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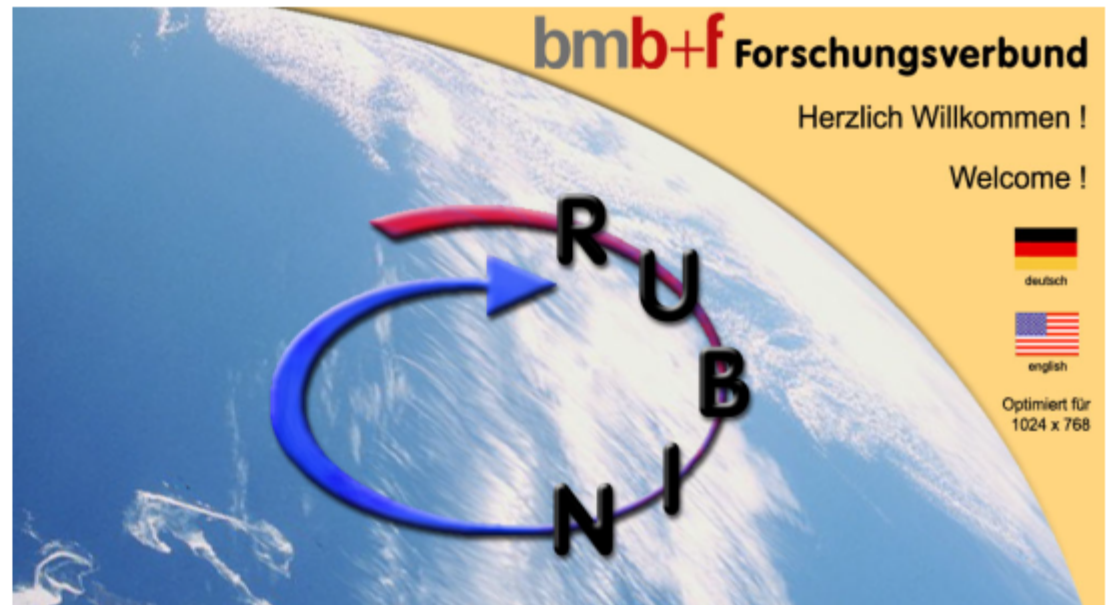


PRBs in Germany and Austria

Overview of 10 PRB Sites and Upcoming Projects

www.rubin-online.de

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PRBs in Germany

■ **Two R&D networks** (funded by the Federal Government)

“SAFIRA“ (6 Mio \$)

Basic R&D, semi-technical scale
reactive materials for cVOCs/chlorobenzenes/PAHs

“RUBIN“ (4-5 Mio \$)

