

# **GCW - Case Study – Berlin**

**In-situ Remediation of a Former Dry-Cleaning-Facility with  
Groundwater-Circulation-Well (IEG-GCW®) Technology**



# Activities & Used Substances

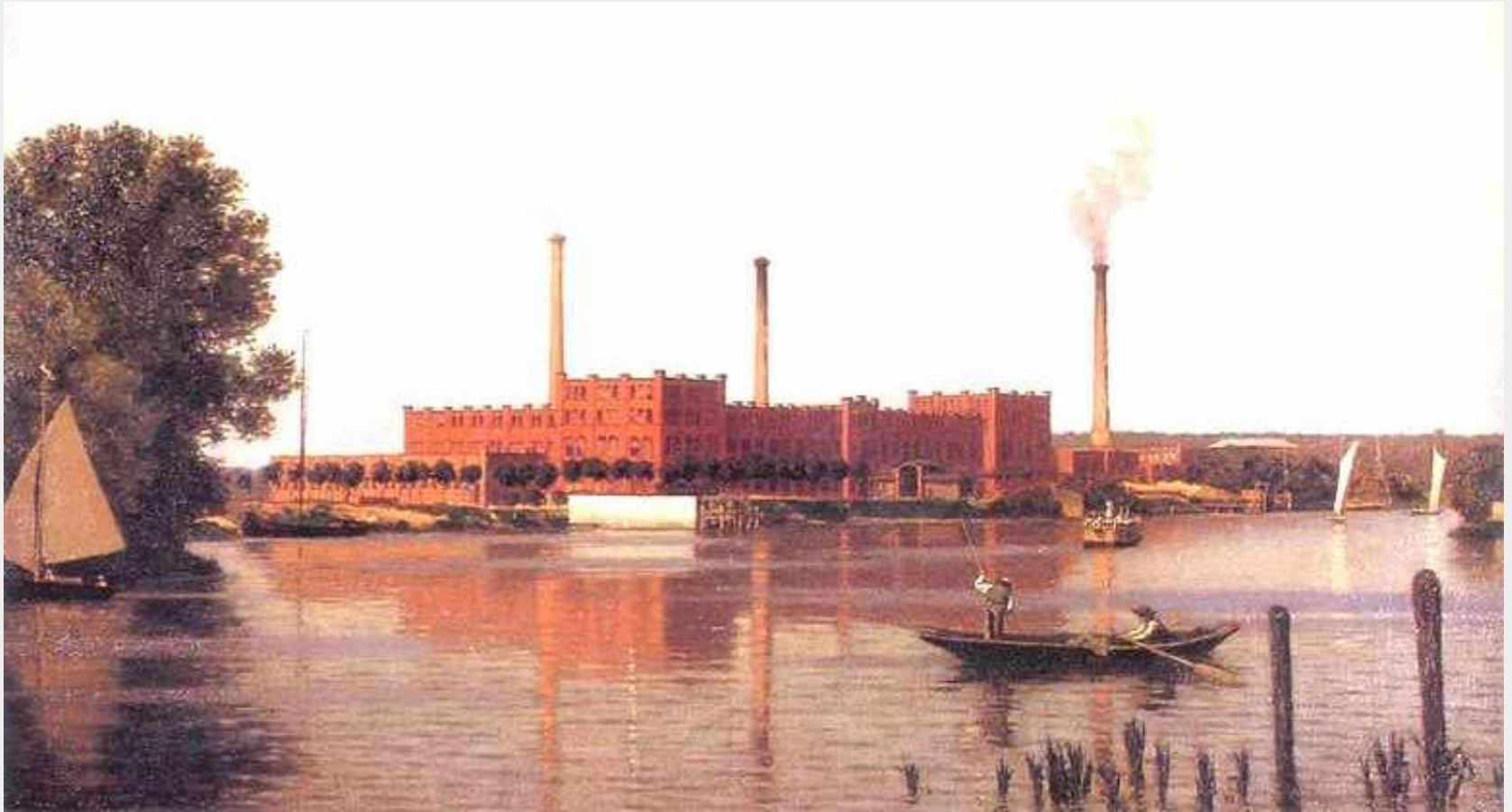
**On this site, a variety of activities have been carried out since the middle of the 19th century:**

- **Chemical dry-cleaning**
- **Industrial laundry**
- **Textile dyeing**
- **Varnish production**

**The following substances have been used on the site (among others):**

- **Turpentine**
- **Aromatic Hydrocarbons (BTEX)**
- **Benzine**
- **Chlorinated Hydrocarbons (CHC)**

# The Facility around 1860



# Soil and Groundwater Contamination

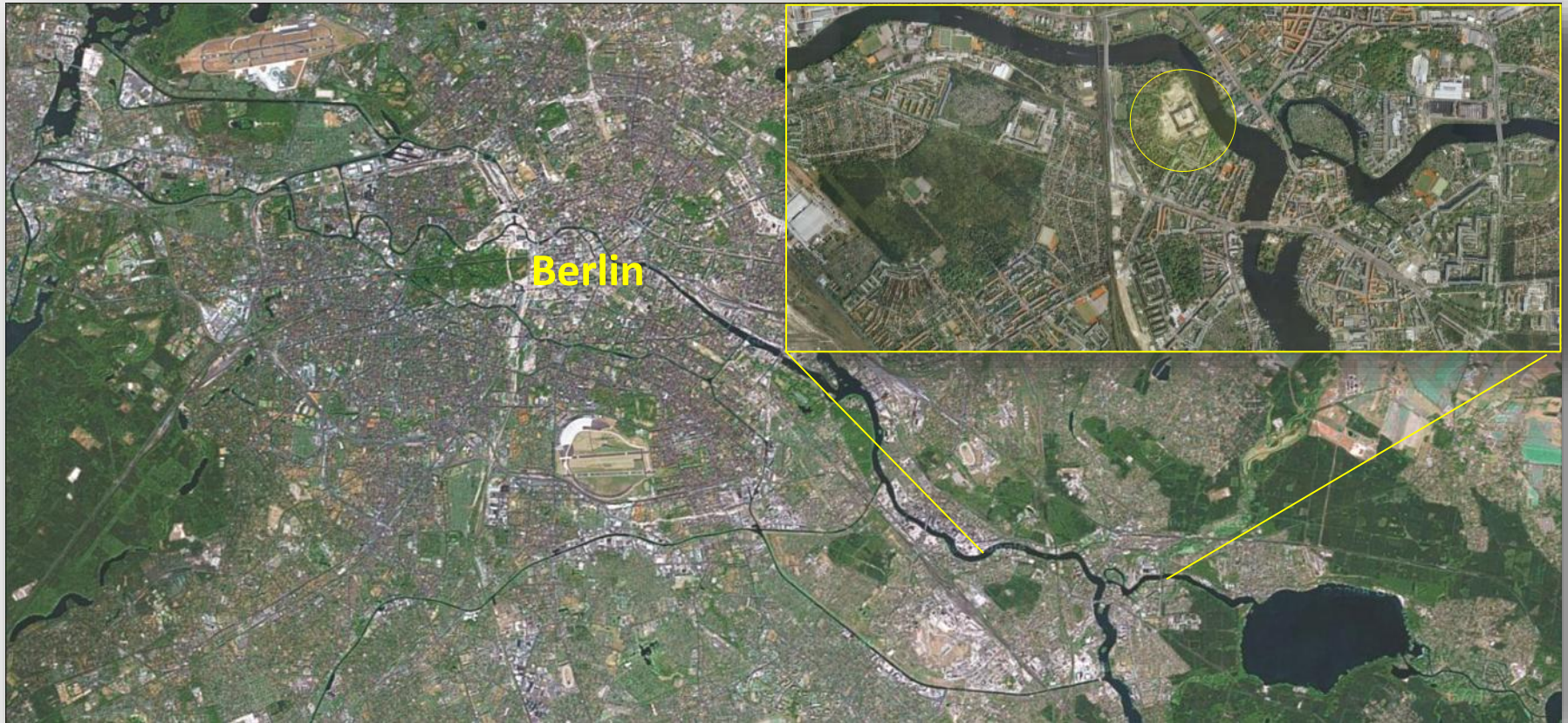


## Contaminants in the subsurface:

- Tetrachloroethene (PCE), Trichloroethene (TCE) and break-down products
- Aromatic Hydrocarbons (BTEX)
- Polycyclic Aromatic Hydrocarbons (PAHs) and Petroleum Hydrocarbons (TPH)



