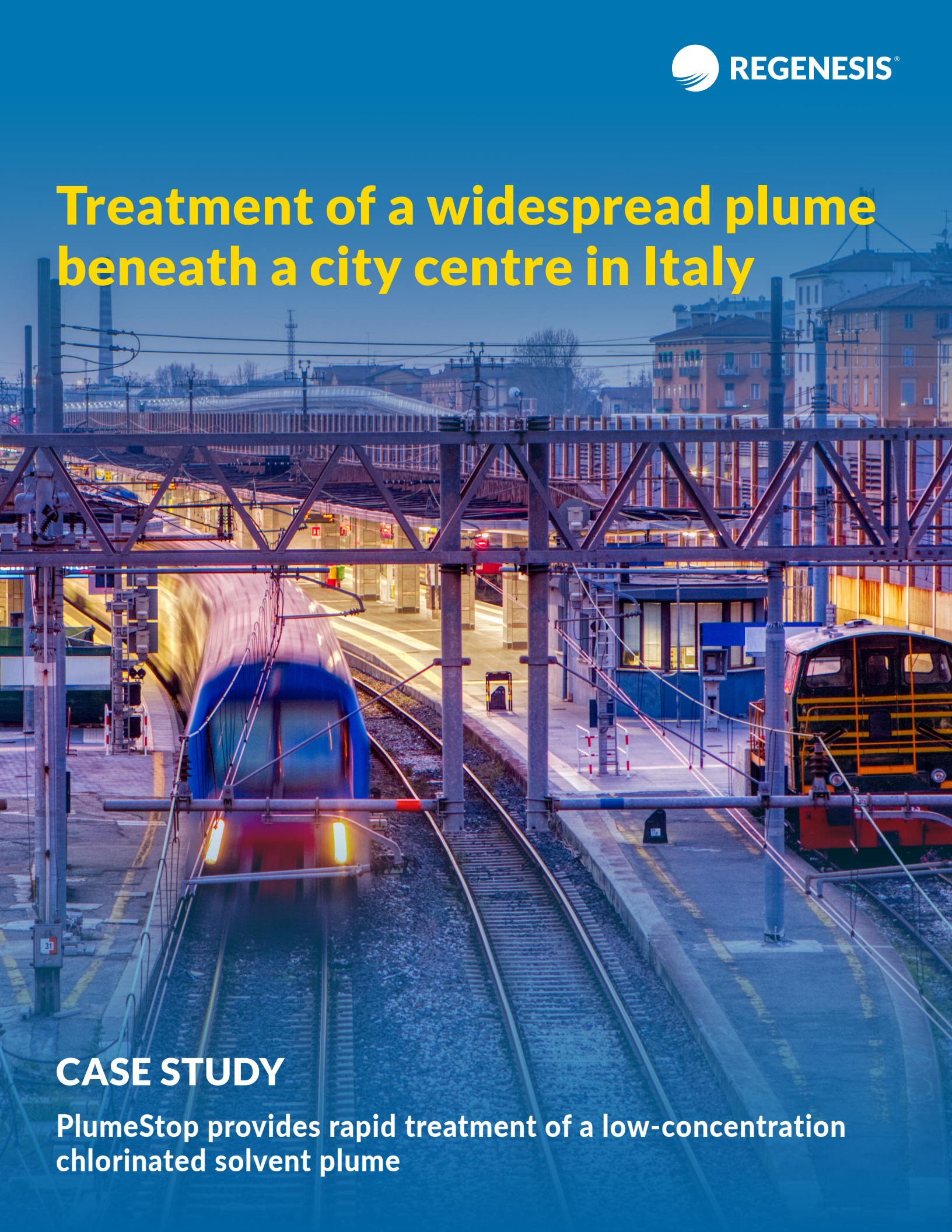
REGENESIS®

Treatment of a widespread plume beneath a city centre in Italy



CASE STUDY

PlumeStop provides rapid treatment of a low-concentration chlorinated solvent plume

INTRODUCTION

As part of a major infrastructure renewal project comprising the construction of an underground high speed train railway terminal, a widespread plume of chlorinated solvents (CHC) had been identified.

Monitoring was completed for more than a decade, underneath the train station and extending out under the surrounding city centre of Bologna, Italy. One location showed concentrations exceeding 1,000 µg/l, but most of the chlorinated solvent concentrations were low (100 µg/l or less) yet persistent and with no effective natural attenuation occurring.