R&D *and* technical implementation of PRBs at
different sites across the country

■ **Public funds spent \approx 14 Mio \$**

■ **Different private sites \approx 6 Mio \$**

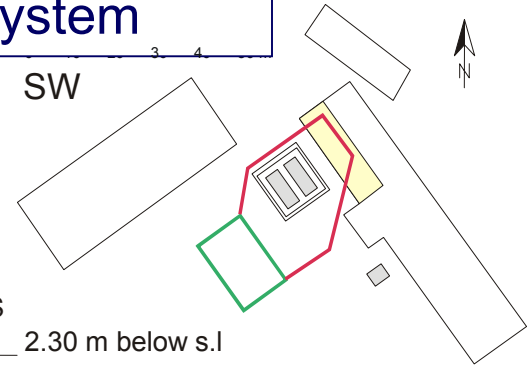
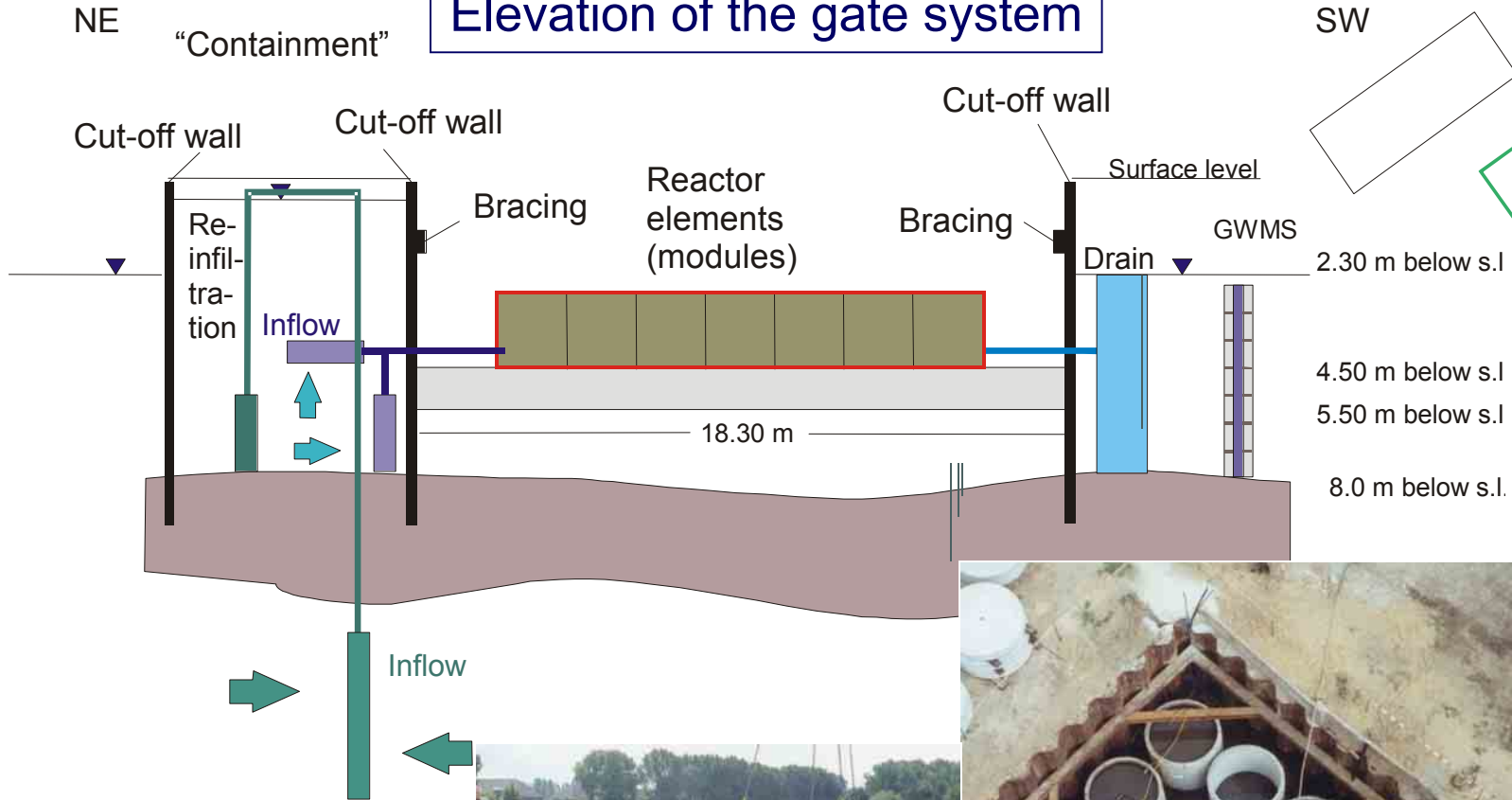
Bernau

- High contamination of cVOCs affecting two aquifers (TCE up to around 100 mg/L)
- Special reactor design capturing *both* aquifers by pumping GW and injecting it into a collecting zone and additional tanks
- Closed funnel = containment for the source and serving as a collecting/mixing zone for accumulating lifted GW before it enters the gate
- RUBIN project, volume: appr. 1.5 Mio \$ (50 % public funds)

