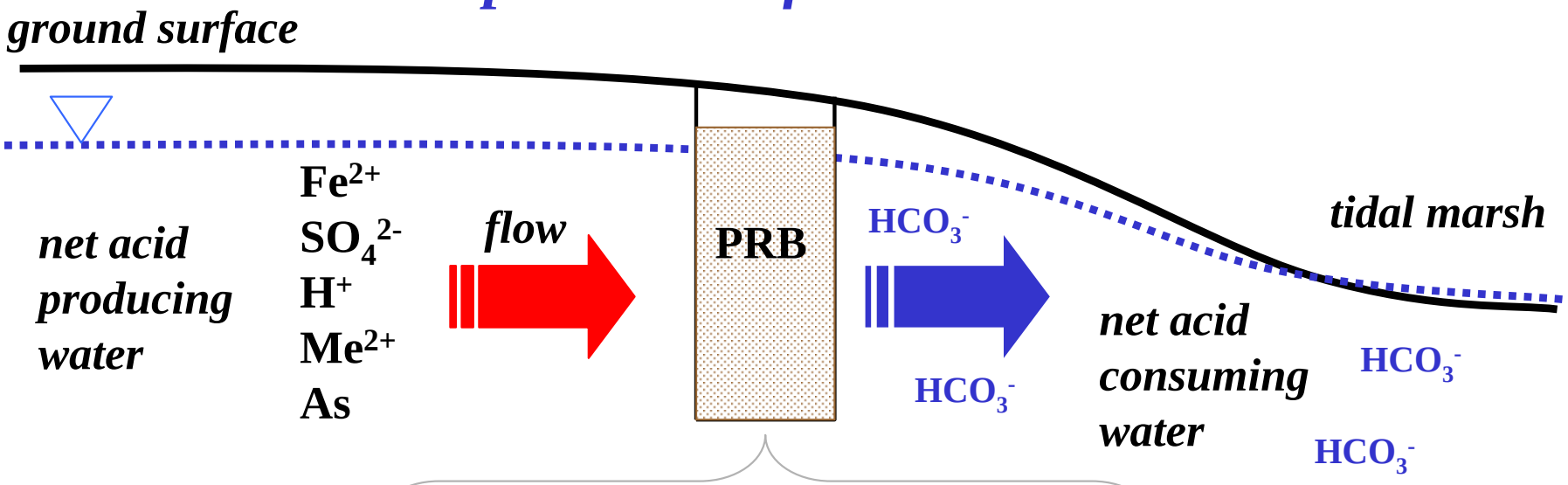
- Site impacted by former phosphate fertilizer manufacturing operations
- Pyrite and elemental sulfur used in production of sulfuric acid
- Sulfuric acid stored in Pb-lined concrete vats
- Site extensively filled with operational materials and debris
- Ground water impacted by heavy metals (Pb, Cd), arsenic, and low pH

Current Scenario



PRB Treatment Objective

promote sulfate reduction



$$SO_4^{2-} + 2CH_2O \longrightarrow H_2S + 2HCO_3^-$$

$$Me^{2+} + HS^- \longrightarrow MeS + H^+$$

$$Fe^{2+} + HS^- \longrightarrow FeS + H^+$$

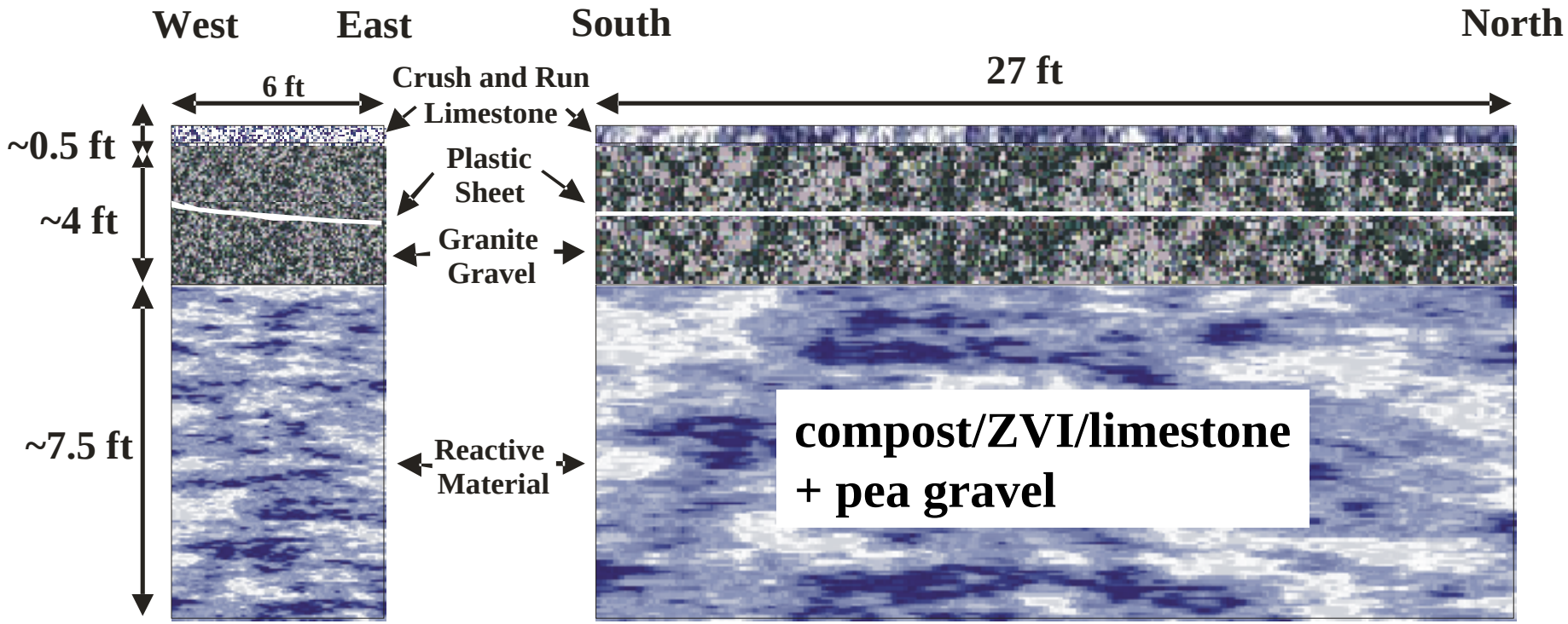
PRB Treatment Objectives

- Raise pH of ground water
- Promote sulfate reduction to remove heavy metals, arsenic, and ferrous iron
- Prevent additional down-gradient ecosystem impacts by preventing acid production associated with ferrous iron oxidation
- Contribute to ecosystem restoration by converting ground water from acid producing to acid consuming system (i.e. generate an alkalinity plume)

PRB Design Tests/Studies

- Laboratory column tests
  - Focused on optimizing reactivity and hydraulic conductivity
  - Mixture of 30% compost, 20% ZVI, 5% limestone and 45% pea gravel selected
- Permeameter tests
  - Three samples from final mixture tested for permeability to ensure permeability greater than that of aquifer
  - Result of permeability testing: K = 6.7E-02 cm/s

