

Pilot Testing of an Electrokinetic Barrier— Dissolved Chloride at the Former CN Irma Landfill



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Presentation Outline

- Background and Site Conceptual Model
- Remedial Objective
- Description of Electrokinetics (EK)
- EK Pilot Setup
- Pilot Results
- Next Steps

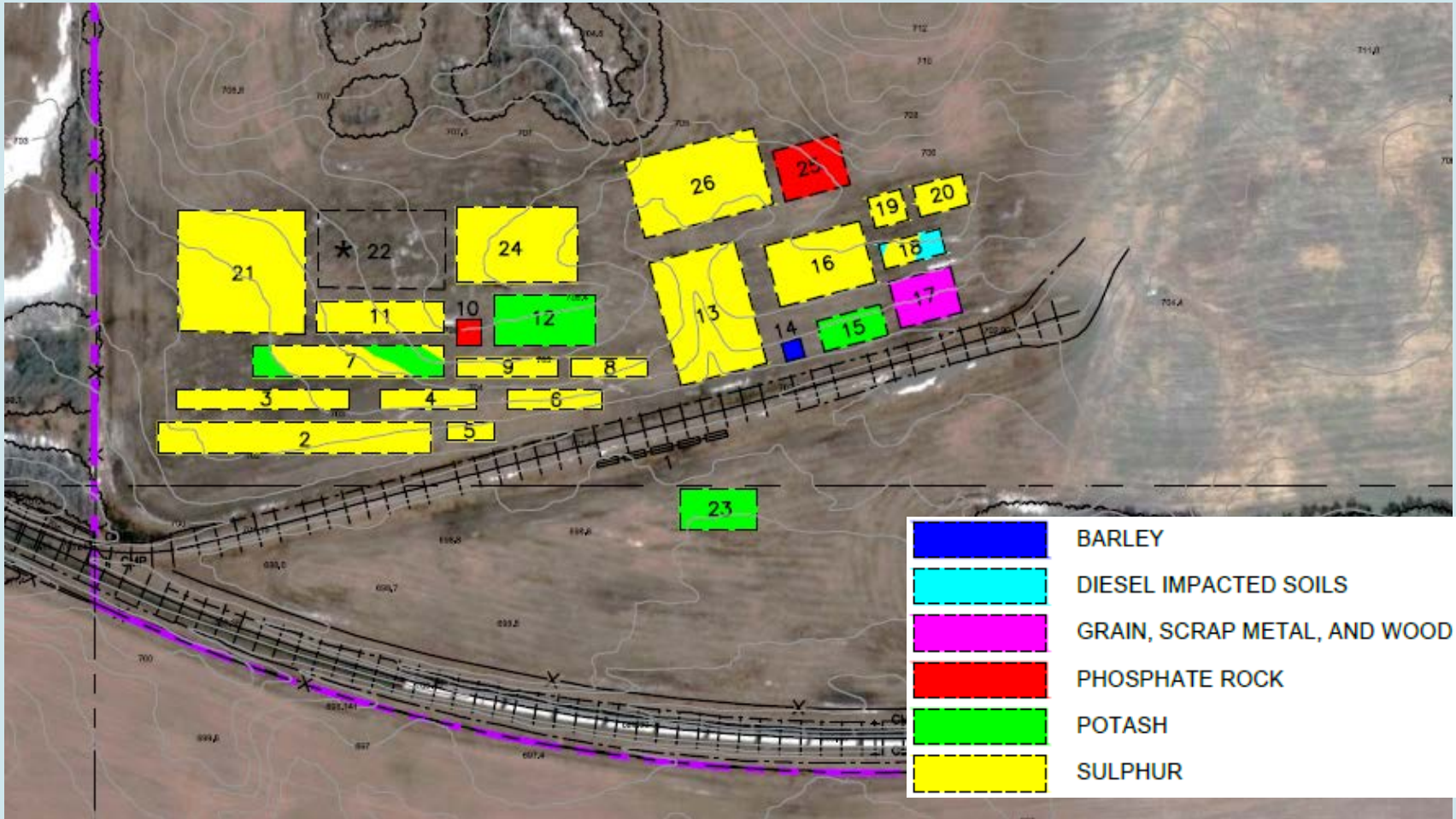


Site Location and Setting

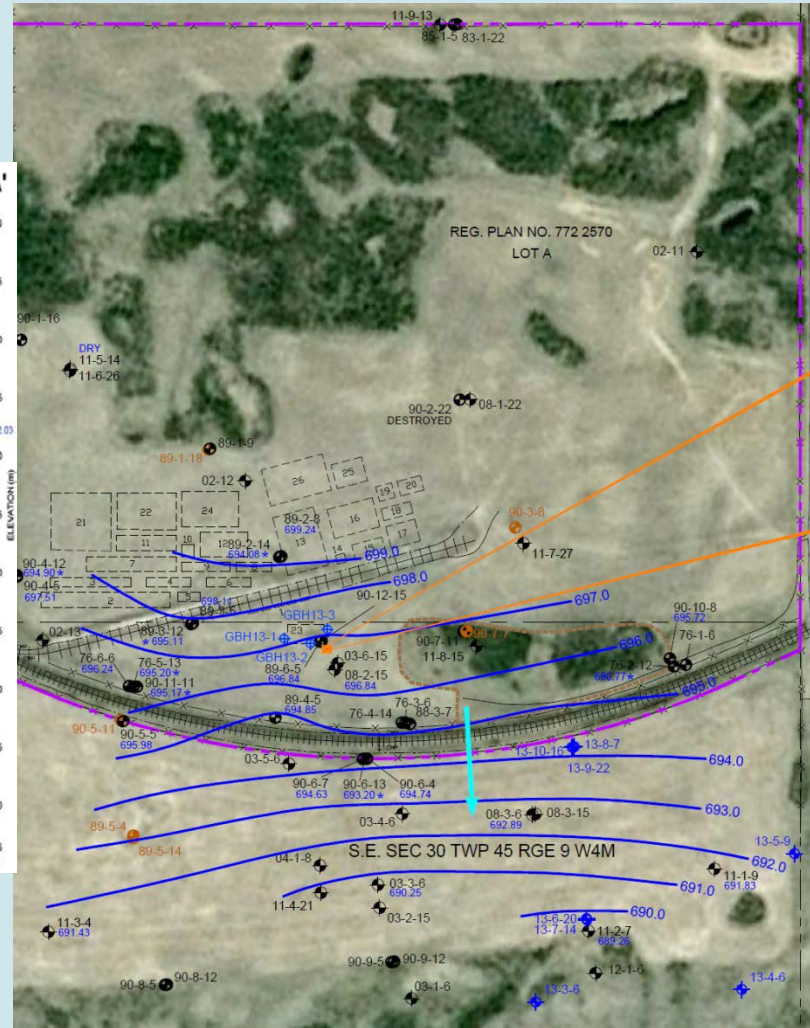
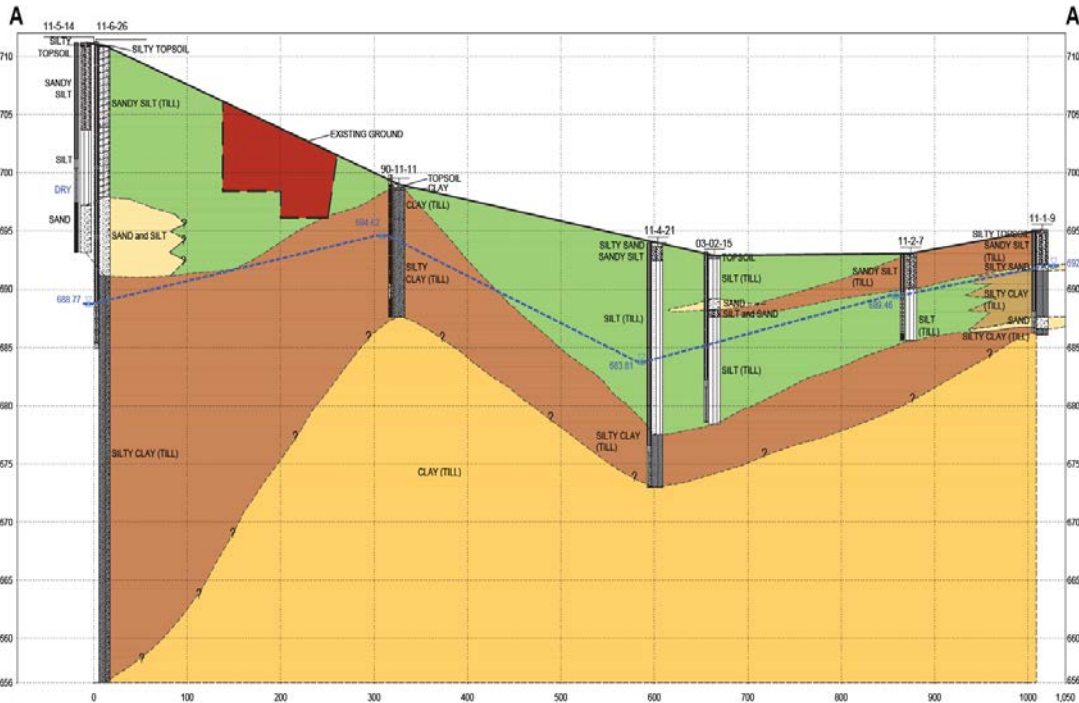




