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Sustainable In-Situ Remediation of a CHC Plume with Targeted Solids Emplacement (TSE) for Expedited Brownfield Redevelopment – A German Case

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Bestes Brownfield: Besonders nachhaltig
BROWNFIELD AWARD® 2024
3. Platz

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Agenda

- 01 Introduction
- 02 Groundwater Remediation
- 03 GSR Performance
- 04 Conclusions

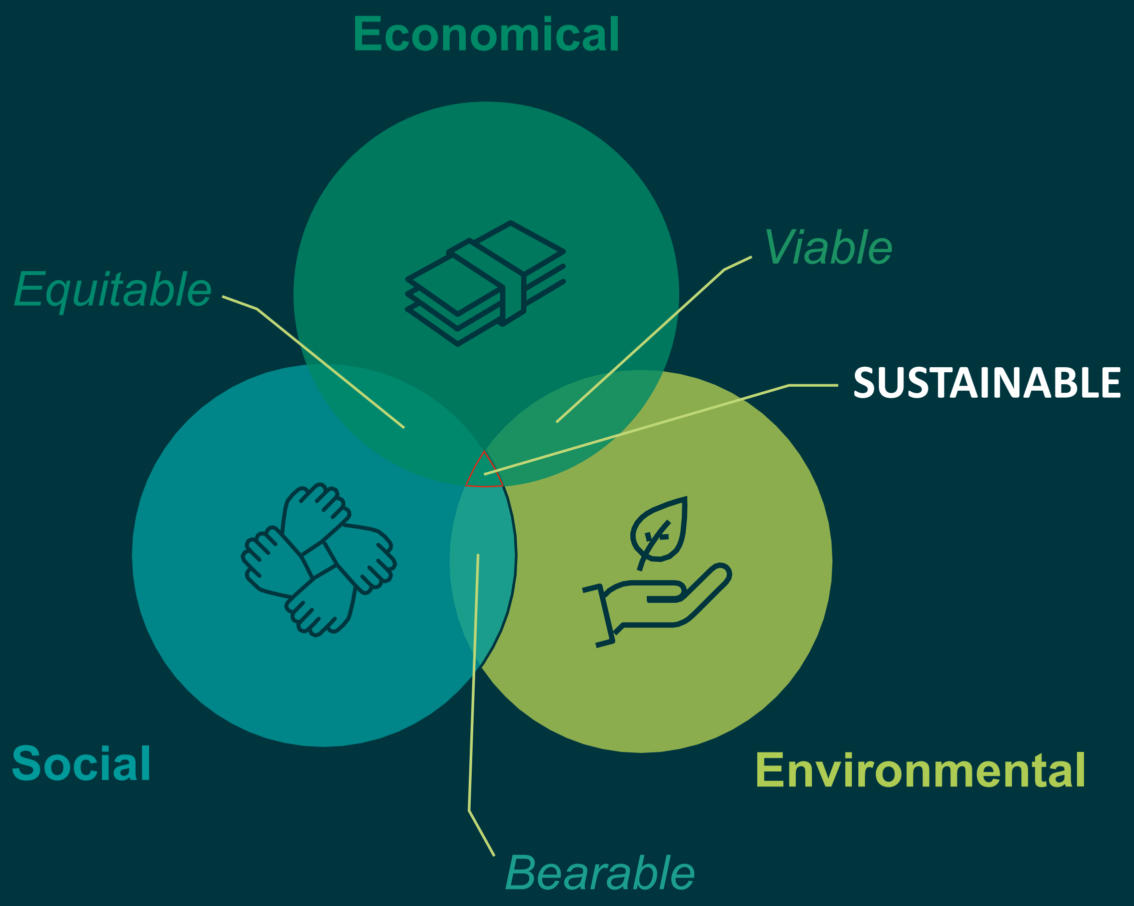
01

Introduction

Site History

Green and Sustainable Remediation (GSR)

- The ITRC defines GSR as "[…] the site-specific use of products, processes, technologies, and procedures that mitigate contaminant risk to receptors while balancing community goals, economic impacts, and net environmental effects."
- Compared with traditional methods, GSR technologies can typically reduce the life-cycle greenhouse gas emissions by **~50–80 %** (Hou et al., 2023)



The Pioneer Park Project

- 500M EURO private / public sector investment
- 50 hectare size (123 acres)
- new neighbourhood for 5,000 residents
- Stringent site development requirements