Vertical X-Section of Pilot PRB




compost

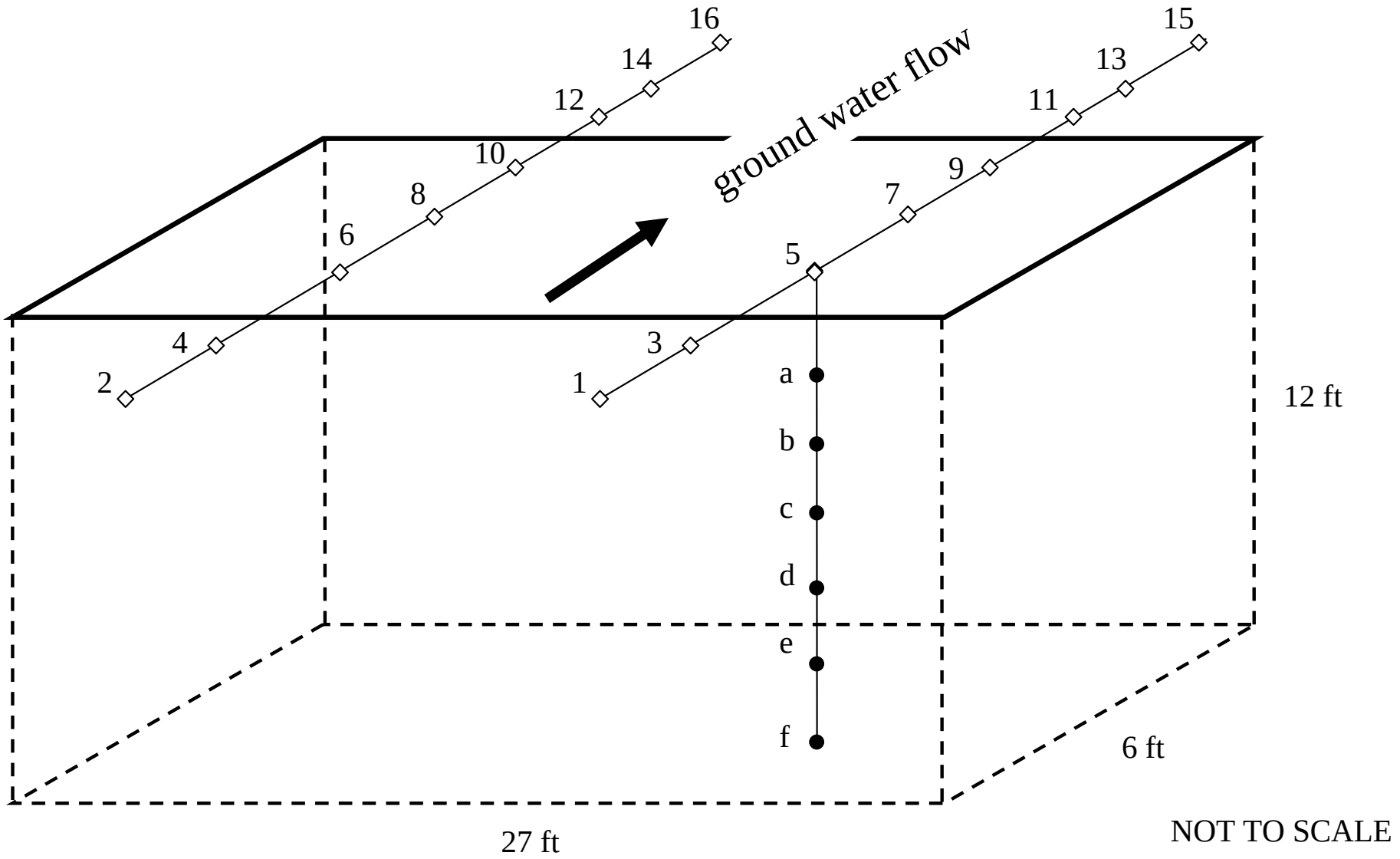

624H


KOBELCO


624H


KOBELCO

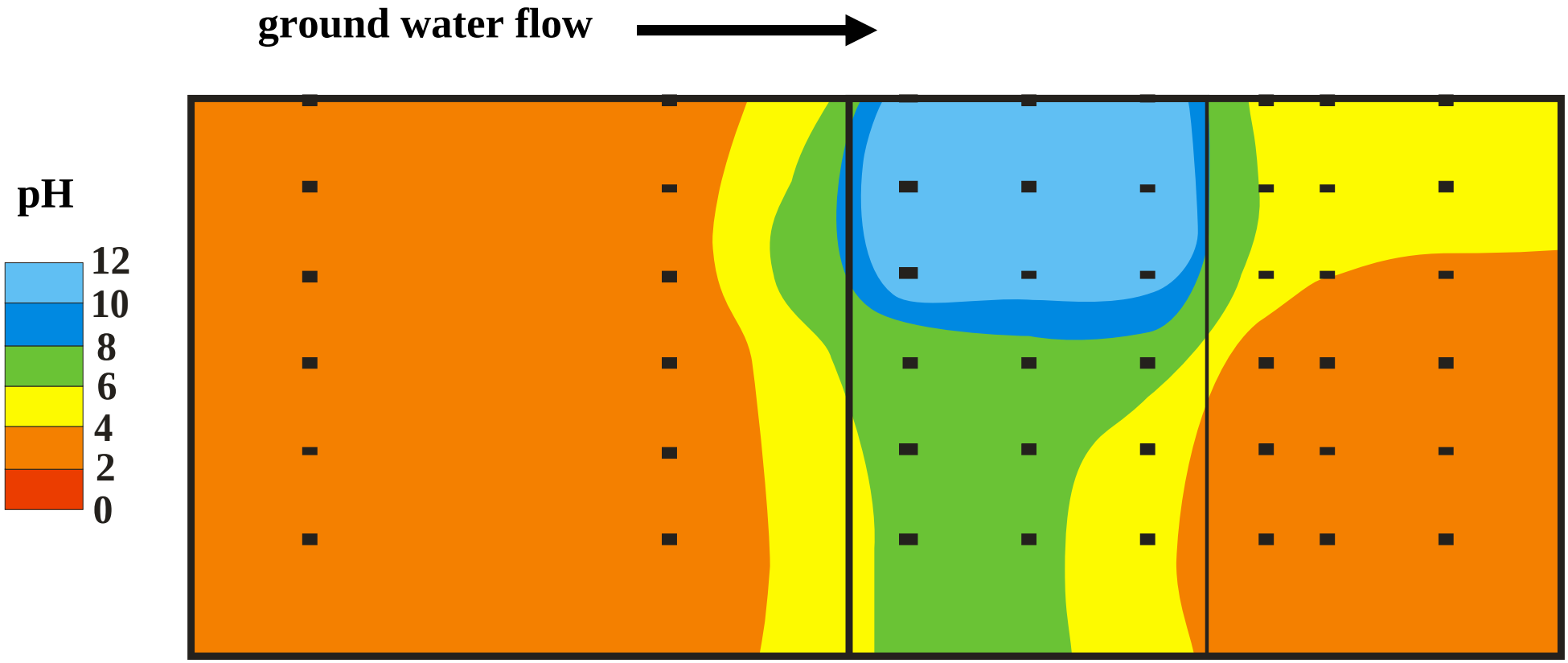
Multi-Level Monitoring System Layout



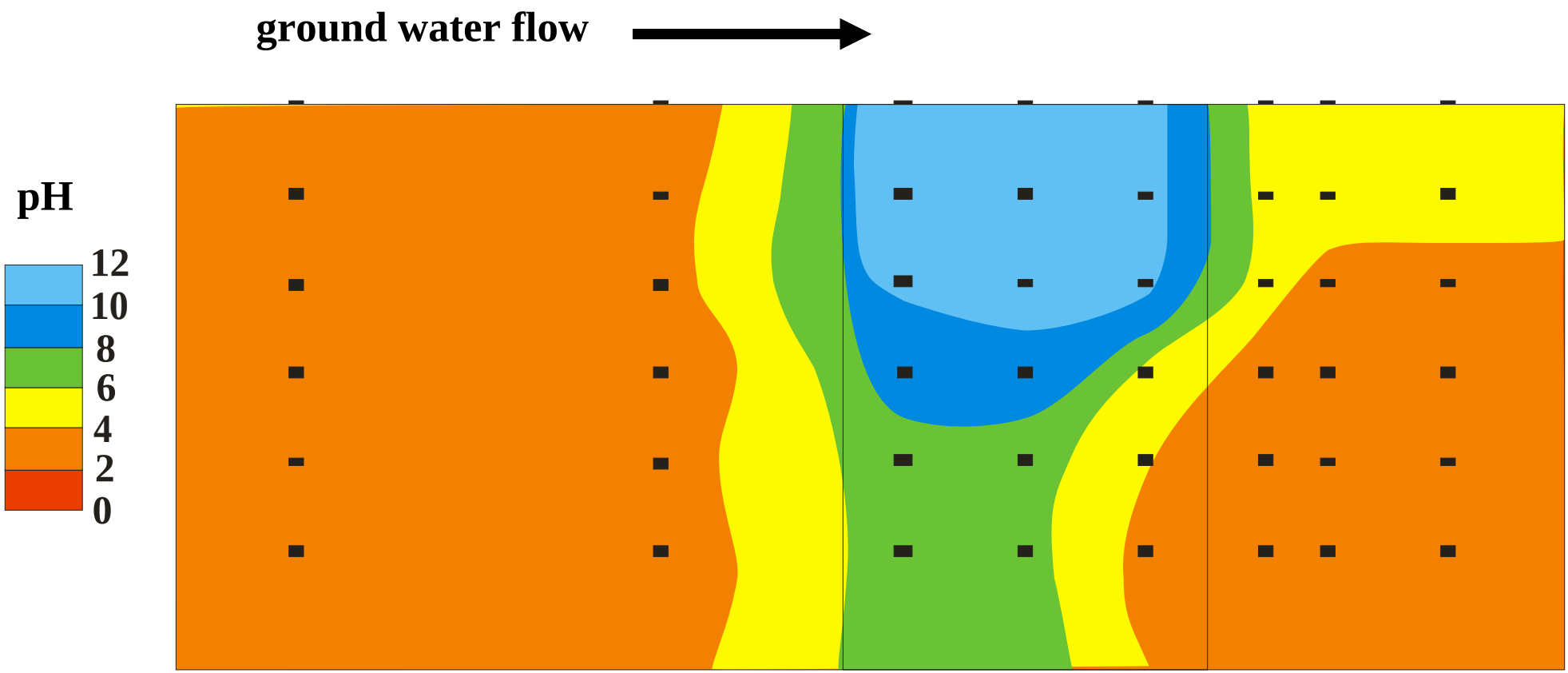
Performance Monitoring

- Chemical monitoring conducted 1, 3, 8, 13, and 18 months after installation
- Chemical parameters evaluated: Pb, As, Cd, Fe, pH, Eh, alkalinity, cations, anions, TOC/DOC, sulfide
- Microbial parameters: MPN sulfate reducers
- Hydraulic monitoring – slug tests