Historical Site Operations



Monitoring Well Network and Geology



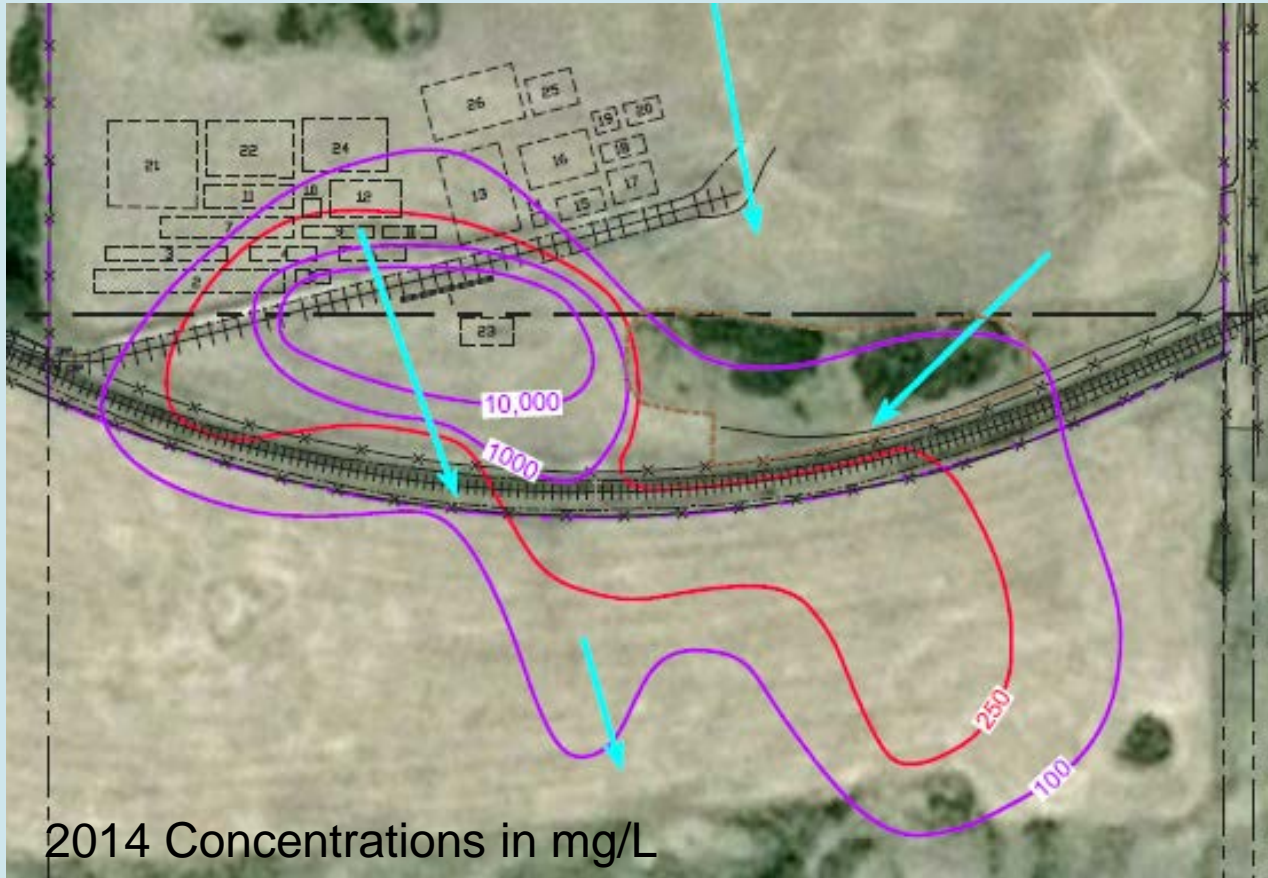
October 21, 2014





Contaminant of Concern in Groundwater

- Chloride (From Landfilled Potash - KCl)
 - 2 Components: Localized Brine Pool, Dilute Plume

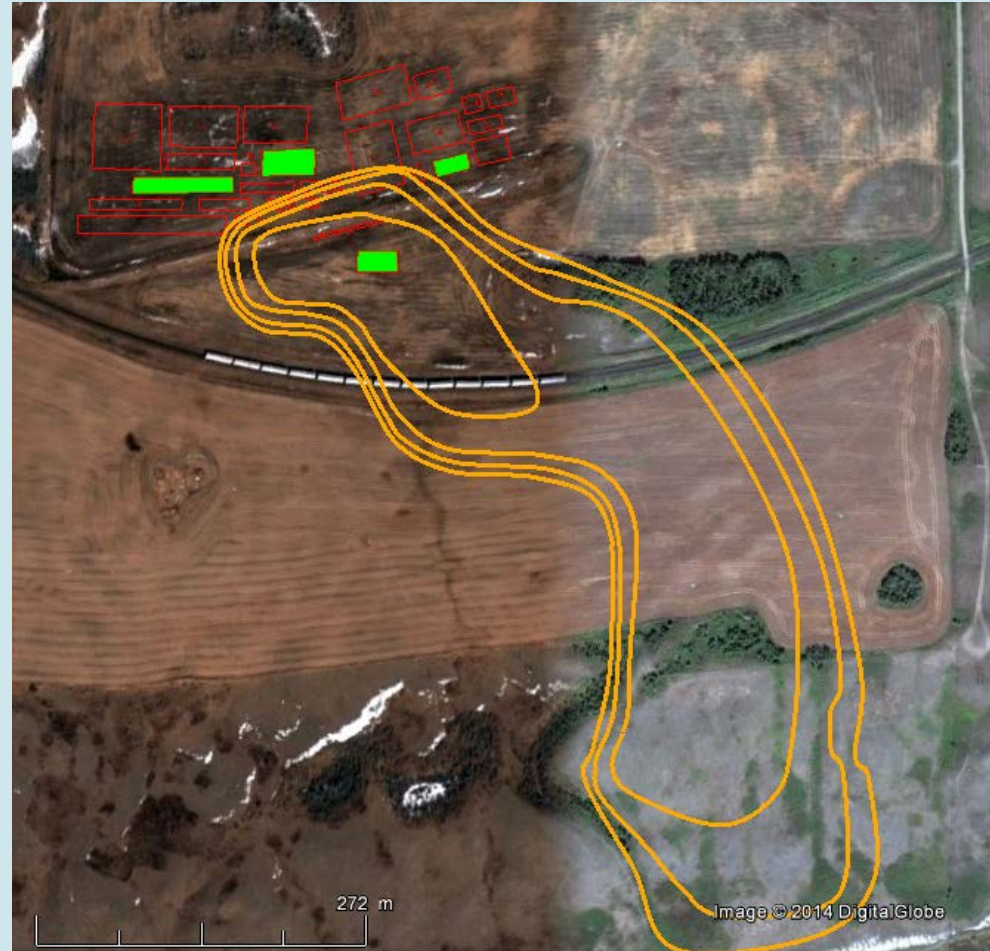




2013 Groundwater Modelling Results

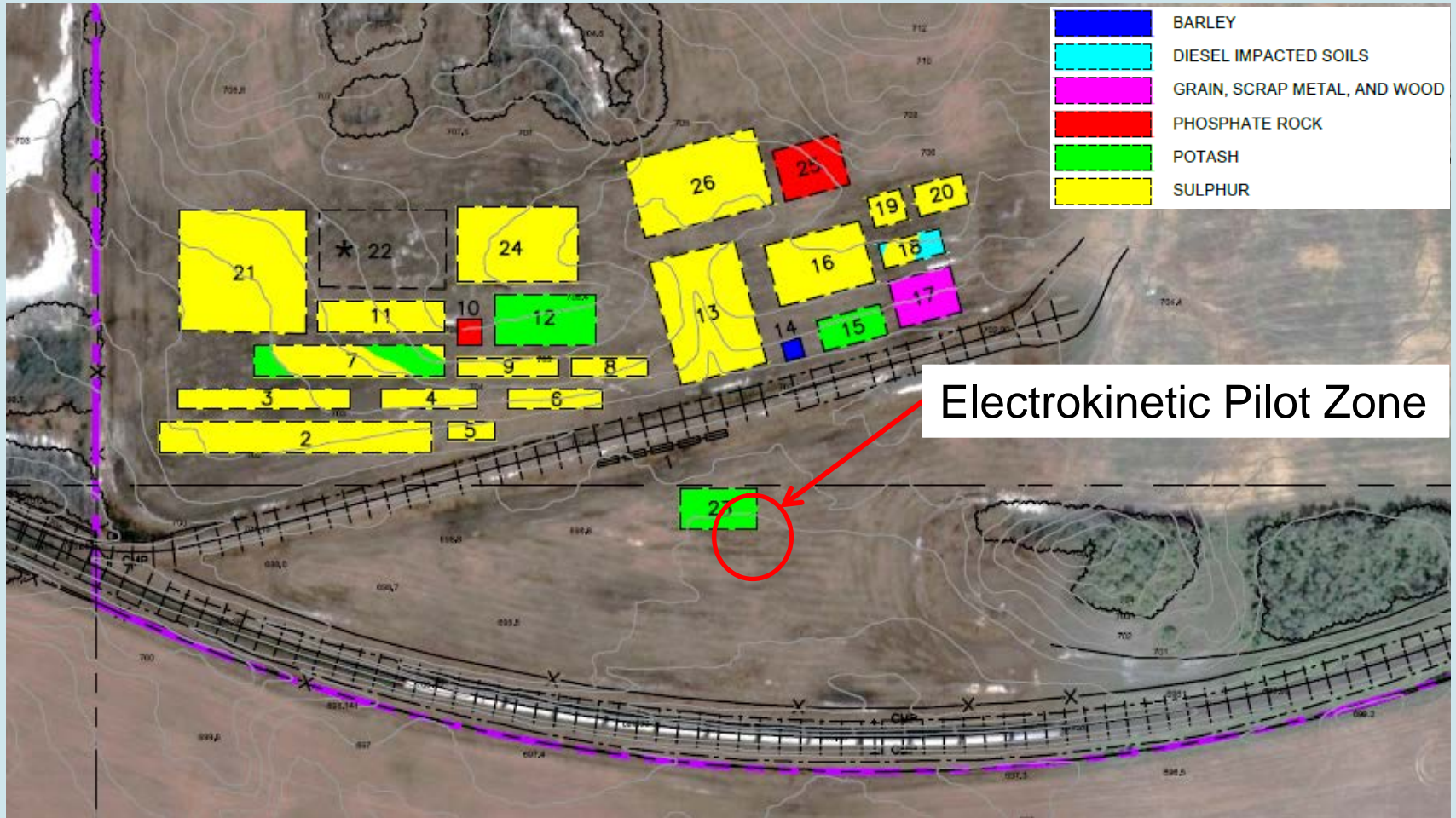
Simulation 2013 - 2059

- FEFLOW 6.2 used to predict impacts on Gratton Creek
- Chloride concentrations above guideline expected to reach Gratton Creek in about 50 years
- Suggested mitigation is required to control chloride plume
- Remedial Options Analysis using GoldSET CN SR® carried out in 2013
- Recommended a combination of Electrokinetics and Phytohydraulics