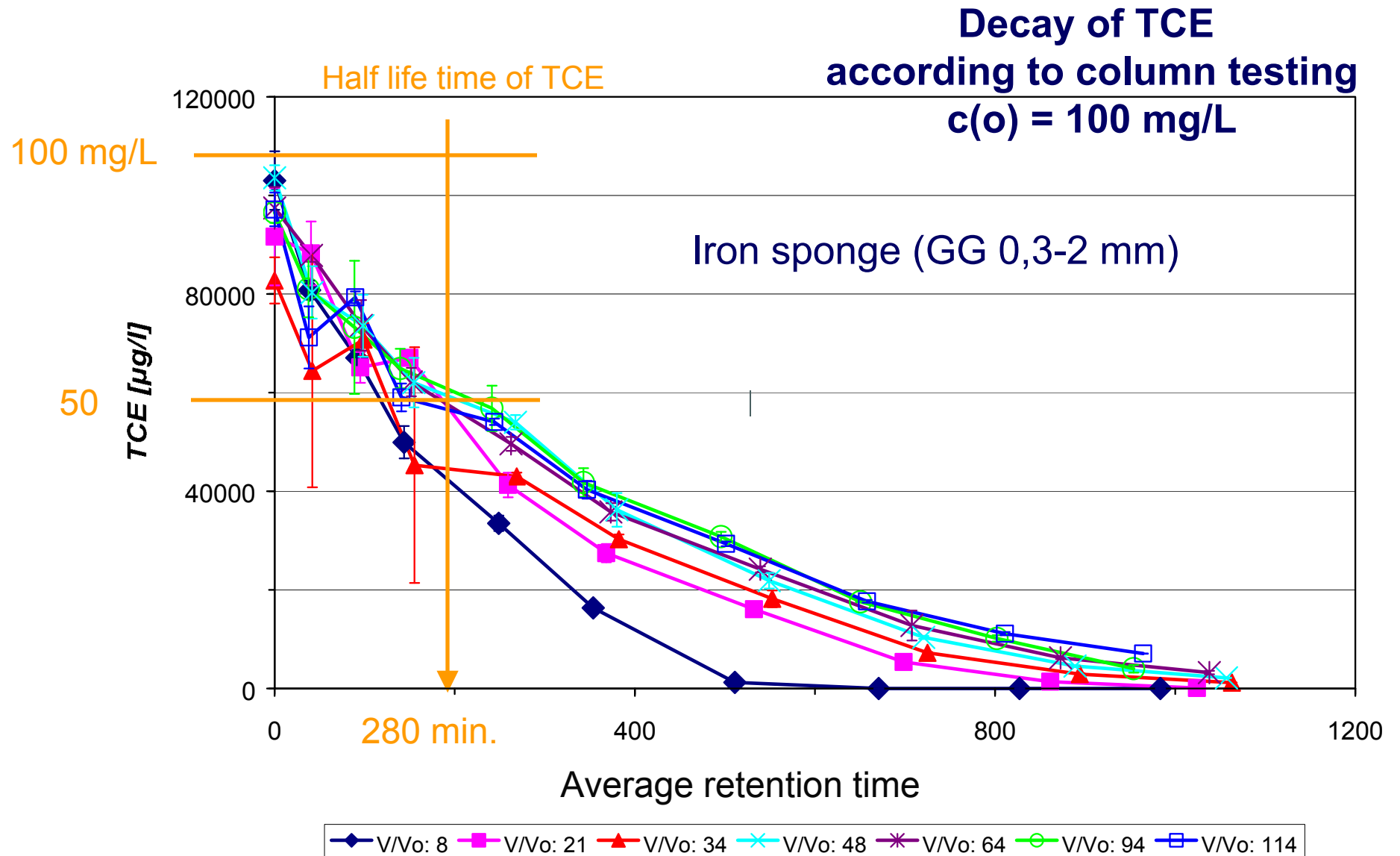
Bernau

Top view of the funnel-and-gate system