→ Largest Frankfurt, Germany regional construction project in 2020

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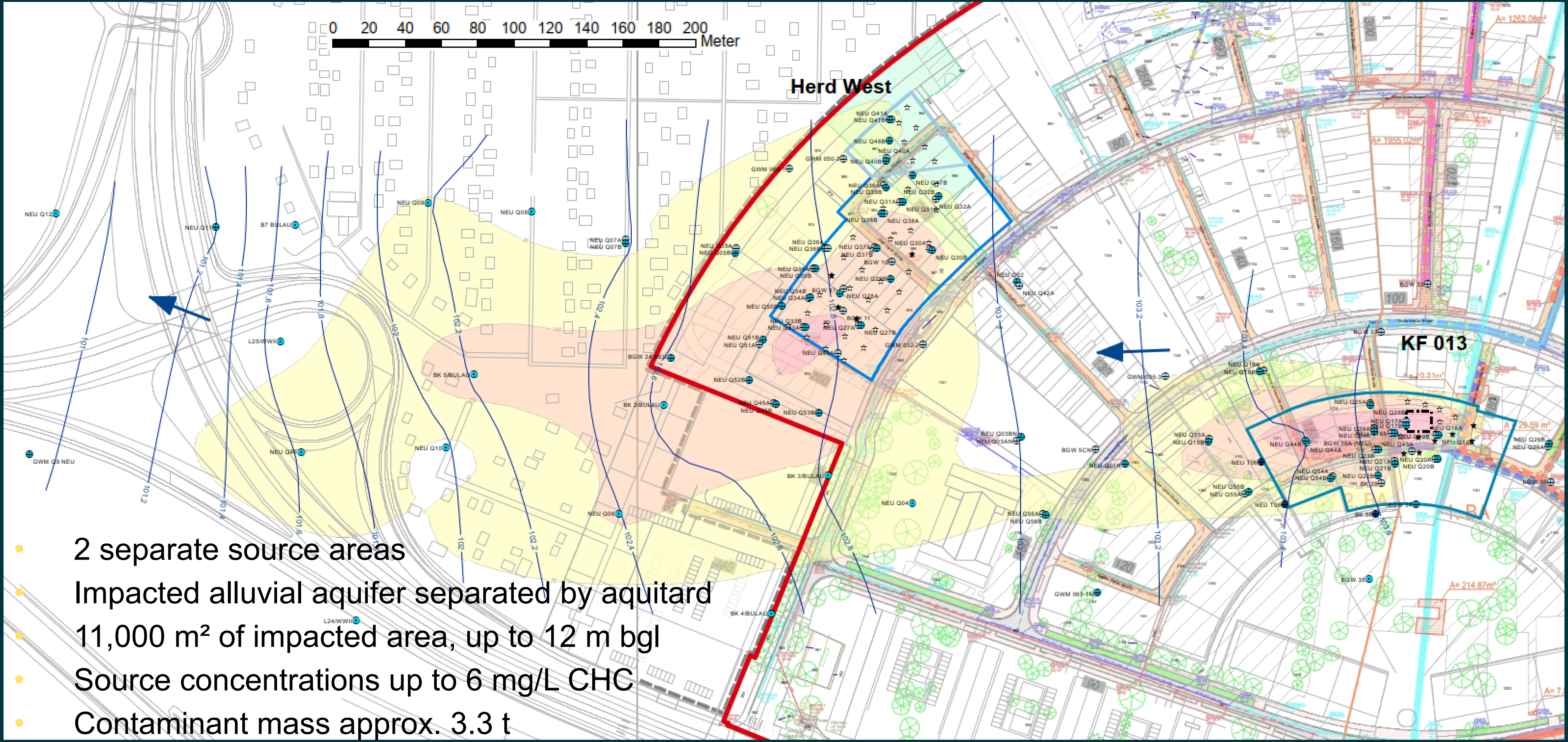
Groundwater Impact and Injection Locations



- 2 separate source areas
- Impacted alluvial aquifer separated by aquitard
- 11,000 m² of impacted area, up to 12 m bgl
- Source concentrations up to 6 mg/L CHC
- Contaminant mass approx. 3.3 t