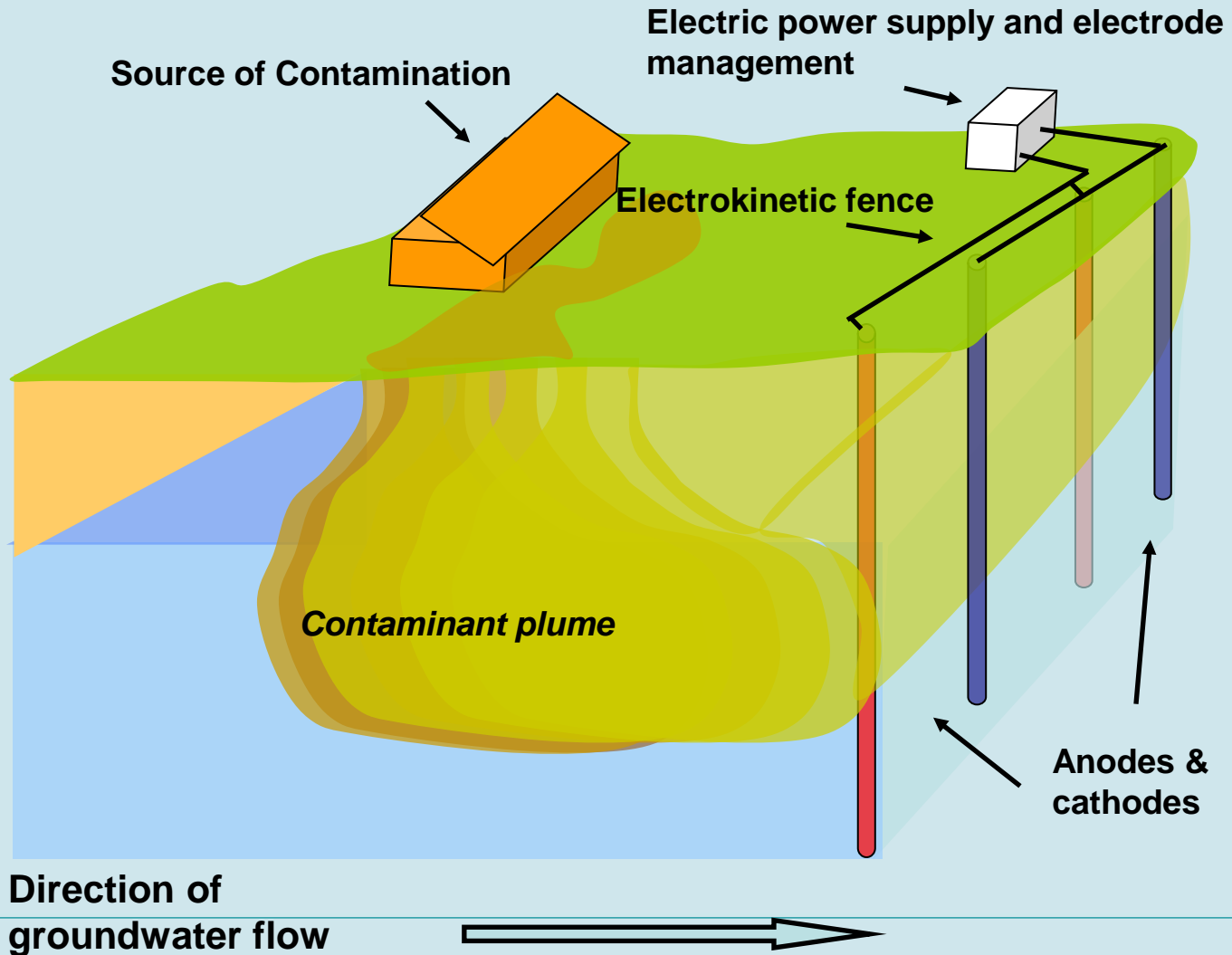


Pilot Test Location





Electrokinetic Fundamentals



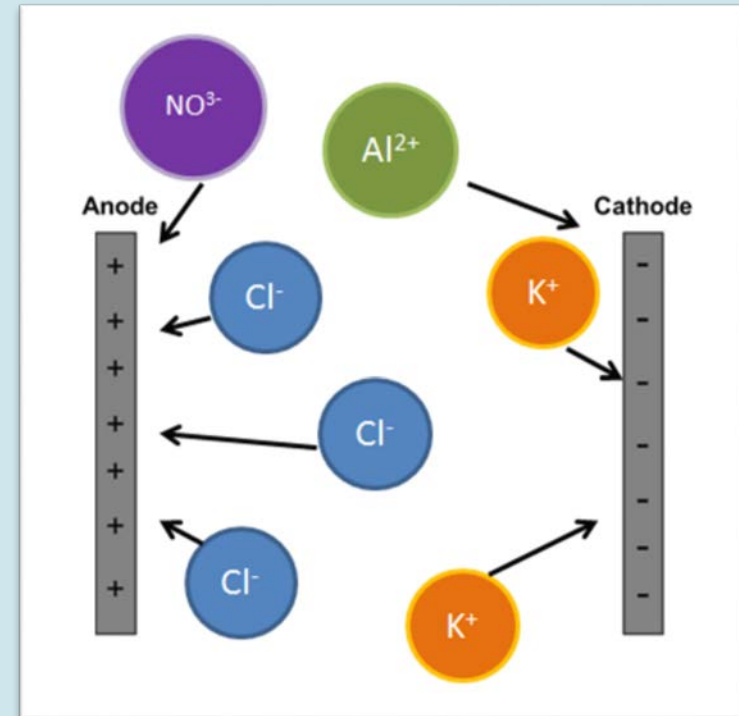
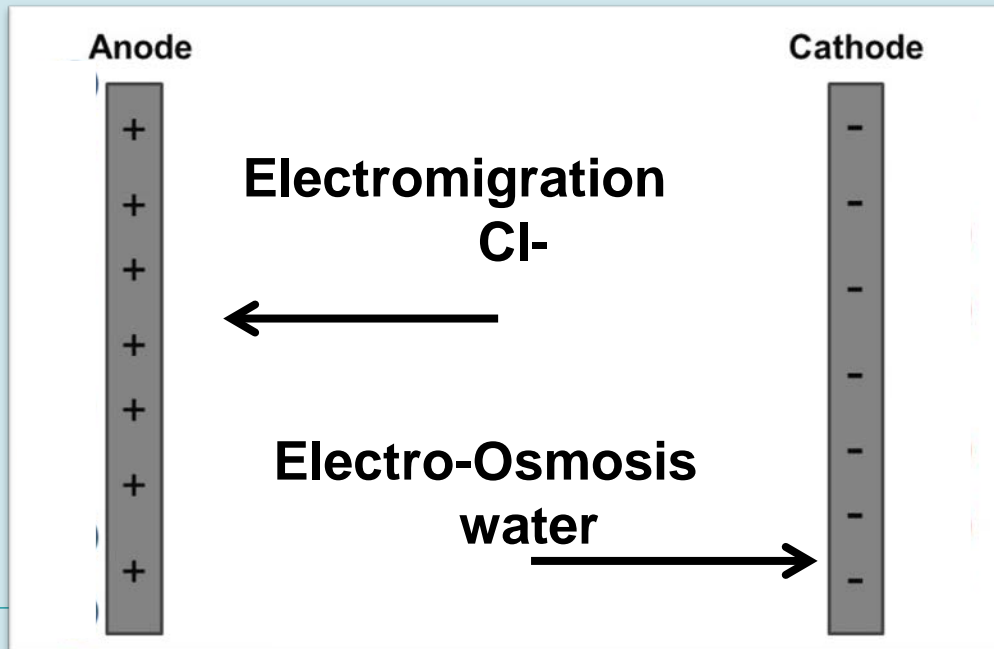


Electrokinetic Fundamentals

Two Main Processes Involved:

Electromigration: Migration of ions toward the oppositely charged electrode

Electro-Osmosis: Migration of water from the anode to the cathode

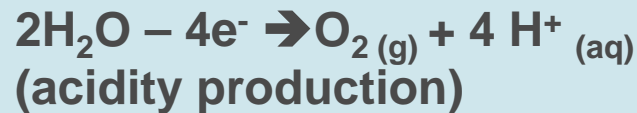




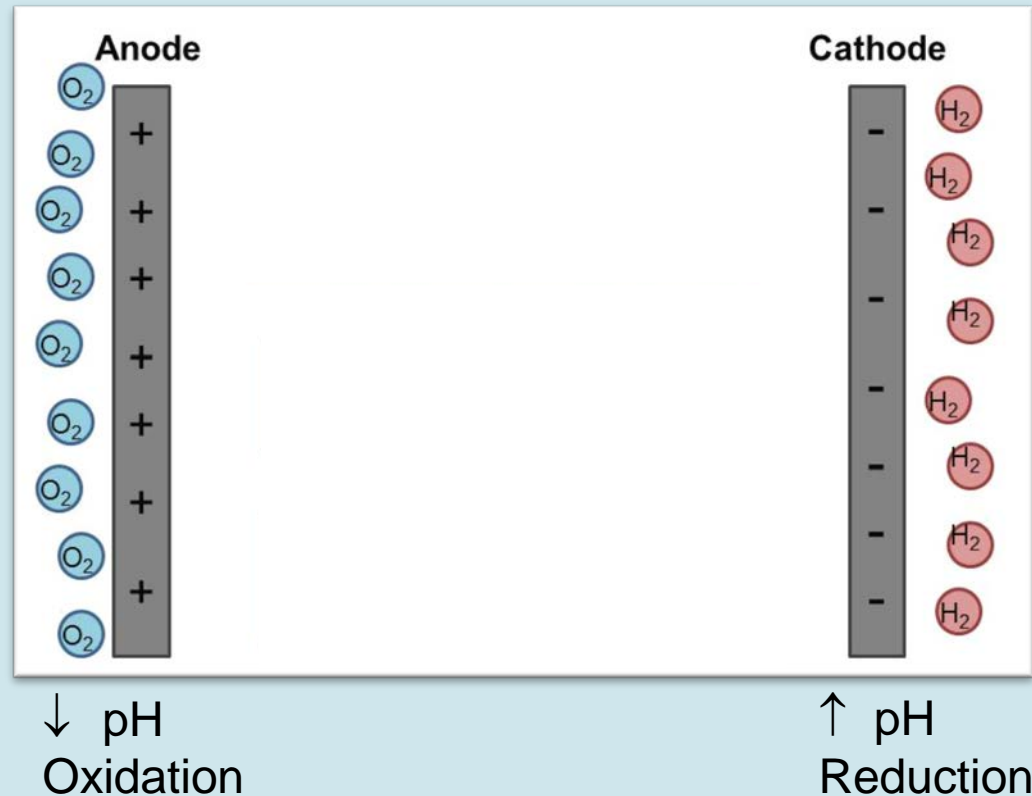
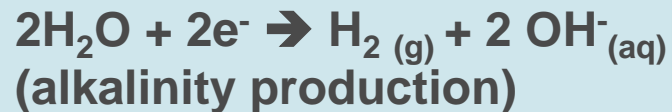
Electrokinetic Fundamentals

