GROUND EFFECTS
ENVIRONMENTAL SERVICES INC.

Oxidant Dispersal in Tight Clay Formations using EK3 Technology

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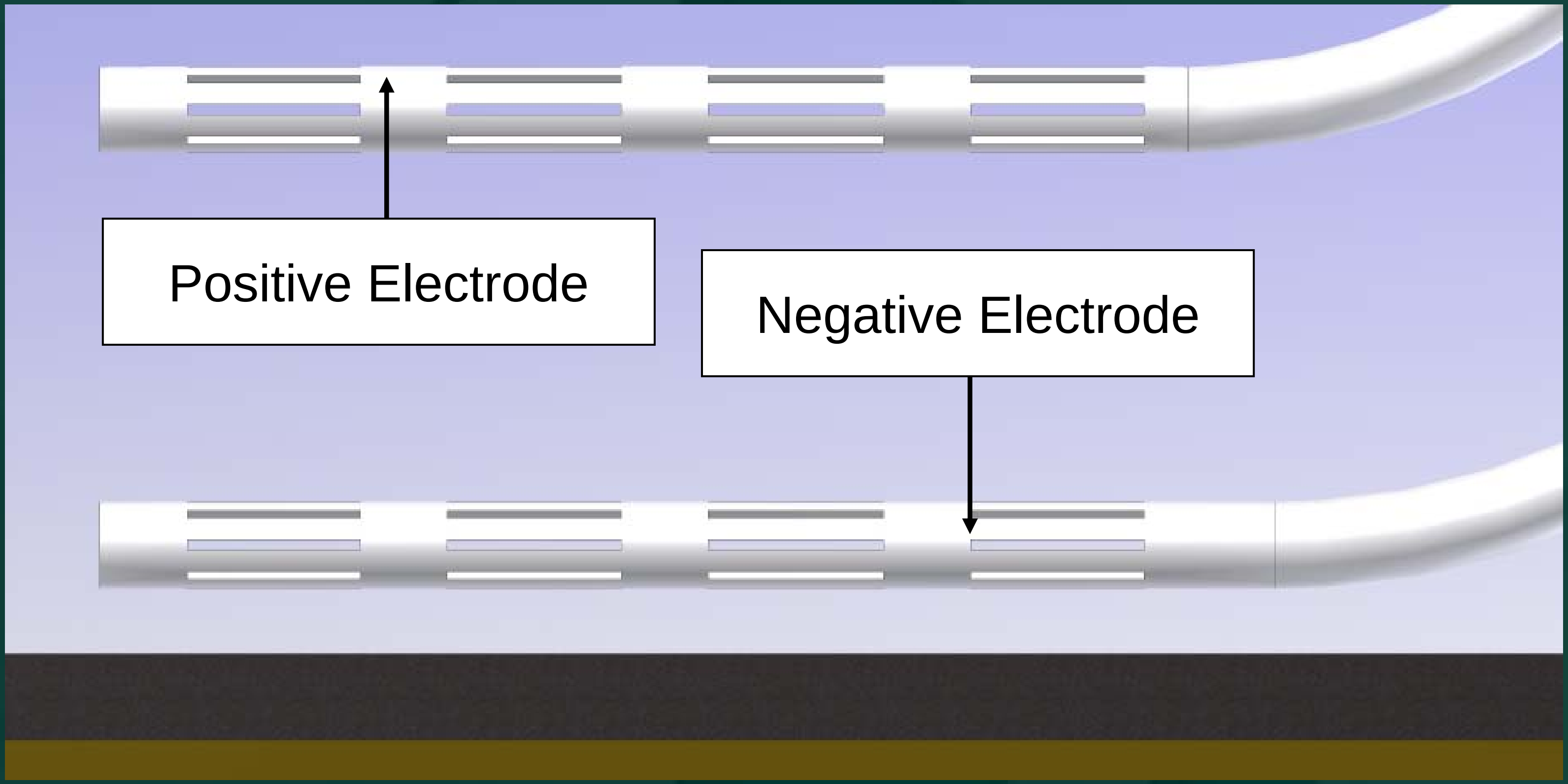
RemTech 2010