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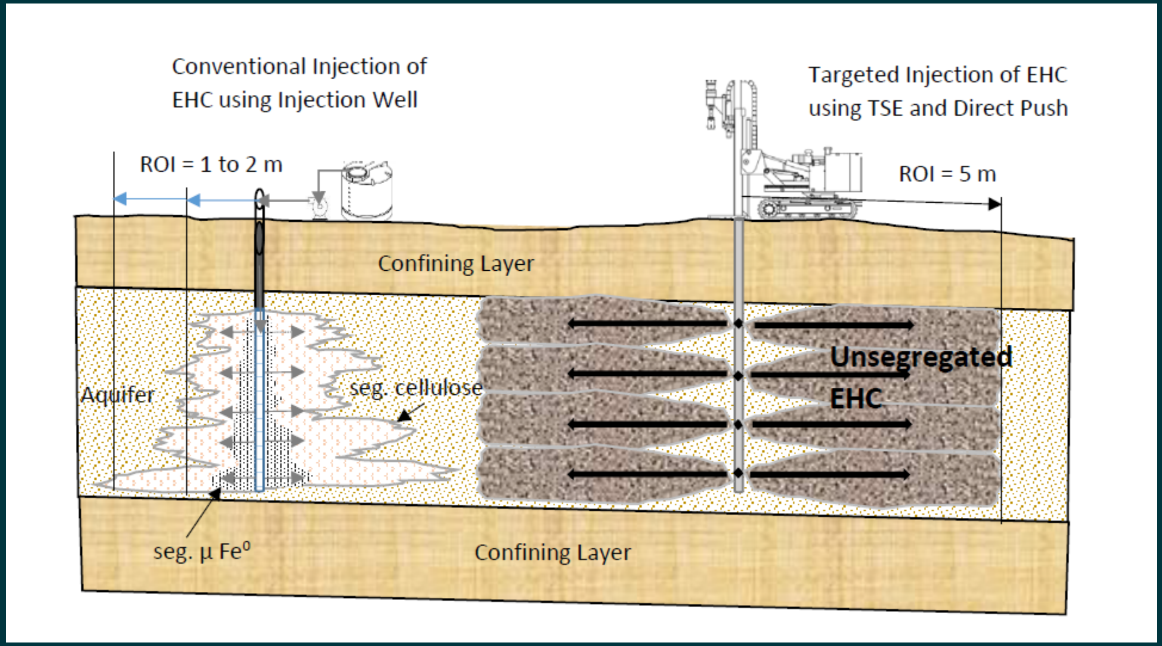
02

Groundwater Remediation

TSE-Targeted Solids Emplacement™



- Uniform distribution of treatment reagents at injection depths to maximize contact with contaminants and increase remedial effectiveness.

- The TSE™ approach comprises targeted, hydraulic pressure-injection of a viscosified *solid treatment amendment* into subsoils using direct push drill rods.
- The viscous suspension carrying remedial amendments prevents the segregation of its various treatment components (e.g. EHC).
- TSE enables high concentrations of treatment solids to be emplaced compared to dissolved remedial reagents.
- TSE increases the effective soil porosity for enhanced treatment of contaminants through either fracturing or injection modes of amendment emplacement.
- The emplacement of treatment solids provides long term „remedial reservoirs“ that provide years of treatment effectiveness.

