REGENESIS®

Protecting a Lake from a Catastrophic Benzene Spill in Czechia

PetroFix barrier reduces benzene concentrations by three orders of magnitude following major rail spill



Project Highlights

Site Type
Railway spill response at a former gravel pit

Location
Hustopeče nad Bečvou, Czechia

Contaminant
Benzene

Hydrogeologic Setting
Highly permeable gravel aquifer with groundwater velocity up to 4 m/day

Remediation Approach
Integrated remedy consisting of a 680 m long PetroFix CAC barrier complex, with sheet-pile containment and groundwater recovery and treatment in the source zone

Results
99.85% benzene concentration reduction, with no benzene detected in the lake after implementation

Summary

Following the derailment of a freight train releasing up to 300 tonnes of pure benzene to the subsurface, a PetroFix colloidal activated carbon (CAC) barrier was integrated into a multi-faceted emergency response. The in situ barrier, implemented by DEKONTA, rapidly controlled dissolved benzene that had migrated beyond the primary sheet-pile containment, protecting an adjacent gravel-pit lake while also supporting longer-term biodegradation.

Background

A freight train transporting pure benzene derailed and caught fire near Hustopeče nad Bečvou, releasing an estimated 400 tonnes of benzene from 14 damaged tank cars Figure 1. Approximately 200 to 300 tonnes were estimated to have entered the subsurface. As one of the largest recorded benzene spill in Europe's modern history, the incident created an immediate threat to site workers, groundwater, a nearby lake, and connected downstream surface waters.

The site geology intensified that threat. Beneath a thin loam cover, coarse gravels extended to an underlying clay unit at approximately 8 m below ground surface. Groundwater was shallow and moved through the highly permeable aquifer at velocities reported up to 4 m/day. Free-phase benzene accumulated at the water table, while dissolved benzene migrated toward the lake approximately 100 m away. Benzene was observed in the lake within days of the incident.

Figure 1 Train Derailment Results in Benzene Release

Damaged rail tank cars following the Czechia derailment that released approximately 400 tonnes of benzene. Source: DEKONTA





Remedy Selection



A sheet-pile wall approximately 700 m long and 8m deep was installed to isolate the primary release area and stop most free-phase migration. Source: DEKONTA

DEKONTA developed a continuously updated conceptual site model (CSM) using trial pits, monitoring and recovery wells, soil borings, soil-vapor surveys and MIHPT (Membrane Interface Probe + Hydraulic Profiling Tool, Geoprobe) investigation. Emergency measures included LNAPL (Light Non-Aqueous Phase Liquid) recovery, groundwater extraction and aboveground activated-carbon treatment. A sheet-pile wall approximately 700 m long and 8 m deep was installed to isolate the primary release area and stop most free-phase migration.

However, several tonnes of benzene had already moved beyond the sheet pile containment. Because the remaining mass threatened the lake, the response team needed a rapidly deployable treatment that could intercept dissolved benzene in situ without impeding groundwater flow. A short duration proof-of-concept pilot test demonstrated that PetroFix could be distributed through the coarse aquifer and could quickly lower dissolved benzene concentrations. The pilot test results were then used to inform the full-scale design.

PetroFix Application Details

Total barrier length	680 m
Treatment depth range	2 to 8 m
Injection points	136
Quantity applied	49 tonnes