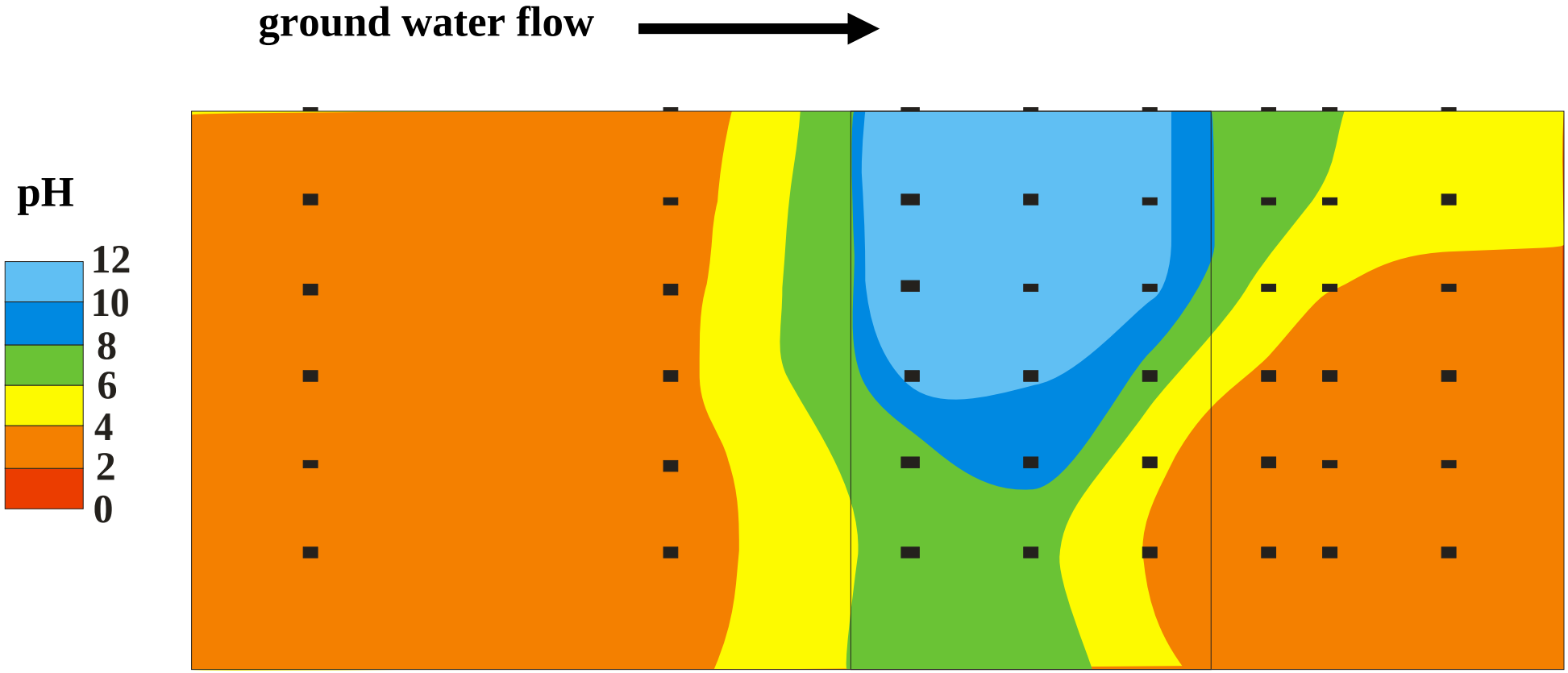
pH profile – 8 months



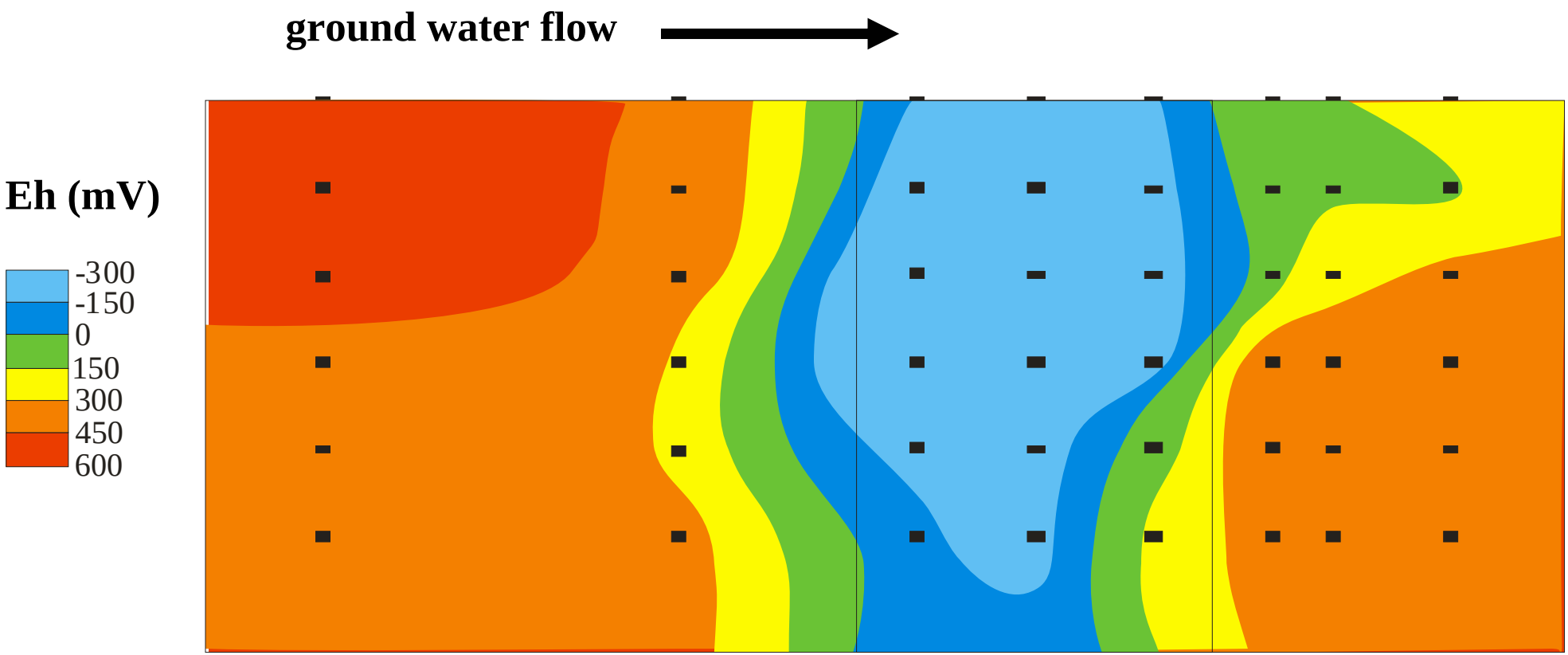
pH profile – 13 months



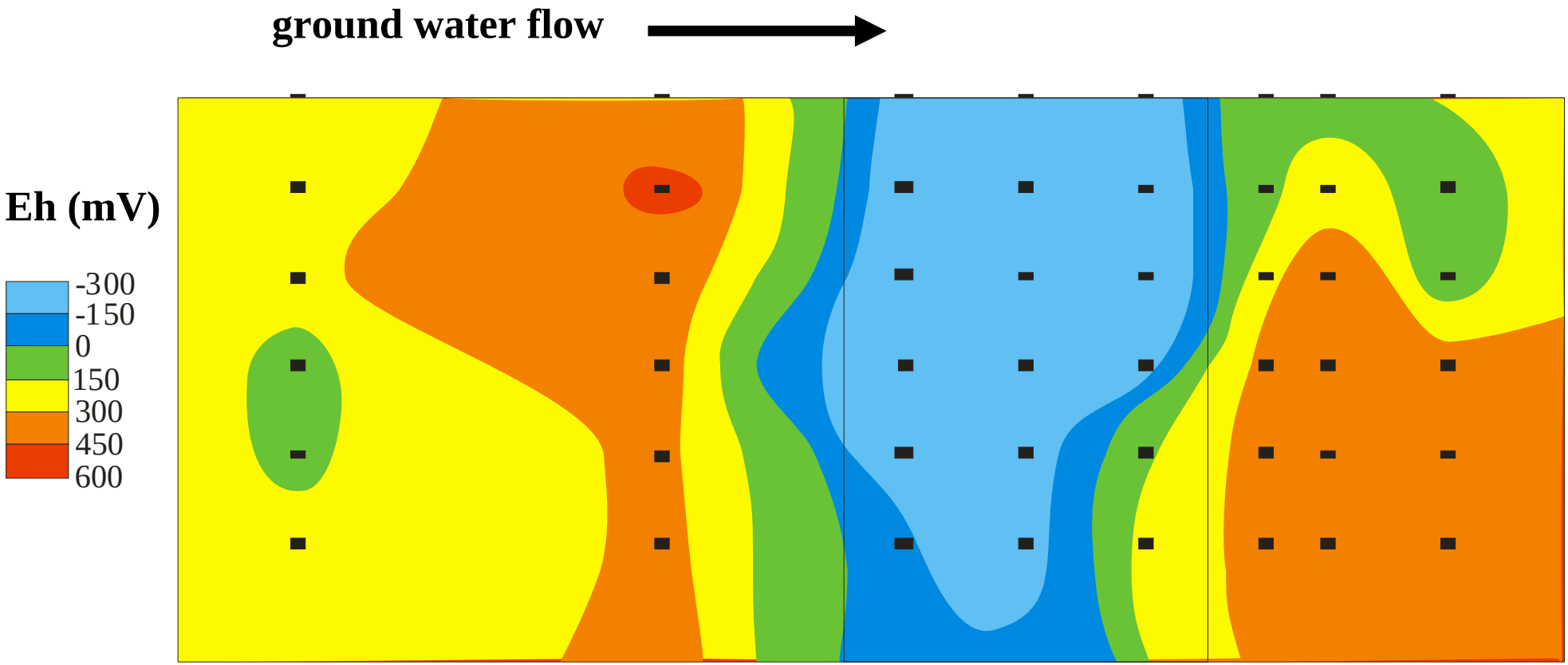
pH profile – 18 months



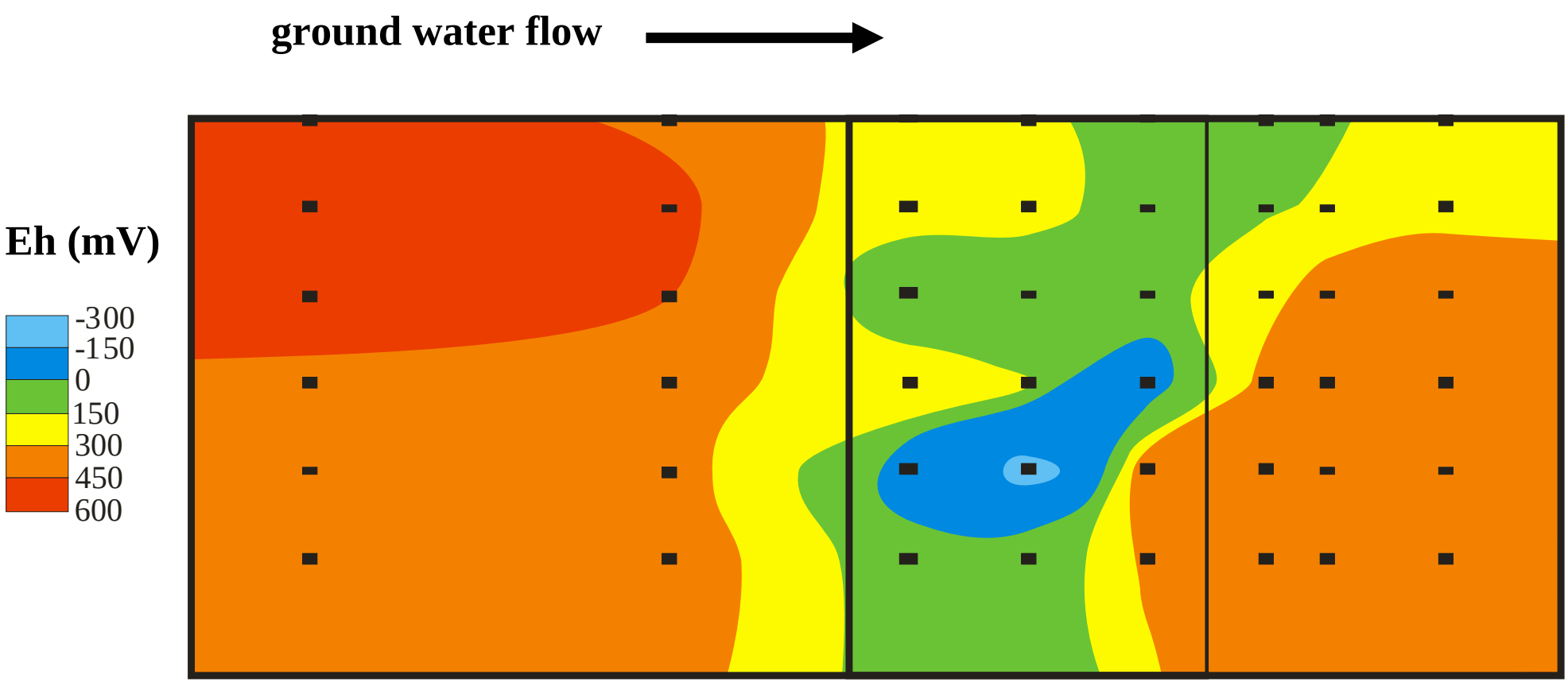
Eh profile – 8 months



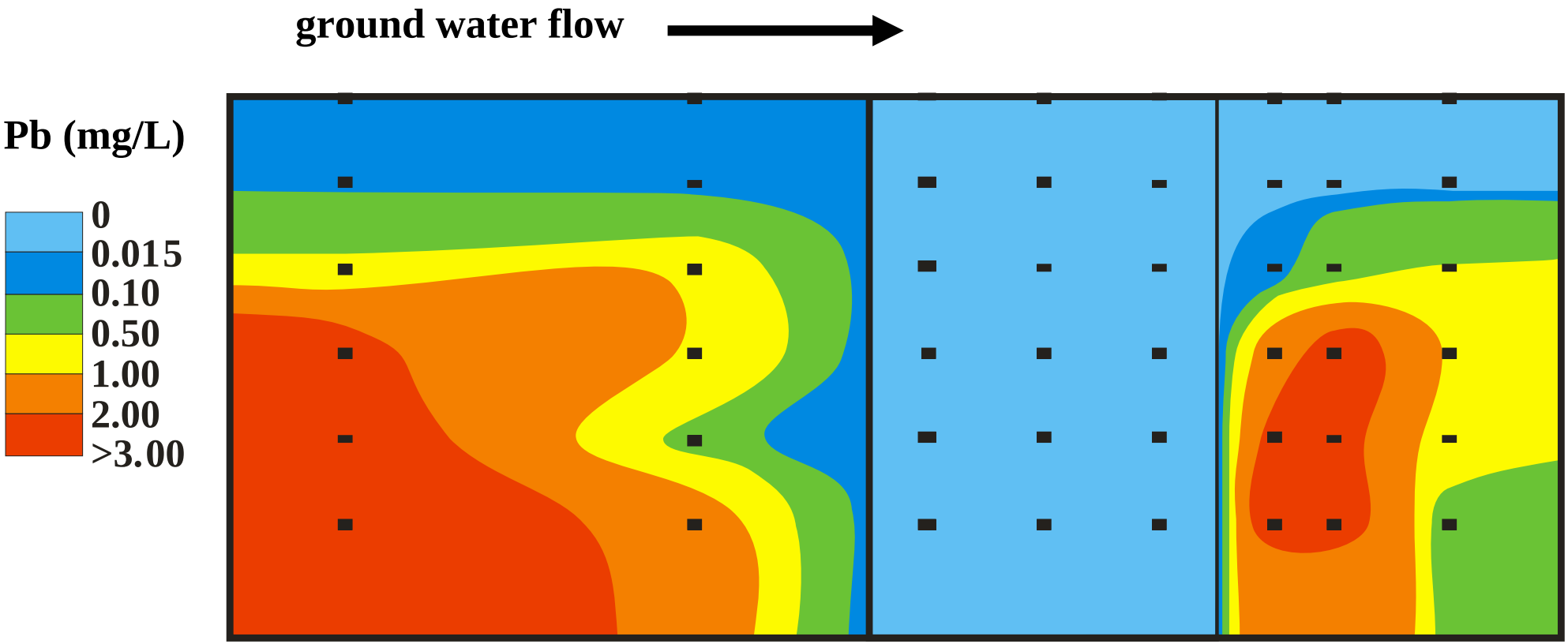
Eh profile – 13 months