The main contaminants are **TCE** and **cis-1,2-DCE**, which are present in two aquifers with different geological characteristics:

- The superficial aquifer has a thickness of 6 to 8 meters and consists of fine sands and silts;
- The deeper aquifer has a thickness of 2 to 4 meters and consists of higher permeable sand.

This contamination had previously been considered as practically untreatable, due to its low concentrations, location and size.

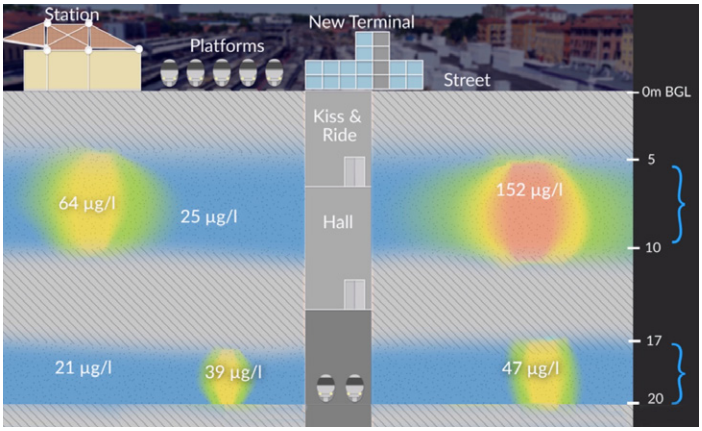


Fig. 1 (above) Section illustration showing the superficial and deeper contaminated aquifers; Fig. 2 (below) Overview of the train station and surrounding city centre.

REMEDIAL APPROACH

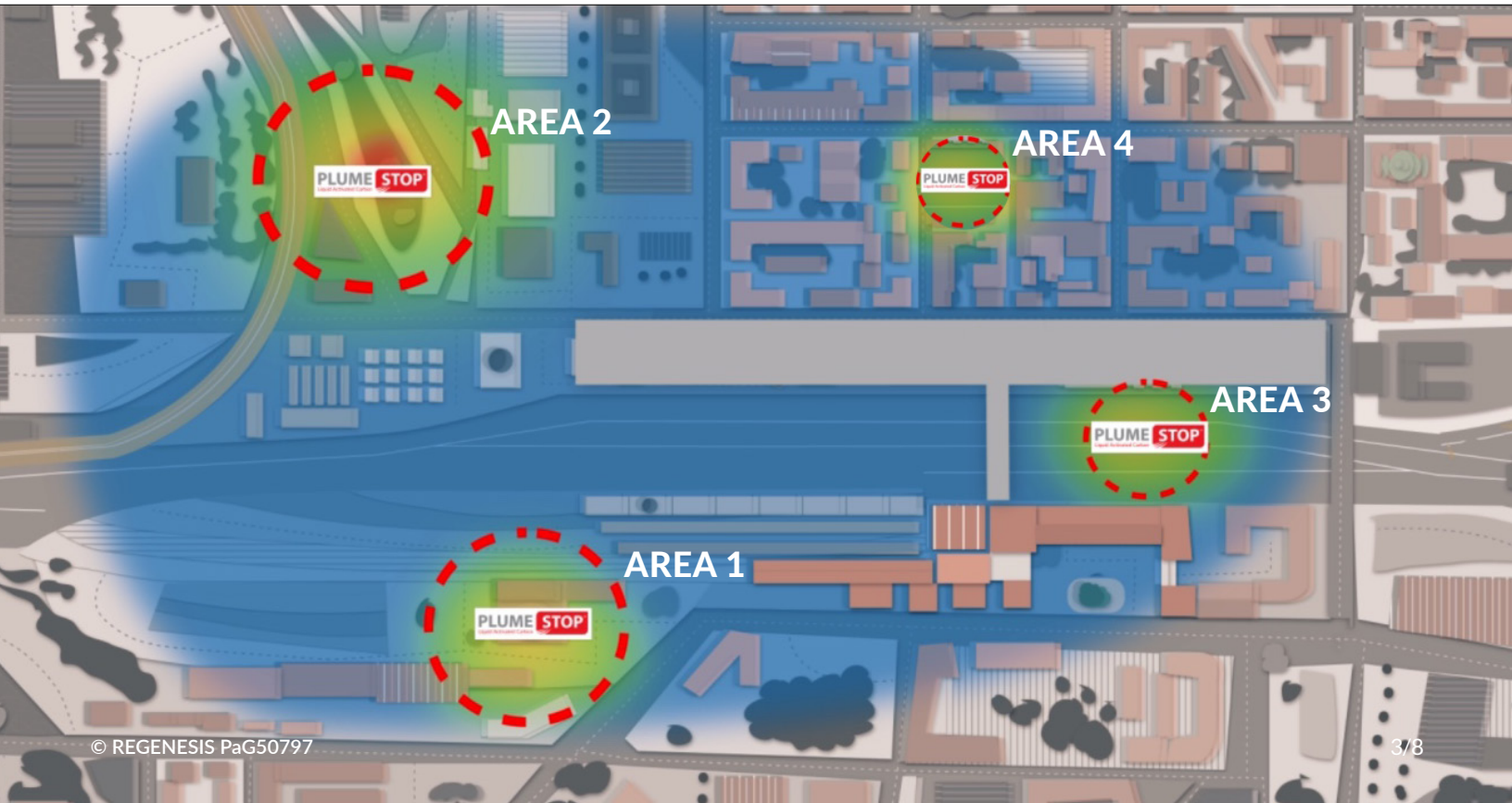
The **University of Rome 'La Sapienza'** had been commissioned to evaluate strategies for the remediation of this large urban site. Based on the results from site investigation, lab testing and microcosm studies, biological reductive dechlorination was recognized as a potential approach. Yet, biological degradation was considered impractical for treatment on the site, due to the potential inefficiencies at such low contaminant concentrations. However, with the creation of the **PlumeStop® Liquid Activated Carbon** technology, another treatment approach became an option.

