

# Pesticides, VOCs and petroleum hydrocarbons remediated with a suite of in situ technologies

## CASE STUDY

Shallow aquifer treatment via injection of RegenOx<sup>®</sup>, PersulfOx<sup>®</sup>, ORC-Advanced<sup>®</sup> and Plumestop<sup>®</sup> at a former industrial site in Suffolk, UK

CLIENT  
FTSE100 Company

CONSULTANT  
Ramboll

CONTRACTOR  
Soilfix



## INTRODUCTION

Located in the south east of England, this industrial site had been occupied by a timber yard, incinerator, fuel storage tanks and a saw mill. These were later demolished and the site-use changed to light commercial and a car park for a FTSE 100 Company. It was decided that the site should be prepared for redevelopment and a due diligence site investigation was carried out by Ramboll to support lease surrender.

This identified significant contamination of soil and shallow groundwater in a corner of the car park on the 500m<sup>2</sup> site. It was discovered that the soils and groundwater were impacted with a wide range of contaminants including **total petroleum hydrocarbons (TPH)**, **volatile organic compounds (VOCs)** including **BTEX**, **trimethylbenzene**, **pentachlorophenol** and a mix of **pesticides**, including **organochlorine pesticides (Dieldrin)** and **gamma-HCH (Lindane)**.

DQRA modelling by Ramboll confirmed an unacceptable risk to the surrounding Secondary 'A' Aquifer and nearby river, along with unacceptable human health risks to potential

future site receptors. The remedial targets derived were based on human-health risk for the upper 1m of soils, in order to provide protection for potential future residential use. The groundwater remedial targets generated by Ramboll's DQRA were agreed to be unattainable and instead a 75% reduction in the concentrations of contaminants of concern was agreed upon.

Remediation of this complex mix of contaminants was therefore required and with the lease surrender scheduled for only 6 months' time, a rapid approach using a number of integrated technologies would be required.



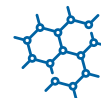
### SITE TYPE

Former industrial site  
(timber treatment yard)



### GEOLOGY

Made ground  
Sand and gravel over clay



### CONTAMINANTS

Pentachlorophenol: 2,065 µg/L,  
TPH: 28,000 µg/L, Lindane: 129 µg/L,  
Dieldrin: 50 µg/L, Naphthalene: 449 µg/L



### PROJECT DRIVER

Site Redevelopment



### TREATMENT

In Situ Chemical Oxidation (ISCO)  
followed by In Situ Sorption and  
Enhanced Biodegradation.



### TECHNOLOGIES

PersulfOx<sup>®</sup>, RegenOx<sup>®</sup>,  
PlumeStop<sup>®</sup>, ORC Advanced<sup>®</sup>

## REMEDIAL APPROACH

Soilfix worked closely with Ramboll and REGENESIS to develop a tailored multi-phase remediation solution for the site, comprising:

Targeted excavation was completed by Soilfix on the impacted soils. Backfill was completed using clean granular material to the top of groundwater, above which a clay backfill was used to minimise short-circuiting of injectate to the surface, during the following phases of the remedial works.

Further validation wells and an in situ chemical oxidation (ISCO) injection-well grid were installed in the treatment area. Groundwater sampling was completed in a number of these wells to establish an accurate baseline concentration for each of the contaminants. The extra wells also allowed lateral delineation of the contaminant plume. Variable head tests and groundwater levels measurements were complemented with the use of a Hydraulic Profiling Tool (HPT), as suggested by REGENESIS, to ascertain groundwater flow direction, permeability and to identify flux zones in the target area.