HOW EK3 WORKS

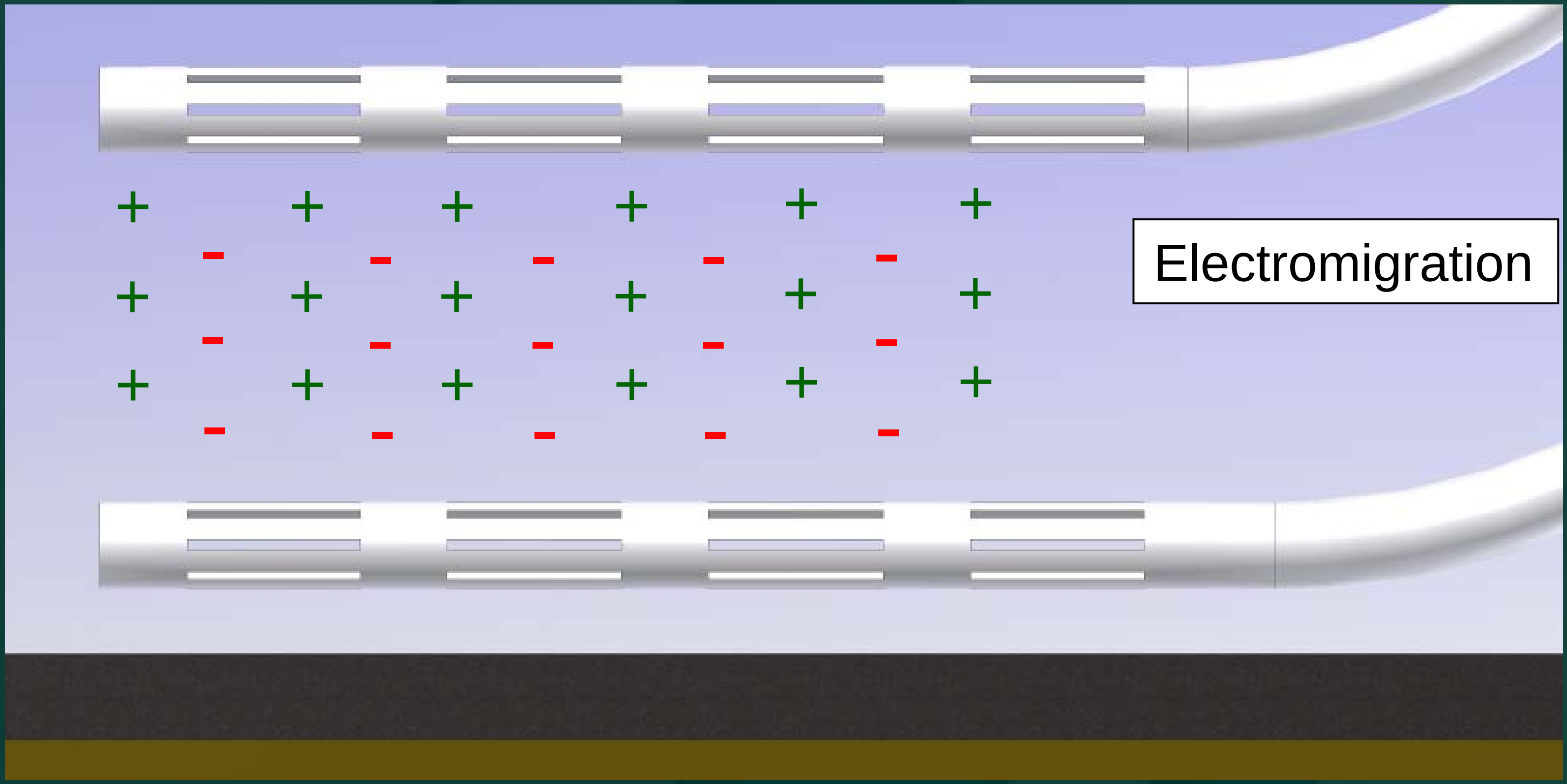


ELECTROKINETIC PHENOMENA

Electromigration

Involves movement of ions towards their respective electrodes, creating a basic plume at the cathode and an acidic plume at the anode.

ELECTROKINETIC PHENOMENA

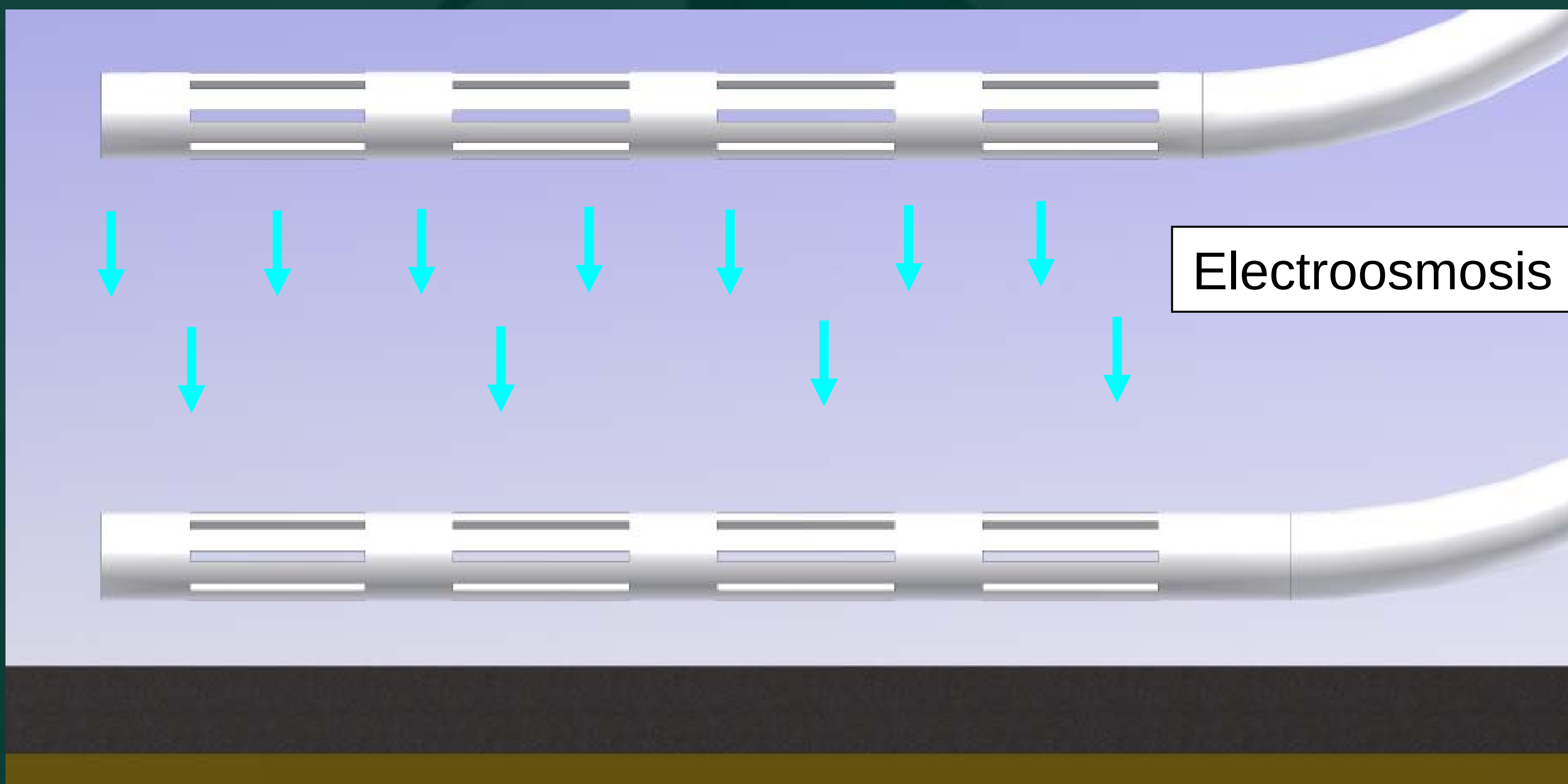


ELECTROKINETIC PHENOMENA

Electroosmosis

Uniform movement of water from anode to cathode. Clay typically has a negative surface charge meaning more cations than anions in the pore water. The extra cations, lined up along the pore walls and moving toward the cathode, drag the pore water along causing a net pore water flow to the cathode.

