

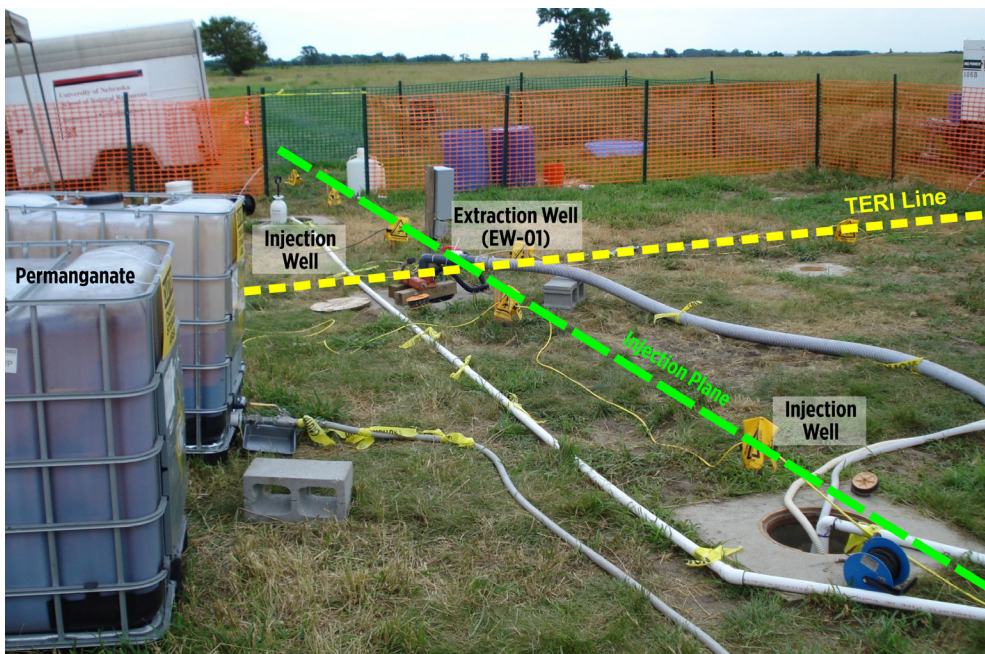
CASE STUDY

TEMPORAL ELECTRICAL MONITORING OF REMEDIAL INJECTIONS

An estimated 23 billion gallons of groundwater beneath a former ordinance plant in Nebraska was contaminated with RDX and TCE above regulatory standards. Remedial efforts originally included an extensive and costly pump-and-treat system to manage the plume. Projections estimated this system would need to operate for more than 125 years.

In need of a more effective remedial strategy, ESTCP funded a pilot-scale ISCO injection demonstration. When twelve downgradient wells and eight direct push profiles could not provide enough data to quantify the distribution of permanganate within the aquifer material, Temporal Electrical Resistivity Imaging (TERI) was utilized to monitor the injectate movement by imaging the subsurface before, during, and after injection.

TERI works like standard (static) ERI; however, rather than producing a single snapshot of the subsurface, it characterizes the electrical changes that occur between different imaging events. This methodology is ideally suited to tracking injected materials as any injectate will have different electrical properties than native materials. A high-sensitivity version of the technology demonstrated injection tracking to 100 ft bgs (30 m) for this pilot scale project. This enhanced capability is commercially available as Aestus GeoTrax Monitoring™.



The graphic above shows how a TERI line (yellow) for this investigation (results on page 2) was oriented in conjunction with the permanganate injection plane (green).

ESTCP Report: Comfort, S., Halihan, T., and V. Zlotnik, 2009, Using Electrical Resistivity Imaging to Evaluate Permanganate Performance during an In Situ Treatment of an RDX-Contaminated Aquifer, ESTCP Report, US DoD, 129 p.

RESULTS

- ☑ Injected materials rarely behave as expected and often follow preferential flowpaths that are not known in advance when informed only by monitoring wells/borings
- ☑ A network of monitoring wells was unable to adequately track a permanganate injection across an impacted site
- ☑ Mapping spatial distribution of *in-situ* injections was possible using Temporal Electrical Resistivity Imaging (TERI)

MORE CERTAINTY & OPTIMAL OUTCOMES

When clients need more certainty in their subsurface data, GeoTrax Monitoring™ electrical images integrated with existing site data and confirmation drilling data yield a more complete understanding of the subsurface, allowing them to:

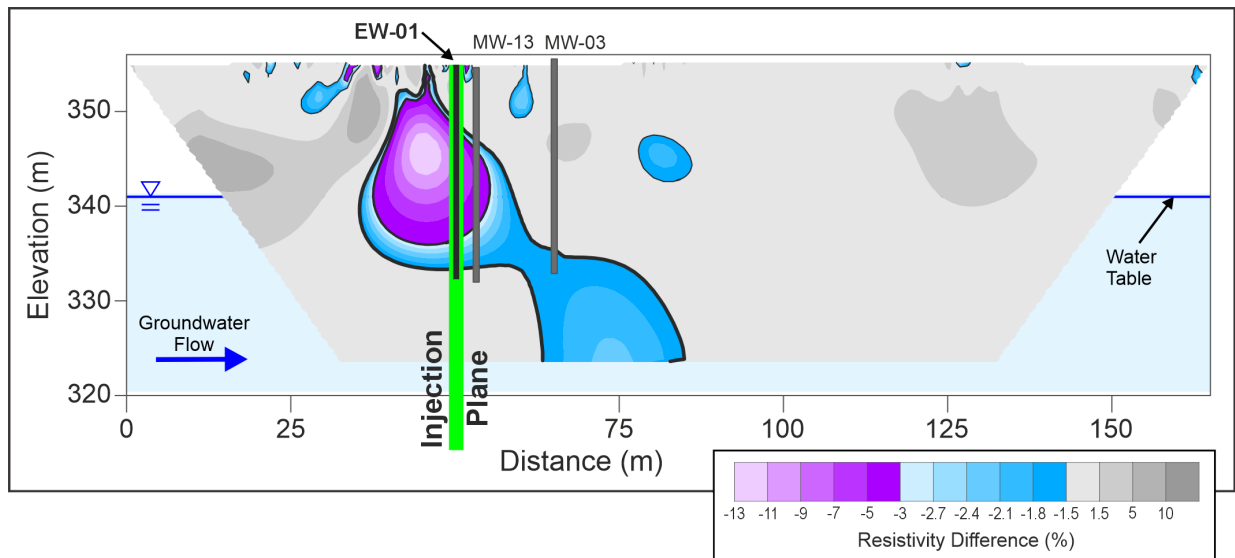
- ☑ Make better technical/business decisions
- ☑ Have clear roadmap for next steps
- ☑ Achieve project goals faster and cheaper

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Delineation of ISCO Injection:

The graphic below shows the TERI transect perpendicular to the injection plane that tracked subsurface changes around an extraction well, EW-01, and a system of monitoring wells. The vertical green line indicates the orientation of the injection plane, and the vertical dark grey lines are monitoring well locations. The TERI data show what changed from pre-injection to post-injection: the purple and blue anomaly represents a decrease in electrical resistivity (i.e., an increase in electrical conductivity), which is interpreted to be the permanganate injection as it migrated from the injection wells.



TERI images revealed that the permanganate was not creating a uniform curtain of injectate as intended but followed preferential flowpaths and migrated below several monitoring well screens, and (in some cases) even flowed against the regional groundwater gradient. Unexpectedly, the images also showed that a large amount of permanganate squirted upwards into the vadose zone rather than staying below the water table (note that the bulk of the purple anomaly is above the water table).

TERI provided predictive insight, which was validated by monitoring well sampling:

- Imaging indicated that the injectate plume would intersect the screened interval; groundwater sampling from MW-13 confirmed the presence of permanganate within the well
- Imaging showed the injectate plume had migrated below the screened interval; permanganate was not detected in groundwater samples collected from MW-03.

Injectate Monitoring using Temporal Electrical Resistivity Imaging (TERI):

Injected materials rarely behave as expected and often follow flowpaths that are not known in advance, especially without continuous imaging. The temporal imaging and well sampling suggested that the monitoring well network was not well suited to track injectate flow across the site as the wells could not delineate the flowpaths controlling the bulk of the permanganate distribution. TERI, however, is particularly well suited to informing the radius of influence for injection events and successfully highlighted the subsurface preferential flowpaths controlling the injectate migration at this site.

Published study available as Halihan, T., et al., 2011, Electrical Resistivity Imaging of a Permanganate Injection During In Situ Treatment of RDX-Contaminated Groundwater: Groundwater Monitoring & Remediation (<https://doi.org/10.1111/j.1745-6592.2011.01361.x>)

YOU DESERVE MORE CERTAINTY IN YOUR SUBSURFACE DATA