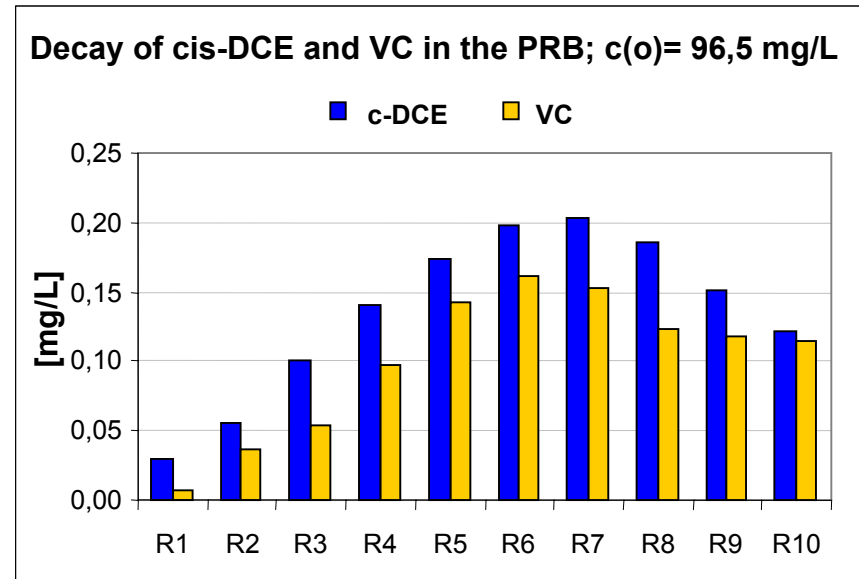
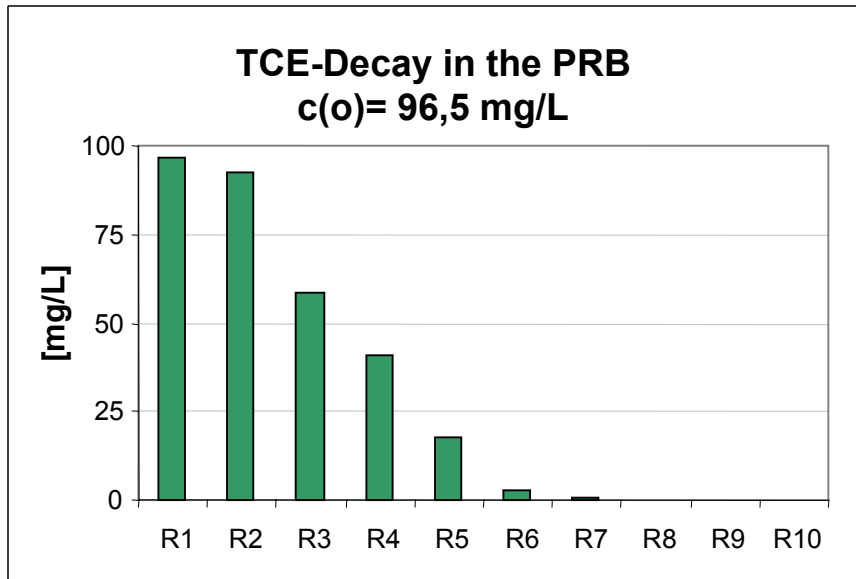
Elevation of the gate system