ELECTROKINETIC PHENOMENA



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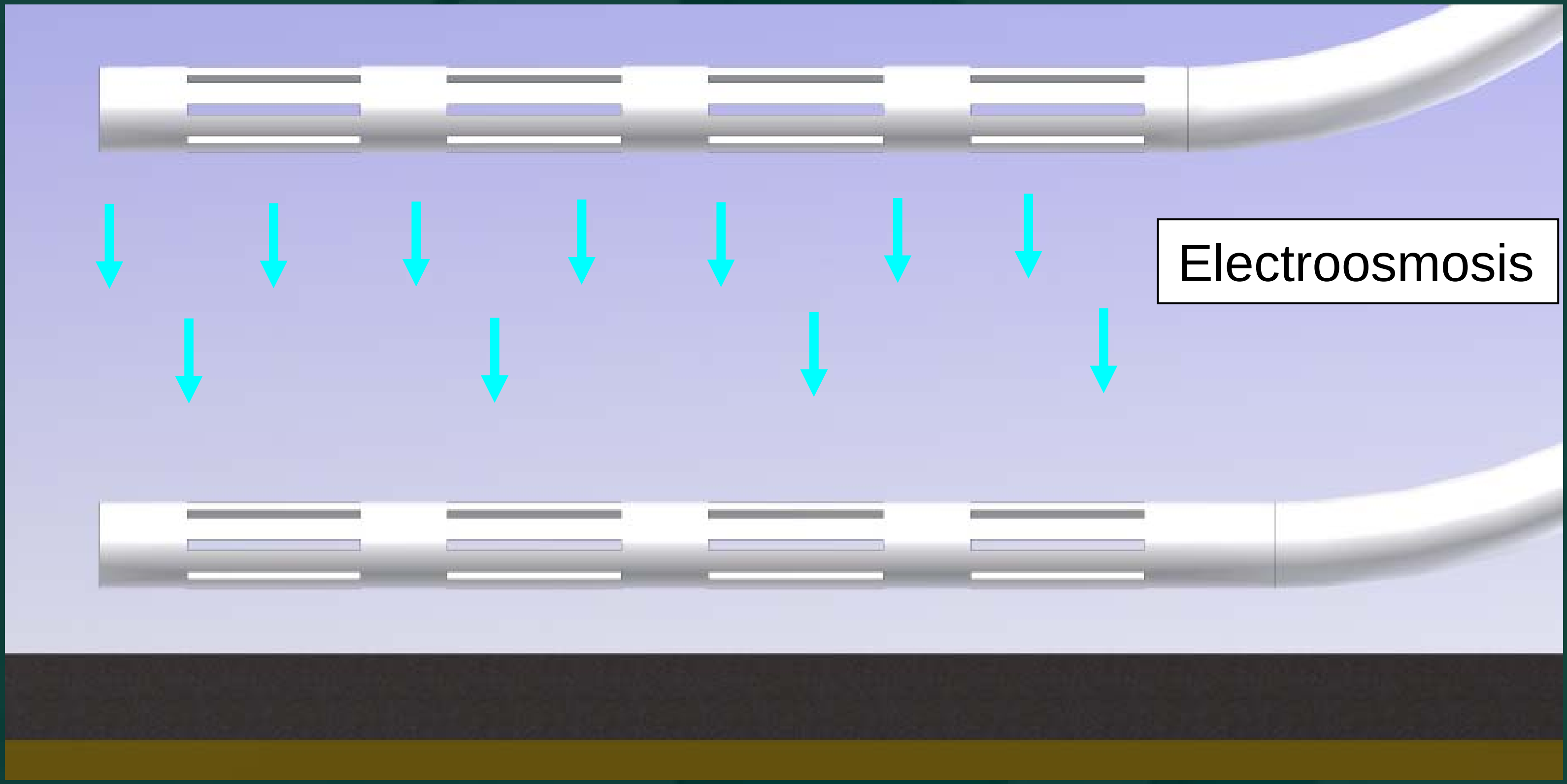