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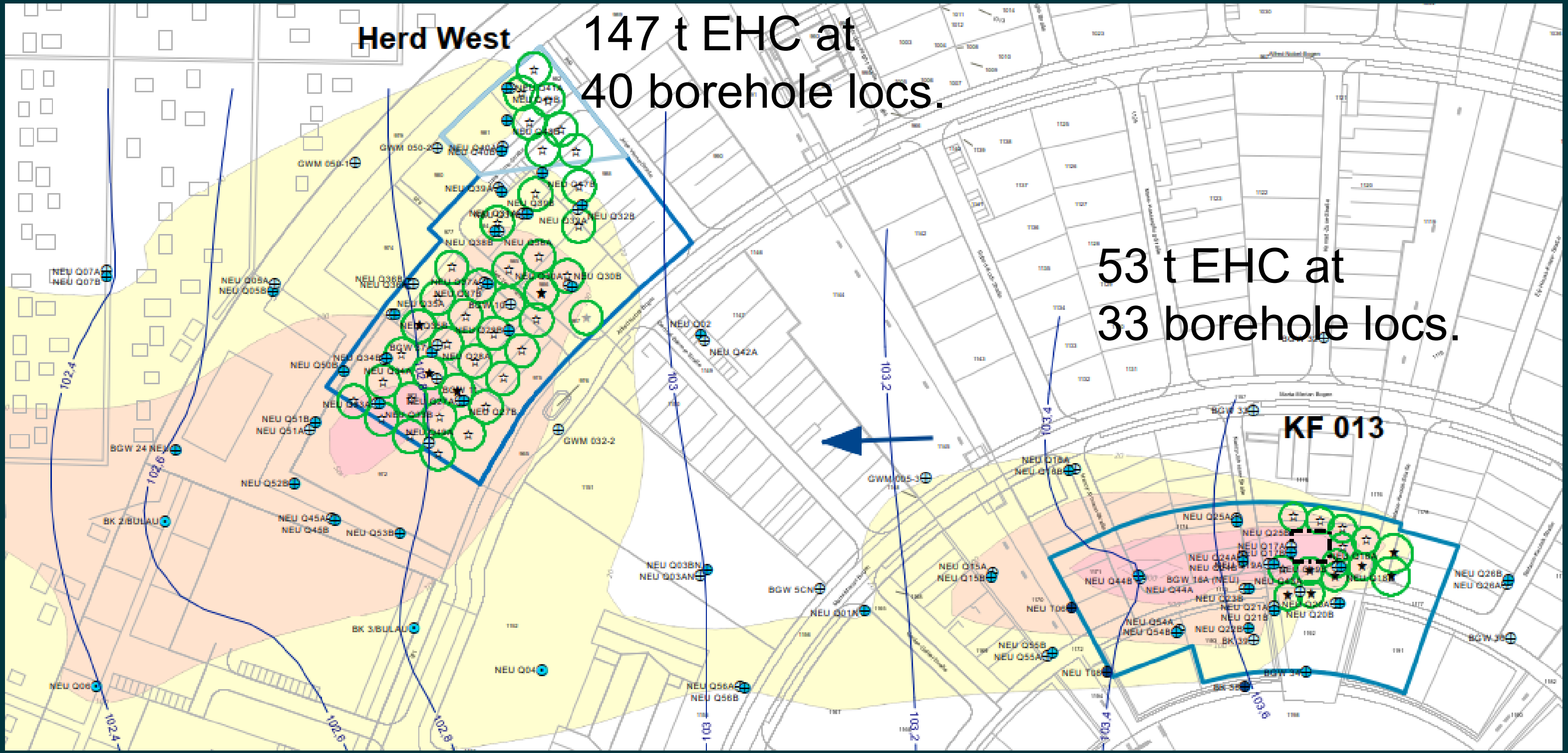
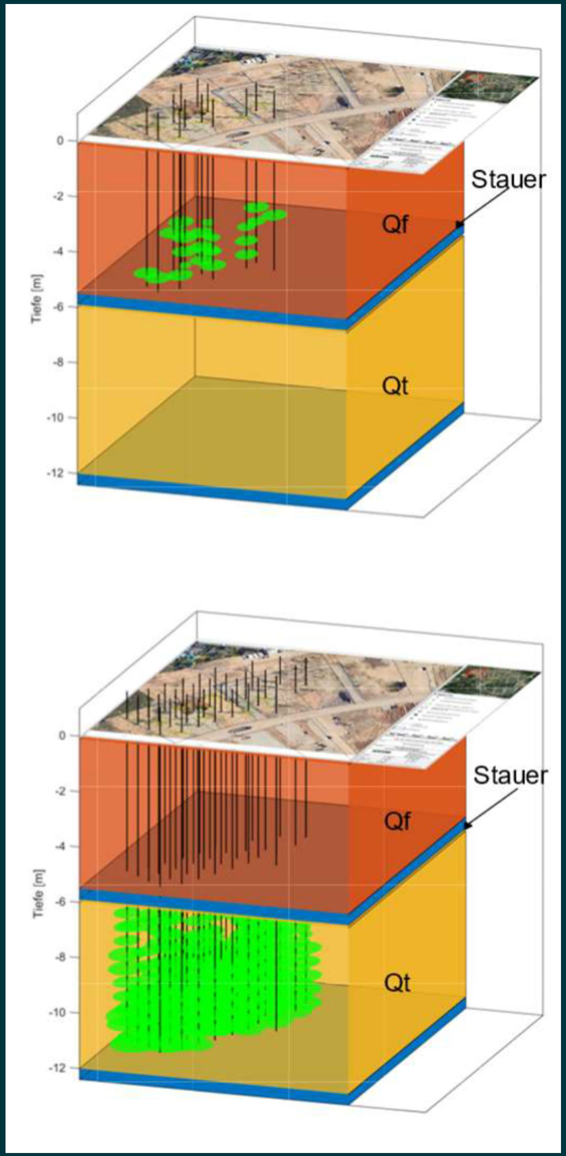
Amendment Application January to July 2023

- Hot Spot treatment by Top-Down injection of a viscous EHC suspension using hydraulic injection by TSE™.
- 3-5 year post-treatment monitoring to achieve stringent cleanup goal of 20 µg/L CHC