Geochemical Reactions:

- At the Anodes:



- At the Cathodes:



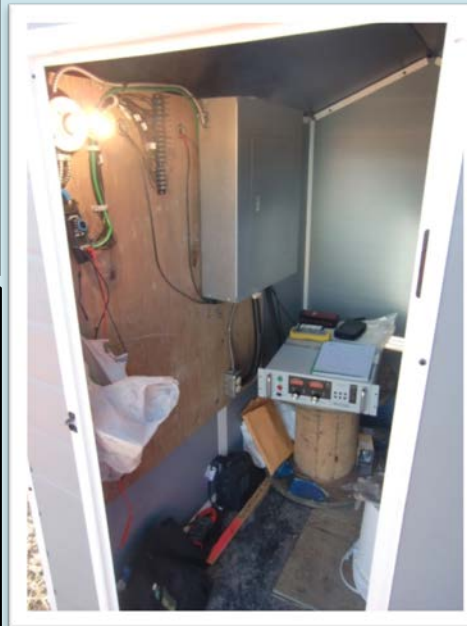
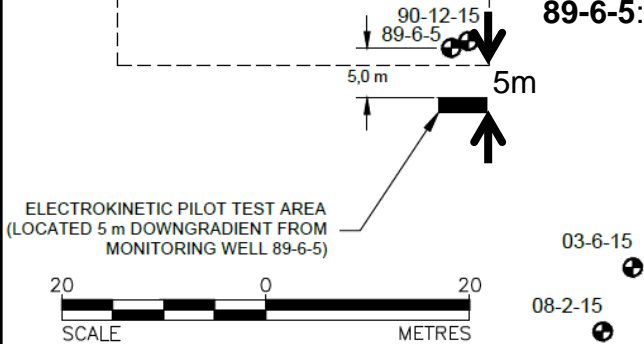


Electrokinetics In The Field

CELL 23

CELL 23: Chloride Source

89-6-5: Up-Gradient Reference Monitoring Well



Shed (Power Supply & Voltage Readings)

Exclusion Zone

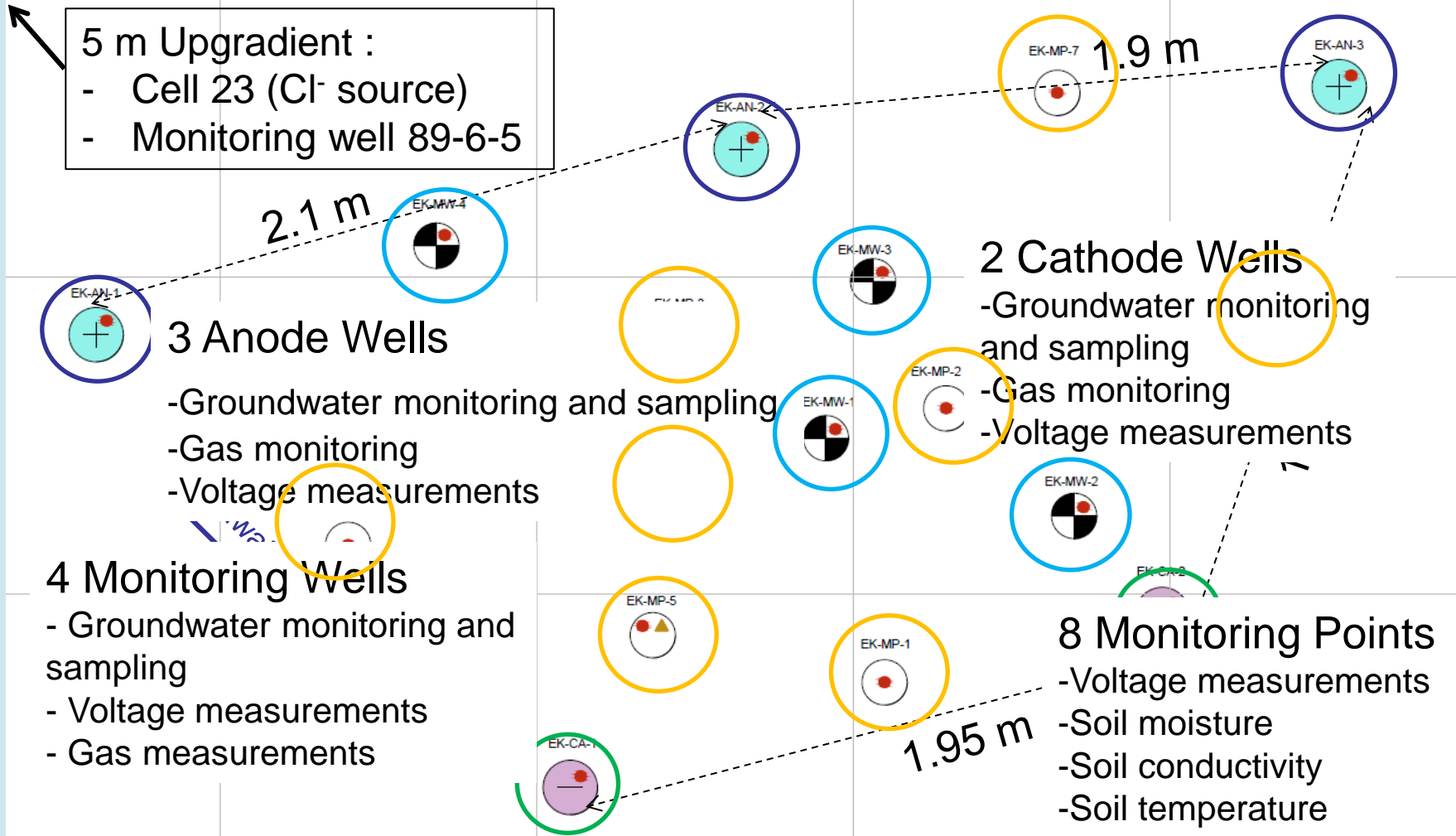
Anodes

Cathodes

Generator



Electrokinetics In The Field – Layout



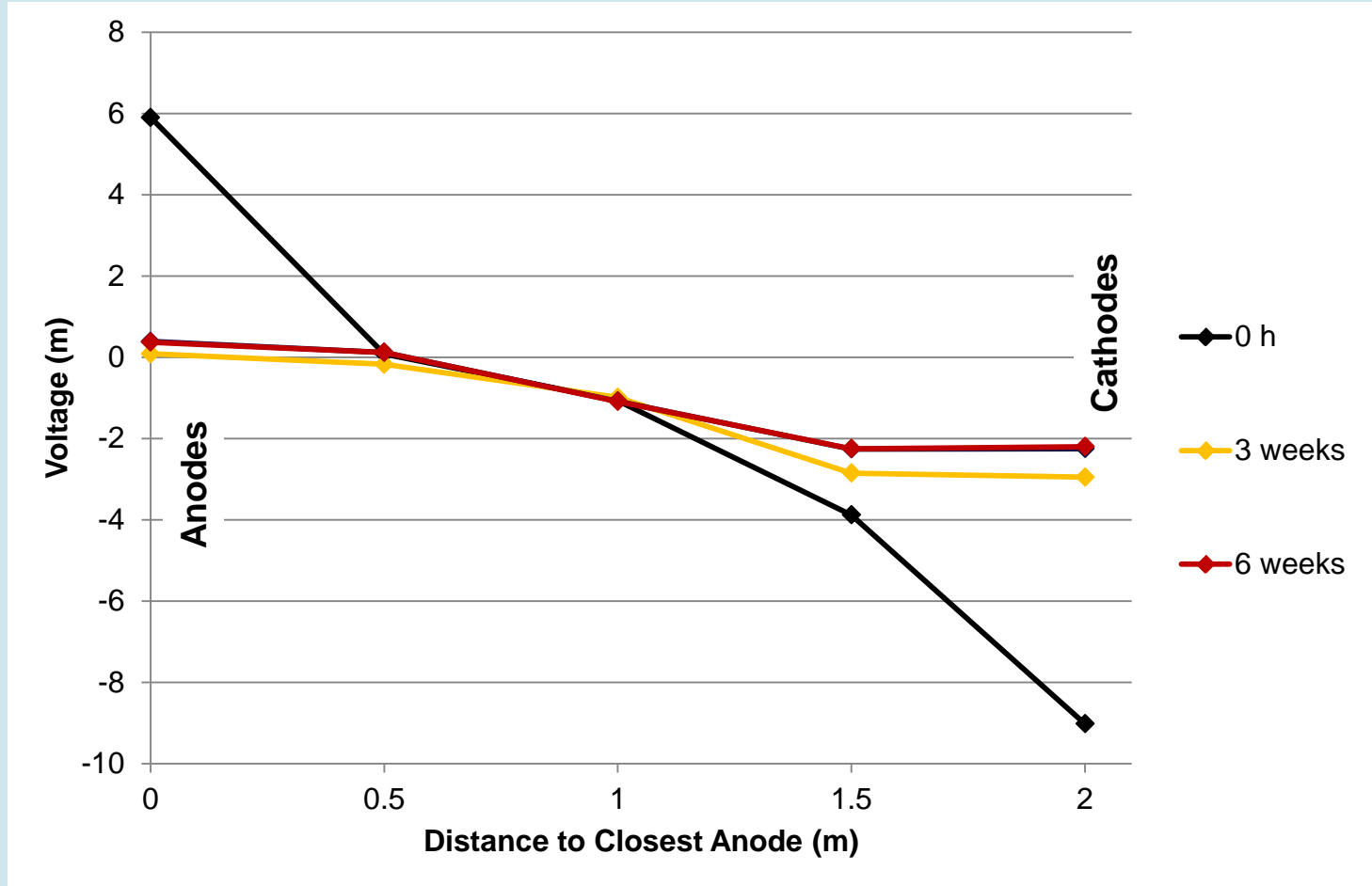


Groundwater Baseline Values Before EK Pilot Test

Parameters	Baseline Value
Groundwater level	1.654 to 1.985 mbgs
Groundwater temperature	10.3 to 11.2 ° C
pH	5.8 to 6.11
Dissolved oxygen	1.0 to 5.9 mg/L
Redox potential	258 to 276.6 mV
Conductivity	38 000 to 50 000 µS/cm
Cl- concentration	24 000 to 25 000 mg/L
Trace metals (Al, Co, Cr, Cu, Fe, Ni, Pb, Se, Zn)	Below detection limits