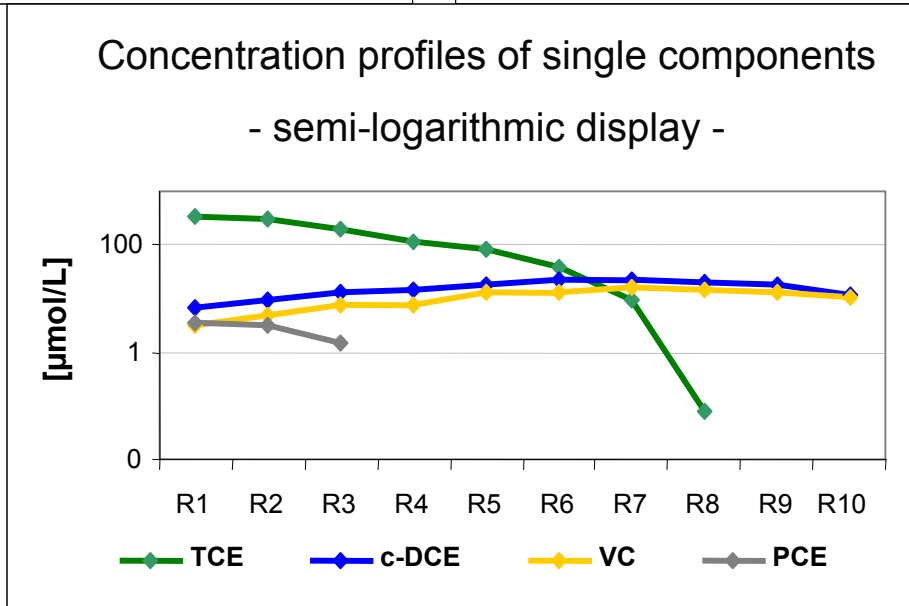
Bernau – Performance



Bernau – Performance

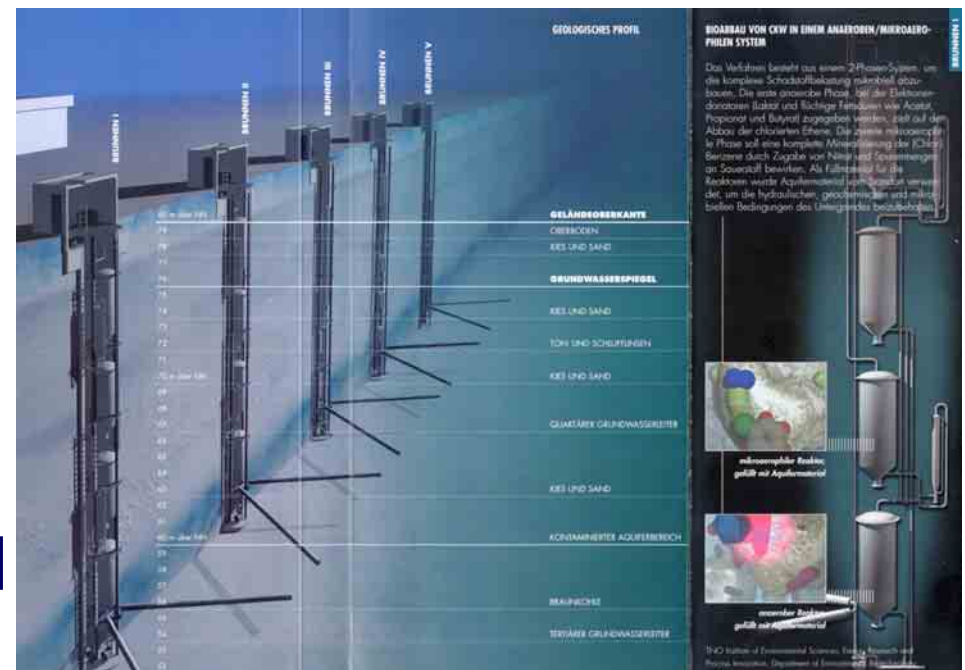


Field results
 (appr. after one
 pore volume
 has been
 exchanged)



Bitterfeld (“SAFIRA“)

- Semi-technical test site for new PRB materials; five shafts (30 m deep, 3.50 m Ø) containing diff. steel reactors, loaded with different media:
- Microaerophilic, anaerobic reactors (aquifer material)
- Combined media, e.g., GAC/microbiol.; ZVI/ORC)
- Membrane- and zeolite-supported Palladium (Pd)
- Catalytic oxidation using metal catalysts; ultrasound



