

## Pilot site application of Carbo-Iron® particles

### Project Background:

Pilot site application of Carbo-Iron® particles will be conducted within the NanoRem project ("Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment") granted by the European Union Seventh Framework Programme (Project Nr.: 309517). Pilot Site Applications and Field Demonstrations are to be implemented between February 2013 and January 2017.

### Project Site:

The NanoRem pilot site for applying Carbo-Iron® particles into contaminated groundwater is located in the outskirts of the city of Balassagyarmat, Hungary. Balassagyarmat has 16.000 inhabitants and is located approx. 80 km north of Budapest. The production of electrical components for industry on site started in the 1970s. In 1994 production ceased and the buildings were removed. Nowadays, the area of groundwater contaminated with chlorinated solvents (CHC) is about 250 m wide (E-W) and 700 m long (N-S). At the moment, the site is an industrial brownfield (source zone), parts of the area (plume zone) are used as a soccer pitch.



Figure 1: Encircled pilot site area with former electronic component facility (CHC source, southern square) and selected pilot site injection area (northern square)

### Project Partner:

Pilot site applications are performed by *Golder Associates GmbH*, Germany and *Golder Zrt.* in Hungary. Particle specification involves the production and injection of Carbo-Iron® particles, which will be produced by *SciDre* in Dresden, Germany. Planning and field application of Carbo-Iron® at the pilot site is supported by lab-scale testing, conceptual and hydraulic modeling, sustainability assessment and others, all in close coordination with the associated work package groups like the German research institutions *UFZ Leipzig* and *VEGAS Stuttgart*.

### Contaminant situation:

The groundwater table at the pilot site is found at about 3 m below ground level. The major contamination of about 21,000 µg/L CHC at the pilot sites is mainly situated in a depth of about 12-14 meters within the gravel aquifer with a porosity of 0.4 and conductivity of  $5 \times 10^{-3}$  m/s, followed by a clay aquiclude. Plume contamination is estimated to about 15 kg CHC (95 % PCE). The redox potential in groundwater is in the range of: +86 - +138 mV with dissolved oxygen between 1,59 mg/l and 2,87 mg/l; Figure 2).

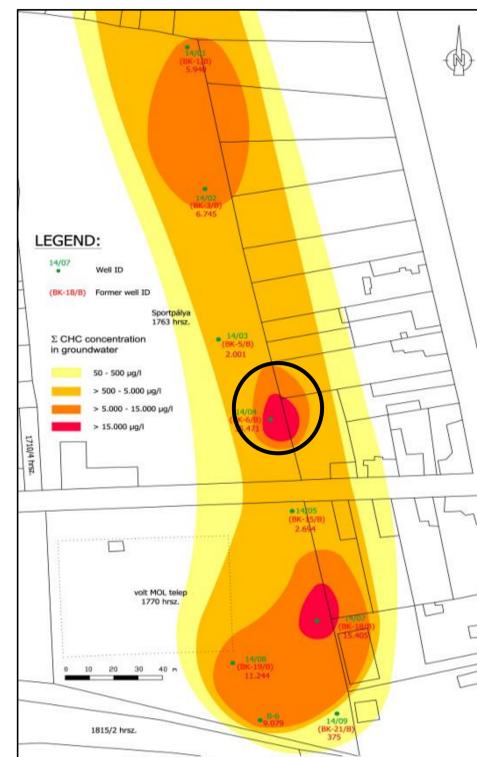


Figure 2: Encircled pilot site area with CHC contaminant distribution

Based on the geological information and the previous groundwater monitoring results, four CMT wells (screened in 3 different intervals) were installed at the site in November 2014. The CMT wells are located at 3 m, 4 m, 10 m and 14 m of distance from the proposed injection points (I1-I3) in down-gradient direction. There are 2 monitoring wells, where data loggers will be installed to gain geochemical data during the injection (M; Figure 3).

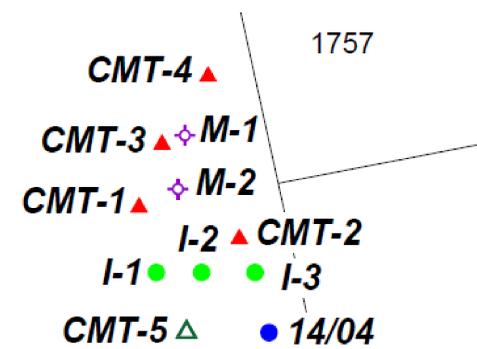


Figure 3: Pilot site area with the sampling points (CMT 1-5, M, 14/4) and proposed injection points



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### Conceptual Site Model (CSM)

Based on the analytical results, a conceptual site and contamination transport model were generated and the pilot site with an area ca. 150 m<sup>2</sup> was selected. The CSM has outlined the risk associated with the subsurface contamination transport of chlorinated hydrocarbon towards different receptors in the pilot site test area. As well, a scheme was presented to address the proposed remedial effect of Carbo-Iron® injection at the pilot site (Figure 4).