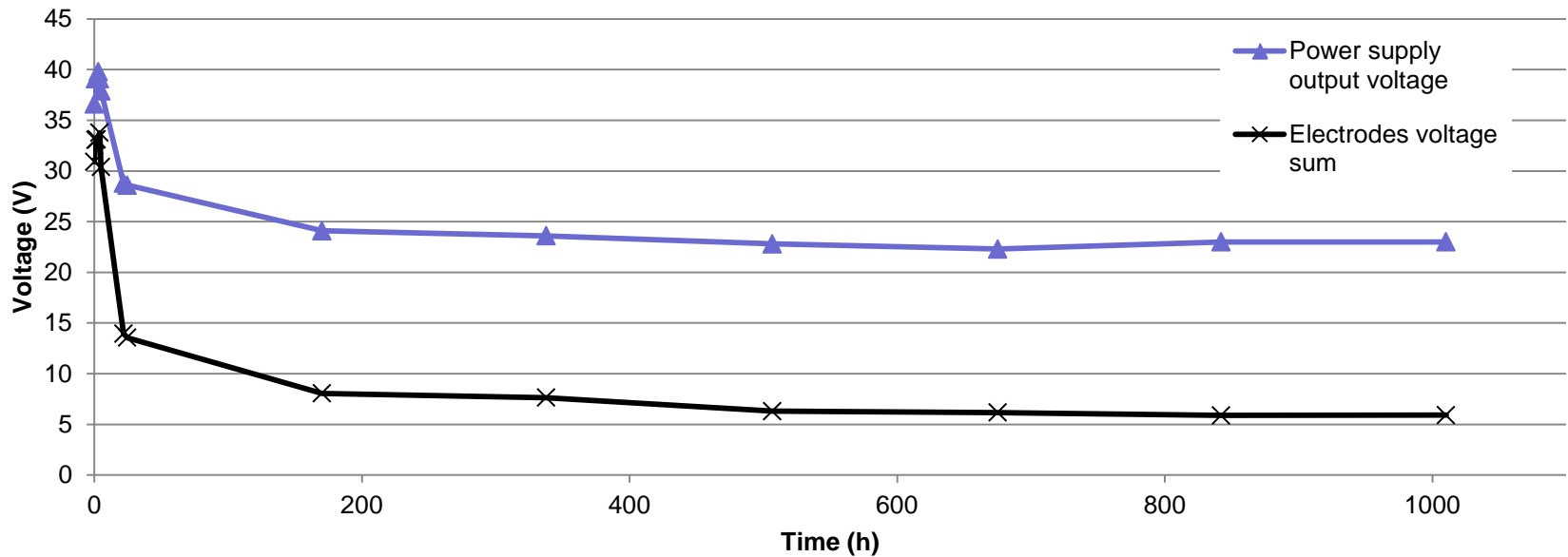
Voltage Measurements In The EK Test Cell During 6 Week Pilot Test





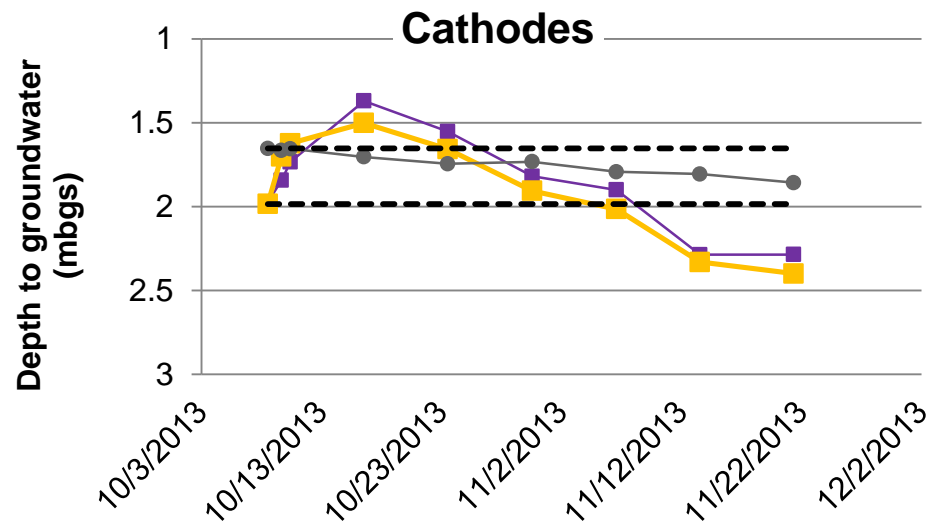
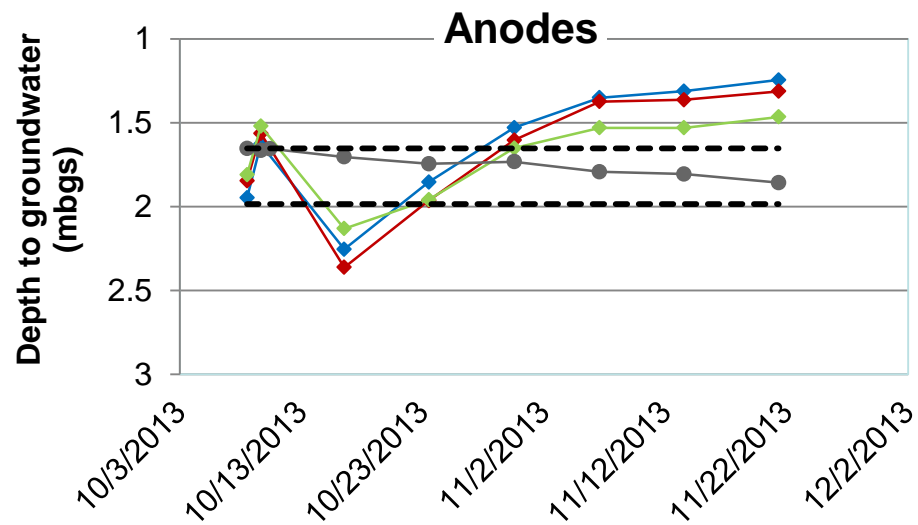
Voltage Evolution Through Time

Power supply output voltage and voltage sum at the electrodes



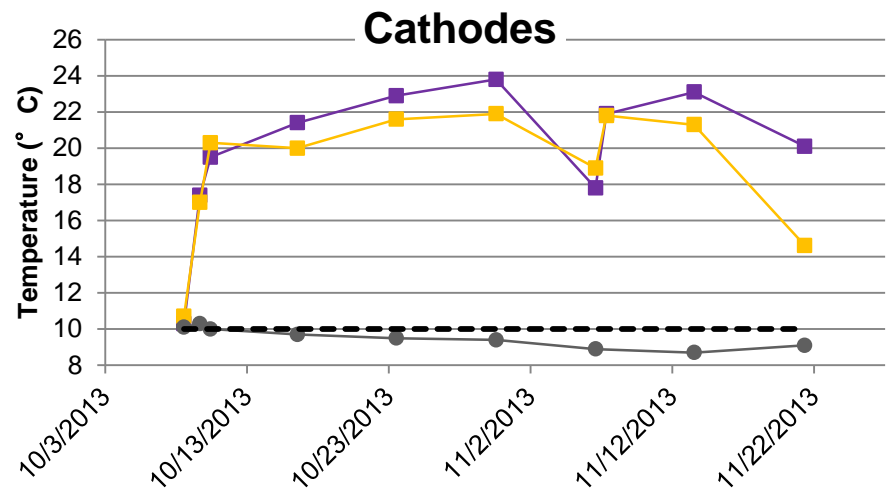
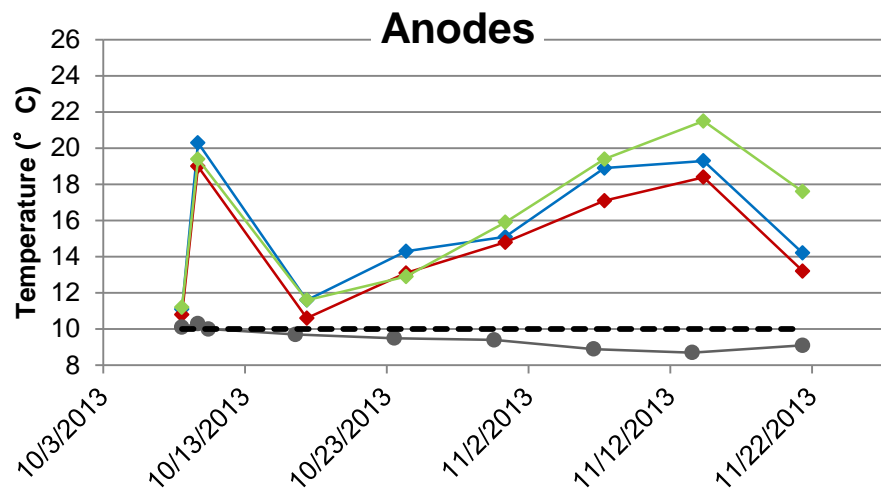