Remedial Design and Application

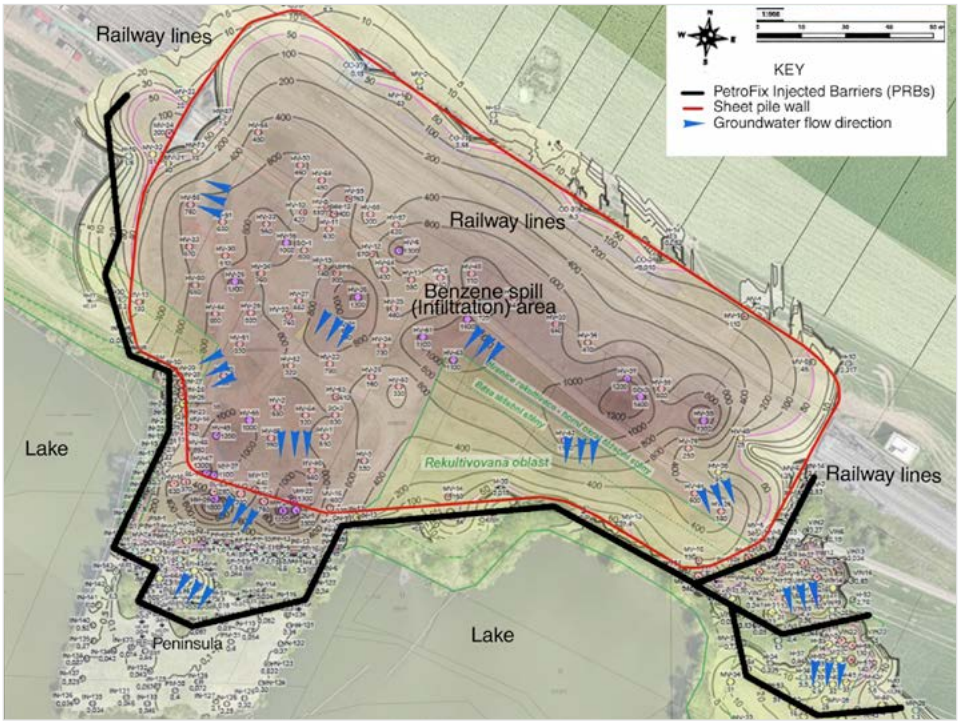
The primary full-scale PetroFix permeable barrier extended approximately 470 m along the principal migration pathways beyond the sheet-pile containment, including the peninsula between the release area and the lake (Figure 2). Later, two shorter barriers (210 m in length in total) were added along the eastern release area to address a lobe of the plume that had migrated eastward.

PetroFix contains 1- to 2-µm colloidal activated carbon particles designed to distribute through the subsurface and attach to aquifer solids. Upon injection, PetroFix creates a permeable sorptive treatment zone that functions as a large, belowground carbon filter. As contaminants are degraded, whether naturally or through enhancement, the carbon particles' sorption sites are regenerated.

PetroFix was injected through closely spaced, small-diameter wells screened at depths ranging from 2 to 8 m below ground surface to address the full gravel aquifer thickness. A calcium-based amendment was used as a parking agent to limit potentially excessive CAC transport in the highly permeable formation and maintain treatment along the intended barrier alignment. Because the remediation strategy targeted aerobic benzene degradation, PetroFix was applied without nitrate addition. The design relied on immediate benzene sorption followed by intrinsic and, where required, enhanced aerobic biodegradation.

Figure 2 Aerial Site Plan

Aerial site plan indicating the approximate locations of: the benzene spill (infiltration) area, sheet-pile containment, PetroFix sorption barriers, peninsula, adjacent surface-water receptor (lake) and groundwater flow directions. Source: DEKONTA, adjusted by REGENESIS.





Results

Monitoring across the peninsula barrier shows a clear concentration gradient despite substantial well-to-well heterogeneity. Mean benzene concentrations in upgradient wells remain in the tens to hundreds of mg/L.

Mean benzene concentrations measured within the PetroFix barrier decreased from 31,700 to 490 ug/L––a reduction of approximately 98.5%. Evaluated across the monitoring dataset, overall benzene concentrations downgradient of the PRB were approximately 0.15% of those measured upgradient. Together these results demonstrate the combined containment and treatment system's effectiveness in reducing benzene concentrations between the source area and the lake Figure 3.

