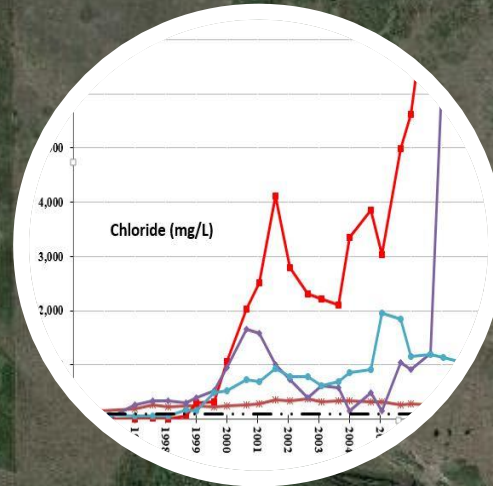
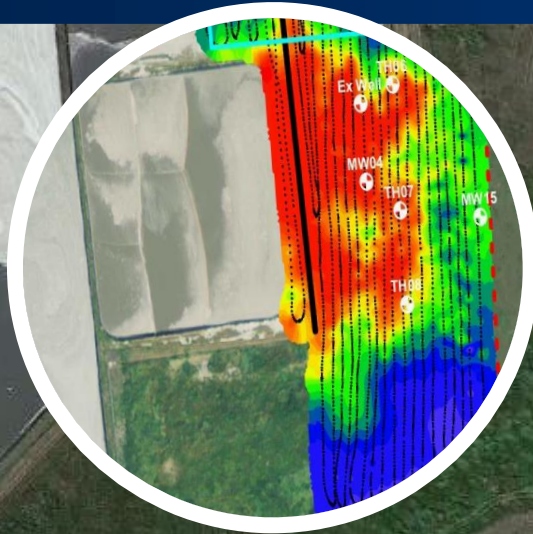


Risk Management and Corrective Action Related to a Leaking Brine Pond



Frans Hettinga & Aziz Shaikh

Problem – Source/Pathway/Receptor

- Source: leakages from brine ponds, capacity $\sim 60,000 \text{ m}^3$
- Pathway: shallow sand and gravel unconfined aquifer:
Water table 1 – 3 m below grade,
Hydraulic conductivity $1 \times 10^{-4} \text{ m/s}$ – $1 \times 10^{-5} \text{ m/s}$.
- Receptor: downgradient meandering creek within 500 m



Site History

- Industrial Facility in Alberta
- Constructed in 1989
- Operating under an EPEA Approval
- 5-yearly soil monitoring
- Semi-annual groundwater monitoring
- Tetra Tech EBA has conducted groundwater monitoring program since the late 1990s
- Large volumes of brine (sodium chloride) stored and handled at the site

Main Concern: Brine Ponds



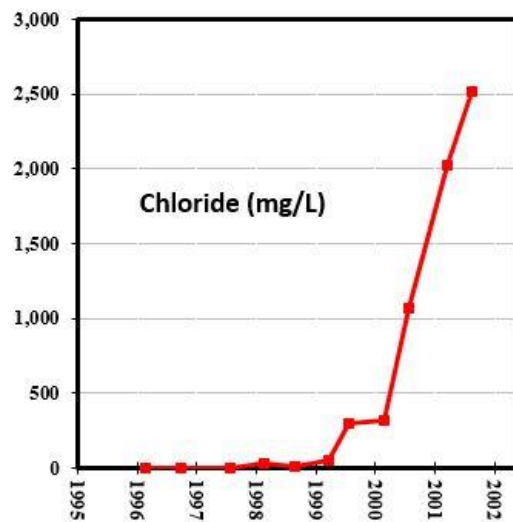
- ~60,000 m³ stored in two ponds
- Brine [NaCl] solution near saturation
- Older (west) pond is single lined
- Newer (east) pond is double lined with interstitial space and leak detection
- Operational spills occurred starting in 1990s
- In early 2000s also evidence of leaks