PlumeStop provides effective treatment of widespread, low concentration plumes as it works **by combining in situ adsorption and enhanced biological degradation**. The technology provides a sustained treatment to very low concentration targets from a single injection into the subsurface.

There is no need for mechanical plant installation and with minimised site activities, the solution is ideal for a site comprising a busy railway station, residential neighbourhood and ongoing redevelopment works.

The intention on this site was to treat all of the accessible 'hot spots' present within the plume, with the first area being used as a pilot test to confirm dose and distribution.

Fig. 3 (below): Full-scale treatment locations: targeting the 4 'hot spots' within the widespread, low-concentration plume



TREATMENT

For the **pilot test**, REGENESIS installed 6 multi-level injection wells and applied specific doses of **PlumeStop** at the target depths. On-site works for the pilot test were completed in 3 weeks and included the execution of a range of tests in order to confirm the treatment effectiveness and create an accurate design for the full-scale application.

Full scale treatment comprised injection into the four identified 'hot spot' areas (see figure 3, previous page). In Areas 1 and 2, multi-level injection wells were used, while in areas with restricted access: Area 3 (rail way station) and Area 4 (residential area), direct push approach was employed. Each area received a single PlumeStop application, that took place when accessibility was granted; this meant that, due to the ongoing major infrastructure works, the full-scale treatment happened over a time-frame of two years.

In all treatment areas, PlumeStop was co-injected with REGENESIS electron donors **HRC®** and **HRC Primer®**, to create biostimulation and promote continual in situ bio-regeneration of the sorption sites on the activated carbon barrier.

Fig. 4, Soil testing during the pilot phase

Fig. 5, Drilling wells prior to injection in Area 2

Fig. 6, Injection of PlumeStop on the platform of the railway station, in Area 3; Fig. 7 (below), Direct push injections in the road at Area 4

RESULTS

Long-term monitoring, up to 5 years post-injection, was performed in all the treatment areas. This resulted in a rapid reduction in CHC concentrations, both parent compounds (PCE, TCE) and daughter products (DCE, VC). Concentrations of all chlorinated compounds decreased in a matter of a few months, with the majority of monitoring wells values achieving stringent regulatory standards ('CSC') and in many cases also below the detection limit.

In most groundwater monitoring results, daughter products, cis1,2-DCE and VC, show a decreasing trend from the start of treatment, rather than a sequential increase and then decrease in concentration, as would be expected in a typical Enhanced Reductive Dechlorination (ERD) approach. This is due to full reductive dechlorination occurring on the surface of the PlumeStop biomatrix, rather than in the groundwater itself.

