USING STEAM TO SOLVE GROUNDWATER COOLING PROBLEMS AT TCH SITES

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Background

The two most commonly used in situ thermal technologies are Thermal Conductive Heating (TCH) and Electrical Resistance Heating (ERH). Energy is delivered based on the subsurface thermal conductivity and electrical resistivity.

Most sites must be heated to 100°C before the remedial goals are met.

The energy delivery by TCH and ERH is typically in the range of 250-1,000 W/ft of heater or electrode (800-3,000 W/m).

Flowing water can carry energy away much faster than that. The flow of groundwater will also cool geological layers located above and below the flowing groundwater.

If groundwater cannot be slowed down by controlling influx via pumping or a physical barrier, other options need to be considered. In these types of situations, the Steam Enhanced Extraction (SEE) technology is the answer.

When to Use Steam

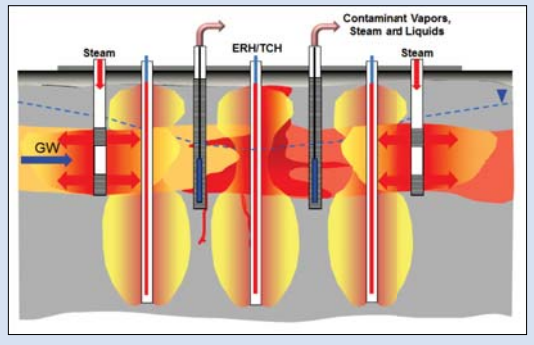
A steam component may be needed to assist ERH and TCH for remedies if:

- A treatment zone with groundwater flow rates higher than approximately 0.5-1 ft/day (0.15-0.30 m/day) is targeted. The flowing water can carry the heat away faster than it is delivered.
- A treatment zone in low permeable silt or sand settings underlain by a faster flowing zone is targeted. Even though the high flowing layer may not be in the treatment zone, the conductive cooling from below will affect the heatup in the lower portion of the treatment zone.
- Fractured bedrock is targeted where the majority of the treatment zone is competent, but high flowing fractures cool portions of the remediation volume.

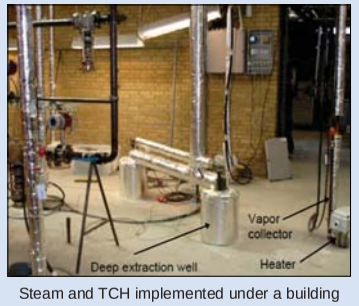
Implementation

Implementation considerations:

- Well spacing – typicallly a minimum of twice as high as ERH and TCH
- Inside out or outside in steam application?
- Capture of mobilized contaminants
- Materials of construction – compatibility with existing heating system
- Is steam needed for the entire project duration, or just for a period?
- Steam injection pressures



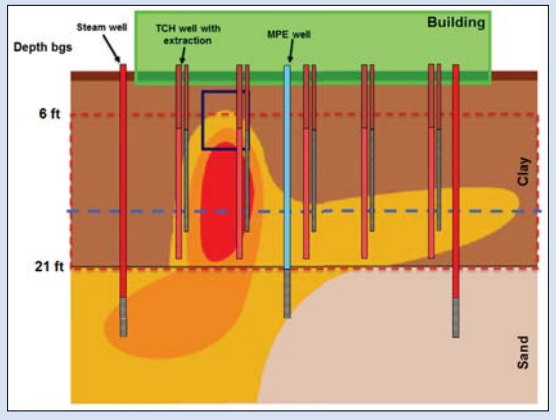
Example combined Steam and TCH site - Switzerland



Steam and TCH implemented under a building

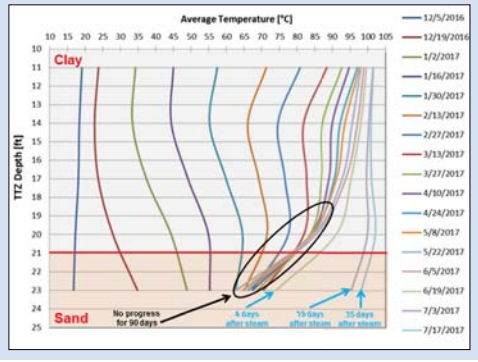
Example Application

Typical application – tight geology overlain by a high flowing groundwater aquifer



Steam benefit:

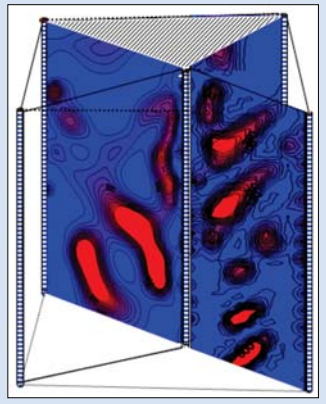
- Temperatures stalled at bottom after 3 months of operation
- Steam added at bottom
- Bottom portion reaching temperature goals after 4-5 weeks



Steam Assisting in Fractured Bedrock

Saturated fractured low-porosity bedrock poses extra challenges:

- Only TCH can heat the volume between fractures
- Fracture flow is typically too high for TCH to overcome cooling effects
- Steam can be utilized to heat high-flowing fractures and block incoming groundwater
- Combination of technologies is essential – implemented alone, each heating method will not be effective.



Design Considerations

- Steam is often the only tool at thermal sites to overcome excessive cooling as a result of groundwater flowing into the treatment volume.
- Combined with ERH and TCH, it may be the only way to reach site goals at high-flowing sites.