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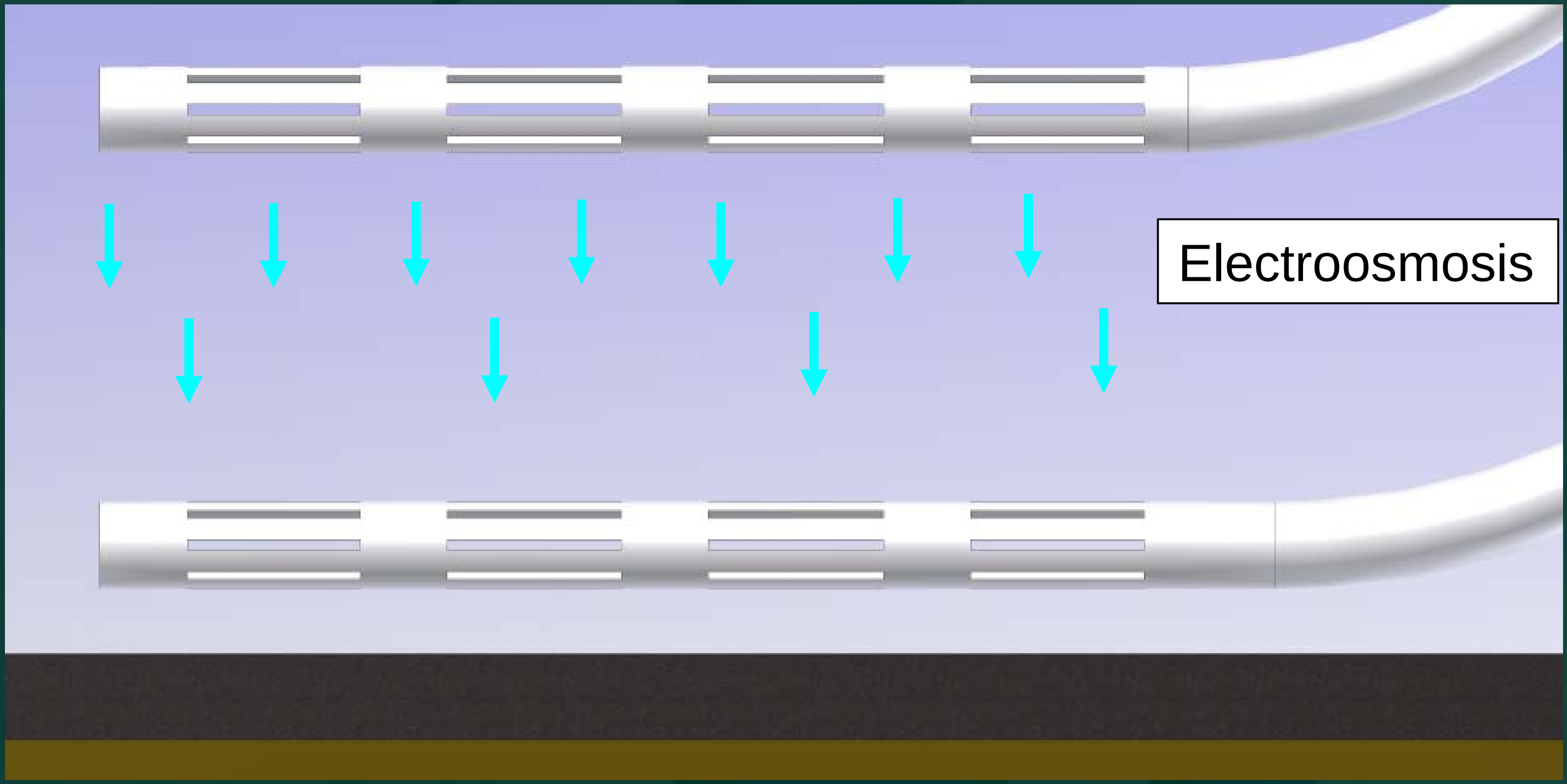
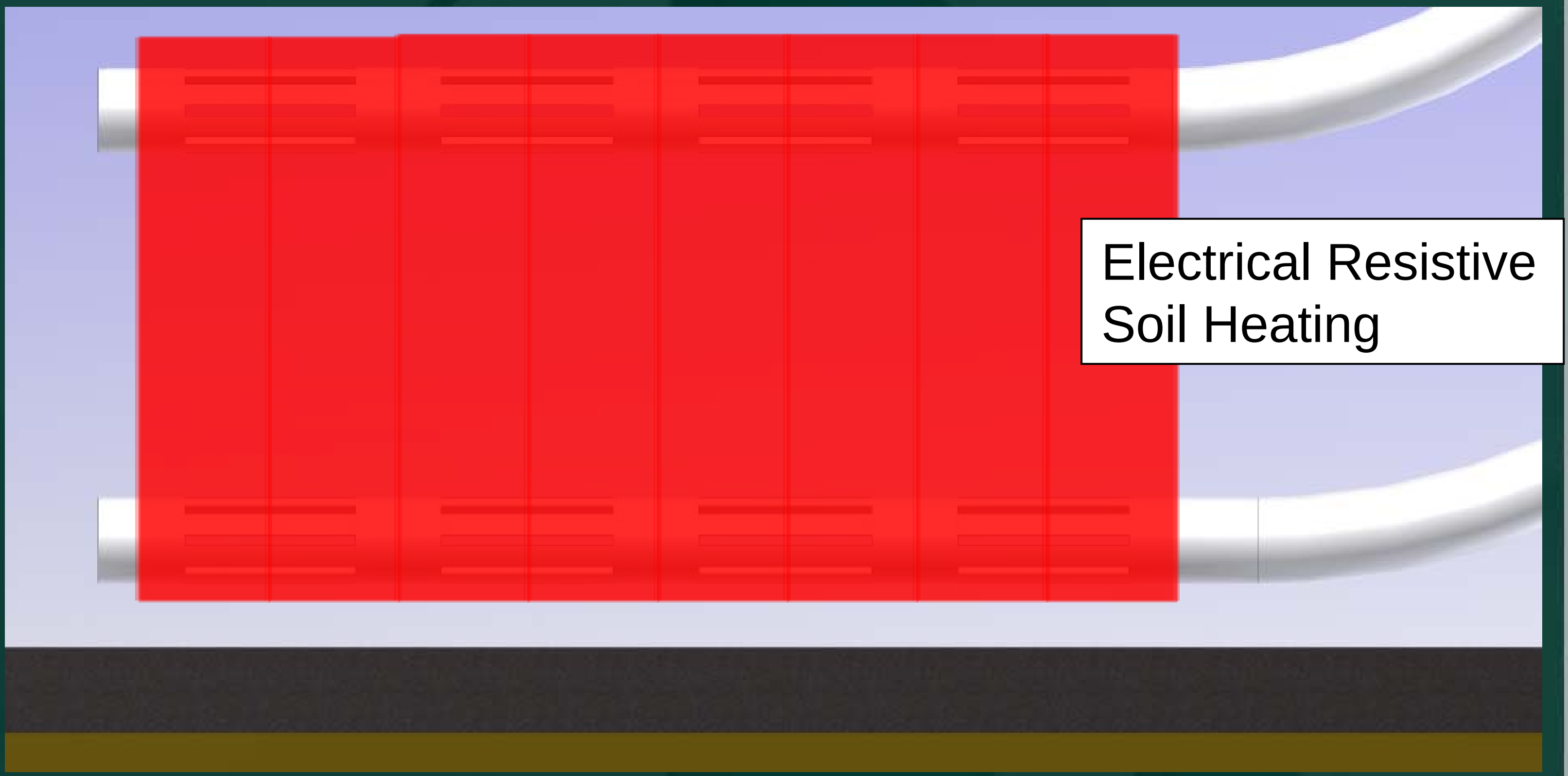