# Aerial View and Site Location



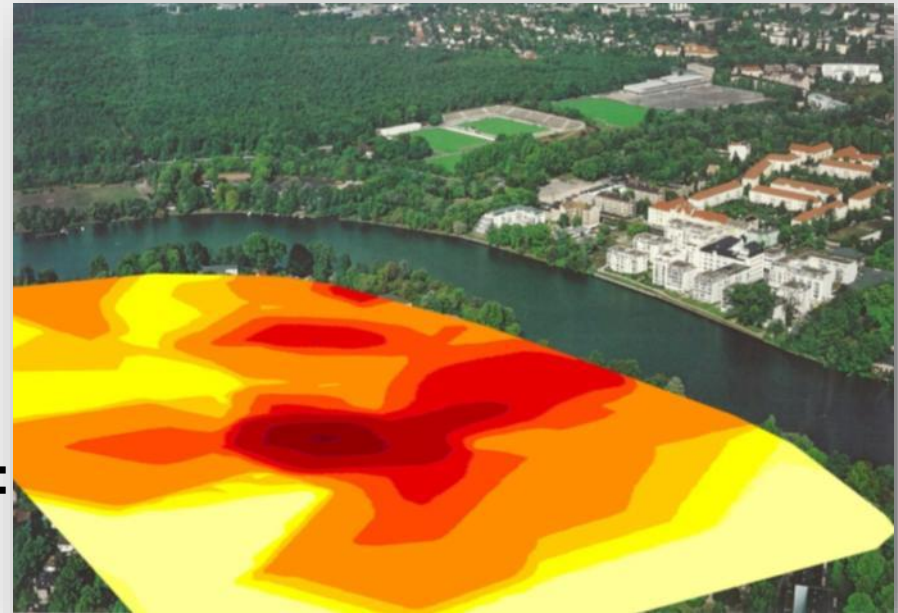
# Site Investigation and Remediation Strategy

**1999 - 2001 site assessment**

**Size and extent of the contamination were examined in various steps**

**> 1,5 meters of the top soil was removed in certain areas**

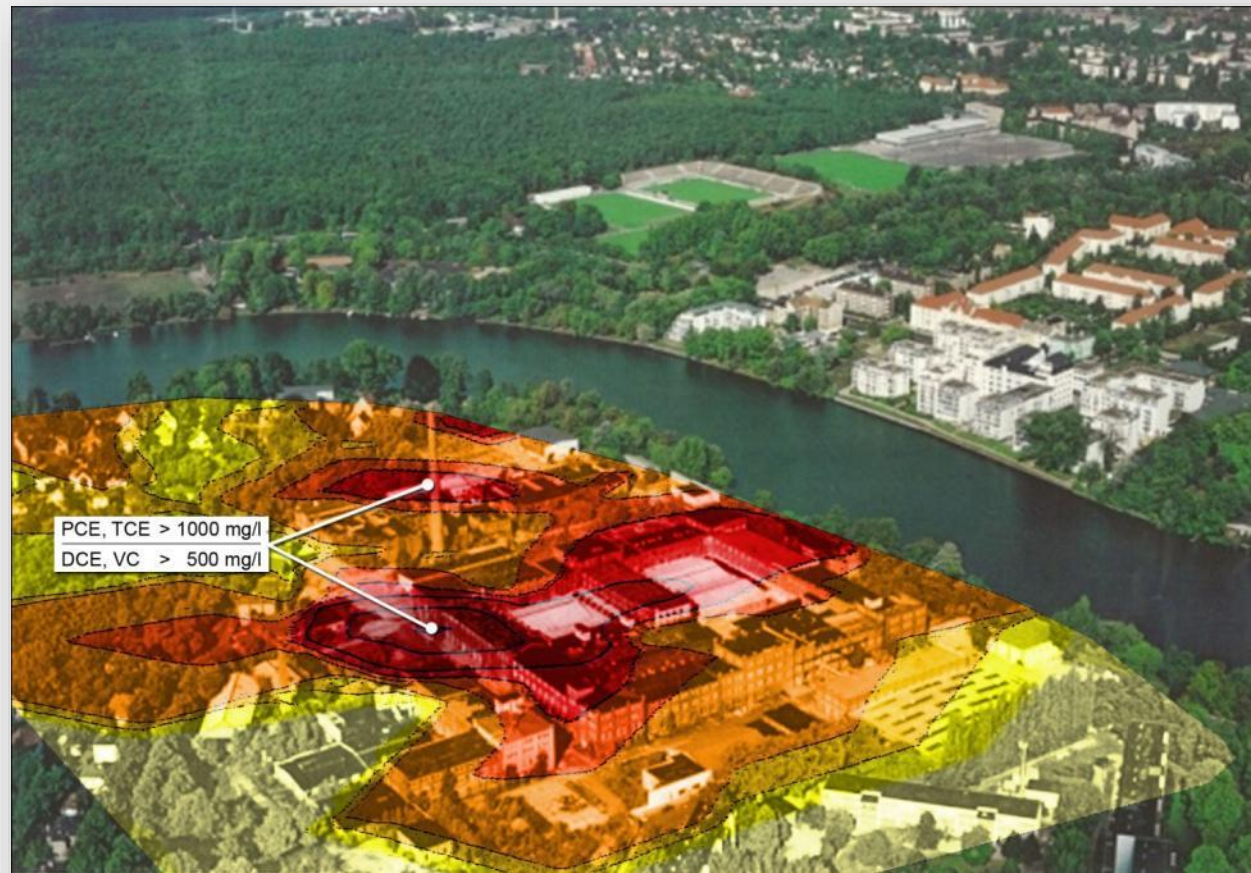
**Remediation plan was coordinated by:  
CSD consulting, Switzerland  
property owners  
Berlin government authorities**





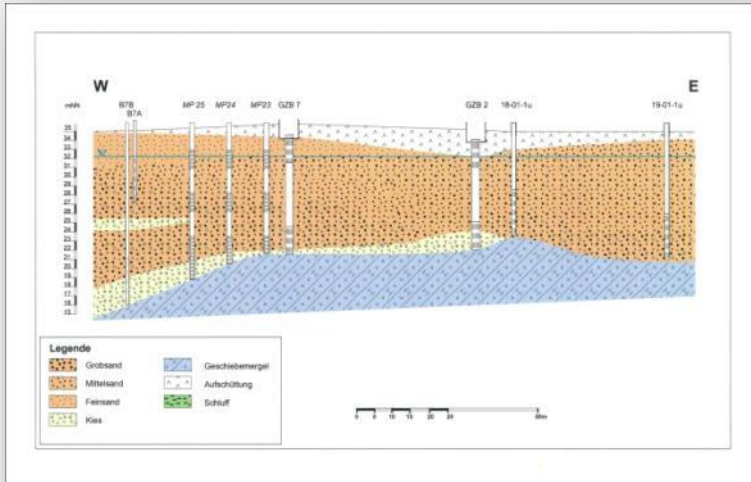
# CHC Distribution in the Groundwater

- Contamination of the saturated and the unsaturated zones in an area of about 66 000 m<sup>2</sup>
- CHC-Concentrations between 10 to 1000 mg/l incl. cis-1.2-DCE und VC (partially DNAPL)
- BTEX, PAHs, TPH only in the southern portion of the property (partially LNAPL)