<http://safira.ufz.de>

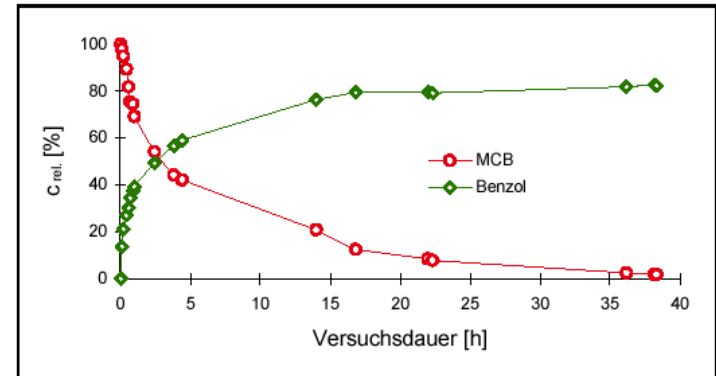
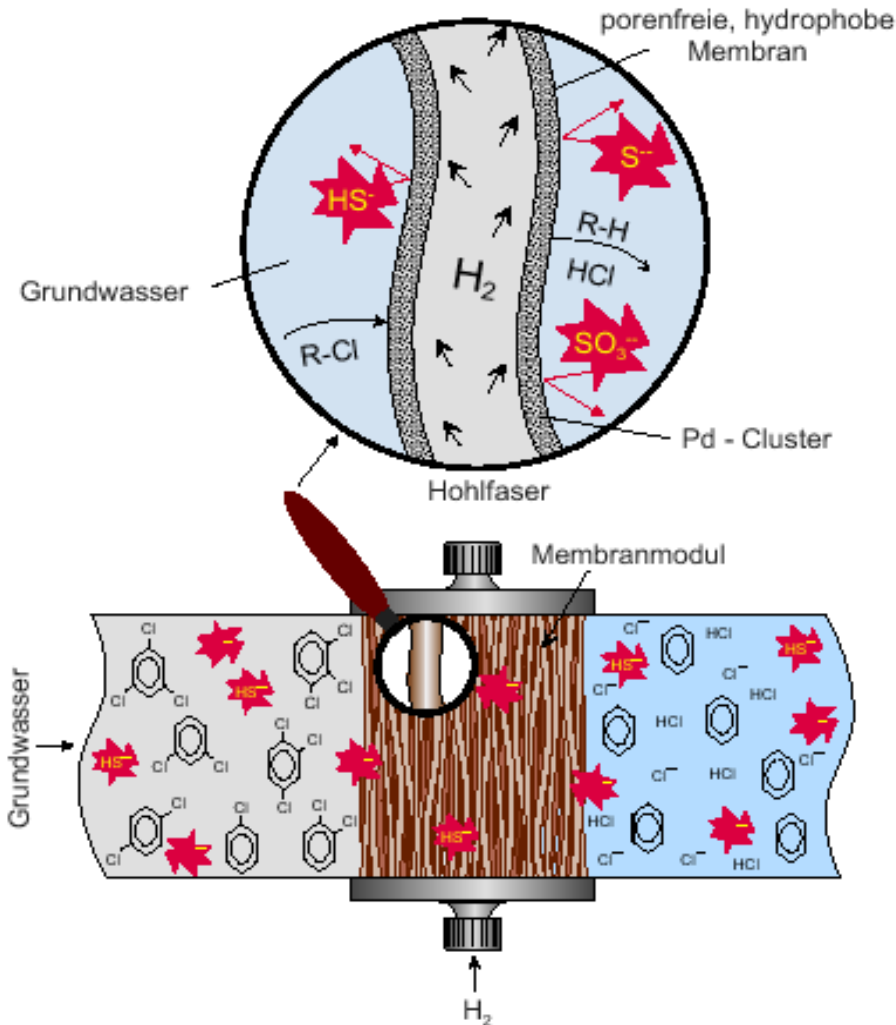