ELECTROKINETIC PHENOMENA

Electrical Resistive Heating

Increases formation temperature to lower hydrocarbon viscosity

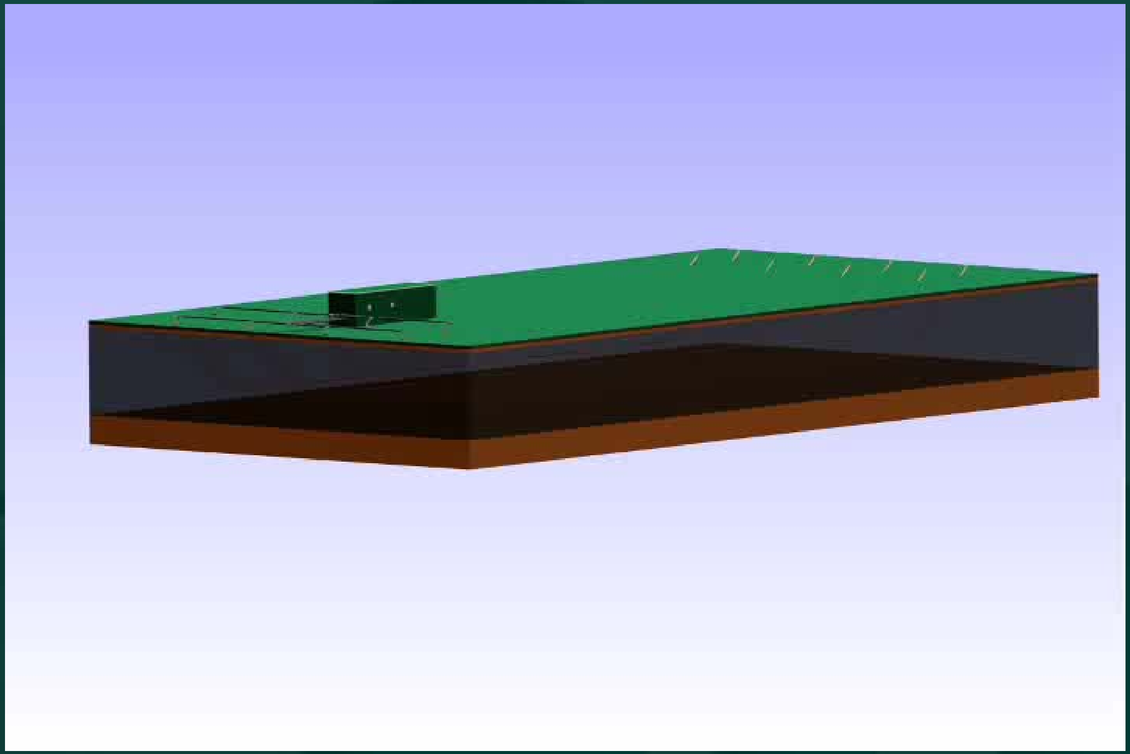
ELECTROKINETIC PHENOMENA



EK3 – Interfacial Tension

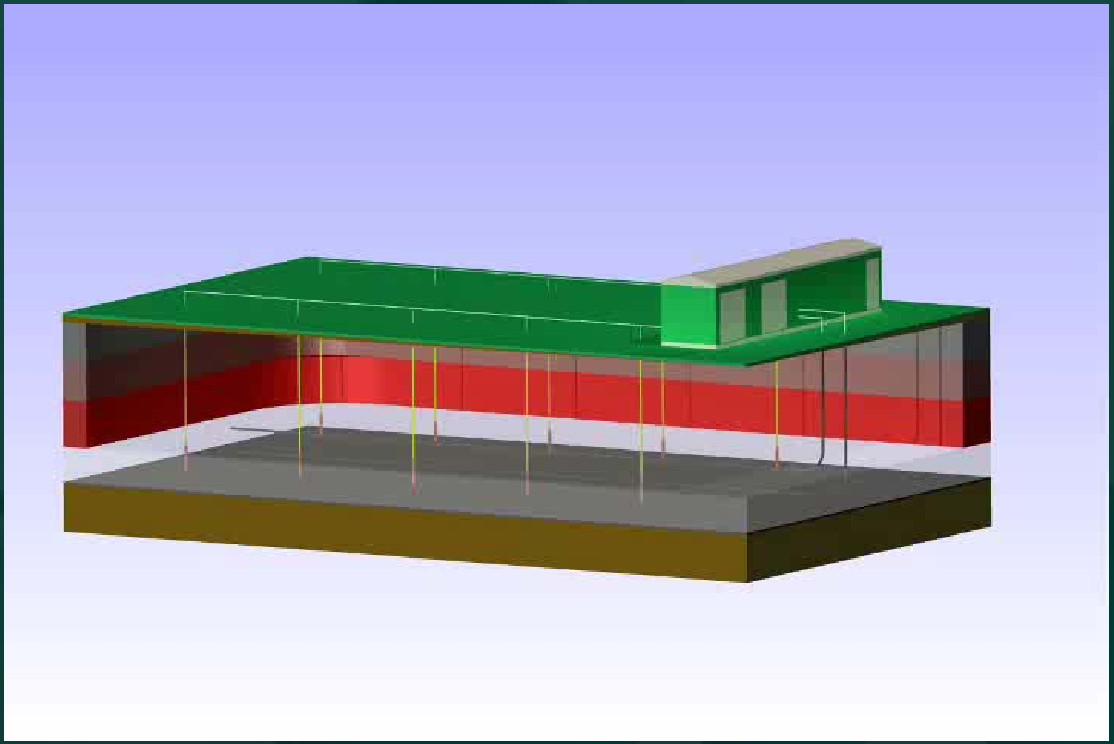
The DC electric field reduces the interfacial tension, which aids in desorption of the hydrocarbons from the soil matrix.

EK3 – Electrode Configuration



Depending on the nature of the contamination plume, EK3 electrodes may be configured horizontally, as depicted here, or…

EK3 – Electrode Configuration



…a combination of vertical and horizontal electrodes may be necessary to achieve desired results.

GEE Satellite Telemetry

EK3 Equipment

EK3 Equipment

EK3 Equipment

EK3 Equipment

Current Technology

Insitu injection techniques rely on physical contact with contaminants.

Difficult to accomplish even distribution in fine grained soil, even with fracturing.

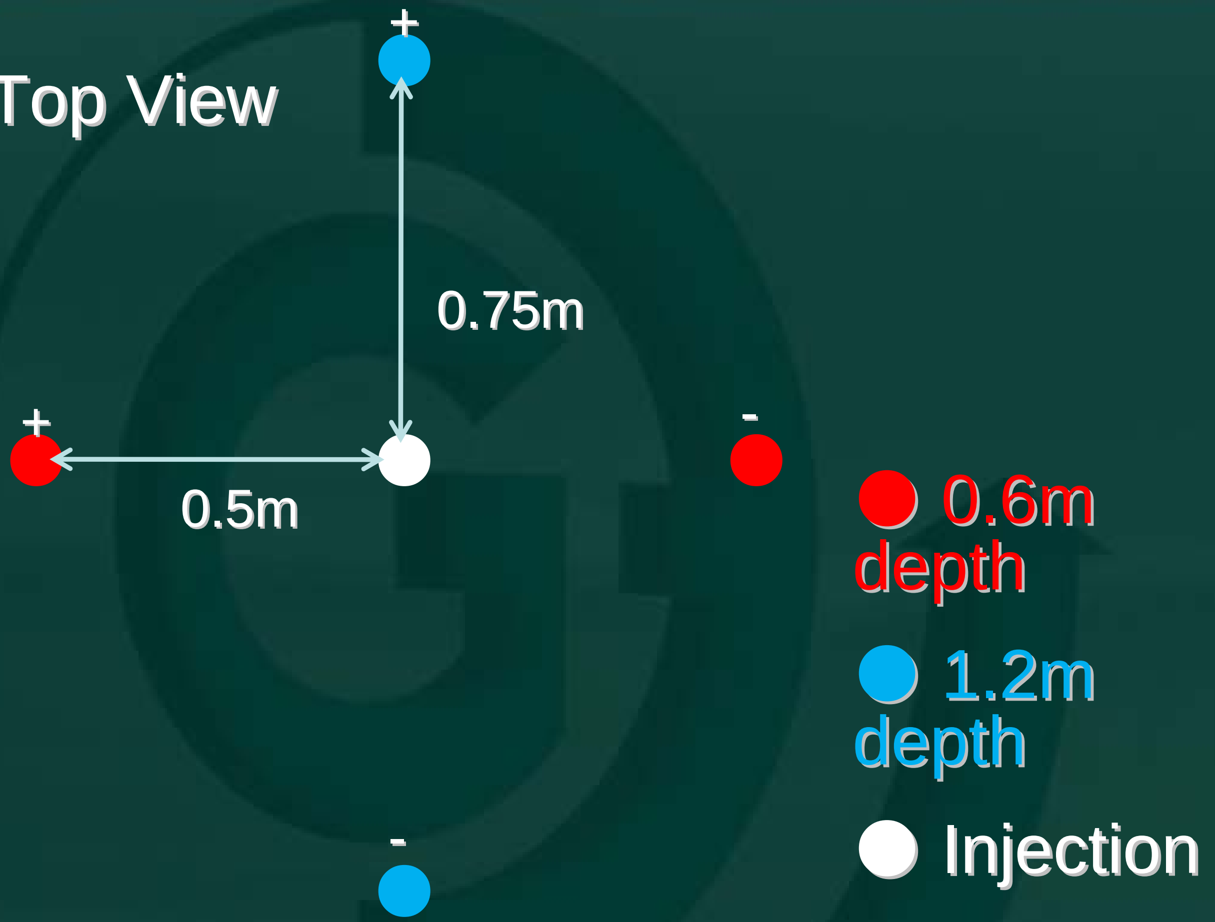
Oxidation Pilot with EK3

Goal:

To accomplish a uniform and efficient dispersal of oxidants across a contaminated section of fine grained soil.

Oxidation Pilot with EK3

Test 1 – Top View



Oxidation Pilot with EK3

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Test 1 - Part A: Water

Movement of water from anode to cathode in less than 4 hours.

Conclusion

Water can be moved efficiently through fine grained soil via electrokinetics.

Oxidation Pilot with EK3

Test 1 - Part B: Potassium Permanganate

Tested solution of potassium permanganate ($KMnO_4$).