Multiple years of monitoring demonstrated that **low concentrations levels were maintained over time, without any rebound**. This is due to the continuous regeneration of the sorption sites on the activated carbon provided by enhanced biodegradation (during the hydrogen release period of the HRC) and then maintained through natural biological degradation, supported by naturally occurring electron donors.

For three of the areas, the validation period is now complete and they have been **certified for compliance and closure**. In Area 1, additional contamination was observed and is thought to be migrating from upgradient of the train station. An application of sulfidated colloidal zero-valent iron product S-MicroZVI was completed to provide In Situ Chemical Reduction (ISCR) of the contamination, which will work in combination with the ongoing sorption and biological degradation.

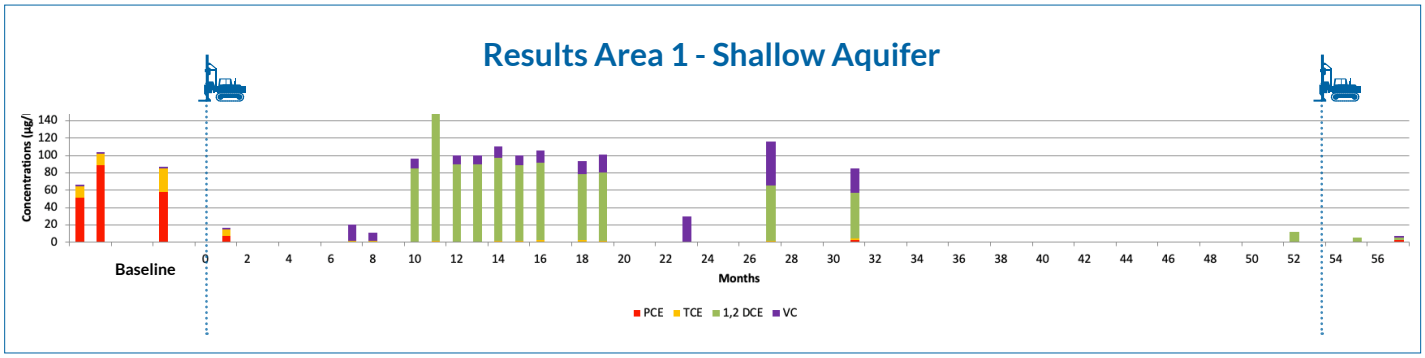


Fig. 8: Area 1 average CHC concentrations over time, pre- and post remediation (shallow aquifer treatment) The area received an extra ISCR application to manage incoming contamination from upgradient

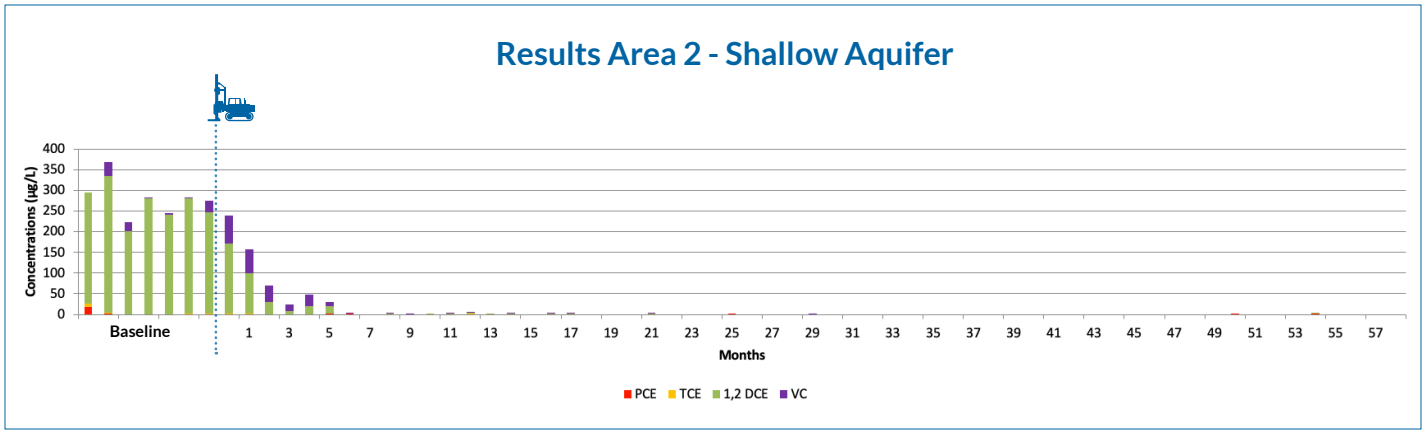


Fig. 9: Area 2 average CHC concentrations over time pre- and post remediation (shallow aquifer treatment)