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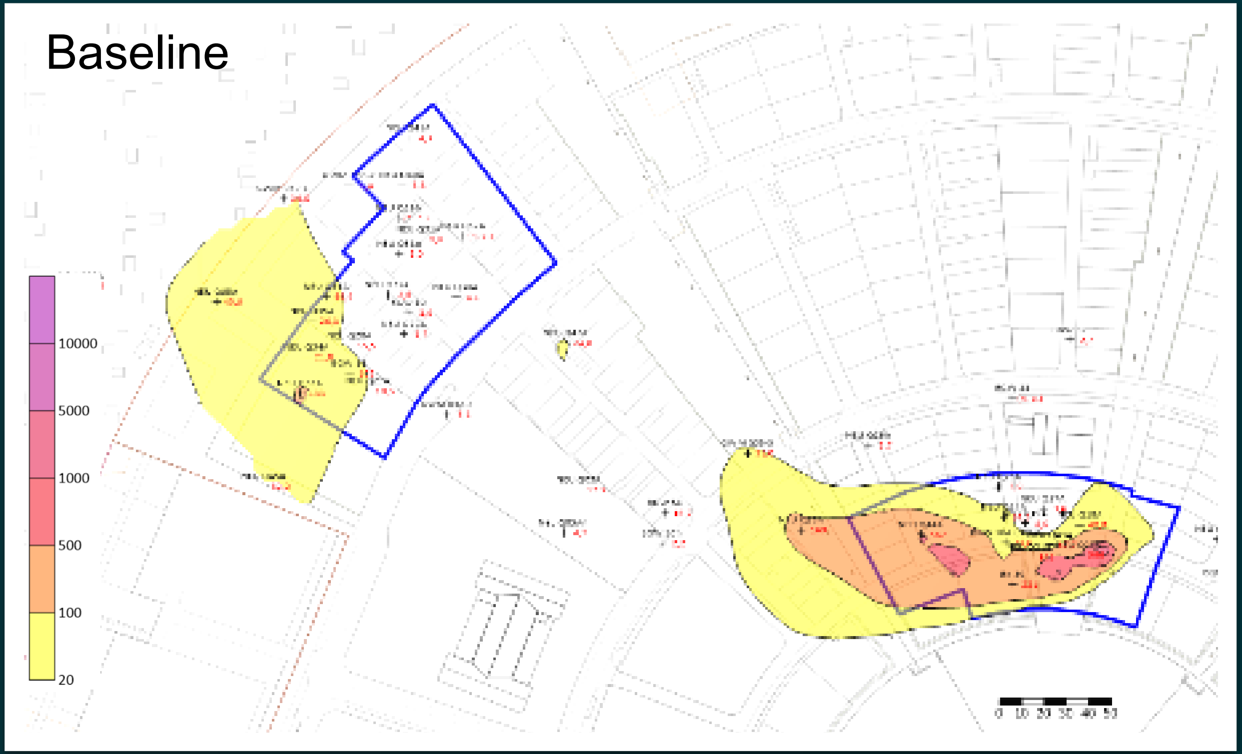
Impressions Amendment Application

EHC® ISCR Reagent

- Solid mixture of GMO-free, fibrous organic plant carbon (~60%) and high reactivity micro-scale zero valent iron (ZVI) ~40%)
- Modes of action based on i) abiotic processes (chemical reductive dechlorination by ZVI), and ii) stimulation/support of microbial anaerobic dechlorination. Additional augmentation with Dehalococcoides species.
- ZVI corrosion (alkaline) and fermentation of carbon (acidic) are in equilibrium = favorably neutral pH value
- Carrier medium prevents segregation of the active ingredients, and serves as an additional substrate (polysaccharides) for CHC biodegradation
- Formation of an in-Situ Chemical Reduction (ISCR) reactive zone
- Source area remediation with a one-time application

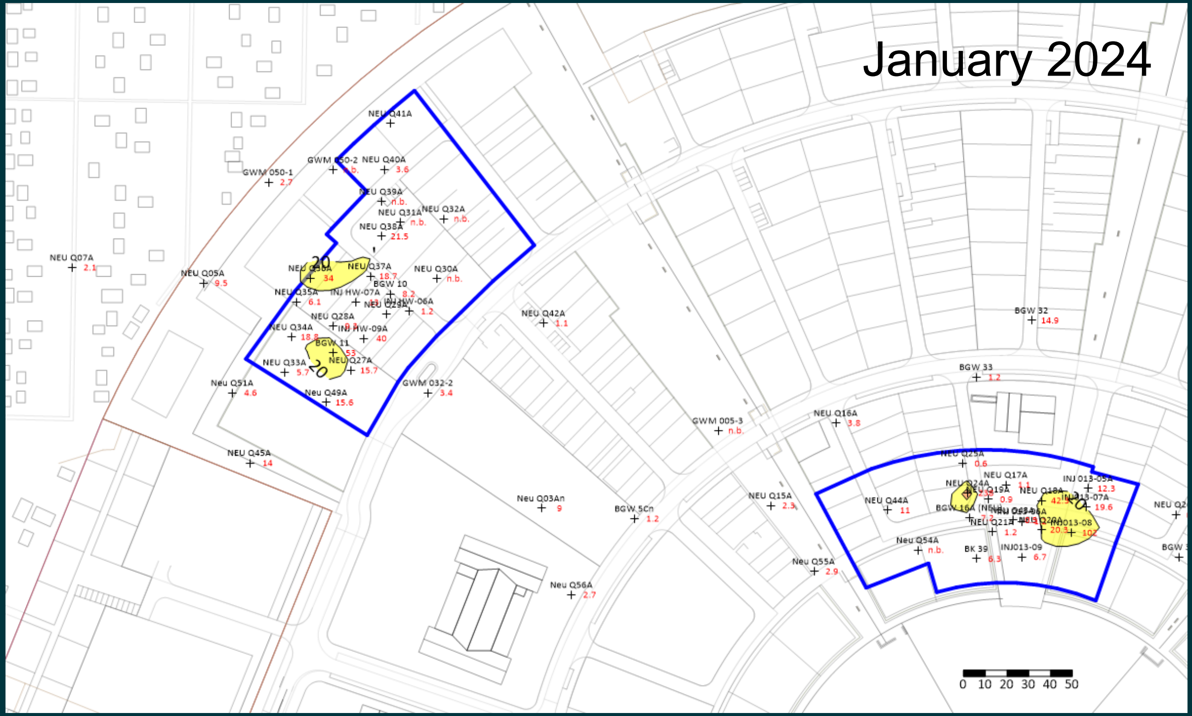
Results Full-Scale Remediation (Shallow Aquifer)