Time (hrs)	Cathode	Conductivity
0	0 mg/l	1551 µS/cm
6	290 mg/l	10233 µS/cm
12	360 mg/l	15964 µS/cm
24	500 mg/l	17320 µS/cm

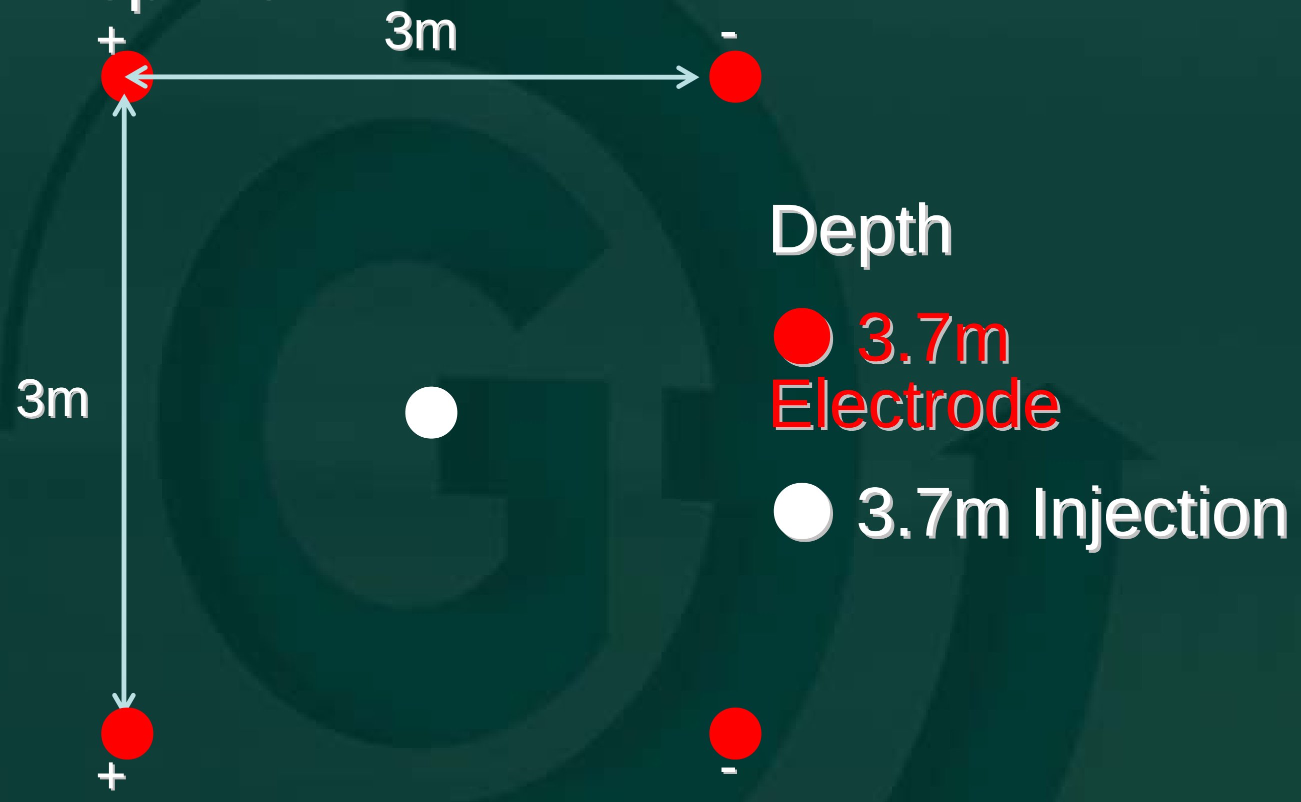
Test 1 - Part B: Potassium Permanganate

Conclusion

Potassium permanganate can be effectively moved in less than 6 hours through fine grained soils.

Oxidation Pilot with EK3

Test 2 – Top View



Oxidation Pilot with EK3

Oxidation Pilot with EK3

Test 2 - Part A: Klosur Persulfate

Injection of 20% solution of activated Klosur persulfate under atmospheric pressure.

Time (hrs)	Conductivity
0	1447 μS/cm
8	19889 μS/cm
24	26644 μS/cm
48	30641 μS/cm
56	31069 μS/cm

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Test 2 - Part A: Klosur Persulfate

Conclusion

Movement of Klosur persulfate horizontally across 3m of clay in less than 8 hours.

Oxidation Pilot with EK3

Test 2 - Part B: Klosur Persulfate under pressure

Injection of 20% solution of activated Klosur persulfate under 80 psi and flooded anodes.

Time (hrs)	Cathode A	Cathode B
0	1447 µS/cm	1447 µS/cm
12	Liquid at surface but immeasurable	
24	12208 µS/cm	16836 µS/cm
40	21205 µS/cm	21387 µS/cm
48	22246 µS/cm	22579 µS/cm

Oxidation Pilot with EK3

Test 2 - Part B: Klosur Persulfate under pressure

Conclusion

Saw movement of Klosure persulfate, but no benefit of pressurized injection over elektrokinetics alone.