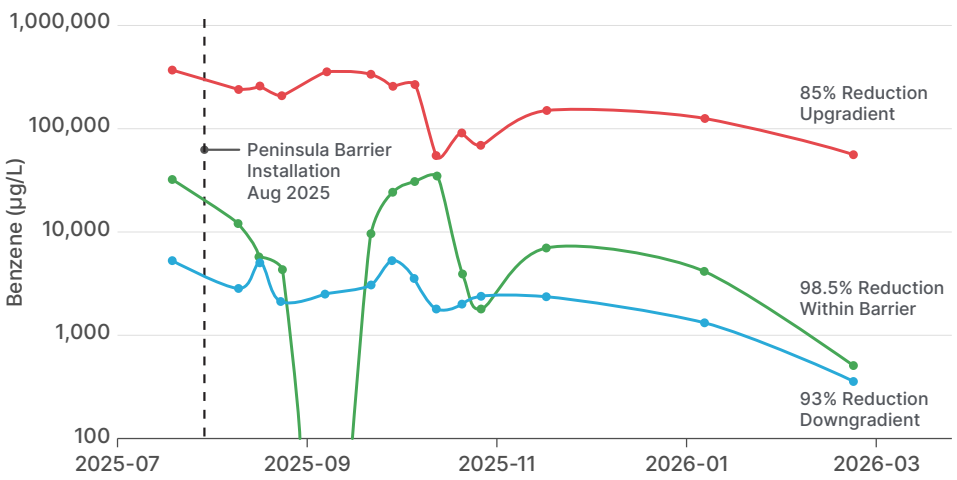
Within-barrier benzene concentrations initially declined following the full-scale PetroFix injections in August 2025. Concentrations subsequently increased temporarily when pumping within the sheet-pile-enclosed source area was paused. This increased groundwater and benzene flux through the barrier, temporarily increasing the contaminant load. Concentrations declined again after pumping resumed.

No benzene has been detected in the adjacent lake following implementation of the containment and barrier system. In other treated areas between the sheet-pile enclosure and the lake, benzene that had previously been present at concentrations ranging from several mg/L to tens-of-mg/L concentrations is typically no longer detected in groundwater monitoring wells within the injected zones.

Figure 3

Avg. Benzene Concentrations in Peninsula Monitoring Wells

Mean benzene concentrations in upgradient, within-barrier, and downgradient monitoring wells for the peninsula portion of the PetroFix barrier. Pilot injections were completed May 19–20, 2025, followed by full-scale peninsula barrier installation in August 2025



Molecular genetic analyses also support an ongoing biodegradation component. Next-generation sequencing identified Pseudomonas and Acinetobacter species, and qPCR confirmed high abundances of genes encoding catechol-2,3-dioxygenase, a key enzyme in aerobic benzene degradation. These organisms and functional genes were more abundant in CAC-treated wells; stronger activity following hydrogen-peroxide addition indicated that oxygen availability was a limiting factor.

Conclusion

The PetroFix barrier provided rapid dissolved-phase mass-flux control within a broader emergency response that also included physical containment, LNAPL recovery, groundwater extraction and aboveground treatment. By reducing benzene concentrations before groundwater reached the lake, the CAC treatment protected a sensitive surface-water receptor while lowering groundwater toxicity and supporting microbial recovery.

The effectiveness of the DEKONTA's response was further demonstrated when regulatory authorities determined that fish health and the aquatic environment had been protected, allowing a fishing competition to proceed on the nearby lake.

The project demonstrates how pilot-tested, field-deployable CAC barriers can be integrated into adaptive emergency spill response when contaminants have already migrated beyond primary containment.