Field Parameters: Depth To Groundwater



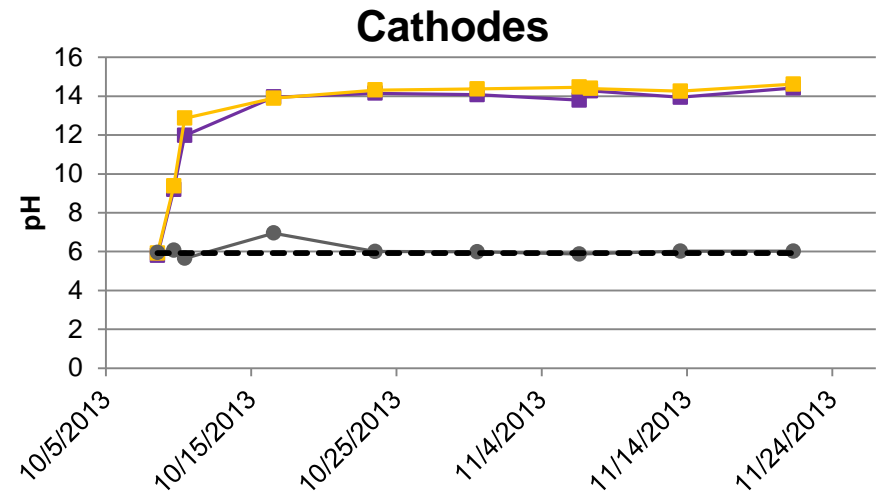
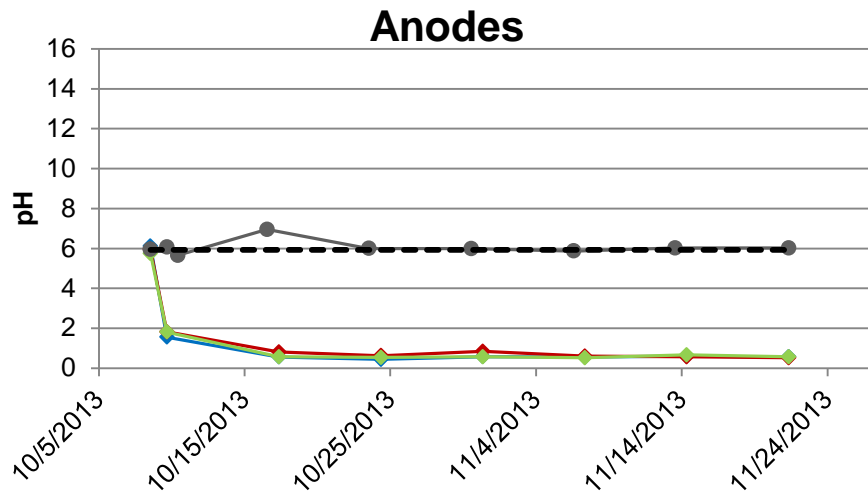


Field Parameters: Groundwater Temperature





Field Parameters: Groundwater pH



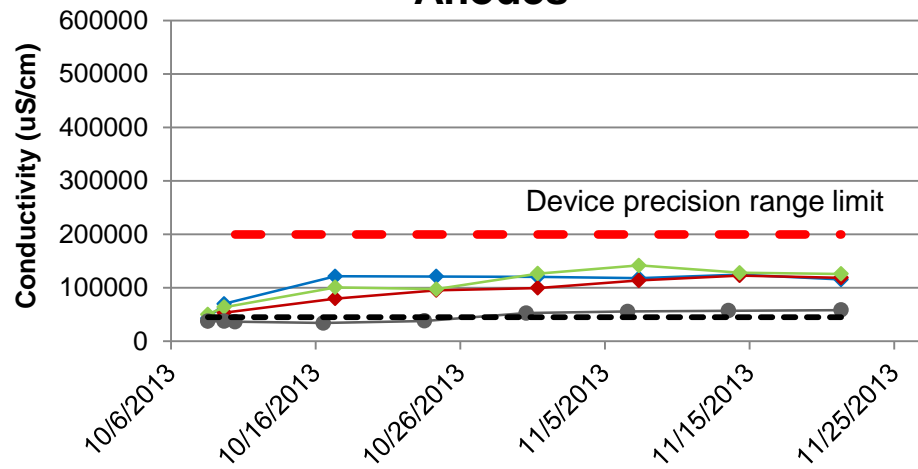
pH at monitoring wells between anodes and cathodes remained close to background