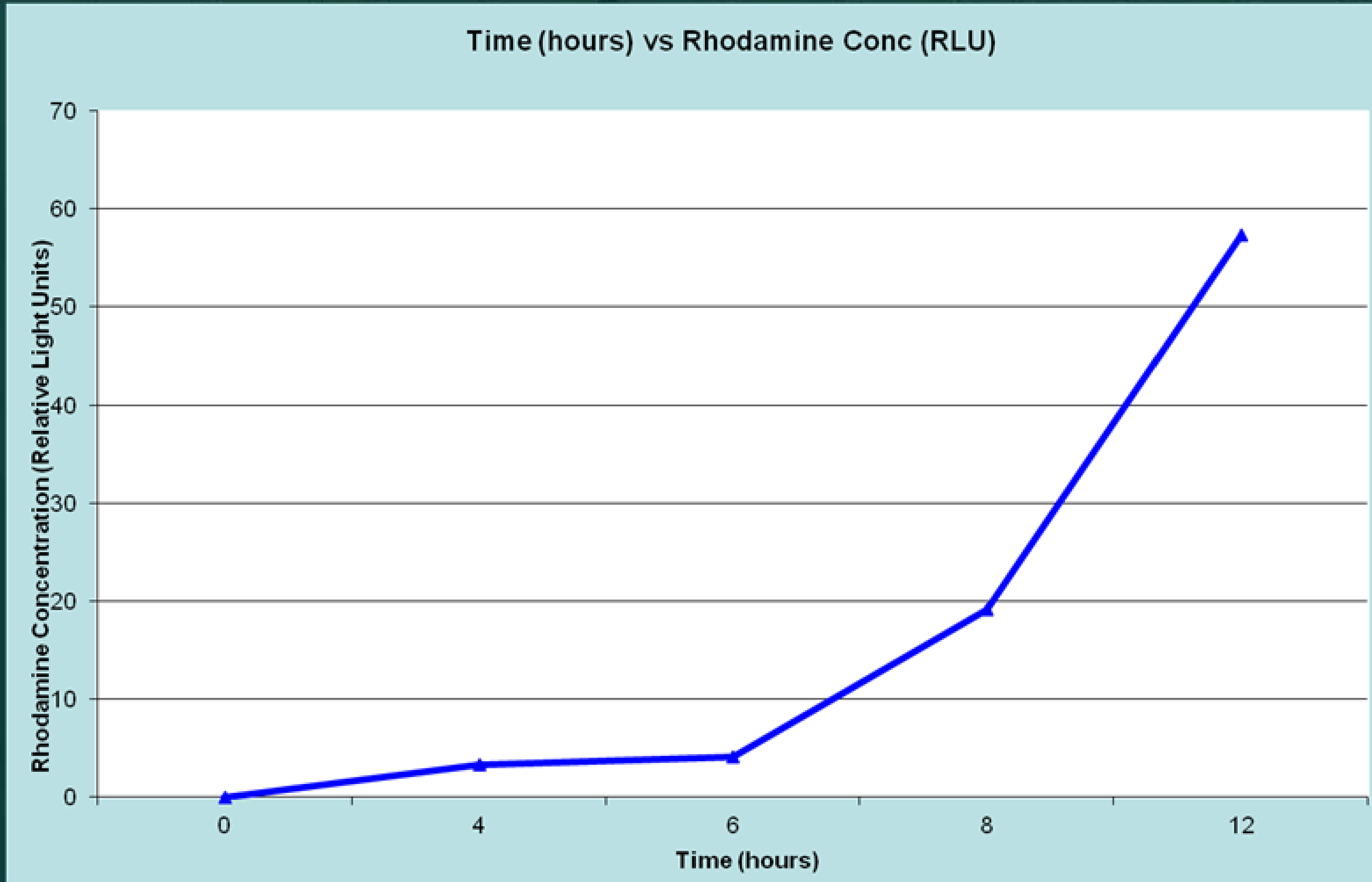
Oxidation Pilot with EK3

Test 2 – Part C: Rhodamine Test

Move rhodamine, an innocuous dye marker, through impervious soil (clay). 2.5% concentration injected into anode under atmospheric pressure, moved horizontally over 3m.

Time (hrs)	Concentration
0	0 Relative Light Units
4	3.302 RLU
6	4.140 RLU
8	19.143 RLU
12	57.313 RLU

Oxidation Pilot with EK3



Oxidation Pilot with EK3

Test 2 – Part C: Rhodamine Test

Conclusion

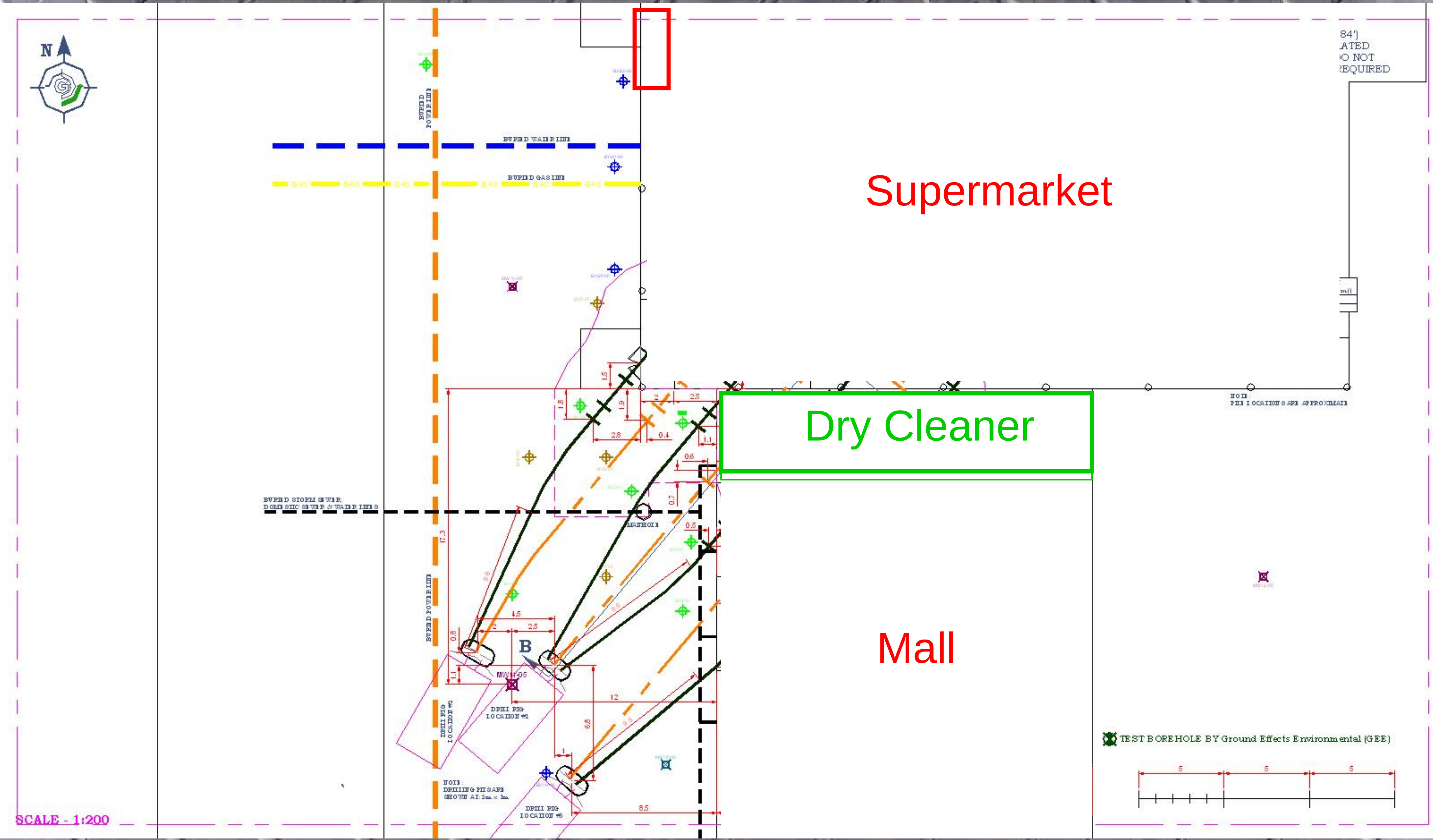
Ablity to move rhodamine horizontally through 3m of clay soil in 4 hours.