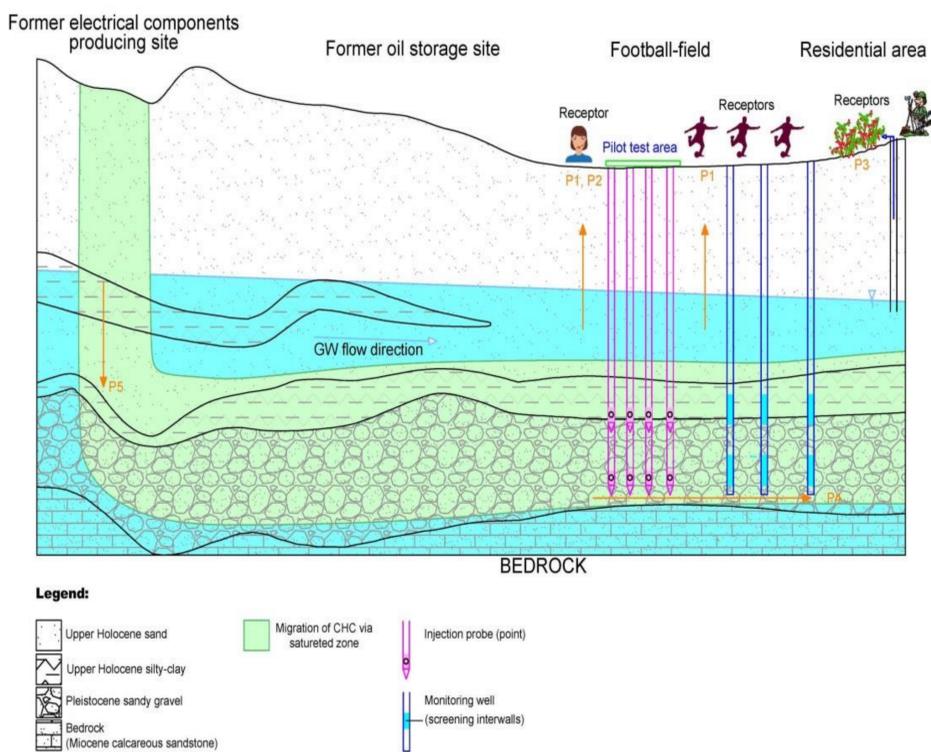


Figure 4: Cross section of pilot site with injection and monitoring scheme

### Injection and Monitoring Planning

- In summer 2015, Carbo-Iron® injection will be conducted at a gravel aquifer contaminated with chlorinated solvents (CHC)
- Injection shall happen in 3 injection points at the depths of major contamination perpendicular to GW flow direction ;
- 4 monitoring CMT wells are installed to verify the injection results in designated three depths (screened section marked with red lines in Figure 5);
- Chemical groundwater analysis shall indicate CHC reduction as well as associated parameters like vinyl-chloride, hydrogen, dissolved iron, ethane, ethene;
- The technical equipment includes direct push penetrometer, nitrogen supply, water, mixing and injection tanks, high pressure membrane pump, with associated monitoring wells (Figure 6)
- Beyond the groundwater monitoring soil and groundwater samples from the pilot site will be analyzed within the project objectives of selected NanoRem work packages.

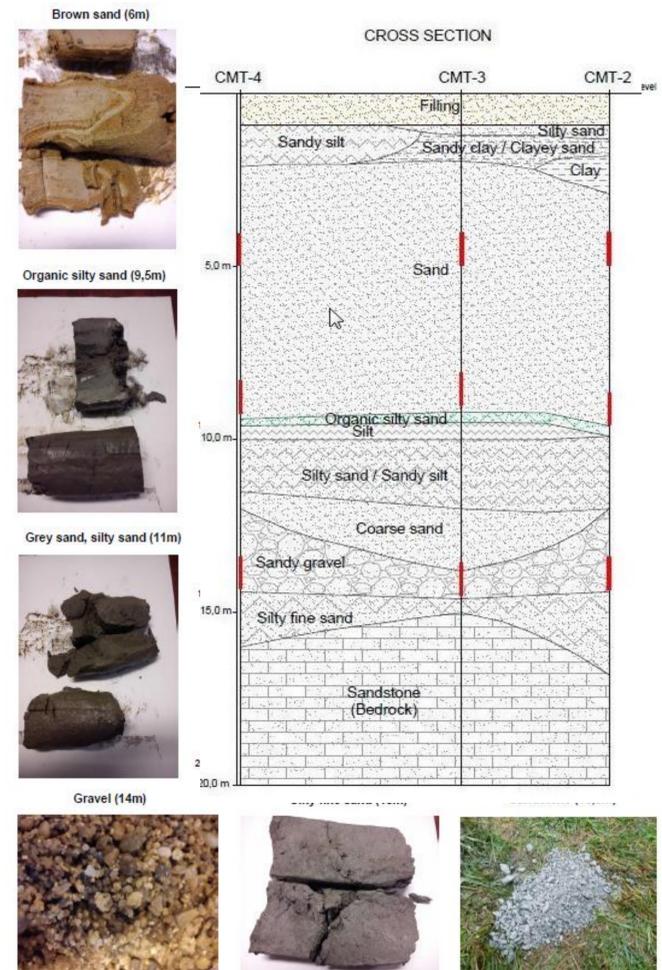


Figure 5: Cross Section of soil profile with wells and sampling points



Figure 6: Technical injection equipment

### Outlook

After injection in Summer 2015, groundwater sampling at 7 monitoring events (-7 to 360 days) will be conducted at all suitable wells (4 x CMT a 3 Channel), and monitoring wells upstream and downstream of the injection area with the intention to verify contaminant mitigation due to Carbo-Iron® injection into the aquifer.