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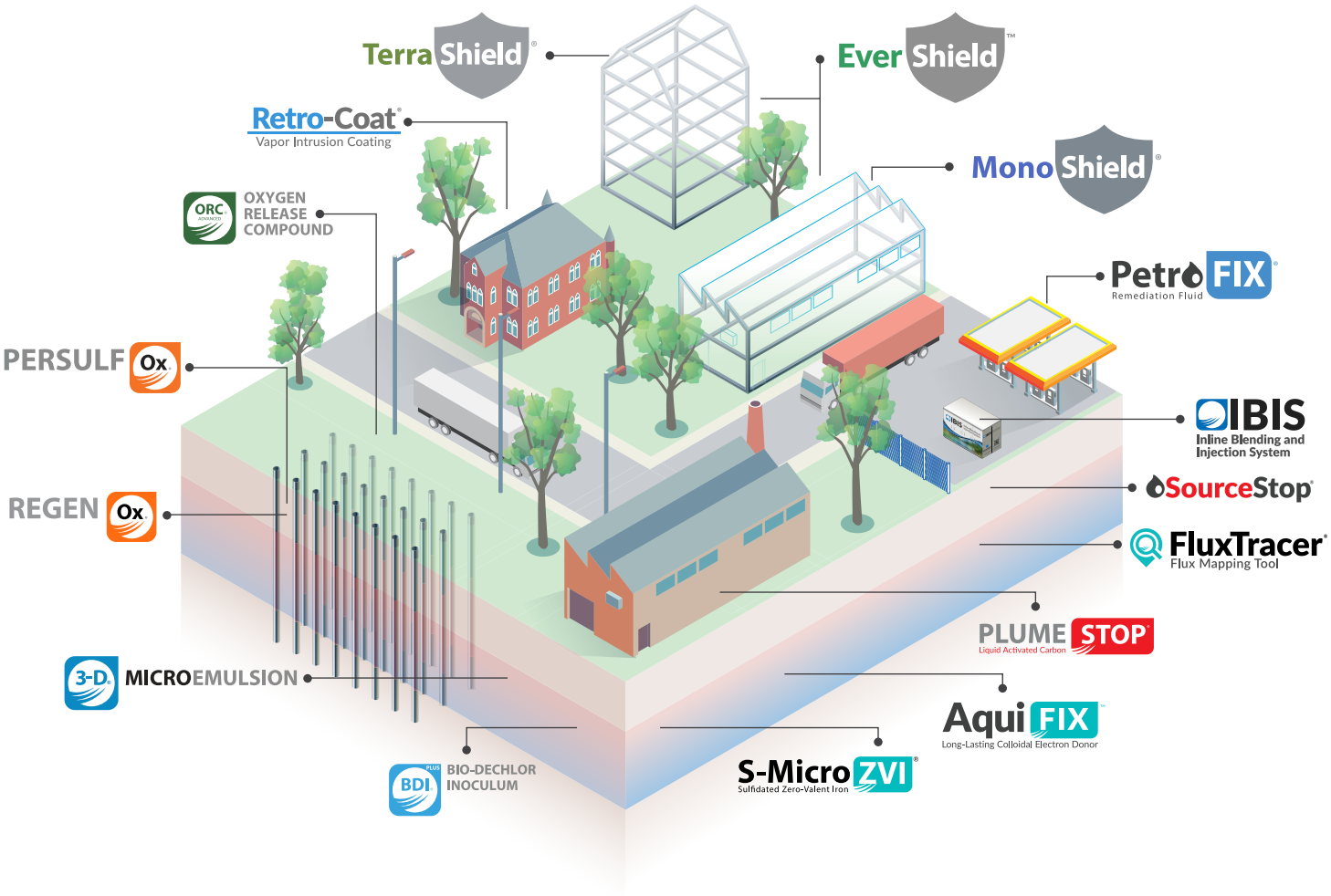


About REGENESIS

At REGENESIS we value innovation, technology, expertise and people which together form the unique framework we operate in as an organization. We see innovation and technology as inseparably linked with one being born out of the other.

Inherently, innovation imparts new and better ways of thinking and doing. For us, this means delivering expert environmental solutions in the form of the most advanced and effective technologies and services available today.