Physical Setting



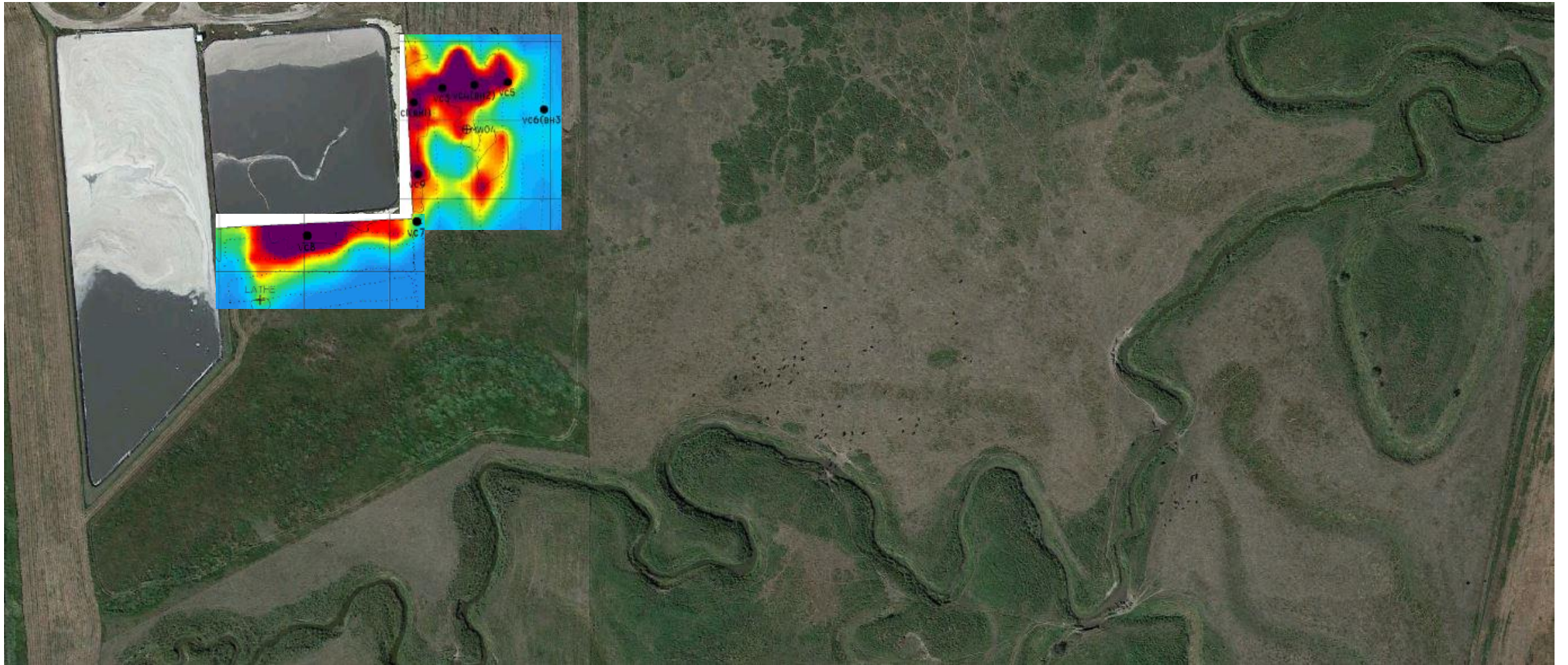
- Relatively flat topography
- Adjacent land predominantly pasture
- Soils are mainly Solonetzics developed on glaciolacustrine and glaciofluvial deposits
- Groundwater 1 – 3 m below grade in sand and gravel layer
- Hydraulic conductivity 10^{-4} – 10^{-5} m/s
- Meandering creek within 500 m
- Hydraulic connection groundwater – surface water

1998 Overflow Event



- Excessive rainfall in June 1998 and insufficient free-board caused brine to overflow berms to the south and east
- Chloride concentrations in groundwater increased
- Subsequent assessment work included: geophysical surveys (EM and resistivity), soil and groundwater assessments
- A Risk Management Plan (RMP) was prepared

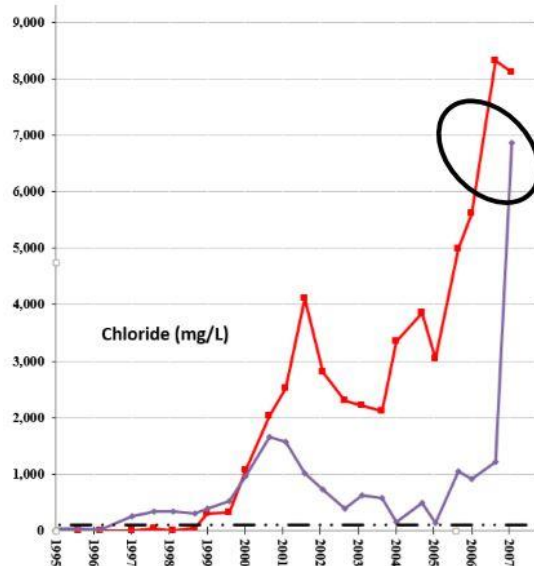
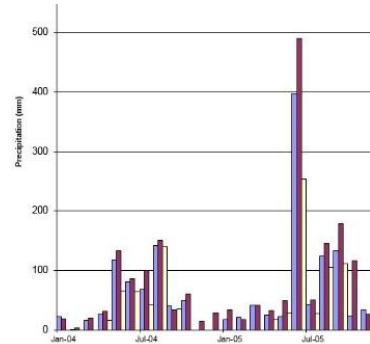
2002 EM-31 Survey