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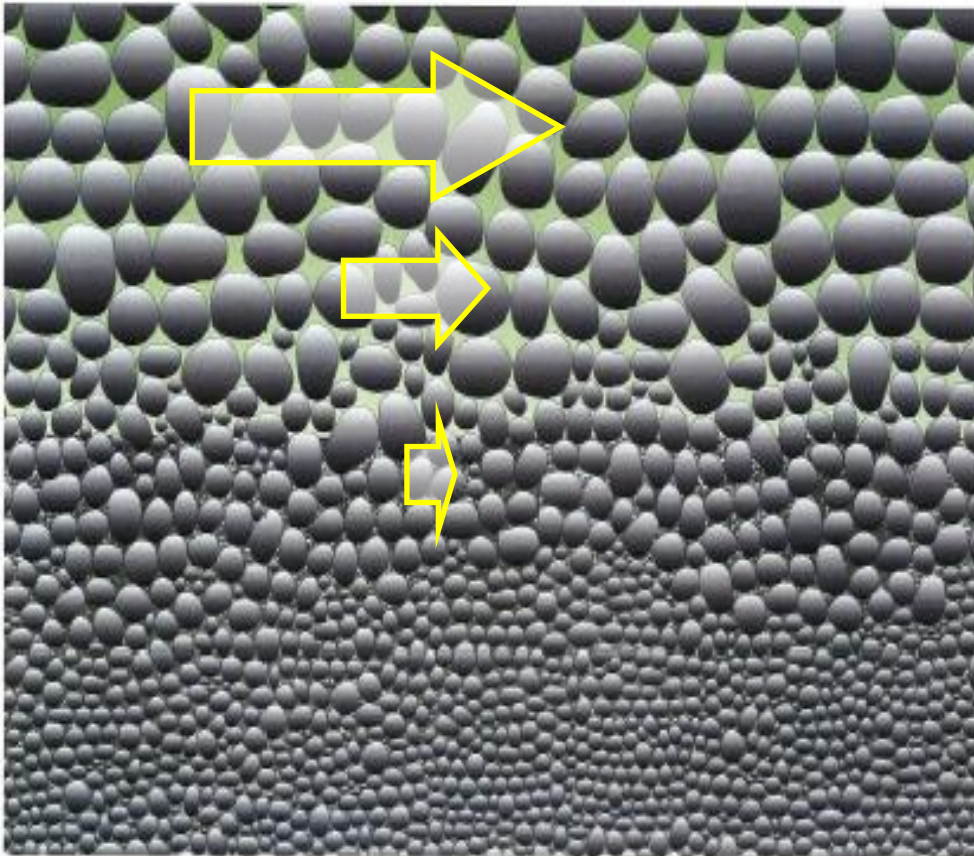
# Geology - Hydrogeology



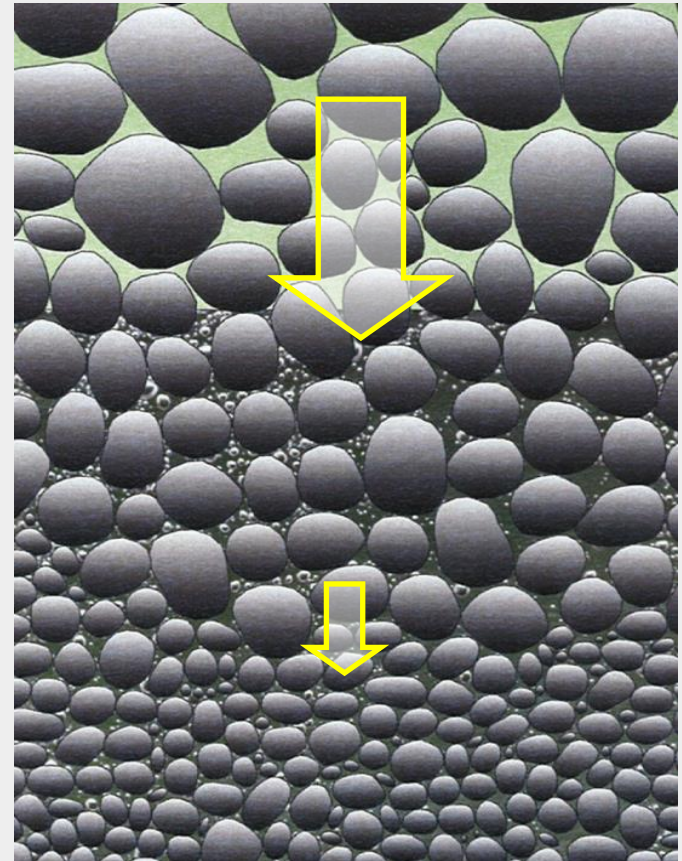
- Alluvial and glacial sediments (Warschau-Berliner Urstromtal)
  - 1. aquifer: fine, intermediate, and coarse sands
  - Hydraulic conductivities (kf)  $1 \times 10^{-3}$  to  $1 \times 10^{-4}$  m/s
  - Aquifer thickness: 12 to 25 m
  - Groundwater table at 2,7 to 3,5 m bgs
- site located near the Spree river
  - groundwater gradient: 0,00025
  - groundwater velocity ( $v_a$ ): max. 0,45 m/day
  - alternating groundwater flow direction