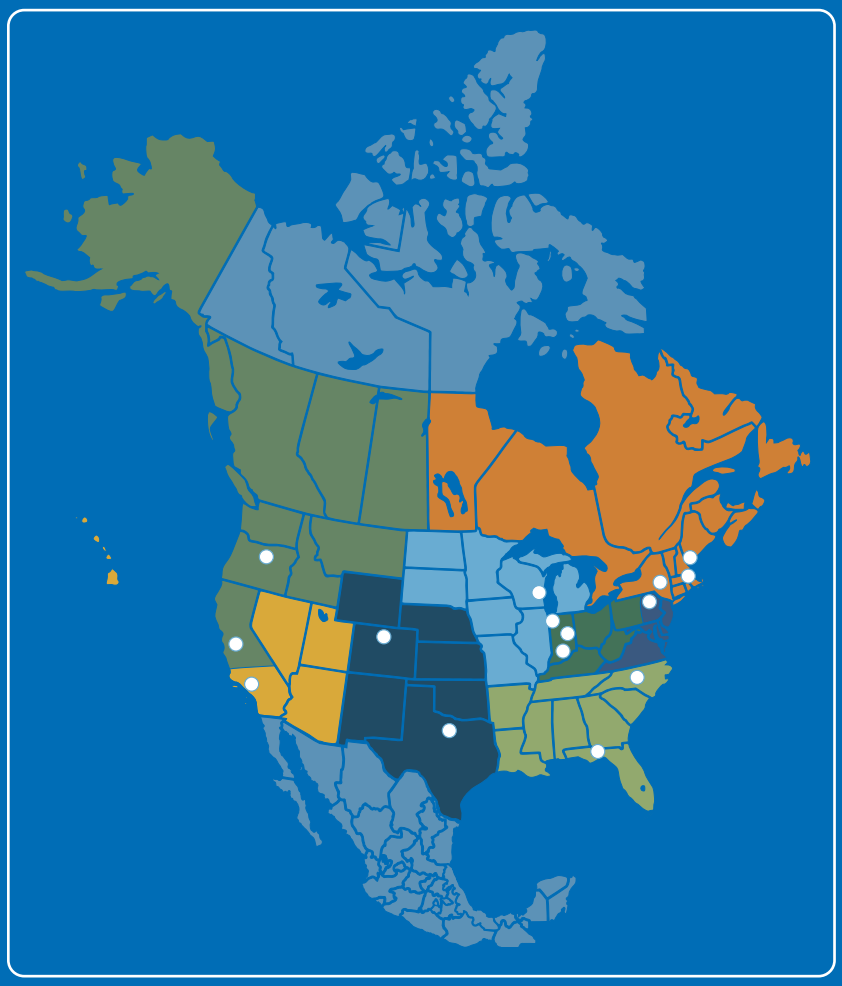
We value expertise, both our customers' and our own. We find that when our experienced staff collaborates directly with customers on complex problems, there is a high potential for success including savings in time, resources and cost.

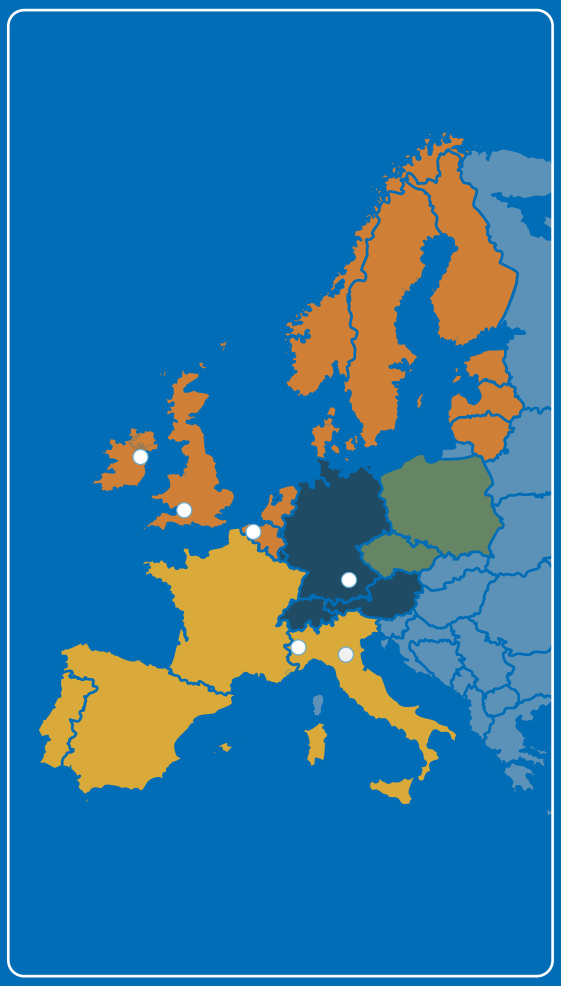
At REGENESIS we are driven by a strong sense of responsibility to the people charged with managing the complex environmental problems we encounter and to the people involved in developing and implementing our technology-based solutions. We are committed to investing in lasting relationships by taking time to understand the people we work with and their circumstances. We believe this is a key factor in achieving successful project outcomes.

We believe that by acting under this set of values, we can work with our customers to achieve a cleaner, healthier, and more prosperous world.

Have a challenge? Let's solve it together.

Contact us today to discuss your specific needs.





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