Initial RMP (2003)

- Soil quality severely affected near east pond
- Remediation not considered feasible due to proximity to lined ponds
- Modelling groundwater flow and contaminant (chloride) transport predicted minimal risk to receptors (creek and water wells users)
- Increased groundwater and surface water monitoring proposed

2004 - 2011



- Initially groundwater chloride concentrations in line with RMP predictions
- Increases in 2005 due to more rain and more infiltration
- Some improvement in 2008 but not to pre-2005 levels
- Leaks identified and repaired in 2008-2010
- No measureable impact on creek water quality
- Deeper (bedrock) groundwater quality not affected

2012 - 2014



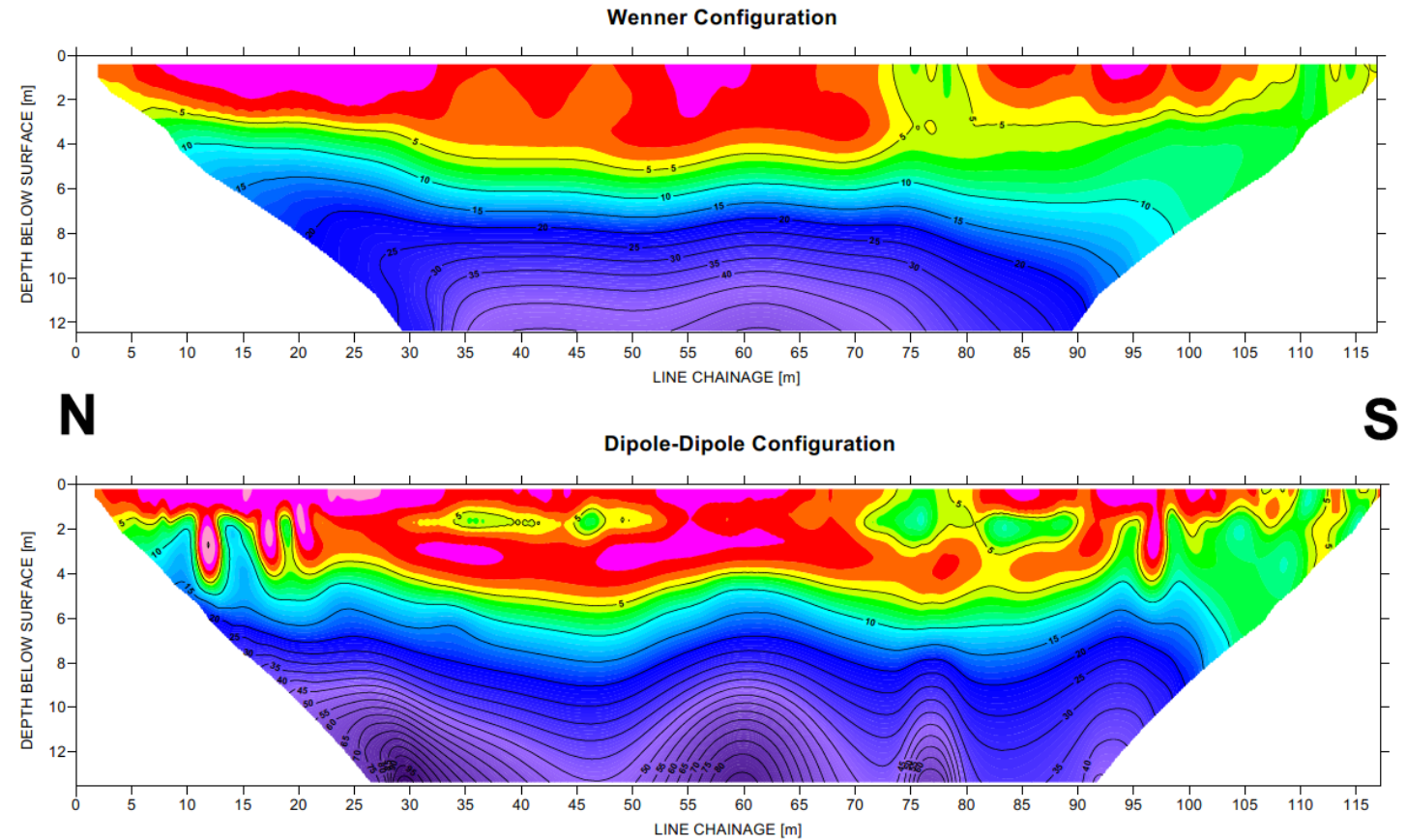
- Further repairs of leaks but groundwater quality not improving
- First time water quality impact in Creek in 2013 and further fresh water aquatic life guideline exceedances in 2014
- Spikes in chloride seem to occur when groundwater table is high and creek flows are low