# Horizontal versus Vertical Flushing

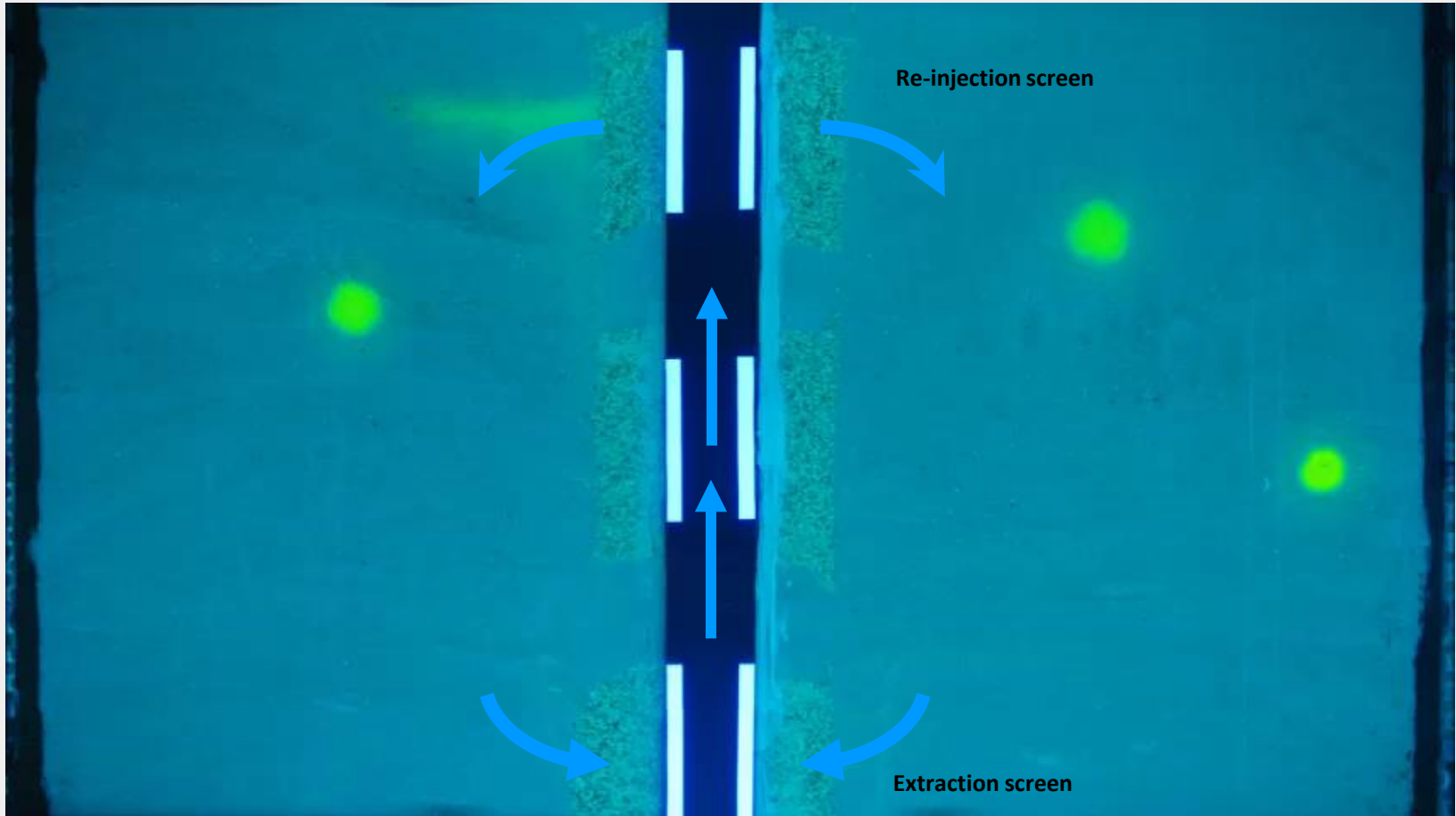


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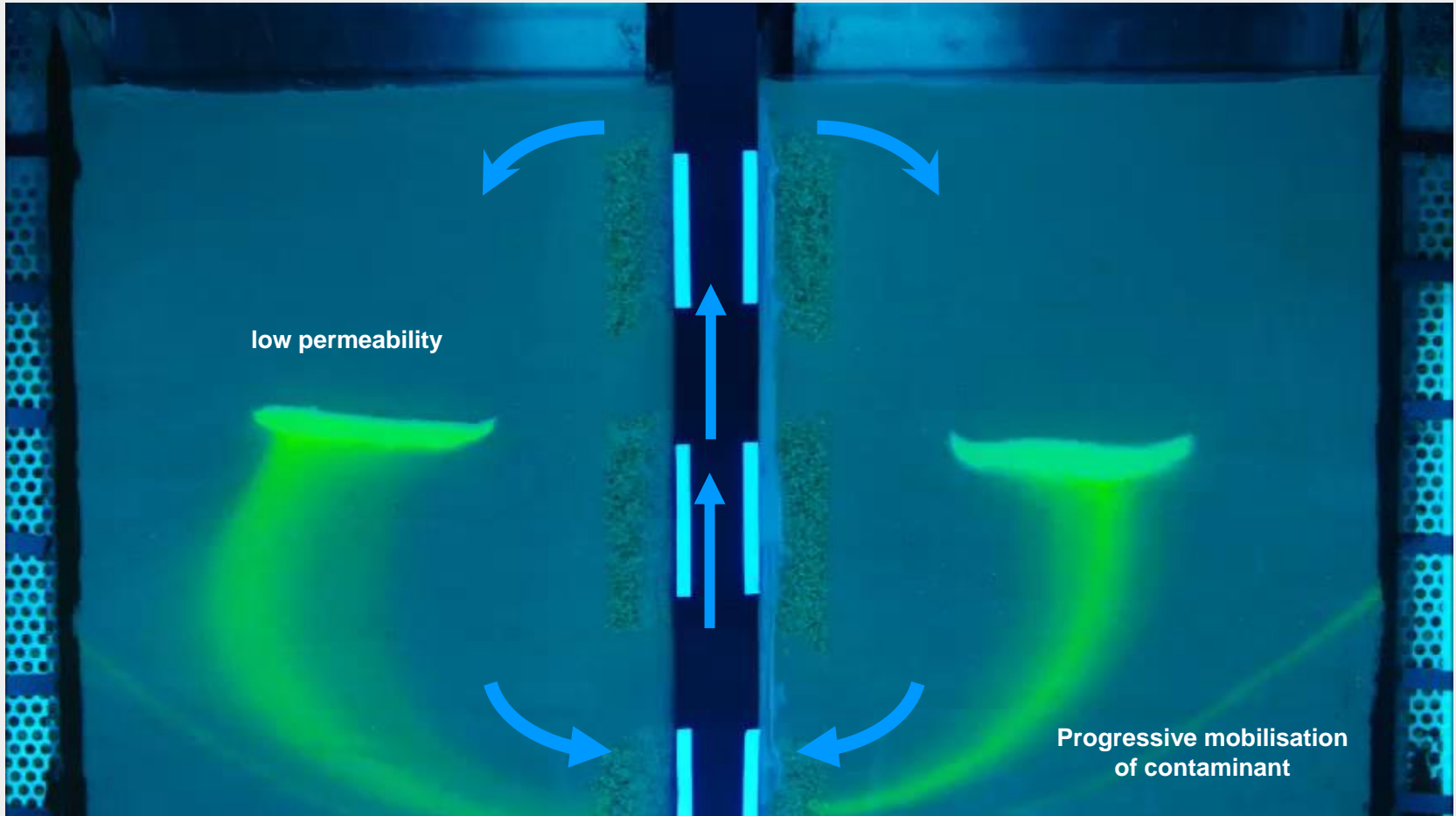
## Box model demo



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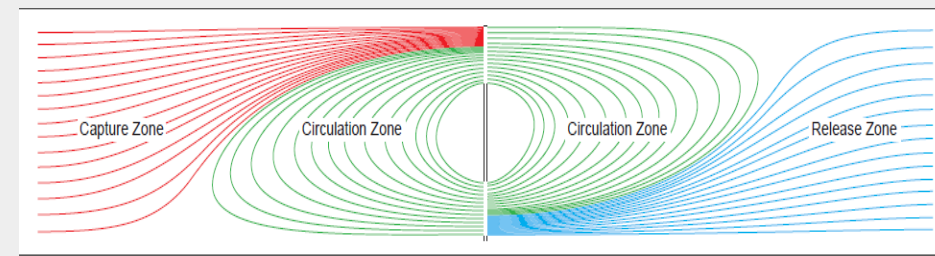
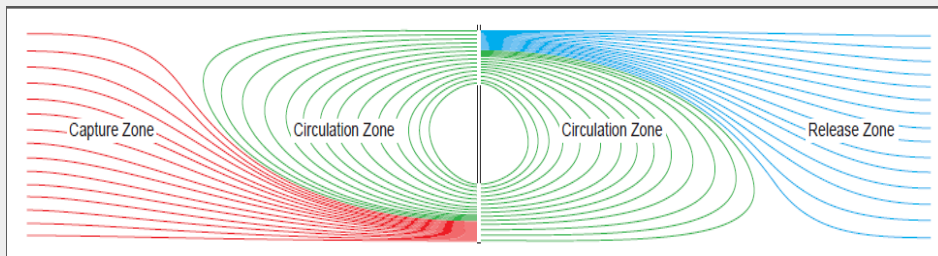
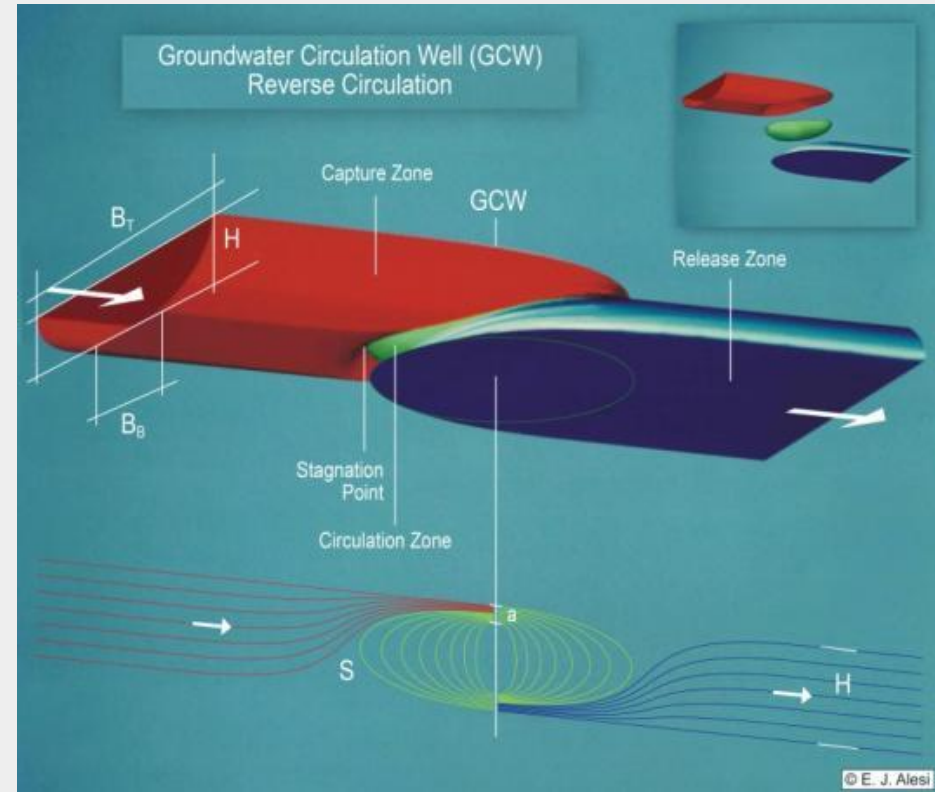
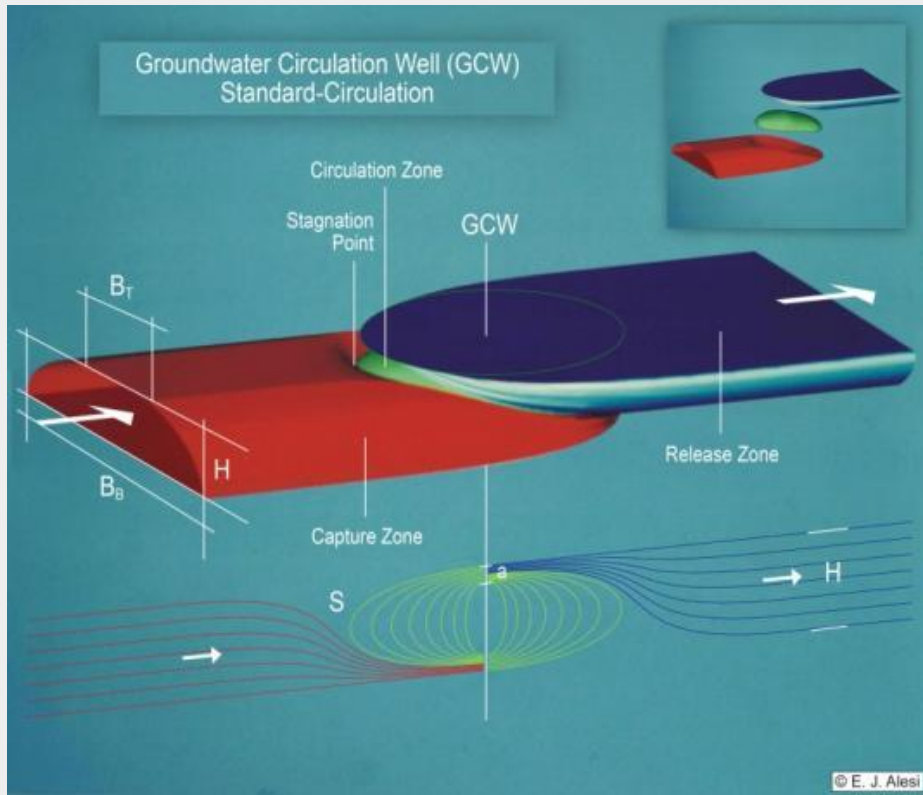
## Box model demo