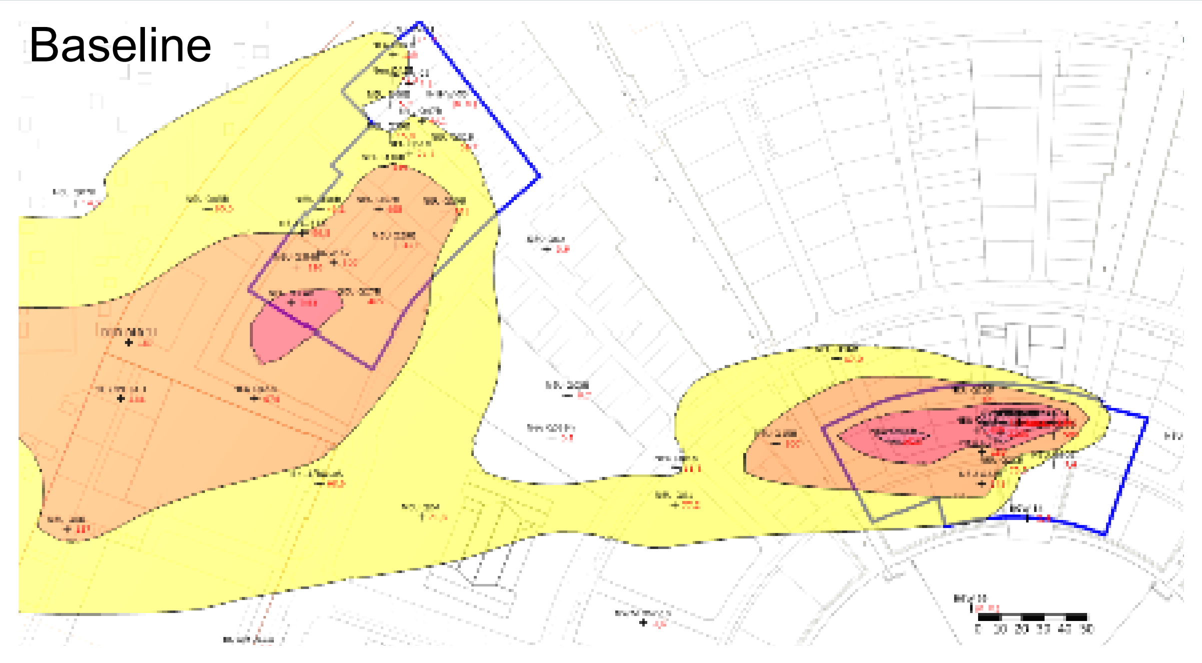
- Remediation goal of 20 µg/L reached in the majority of shallow aquifer wells

- Significantly reduced CHC concs. within the treated source areas within first year post-treatment