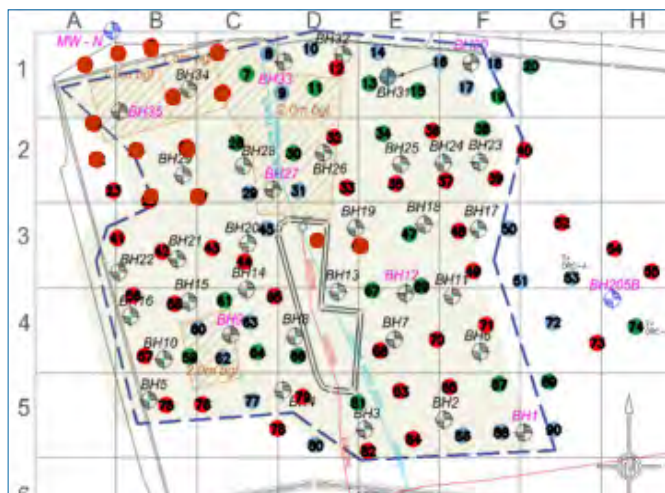


Figure 2: Remediation plan

The aim of first stage of the in situ remediation phase of works, was to rapidly reduce the contaminant mass, particularly TPH, within the saturated zone, i.e. in the groundwater and on the soils in the smear zone (sorbed contamination at the top of the groundwater column). This was completed using In situ Chemical Oxidation (ISCO), which is effective at treating all of the contaminants of concern in the plume. ISCO breaks the contaminants down through direct-, surface mediated- and free radical-oxidation.

RegenOx® (a sodium percarbonate-based oxidant with an iron silicate catalyst) was initially chosen as the most suitable reagent. During the initial ISCO injection round it was found that injection back pressures and daylighting were greater than anticipated, associated with the lower-than-expected permeability of the aquifer. It was decided to complete injection testing with an alternative REGENESIS ISCO agent - PersulfOx®: a sodium persulfate-based oxidant with a built-in catalyst – and it was found that PersulfOx could be more readily injected into the low permeability aquifer. The main injections were then completed using PersulfOx, with RegenOx being used in the vicinity of a buried electric service, as RegenOx does not damage services. Three ISCO injection campaigns were undertaken by REGENESIS Remediation Services (RRS) into the grid of 35 injection wells, on an approximate 5m by 5m across the area, with a fourth round being completed only across half of the points, where required.

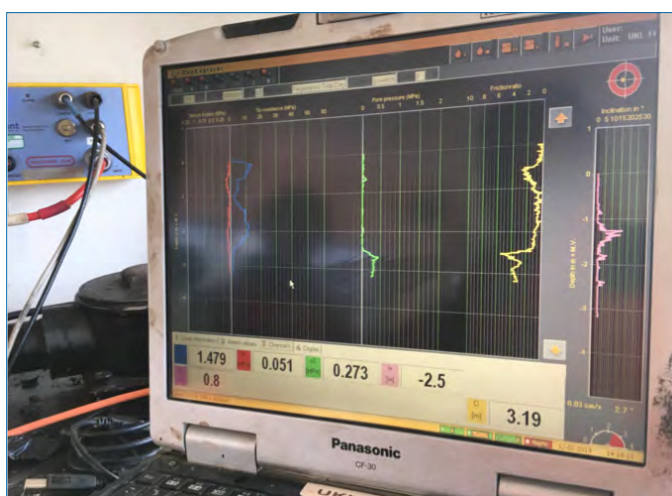


Figure 1: Hydraulic conductivity profiles assessed onsite

The data showed that there were no clear ‘source areas’ in the groundwater, the permeability was lower than expected and that the groundwater regime was much more complex than expected, with different flux directions possible on different scales. This data was used to optimize the *in situ* remedial design, through adjustments to products used, dosage and barrier configuration.



REGENESIS Remediation Services setup for the PlumeStop injections

The final stage of the treatment programme was the injection of **PlumeStop®** to sorb and then biologically degrade the residual, dissolved phase contaminants to achieve low concentrations. PlumeStop comprises 1-2µm size particles of activated carbon suspended in water with dispersion agents. PlumeStop is injected into the subsurface under low pressure, where it coats the aquifer matrix, effectively turning the subsurface into an activated carbon filter. This removes contamination from the groundwater and provides a surface on which microbial growth can occur, biologically degrading the contamination and regenerating the sorption sites. Contaminant influx from back-diffusion is then sorbed and degraded, providing treatment of the contamination within the low permeability zones.