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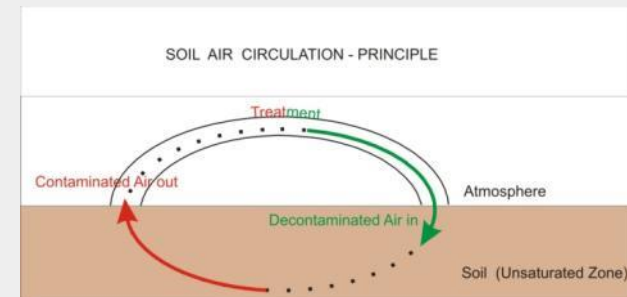
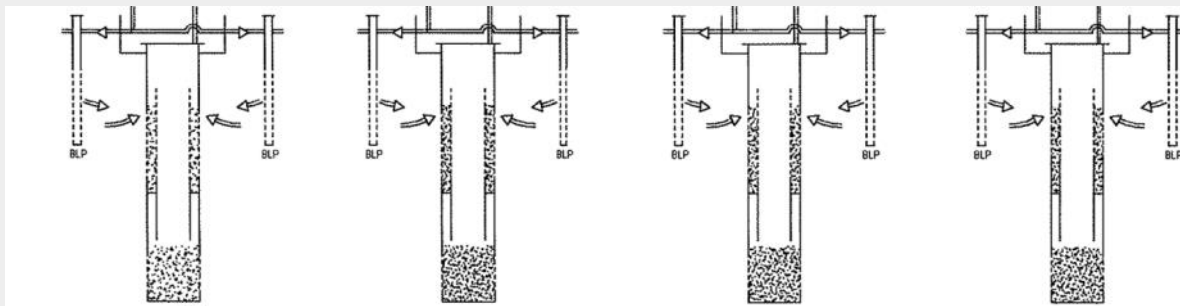


# IEG-GCW<sup>®</sup> Model for Standard and Reverse Flow

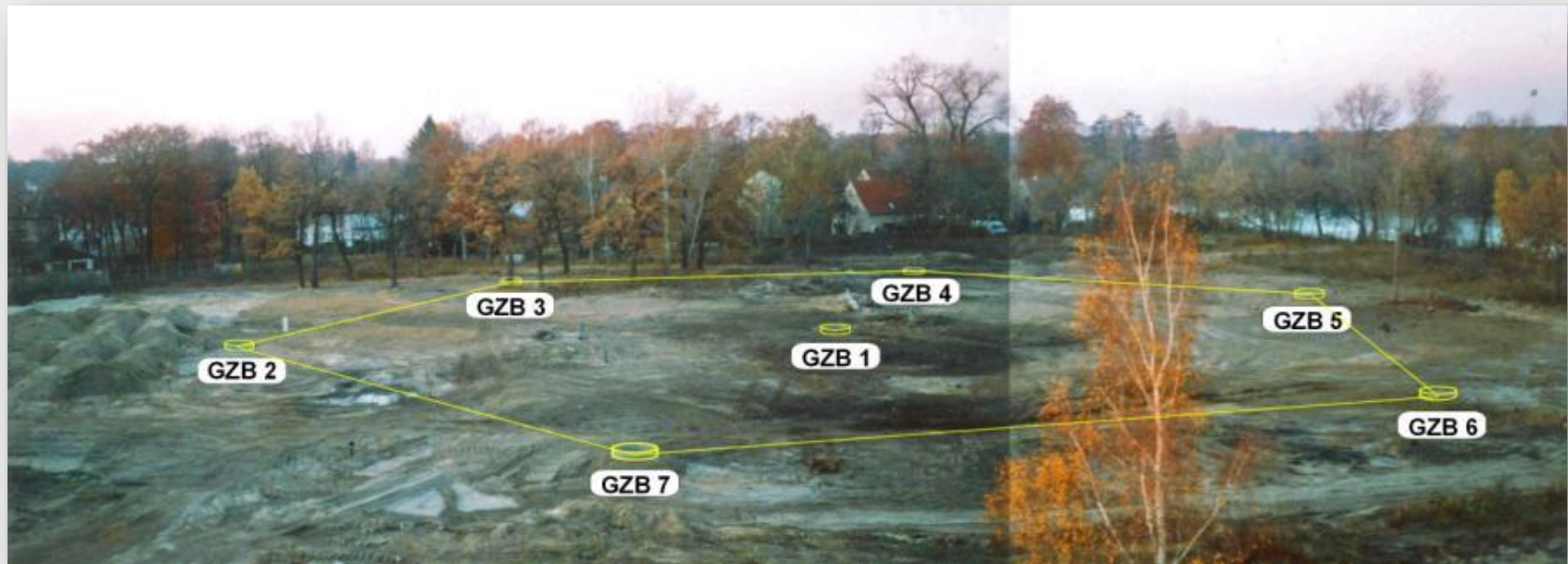


# Remedial Concept for Unsaturated Zone and Capillary Fringe

- Horizontal Soil Air Circulation (SAC)
- Double Cased Screens (DCS)
- Area of 9500 m<sup>2</sup> was covered with impermeable plastic foil to prevent soil air short circuit flow
- Reinjection of soil air into the unsaturated zone through air injection wells
- Soil air extraction via upper GCW screens