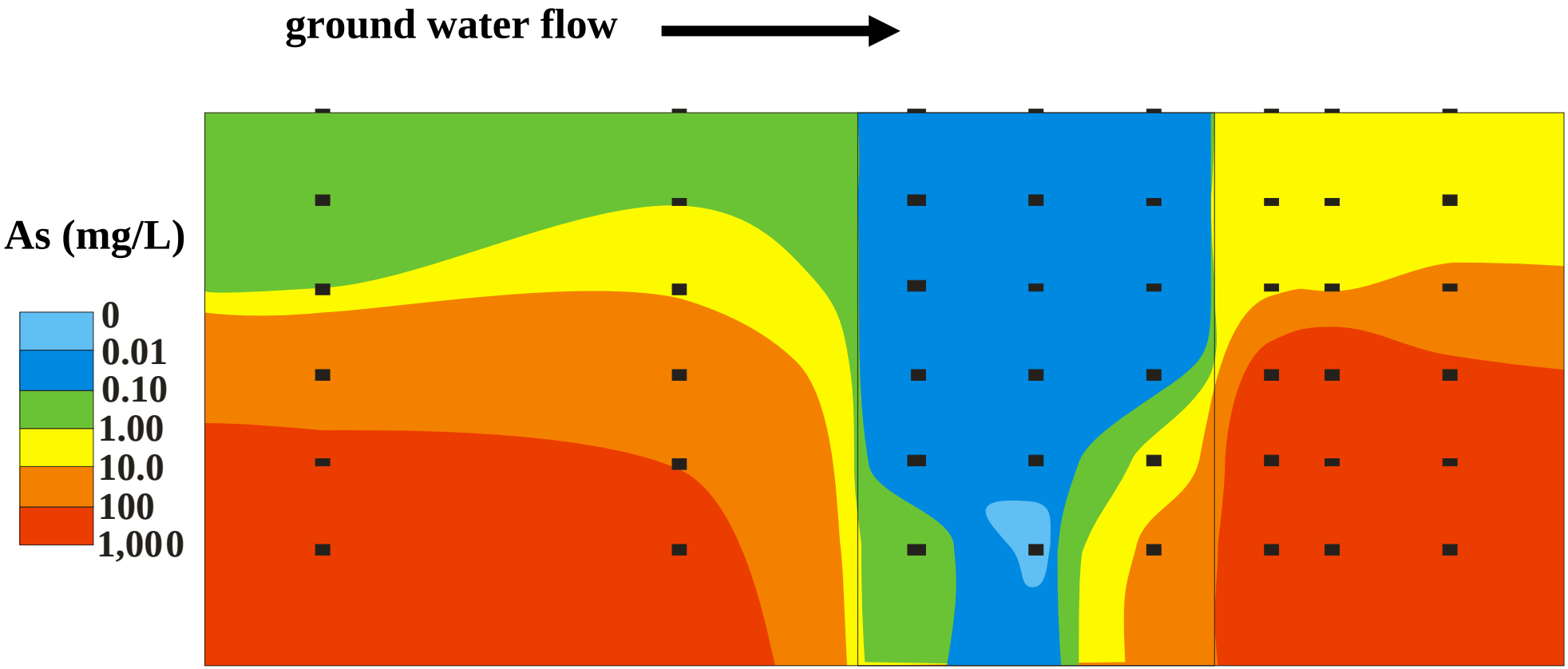
Eh profile – 18 months



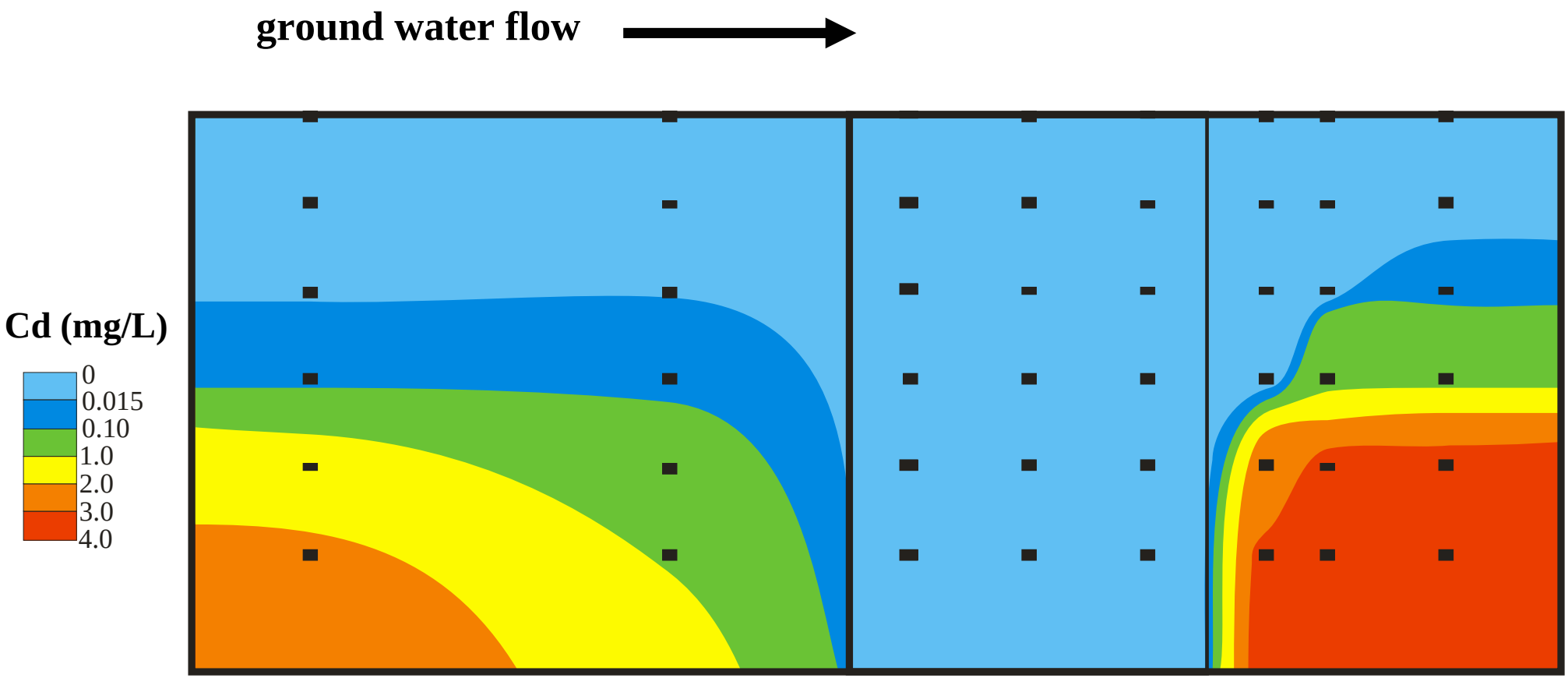
Pb concentration profile – 18 months



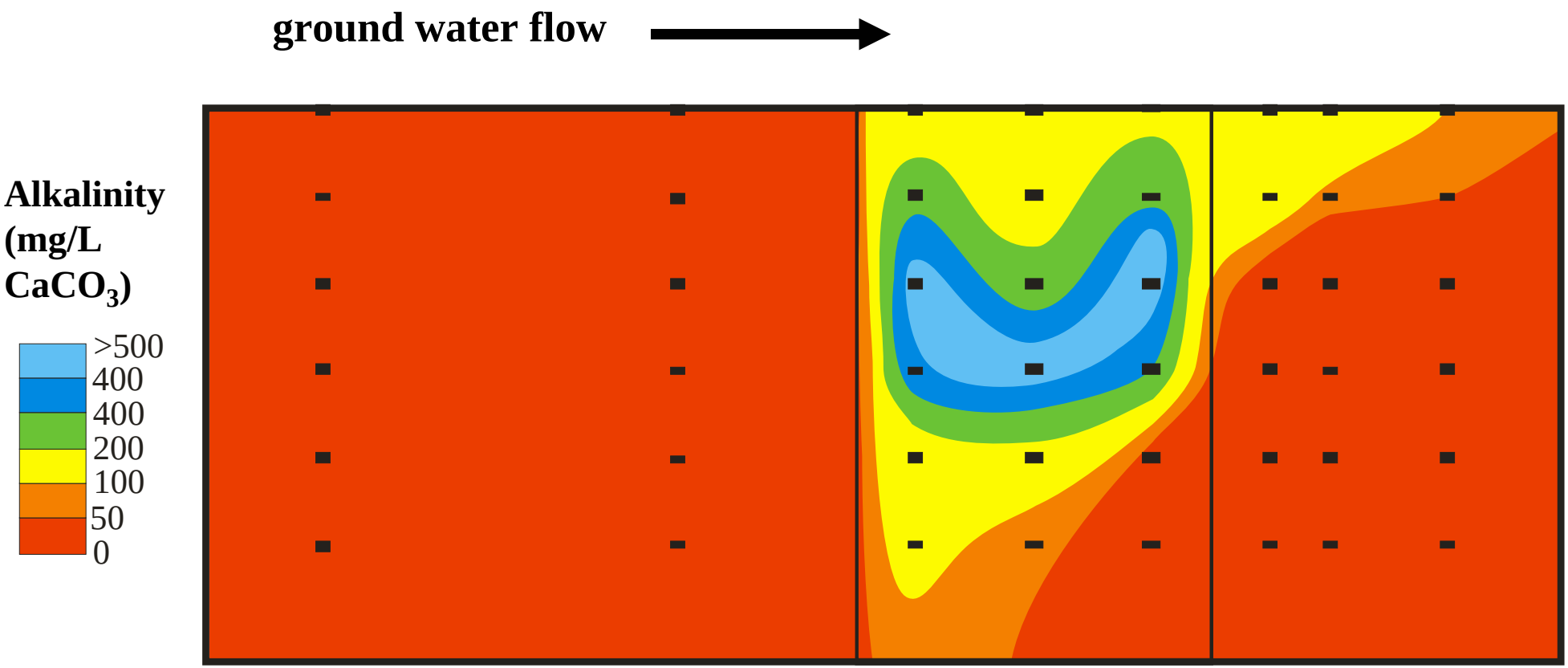
As concentration profile – 18 months



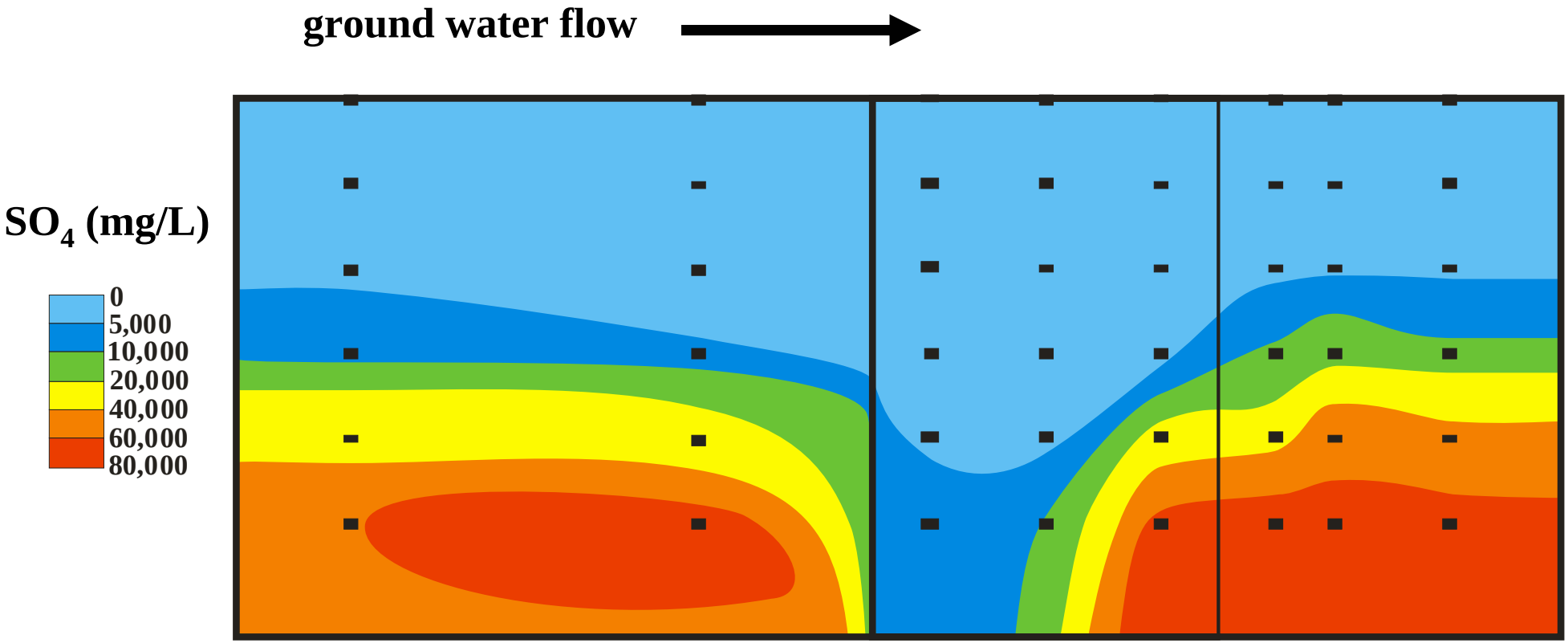
Cd Profile – 18 months



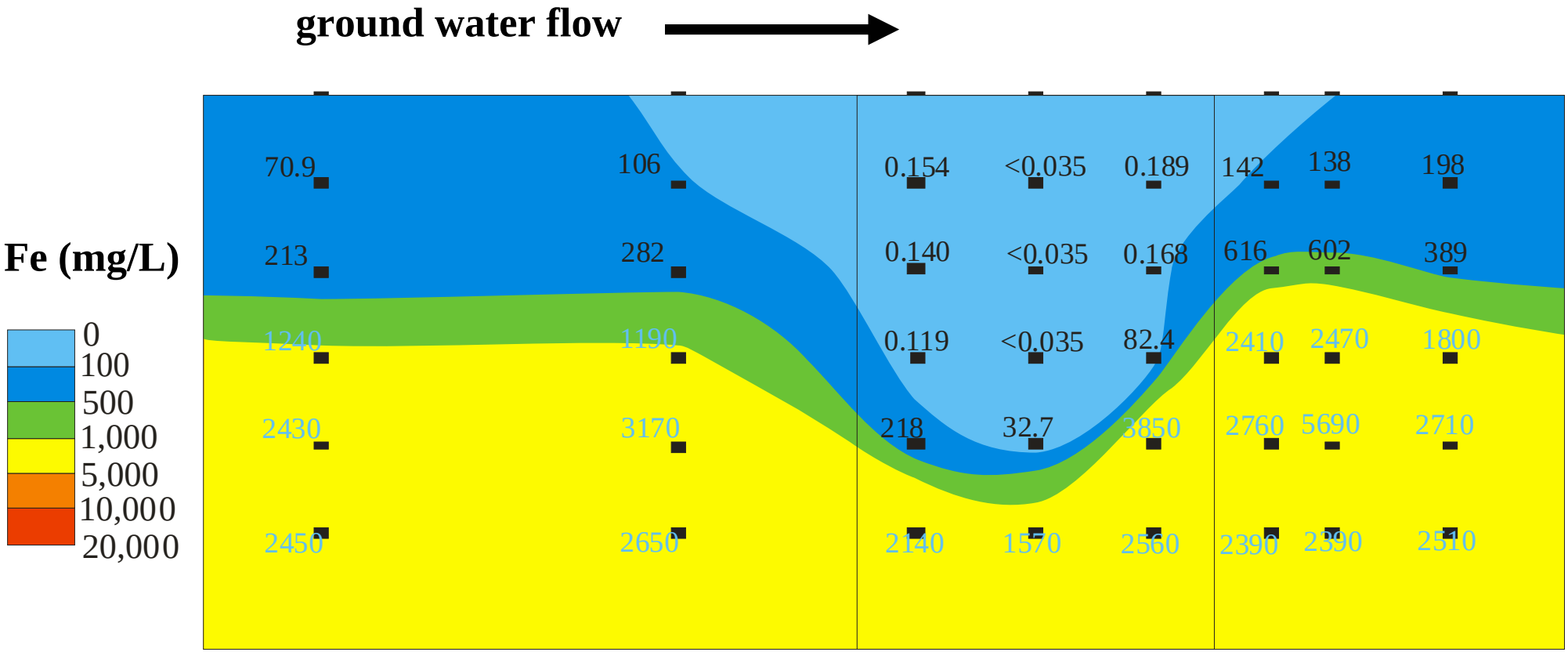