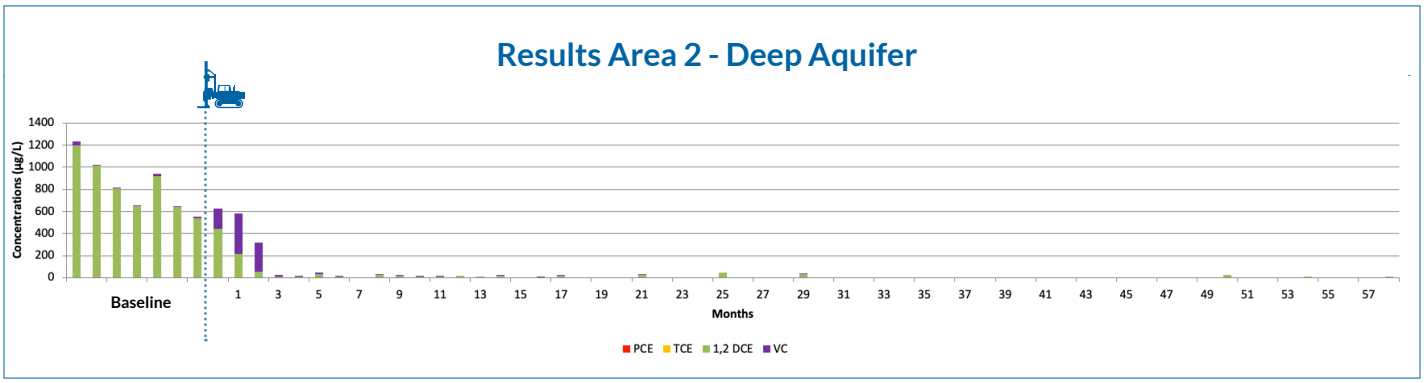


Fig. 10: Area 2 average CHC concentrations over time, pre- and post remediation (deep aquifer treatment)

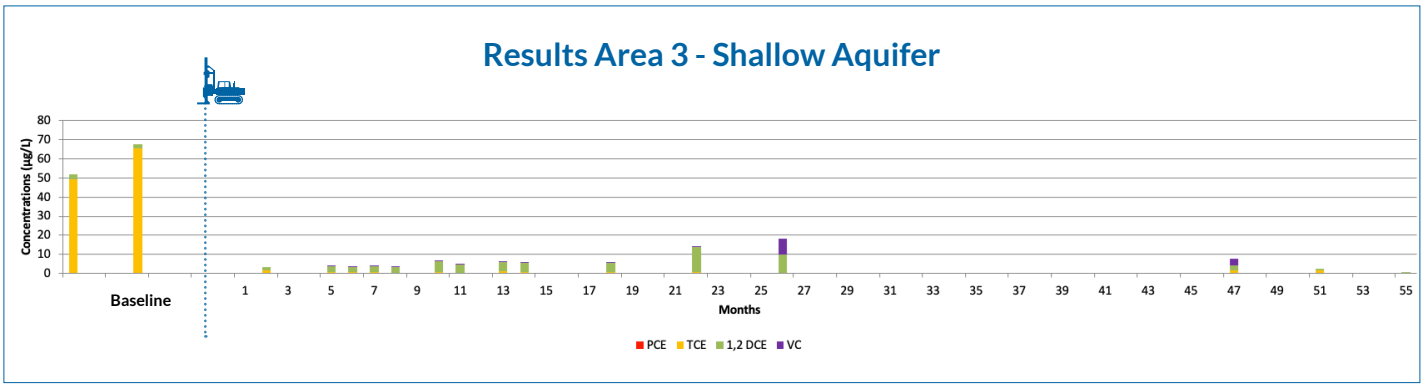


Fig. 11: Area 3 average CHC concentrations over time, pre- and post remediation (shallow aquifer treatment)