It had been initially intended to complete PlumeStop barriers along the upgradient (northern) boundary and the downgradient (south/southwestern) boundary, to prevent recontamination from the upgradient site and prevent residual contamination affecting the downgradient river/offsite environment. However, following the further characterisation works onsite, a simple up- and down-gradient direction could not be determined at all depths and locations. The design was therefore altered to provide a grid treatment across the residual plume, with an

increased dosage along the northern boundary where the most significant contamination had been observed and adjacent to a known historical offsite source.

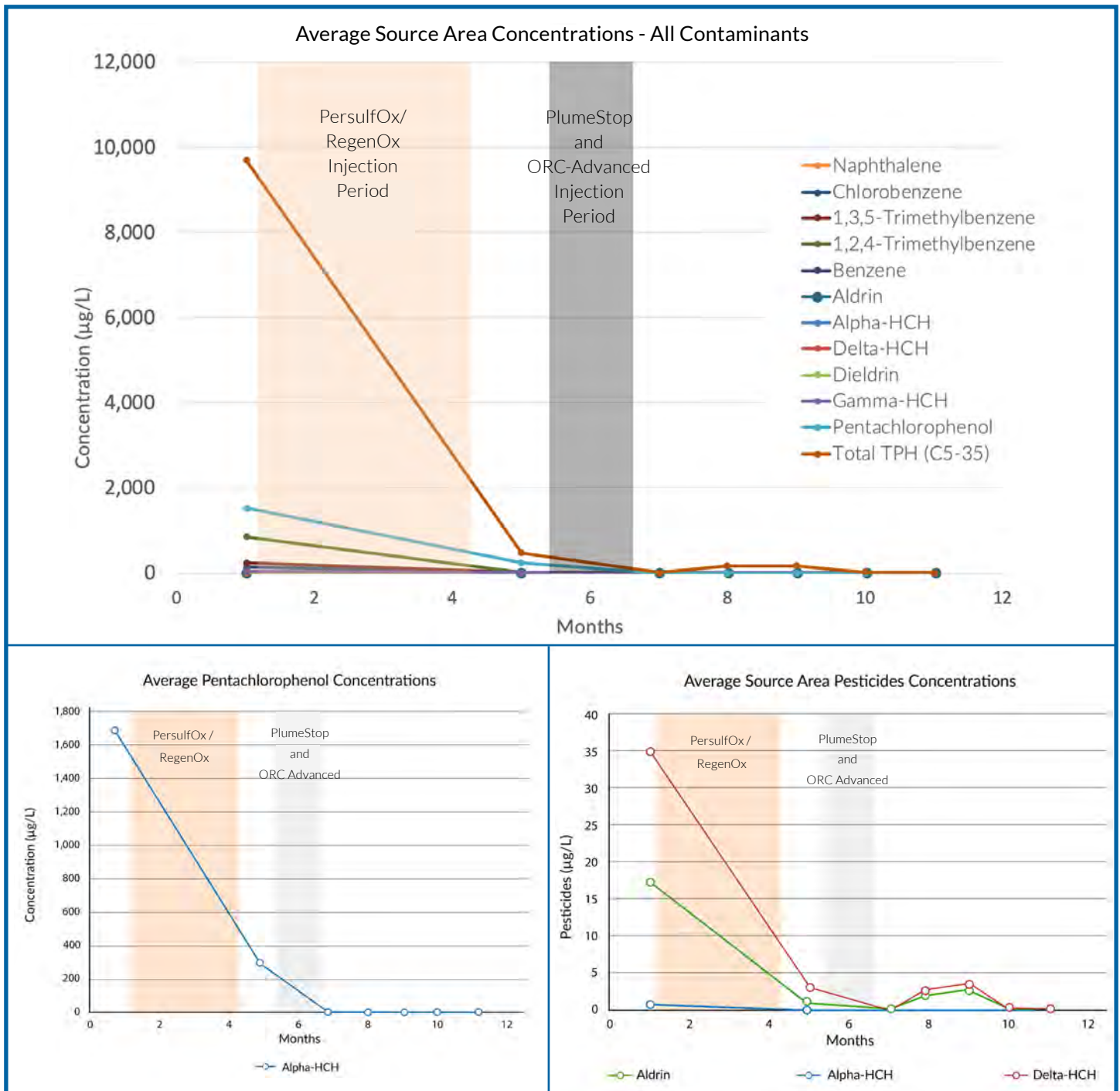
REGENESIS completed a localized injection trial to test whether the full dose could be successfully applied, in to the subsurface. The trial also allowed testing of the optimal injection parameters and observance of PlumeStop around the injection location to determine that the radius of influence (ROI) achieved would be sufficient for the planned injection spacing. This test allowed optimization of the injection regime and direct-push injection was used to apply PlumeStop across the target area.