# Arrangement of GCWs<sup>®</sup> for Pilot test



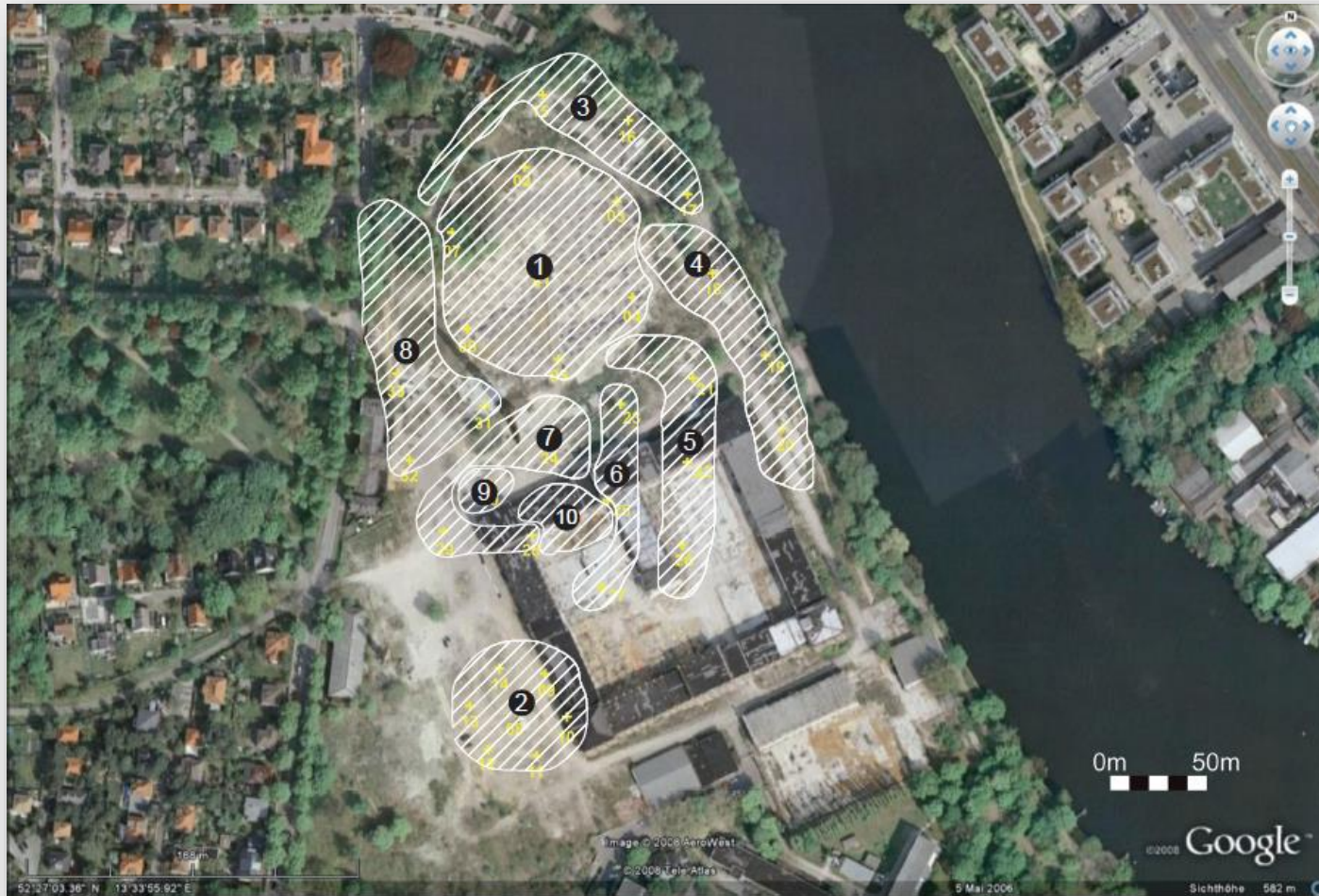


# IEG-GCW<sup>®</sup>- Installation



- „hexagonal“- arrangement of circulation wells
- well diameters  $\varnothing$  400 - 800 mm with 2 or 3 screen sections depending on aquifer thickness
- filtergravel in the upper screen section can easily be removed (Fe-fouling)
- Standard circulation of GCWs
- GW-treatment either in-situ (below ground surface) or on-site via compact air-strippers and reinjection
- Off-gas treatment with granular activated carbon (GAC)

# Sequence of GCW Installations between 2004 and 2008





# The Position of all GCWs and their Radius of Influence (ROI)





# Full-Scale Remediation

- **IEG installed 33 Groundwater-Circulation-Wells (GCW®) and 18 Vapor-Extraction/Reinjection Wells**
- **We added oxygen by stripping, and have been adding, C-Mix and PAC into the GCWs to enhance biodegradation**
- **We have been removing LNAPL (BTEX) and DNAPL(CHC) separately from 3 recovery wells**
- **We also integrated some of the existing monitoring wells for extraction and reinjection of the treated groundwater**

# Physical Treatment of Groundwater and Contaminated Off-Gas

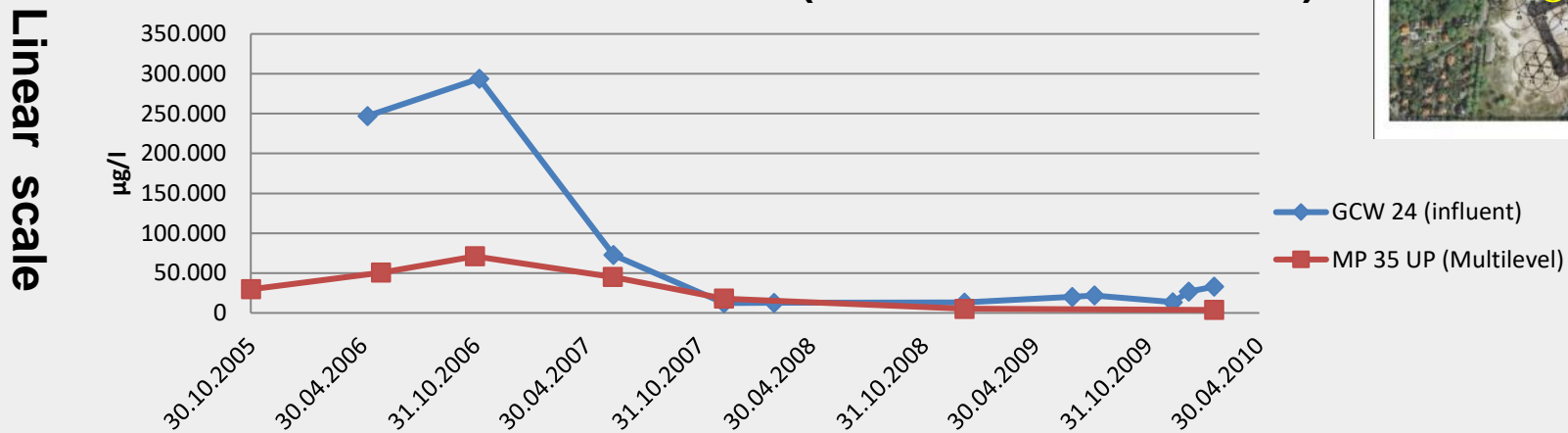


# CHC Concentration over Remediation Time

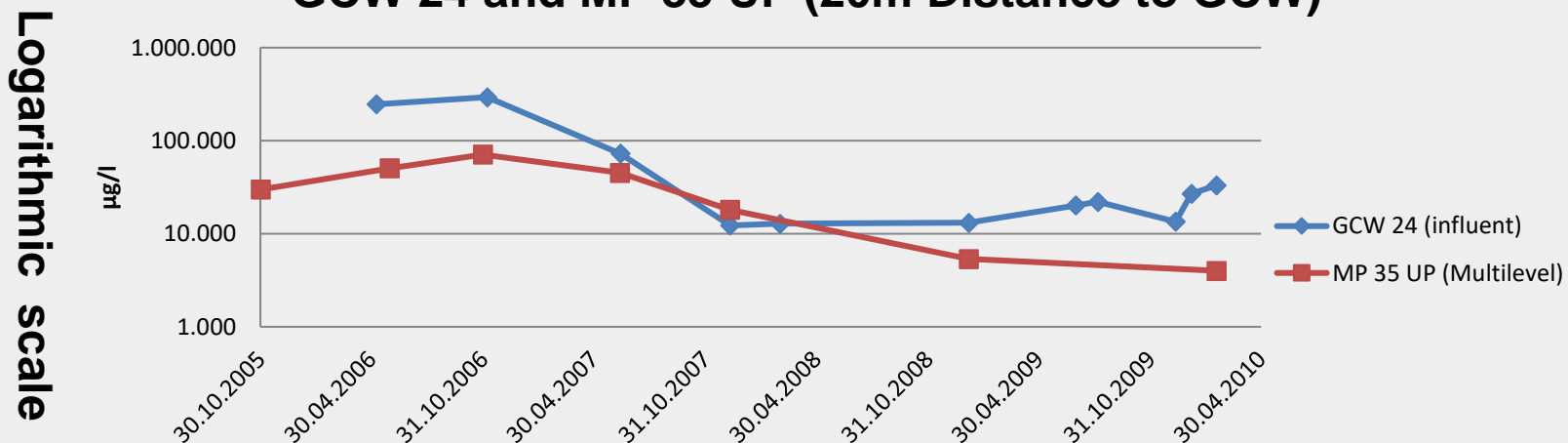
## Source Area



### GCW 24 and MP 35 UP (20m Distance to GCW)



### GCW 24 and MP 35 UP (20m Distance to GCW)





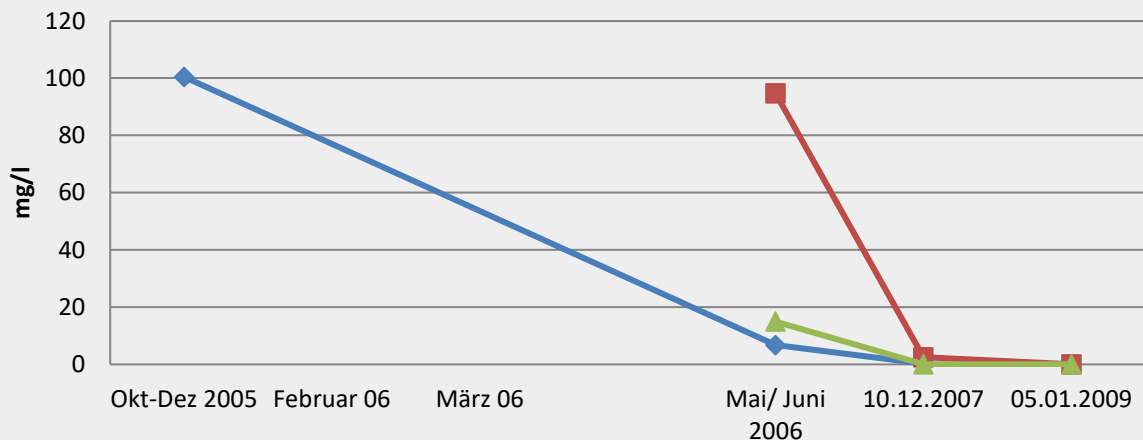
# CHC Concentration over Remediation Time