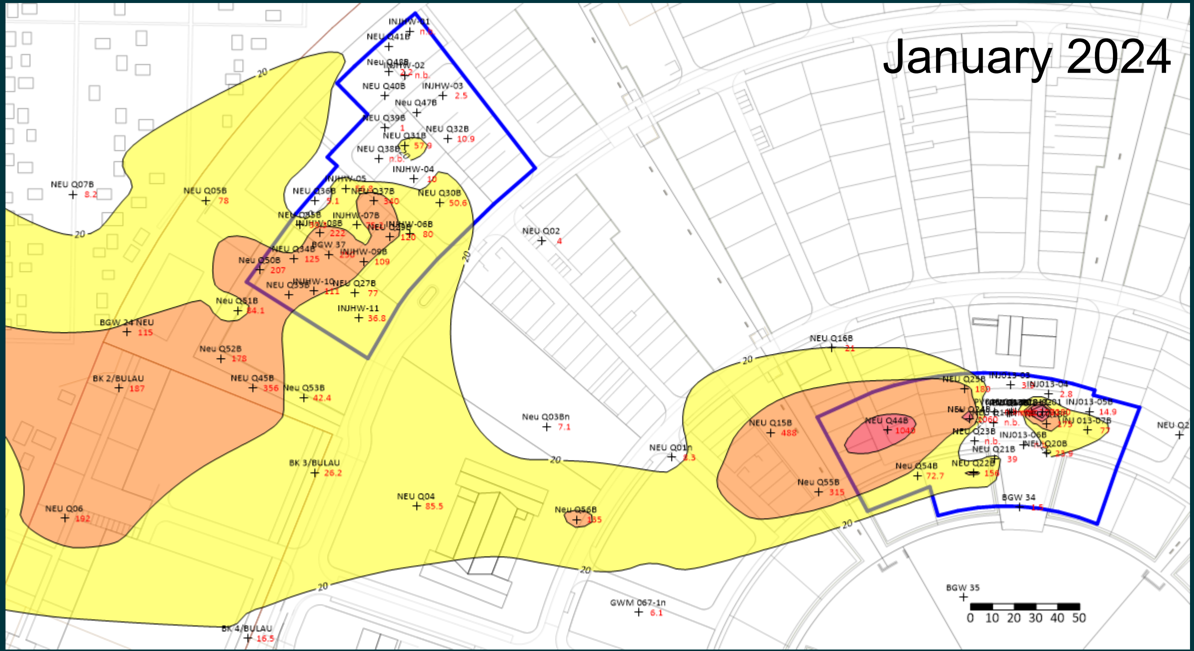
- Breakdown of downgradient contaminant plume



Results Full-Scale Remediation (Lower Aquifer)



- Significantly reduced CHC concs. within the treated source areas within first year post-treatment
- Plume disconnected from source area KF 013



Still 2-3 years to go!

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GSR Performance

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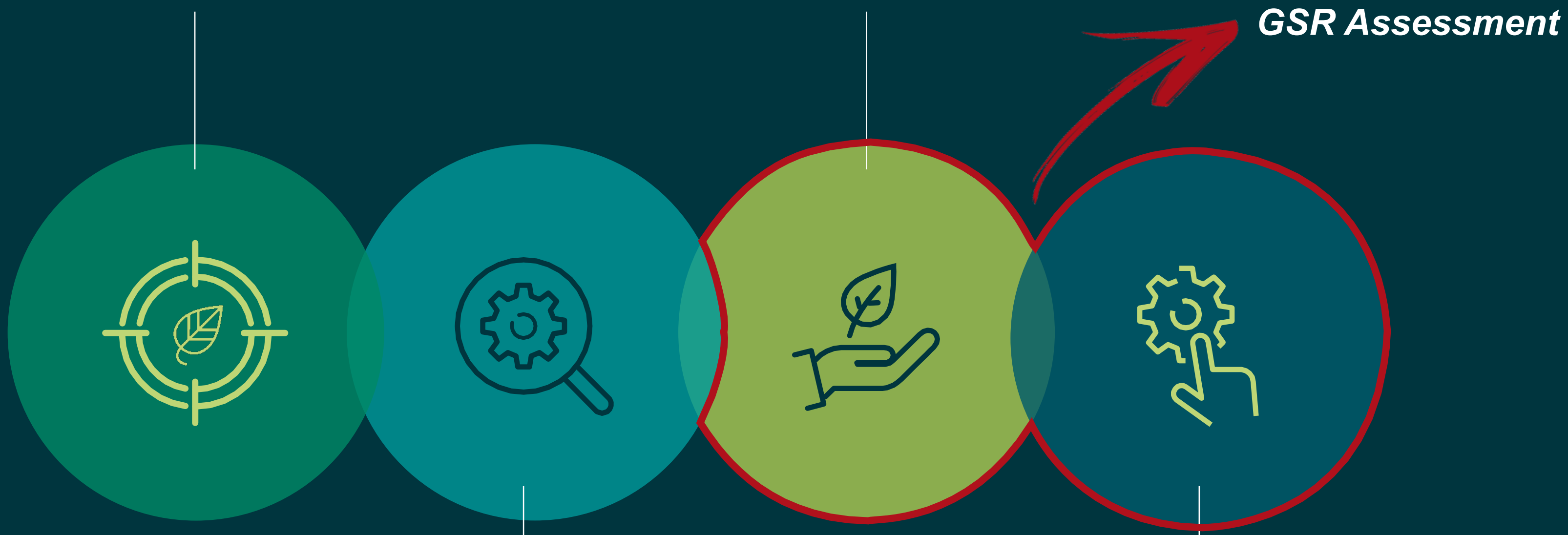
When Sustainability Assessment of Remediation Alternatives?