Where areas had been identified with more elevated contaminant concentrations, a more concentrated dosage of PlumeStop was applied. In those areas where high levels of TPH were located, **ORC Advanced®** was also applied with the PlumeStop to promote further aerobic degradation in those locations.

90 direct push injection points, on a 3m by 3m injection grid, were completed in 4 weeks.

## RESULTS

The validation results show a rapid and sustained reduction in the concentration of all contaminants of concern (COCs). It can be seen that mass reduction of all the COCs was achieved by the ISCO phase: the average constituent was reduced by 86% (range 46%-99%), average total contaminant mass reduction was **94%**. This was followed by further reductions to very low concentrations by the PlumeStop injection: the average constituent was reduced by 96% (range 76%-99.97%), average total contaminant mass reduction was **99.73%**.



## CONCLUSION

Due to the short time available for remediation to be completed only a combination of mass removal and rapid in situ remediation was feasible.

The multi-phase remediation was provided for **£500.000**, on programme and in budget.

Waste generation was minimised through in situ treatment, with no costly waste generated from groundwater treatment.

The remedial targets were achieved in time for lease surrender, with all stakeholders satisfied with the works completed.



“

The project was a great success. Not only did we meet the betterment-based objectives that we agreed with the client's consultant Ramboll; for many of the contaminants we ended up meeting the stringent criteria that were originally derived by the risk assessment. This enabled the client to surrender their lease on their programme.

We felt this was largely down to the project team approach that we took with REGENESIS, from conception through to validation and completion of the project.

Steve Jackson, Director, Soilfix

”



## ABOUT THE CONTRACTOR

Soilfix is an award-winning remediation solutions provider to the development, industrial, commercial and public sectors. Their mission is to continually advance their understanding and management of risk in the ground.

Soilfix endorses a 'brownfield first' approach that can actually speed up the construction process by removing the barriers to construction on brownfield sites, whilst also protecting our environment and improving people's mental and physical wellbeing.

Since establishing the business in 2004, Soilfix has developed an outstanding track record for delivering technically robust and innovative remedial solutions to unlock brownfield sites on a wide variety of industrial settings. This includes former gasworks, chemical works, landfill sites, shipyards and fuel storage facilities to name a few.

Soilfix are committed to building long term relationships by offering a professional service tailored to their clients' individual needs, whilst always helping them solve the problems they have with their land. Soilfix' highly qualified and experienced personnel have the skills to safely deliver demanding projects meeting commercial objectives and regulatory requirements.

Soilfix has significant experience in adopting a wide variety of both conventional and more innovative in-situ / ex-situ soil and groundwater treatment technologies to meet site specific remedial objectives and/or enable excavation and removal of in-ground obstructions. Remediation of soil and groundwater is carried out using the most practical and appropriate technique that is only applied once we have fully understood our clients' objectives.

From offices in Avonmouth, Bristol and Rayleigh, Essex, Soilfix provides its remediation and ground risk management services throughout the UK.



## TECHNOLOGIES APPLIED

**RegenOx®** – Powerful and safe ISCO, compatible with underground structures and services.



**PersulfOx®** – Rapid and sustained persulfate ISCO with built-in activation for safe site work.



**PlumeStop® Liquid Activated Carbon™**  
Liquid formulation of Colloidal Activated Carbon to provide proven, fast and cost-effective achievement of stringent targets for widespread contaminant plumes.



**ORC Advanced®** – Accelerated aerobic biodegradation of hydrocarbons for up to a year from a single application.



For more information, please get in touch or visit our website.



### CONTACT

[europe@regenesisc.com](mailto:europe@regenesisc.com)  
+44 (0)1225 61 81 61

[www.regenesisc.com](http://www.regenesisc.com)