## Peripheral Area

GCW 16, 21 and 26



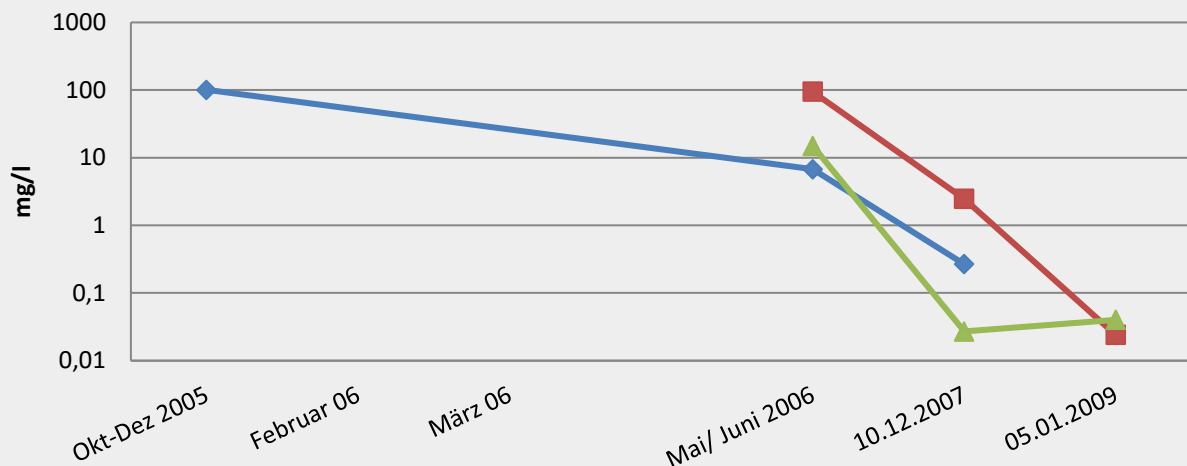
Linear scale



GCW 16  
GCW 21  
GCW 26

GCW 16, 21 and 26

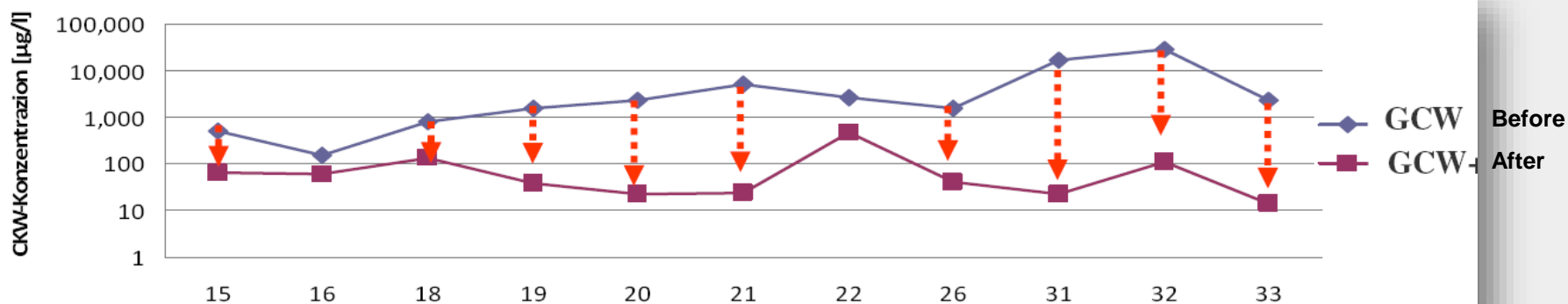
Logarithmic scale



GCW 16  
GCW 21  
GCW 26

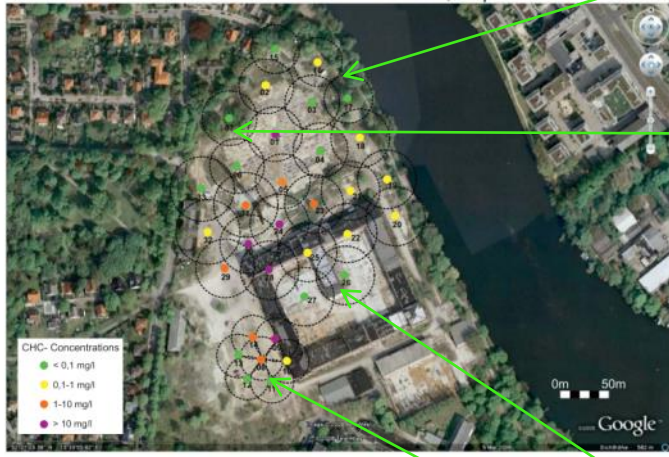
# CHC-Concentrations in GCWs after Addition of C-Mix Enhance Natural Microbiological Activities

GCW	date	µg/l	date	µg/l
15	23.04.2007	490	30.05.2008	65
16	23.04.2007	156	30.05.2008	60
18	23.04.2007	809	30.05.2008	135
19	23.04.2007	1.504	16.10.2008	39
20	23.04.2007	2.376	09.01.2009	22
21	23.04.2007	5.019	09.01.2009	24
22	23.04.2007	2.582	09.01.2009	469
26	23.04.2007	1.517	09.01.2009	40
31	13.06.2007	16.849	09.01.2009	22
32	13.06.2007	27.528	09.01.2009	112
33	13.06.2007	2.244	09.01.2009	14

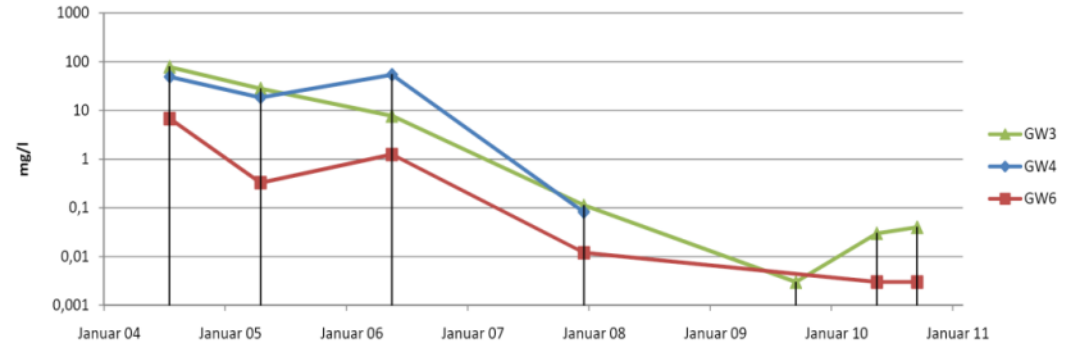


# CHC-Concentrations in GCWs after Addition of C-Mix and PACs to Enhance Natural Microbiological Activities

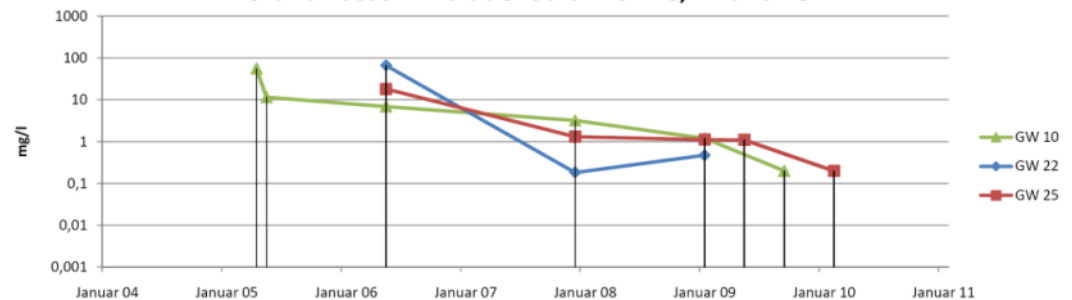
CHC-Reduction in Different Areas, September 2010