Abbildung 4.48: MCB-Reduktion an palladiertem THOMAPLAST[®]-Silikonschlauch (Schlauchabmessungen: (1,8 x 0,4 x 1000) mm; ca. 0,7 Ma% Pd; $c_{0, \text{MCB}} = 3070 \text{ ppmv}$; $V_{\text{H}_2} = 2,35 \text{ l}$)



Membrane-supported Pd/H₂ rapidly dehalogenates monochlorobenzene (MCB) to benzene

Denkendorf

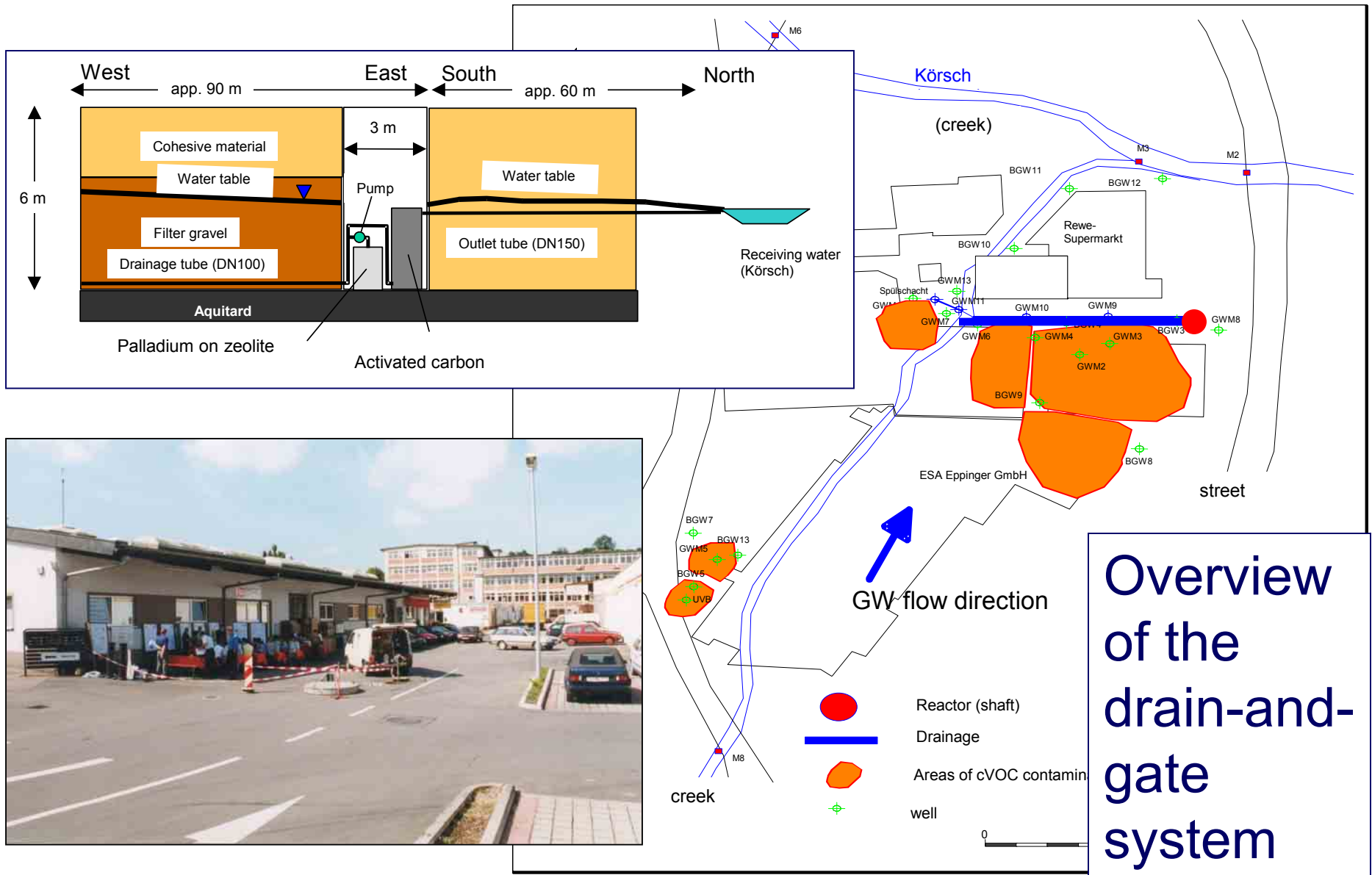
- cVOC contamination (TCE, PCE, cis-DCE, 1,1,1-TCA, VC) is treated with GAC