Alkalinity profile – 18 months



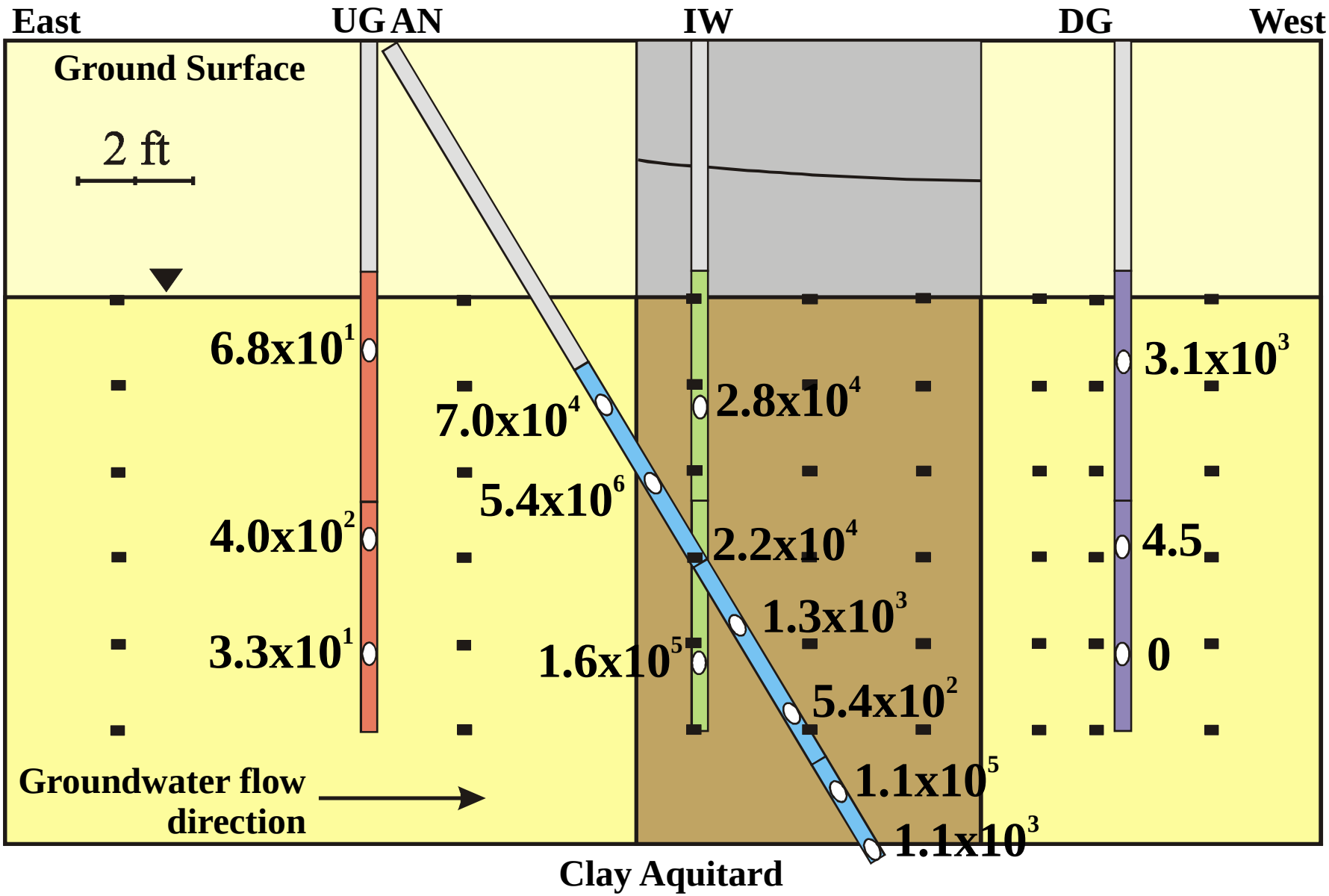
Sulfate profile – 18 months



Iron profile – 18 months

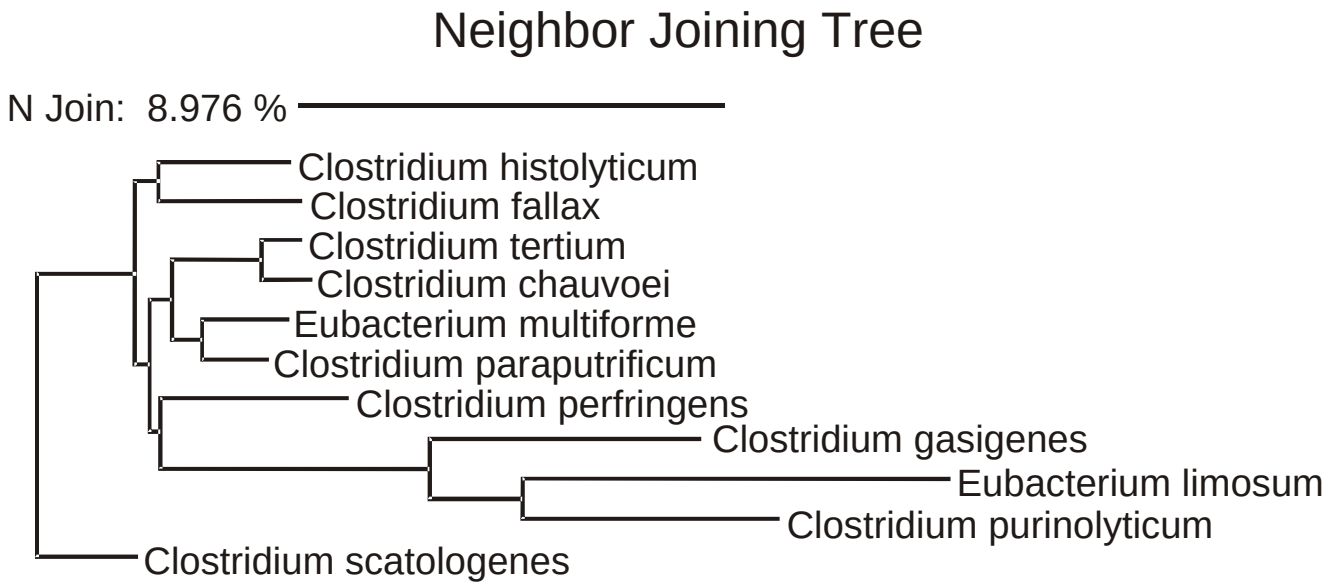


Sulfate reducers (MPN)



Phylogenetic Tree Display

Alignment:
13.55 % 502 Clostridium tertium
14.34 % 502 Clostridium chauvoei
14.74 % 502 Eubacterium multiforme
14.75 % 517 Eubacterium limosum
14.84 % 516 Clostridium purinolyticum
15.00 % 500 Clostridium paraputrificum
15.54 % 502 Clostridium histolyticum
15.54 % 502 Clostridium fallax
15.74 % 502 Clostridium perfringens
16.20 % 500 Clostridium scatologenes



Summary

- 18-month data indicates effective removal of Pb, Cd, and As to date
- pH of influent ground water is increased from < 4 to > 6
- Ground water is converted from acid producing potential to acid consuming potential
- Sulfate reducers are present in PRB in significant numbers
- ^{34}S enrichment being observed in PRB ground water

Issues

- Hydraulics through PRB not yet fully resolved
- Ground water flow through much of site is very slow
- Upper part of aquifer appears to exhibit higher hydraulic conductivity than PRB

Future Work

- Continue semi-annual monitoring to assess performance and longevity of PRB
- Conduct tracer test to better evaluate hydraulics through PRB
- Evaluate solid phase chemistry within PRB
- Refine design of PRB for potential full-scale implementation