Grundwasserzirkulationsbrunnen 3, 4 und 6



Grundwasserzirkulationsbrunnen 10, 22 und 25





# Summary

(November 2013)

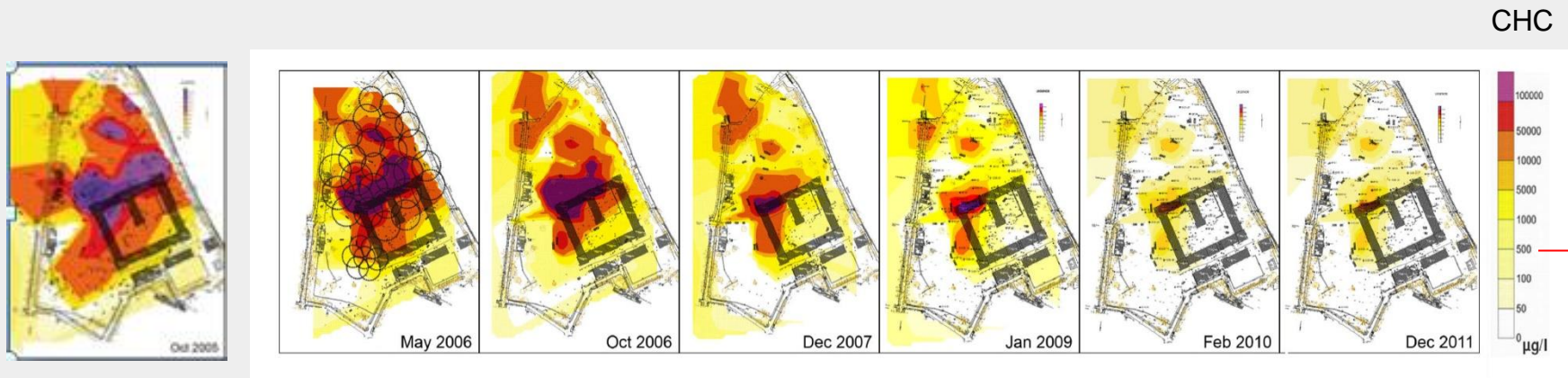
- **In-situ GW-Remediation with 33 GCWs<sup>®</sup>, whereas 6.300.000 m<sup>3</sup> of Groundwater have been circulated**
- **Total Circulation Flow of 155 m<sup>3</sup>/h**
- **Flushing of the Porespace between 5 and 20 times per Year (25 m & 20 m away from GCW)**
- **> 200.000.000 m<sup>3</sup> Ambient Air have been used for Aeration/Stripping of the Groundwater**

# Summary

(November 2013)

- **> 50.000.000 m<sup>3</sup> of Contaminated Soil Air Treated**
- **12.000 kg of CHC and BTEX have been Removed from the Subsurface via Vapor Extraction**
- **> 8.400 kg of BTEX Removed Directly via LNAPL-Recovery**
- **> 119.000 kg of CHC and BTEX have been removed from the Groundwater between April 2004 and November 2011**

# Reduction of CHC- Concentrations at the Entire Site Since 2005



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Spring 2005  
7 GCWs  
Pilot test

Spring 2006  
+ 19 GCWs

in 2007  
+ 7 GCWs

Adding of C-Mix  
and PACs

Target  
Clean-up levels

Primary active physical treatment

Primary microbiological treatment

Sequential Aerobic - Anaerobic degradation



# Total Remediation Costs

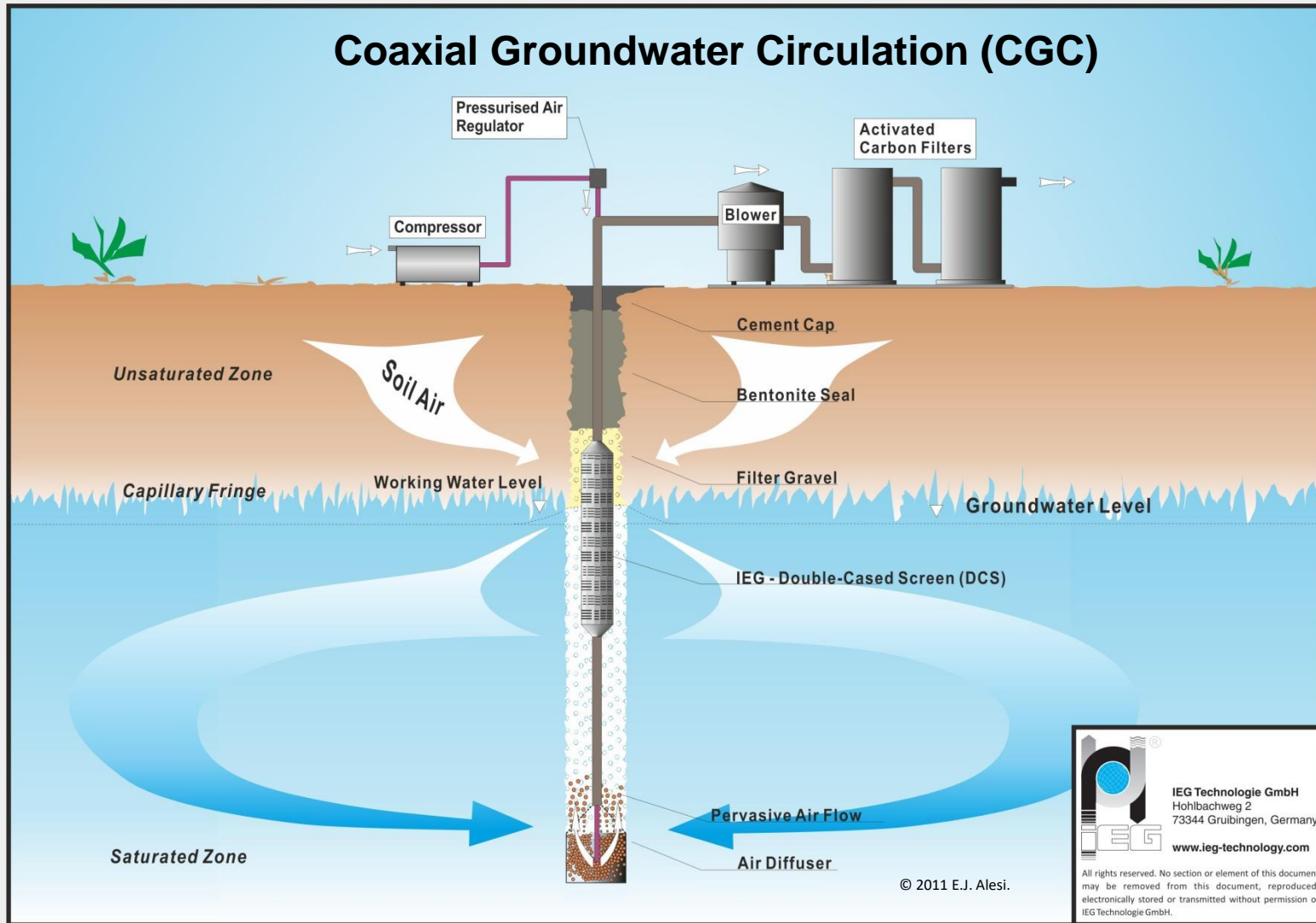
Results show, that a combination of physical and biological techniques in combination with groundwater circulation is efficient and cost effective

- 6 - 7 € per m<sup>3</sup> unsaturated and saturated soil matrix
- 25 € per kg removed CHC

# **BTEX and TPH-Remediation in the South Part of the Site**



# BTEX and TPH-Remediation TF3





# BTEX and TPH-Remediation TF3 (Start-up March 2014)



**18 Combined Vapor Extraction and Coaxial Groundwater Circulation (CGC) Wells**

# **BTEX and TPH-Remediation TF3 (Summary August 2014)**

- **10500 kg BTEX &TPH have been removed from Soil & Groundwater**
  - **7500 kg have been treated by catalytic incineration**
  - **3000 kg by GAC**