2015 Corrective Actions

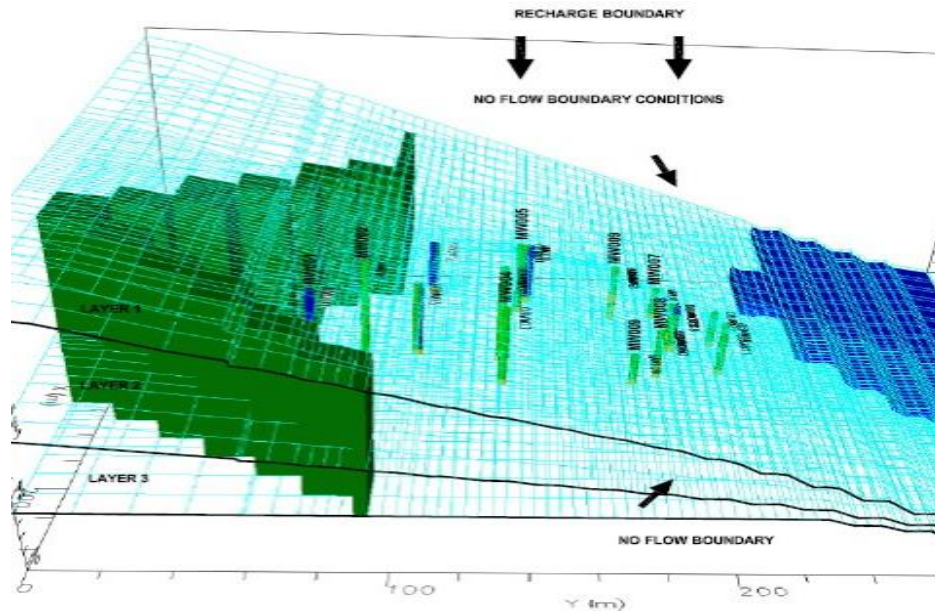
- Decision to replace single lined pond
- Several meetings with Regulator
- Design of new brine pond
- EPEA Approval amendment
- Tendering and construction of new brine pond
- Further assessment work
- Groundwater modelling
- Prepare a new RMP

Electrical Resistivity Tomography (ERT)

Permanent array of electrodes to assess impact: for model input and to determine change over time



Groundwater Modelling



- Quantify movement of chloride-rich groundwater
- Calibrated against monitoring data since 1997
- Simulated concentrations up to 20 years
- Predicts decreases in chloride concentrations in groundwater near the creek, most rapidly (<1-2 years) when limited groundwater extracting takes place immediately east of the east brine pond and with no further leaks

Several uncertainties

- Interaction with creek (recharge/discharge)
- Chloride leaching from impacted soils
- Presence of oxbows, effect of density flow, etc.