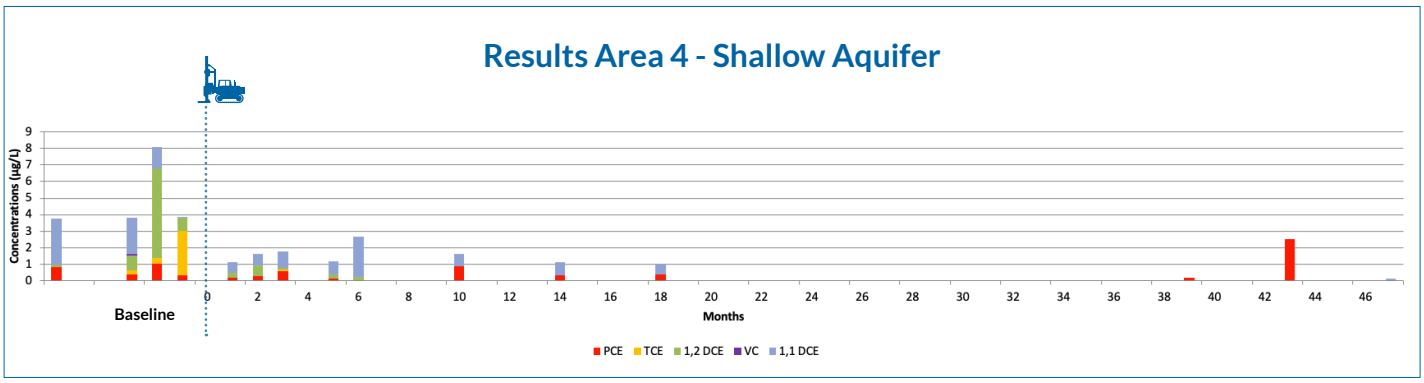


Fig. 12: Area 4 average CHC concentrations over time, pre- and post remediation (shallow aquifer treatment). The target contaminant of concern in this area was 1,2-dichloroethylene

CONCLUSIONS

Combined in situ sorption and biological degradation has proven to be an effective solution for managing a widespread plume, providing quick and stable results with no build up of daughter products. Key aspects of the remediation are:

- Successful remediation has been achieved in two porous media aquifers at the same time, minimizing disruption in the city centre, train station and the major infrastructure activities.
- PlumeStop Liquid Activated Carbon has proven to be an in situ technology with unprecedented capabilities; able to rapidly remove contaminants from the groundwater and degrade them within a few months.
- It had previously been deemed impossible to treat this site due to the low starting concentration, the stringent remediation targets, the widespread plume and its location under a city centre. PlumeStop has made the treatment simple and cost-effective.
- Due to the self-regenerating sorption capability of the biomatrix, there is no requirement for re-application, providing ongoing treatment confirmed by the long term validation monitoring across the site.

“The possibility to use PlumeStop has been key in creating a successful strategy for the management of this site.

The fruitful collaboration, step by step, between all academic and industrial partners has led to robust remediation on, what was at the time, the first European PlumeStop application. ”

PROJECT COORDINATOR

Prof. Petrangeli Papini
Università La Sapienza di Roma

ABOUT THE PROJECT COORDINATOR

Prof. Petrangeli Papini - Università La Sapienza di Roma

Graduating with honours in Industrial Chemistry in 1990 and PhD in Chemical Sciences in 1994, he is Full Professor at the Chemistry Department of the University of Rome 'La Sapienza'. Prof. Petrangeli Papini carries out research activities in the field of study and development of processes and technologies for the remediation of contaminated soils and aquifers. In this context, he is the author of >70 scientific publications in international journals and books and >80 communications at national/international conferences. He is also co-owner of 5 patents concerning water purification and remediation of contaminated sites.

Since 2010 he is Director of the post-graduation Master course in 'Characterization and Remediation Technologies for Contaminated Sites' at the University of Rome 'La Sapienza'. From February 2010 to December 2015 he served as a member of the Technical Secretariat of the Italian Ministry of the Environment as an expert in the remediation of national interest sites and participated in the Working Group for the Reorganization and Codification of the Environmental Regulations and for the revision of Annexes to Part IV, Title V of Legislative Decree 152/2006.

Prof. Marco Petrangeli Papini has been, and continues to work, as coordinator of numerous national and international projects and research units for the remediation of contaminated sites through the use of innovative chemical, physical and biological processes.

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