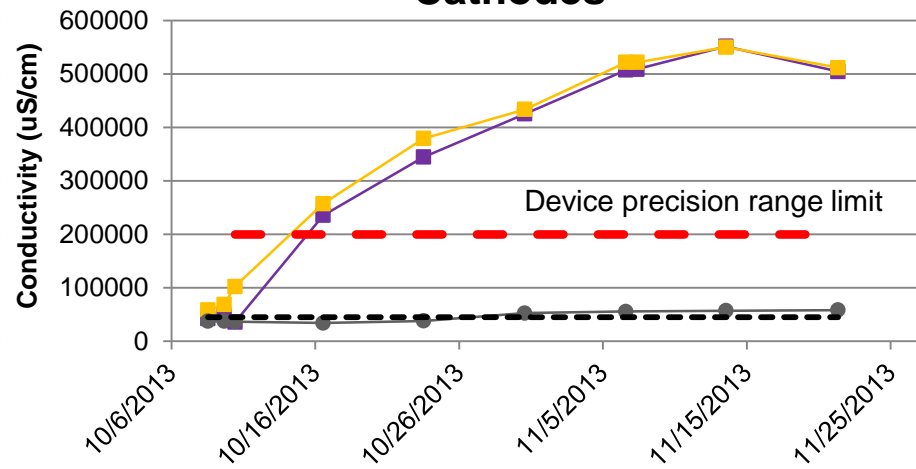


Field Parameters: Groundwater Conductivity

Anodes

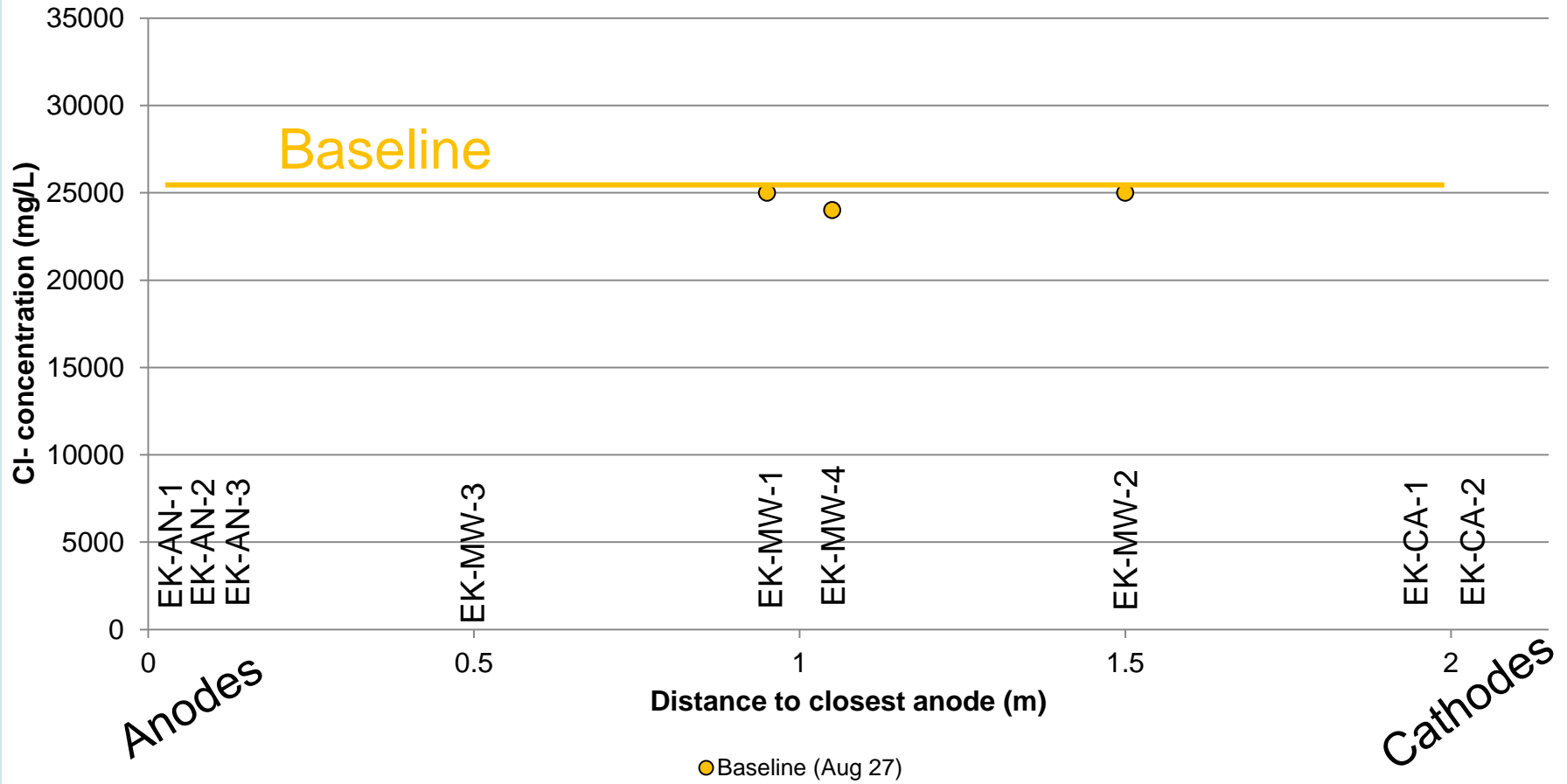


Cathodes

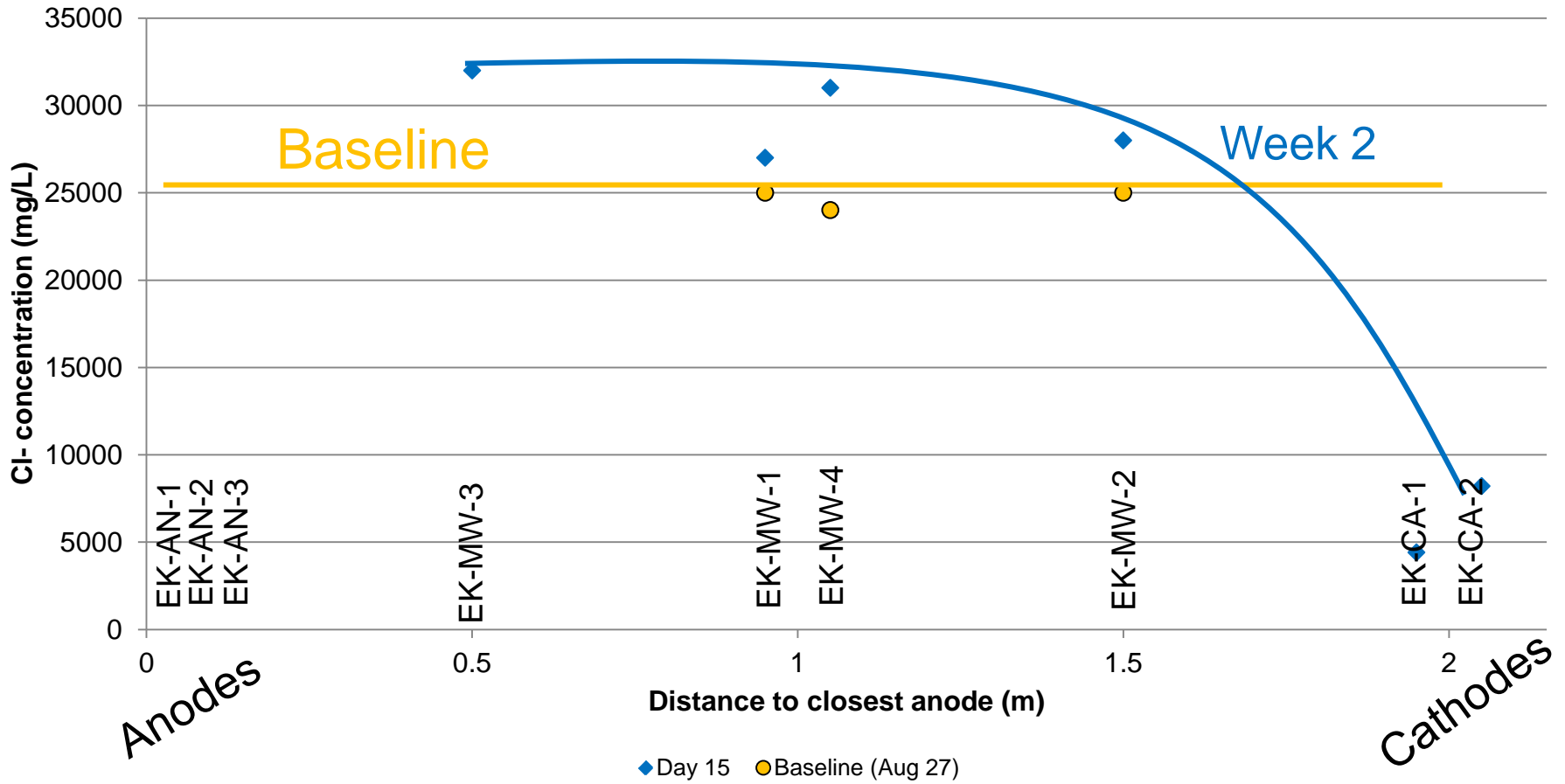




Evolution Of Chloride Concentration During The Pilot Test

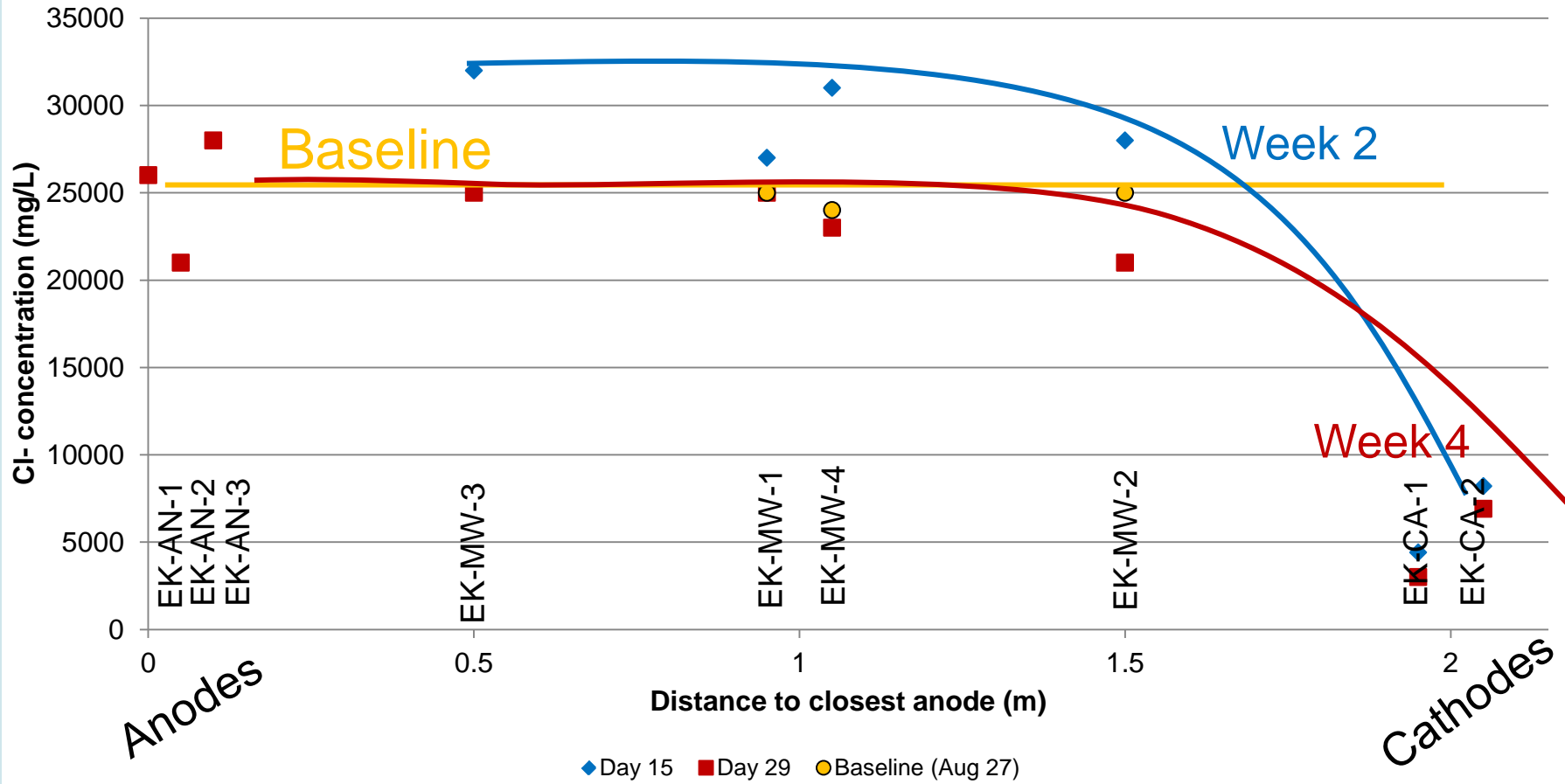


Evolution Of Chloride Concentration During The Pilot Test



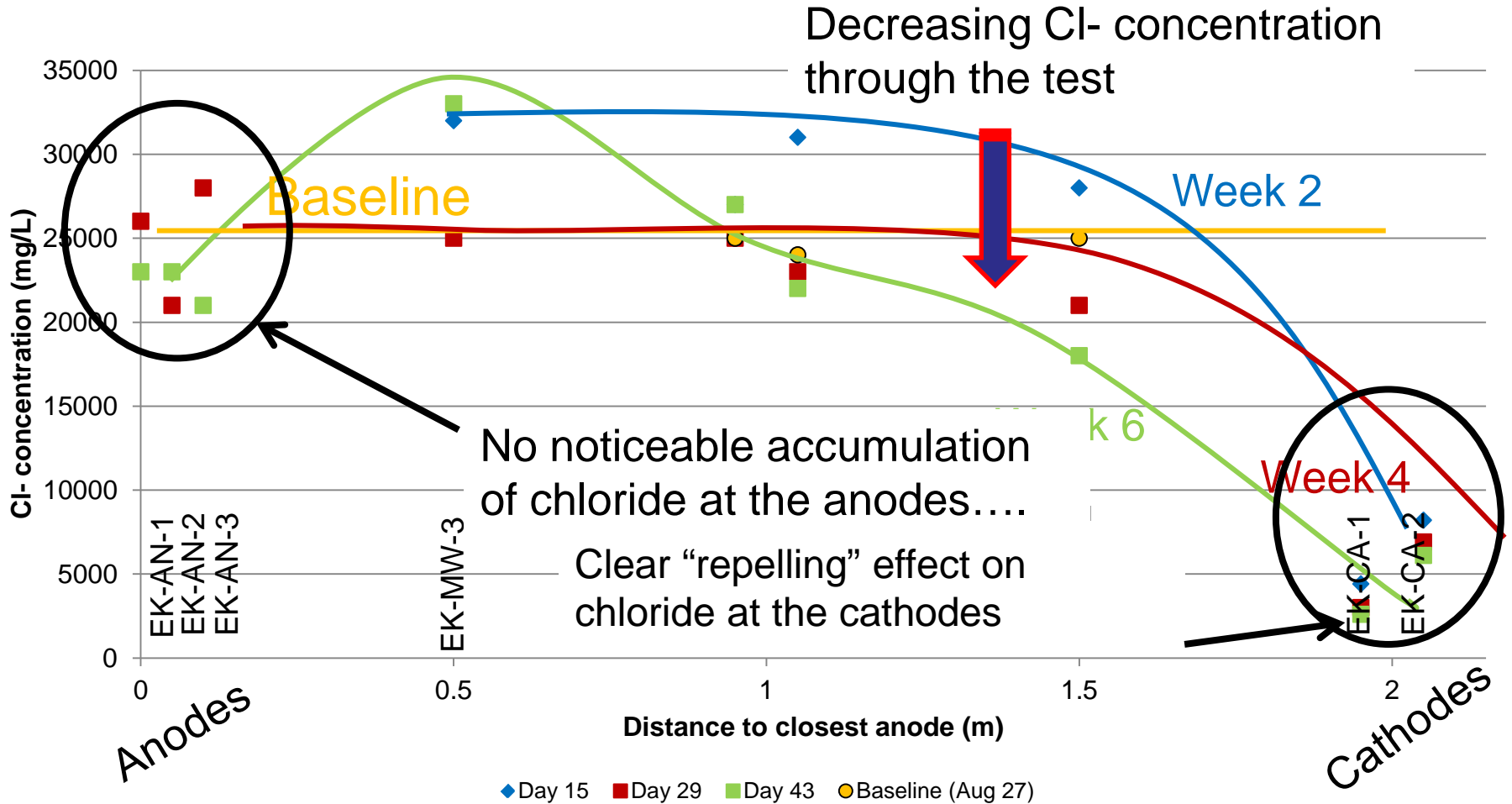


Evolution Of Chloride Concentration During The Pilot Test





Evolution Of Chloride Concentration During The Pilot Test



Potential-pH Equilibrium Diagram For Chlorine-Water At 25° C

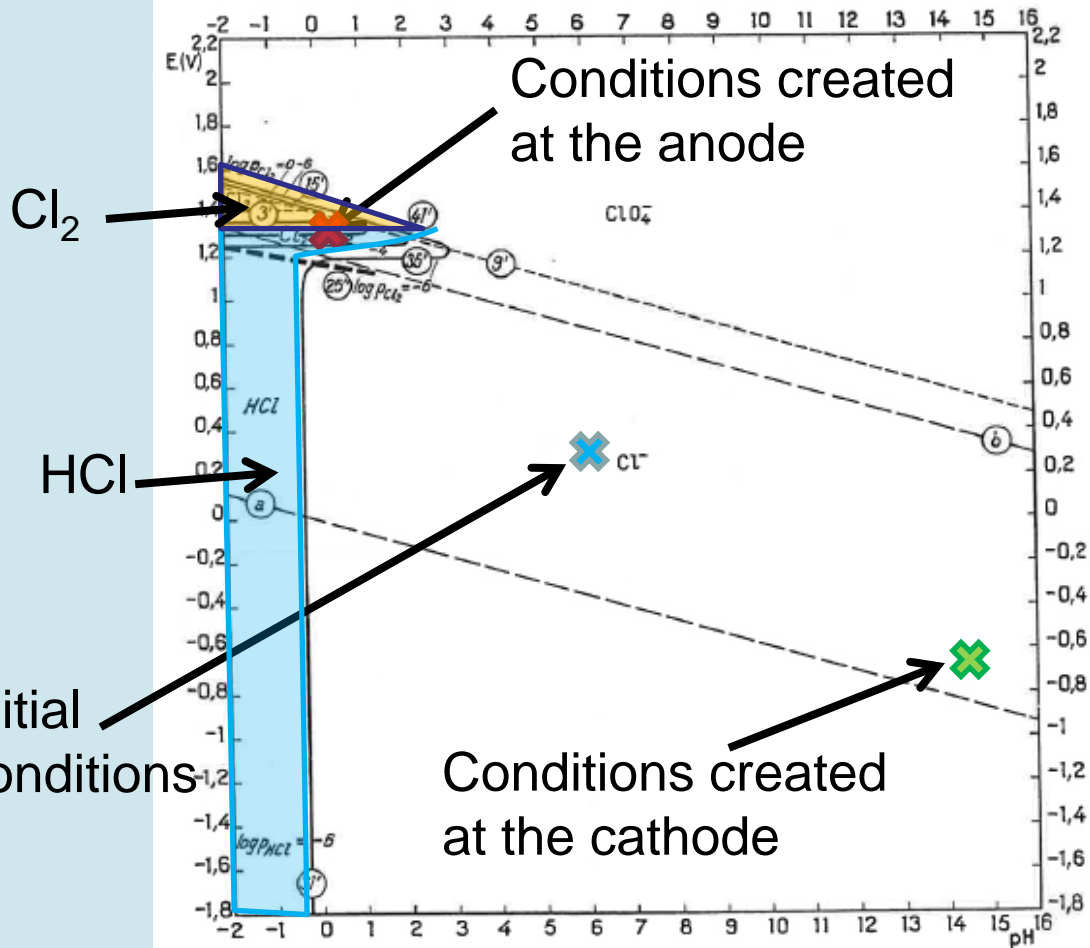


FIG. 1. Potential-pH equilibrium diagram for the system chlorine-water, at 25°C.
Stable equilibria.
(For solutions containing 1 g-at Cl/L.)

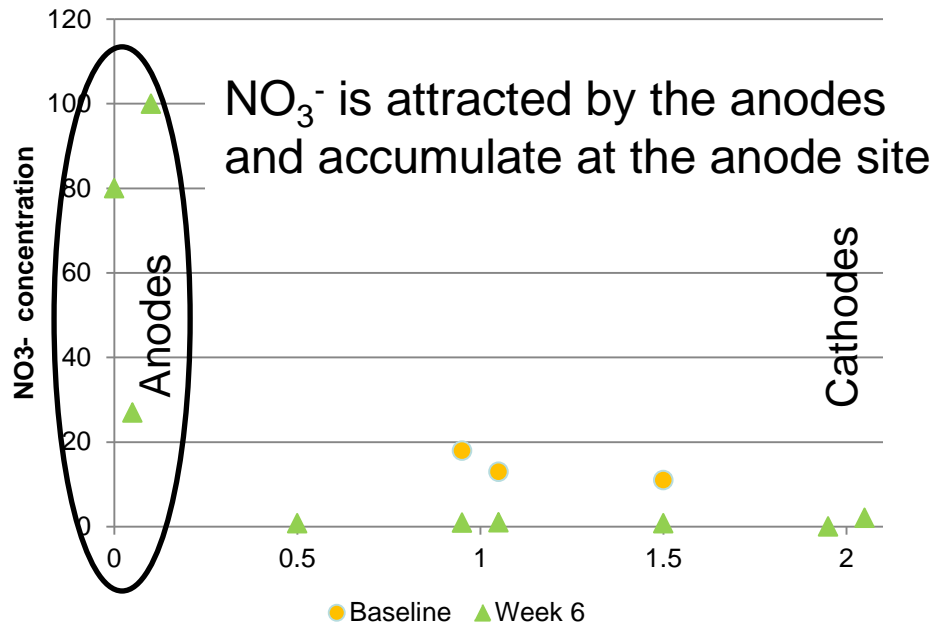
Field Evidence:

- **Greenish/yellowish** water and a **strong Cl odour** were noted during anode monitoring very early into the pilot test.
- **Cl₂** was detected at the **anodes well headspaces** in the field.
- Two samples of air released at the anodes were taken and analysed to quantify **Cl₂** emission (~ 7 ppm).

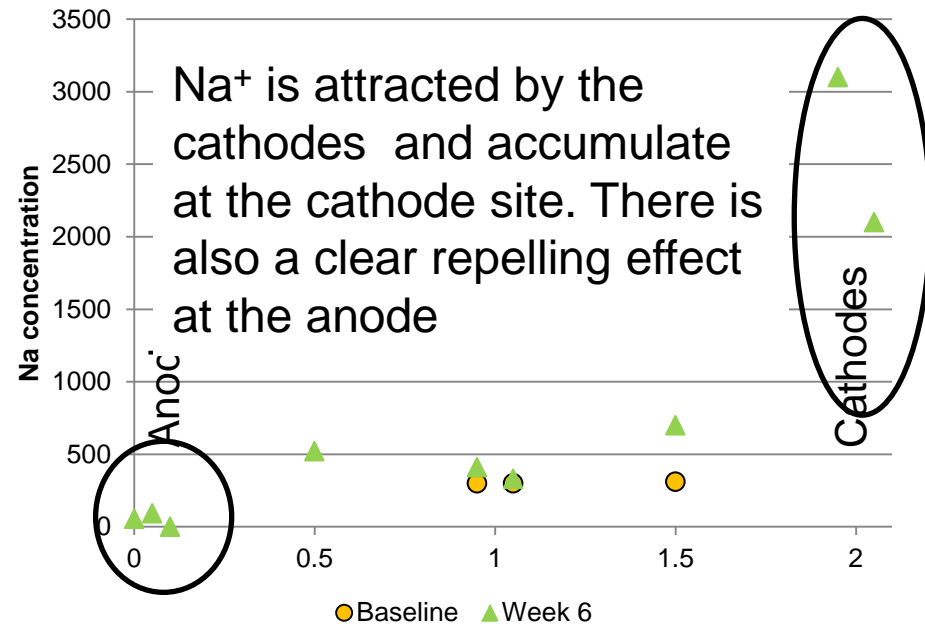


Typical Anion (NO_3^-) & Cation (Na^+) Response To Electrokinetics

Nitrate (NO_3^-)



Sodium (Na^+)



Nitrate and sodium are not affected by changes in geochemical conditions.





Health and Safety Concerns

Acidification/Alkalinisation of Groundwater :

- Low pH at anodes
 - High pH at cathodes.
- These concerns were managed using a specific H&S procedure

Chlorine Gas Emissions:

- Chlorine gas detected in anode wells
- These concerns were managed using a specific H&S procedure



Main Conclusions

- Migration of Cl^- towards the anode was observed during the pilot test.
- As expected, positively charged ions migrated toward the cathodes and negatively charged ions migrated toward the anodes.
- No accumulation of Cl^- near the anodes was identified due to transformation of Cl^- to other forms such as Cl_2 and HCl
 - No need for water treatment?
- pH conditions remained close to background levels between the cathodes and the anodes.





Data Gaps and Next Steps

Data Gaps:

- Determine vertical profile of chloride concentrations in full scale EK barrier area - needed to finalize electrode design (length);
- Evaluate optimal voltage (energy savings);
- Assess effect of longer term pilot on chloride concentrations;
- Determine Cl_2 mass flux (vapor phase treatment);
- Assess alternative sources of energy (solar panels) for full-scale implementation

Next Steps:

- Extended pilot test (August to October 2014)
- Full scale detailed design and GoldSET update
- Full scale implementation in 2015 (depending on 2014 results);

Thank You!