Updated Risk Management

- State-of-the-Art containment of all brine
- Reduce or eliminate brine storage over time
- Empty pond with compromised liner
- Cap impacted soil to limit infiltration/loading
- Ongoing groundwater and surface water monitoring
- Optional/periodic groundwater recovery
- Full remediation upon facility decommissioning

Pond construction

- EM survey and partial removal of impacted soil
- Prepare subgrade for 64,000 m³ pond
- Primary liner: 60 mil HDPE
- Secondary liner: 60 mil HDPE
- Geosynthetic clay liner
- Subdrains and leak detection
- Minimum 1 m free board
- Dual purpose: future use as an anaerobic wastewater treatment lagoon

New Pond: Site preparation and partial source removal



New Pond: Construction of berms



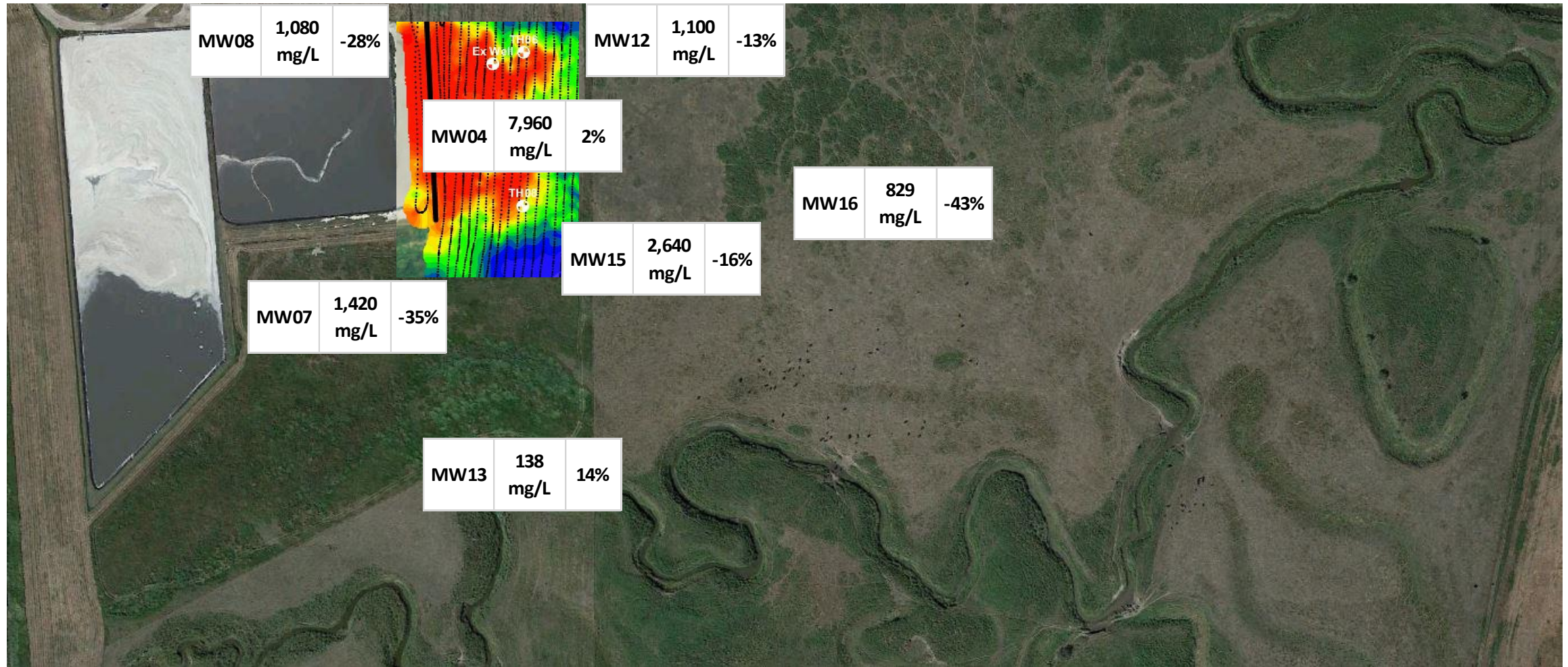
New Pond: Liner installation



Status mid-2016

- Proposed RMP is undergoing Regulatory review
- Leaky pond was emptied early 2016
- Pilot testing of new evaporator technology initiated to drastically reduce the total brine volume
- Two more groundwater and surface water monitoring events conducted
- Groundwater: overall 15% decrease in chloride concentrations
- Surface water: chloride well below guidelines (29 mg/L)
- Leak detection systems have been dry

July 2016: Chloride Concentrations and Year-Year Change



Conclusion

- Operating brine ponds is not without risk
- Important to act on mishaps/spills and water quality trends
- Current risk management is expected to protect receptors

But.. will need to be verified through further:

- Water quality monitoring
- Geophysics (periodic EM/ERT)
- Record keeping (spills/mishaps and leak detection)

And.. the risk management plan may require updating and adjusting if needed

Questions?