Oxidation Pilot with EK3

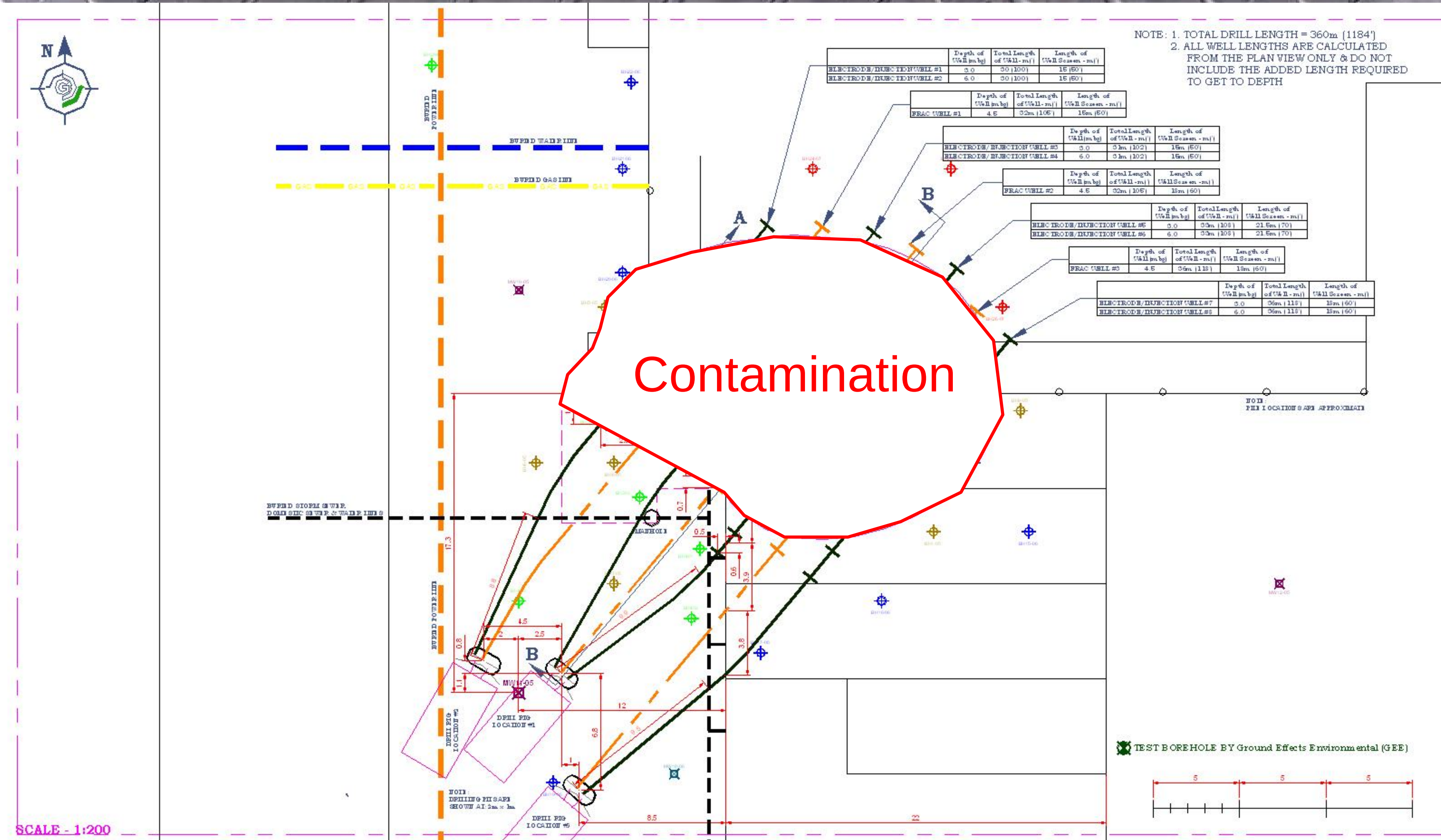
Full scale pilot

- Under former drycleaner and supermarket
- 8 x 35m horizontal anode/cathodes (4 pairs)
- 3 x 35m horizontal injection wells
- Side view:

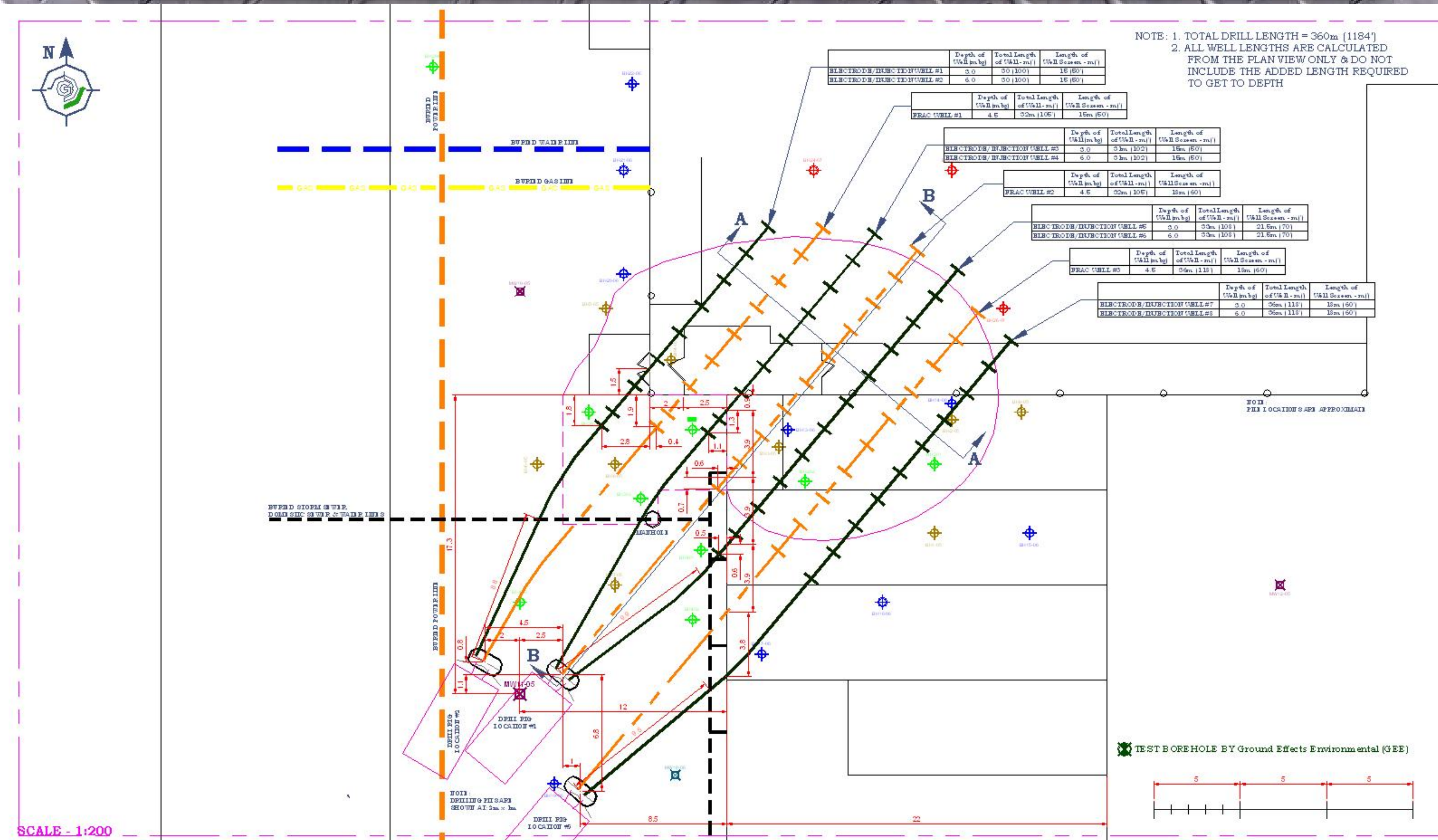
Oxidation Pilot with EK3



Oxidation Pilot with EK3



Oxidation Pilot with EK3



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EK3 BENEFITS

- Even distribution of oxidants through fine grained soils.
- More efficient contact of oxidants with contaminants.
- Best suited for low permeability, low contaminant concentration sites.
- Rapid movement and dispersal of oxidants into contamination zone.
- Reduced remediation time frame.

Questions?

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