Remediation goals
Site-specific for affected media

Sustainability of alternatives
Evaluation of the economic, environmental and social aspects



Feasibility Study
Identify potential remediation alternatives to achieve remediation goals

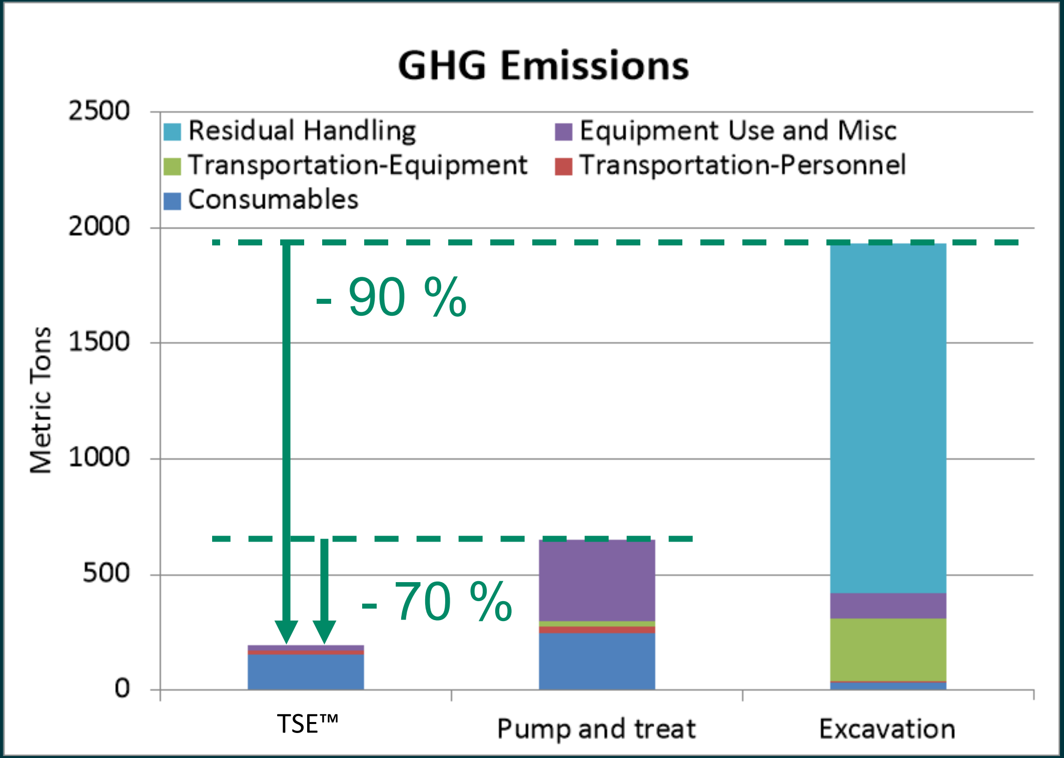
Selection of alternative
Selection of the most appropriate alternative from an economic, environmental and social perspective

GSR Metrics Performance

Phase	Activities	GHG Emissions	Total Energy Used
		metric ton	MMBTU
TSE ™	Consumables	154.35	4.4E+03
	Transportation-Personnel	15.78	1.9E+02
	Transportation-Equipment	1.50	1.9E+01
	Equipment Use and Misc	19.60	2.2E+02
	Residual Handling	0.00	0.0E+00
	Sub-Total	191.23	4.81E+03
Pump and treat	Consumables	246.08	1.8E+03
	Transportation-Personnel	28.23	3.4E+02
	Transportation-Equipment	21.44	1.3E+02
	Equipment Use and Misc	353.18	8.4E+03
	Residual Handling	0.00	0.0E+00
	Sub-Total	648.93	1.06E+04
Excavation	Consumables	33.14	4.9E+02
	Transportation-Personnel	3.63	4.4E+01
	Transportation-Equipment	270.99	3.5E+03
	Equipment Use and Misc	109.60	1.6E+03
	Residual Handling	1,515.08	2.6E+04
	Sub-Total	1,932.44	3.18E+04

1 mmBTU = 293 kWh

Used Excel-based decision-support tool **SiteWise™** for GSR assessment.



Remediation Costs and Sustainability Indicators

- Unit costs (incl. planning, consulting and monitoring for 3 years after amendment emplacement):
  - 20 EUR/t soil
  - 18 EUR/m^3 groundwater
  - 850 EUR/kg CHC contaminants
- Site-specific energy consumption and carbon dioxide emissions (e.g. for the production of treatment reagents, equipment and crew mobilization and travel, drilling and mixing equipment incl. heavy equipment usage, power generation requirements, amendment shipment, etc.):
  - 10.5 kWh/t soil

04

Conclusions

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Conclusions

- A single amendment injection may allow for achieving the stringent remediation goal of 20 µg/L CHC in treatment areas where the length of effectiveness was >20 months

- Benefits: Low impact on the environment, “low profile” application in the field, all works performed during parallel site redevelopment

- GSR metrics performance of TSE showed up to 90 % less GHG emissions compared to the two conventional technologies assessed

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