- “*Drain-and-Gate*” PRB to meet the low hydraulic gradient of 2%:

90 m long and 6 m deep gravel drainage directing the flow right towards a single GAC reactor

- GAC reactor was placed inside a shaft (6 m deep)

Denkendorf



Denkendorf

RUBIN project:

- Bypass: hydrogenation catalysts like palladium on zeolite are tested

- Addition of hydrogen gas:

fast and complete degradation of cVOCs

(first, small column experiments in the first quarter of 2002: especially VC is effectively degraded, too)



Edenkoben

- cVOCs (20% TCE, 50% cis-DCE, 30% 1,1,1-TCA)
- 1998: pilot-scale F&G
2000: expanded to a full-scale F&G
- Gates designed for a *diverted, vertical* flow inside
Groundwater is passively lifted by a vertical drainage (gravel columns) and thus directed through the ZVI bed

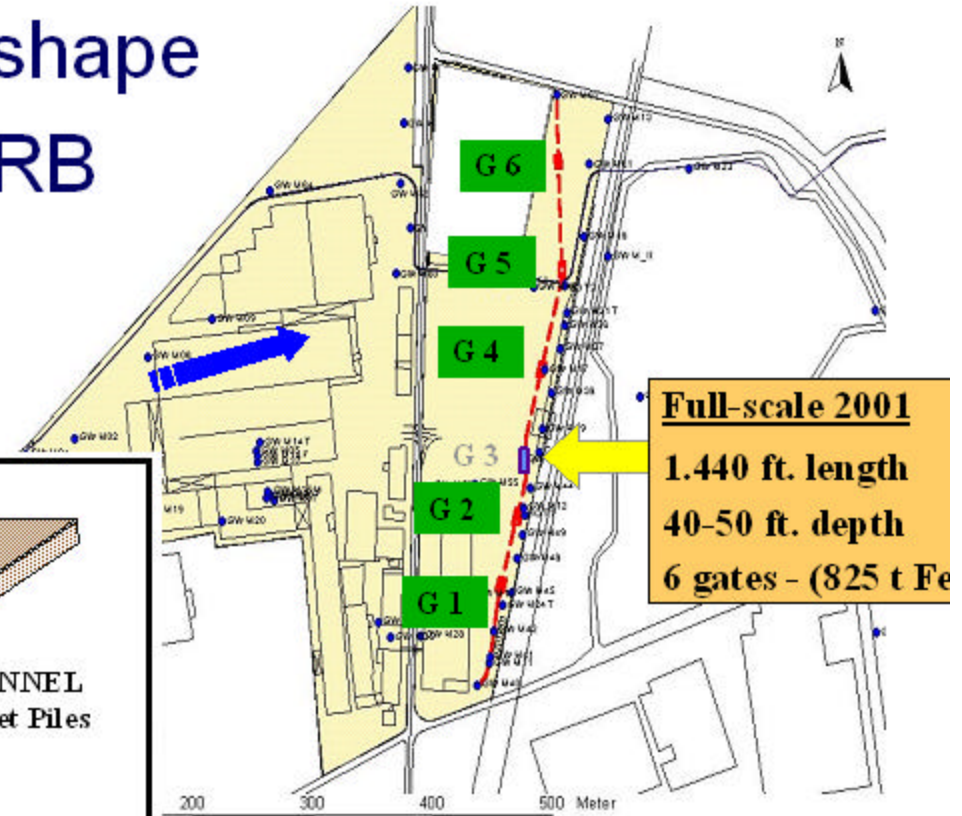
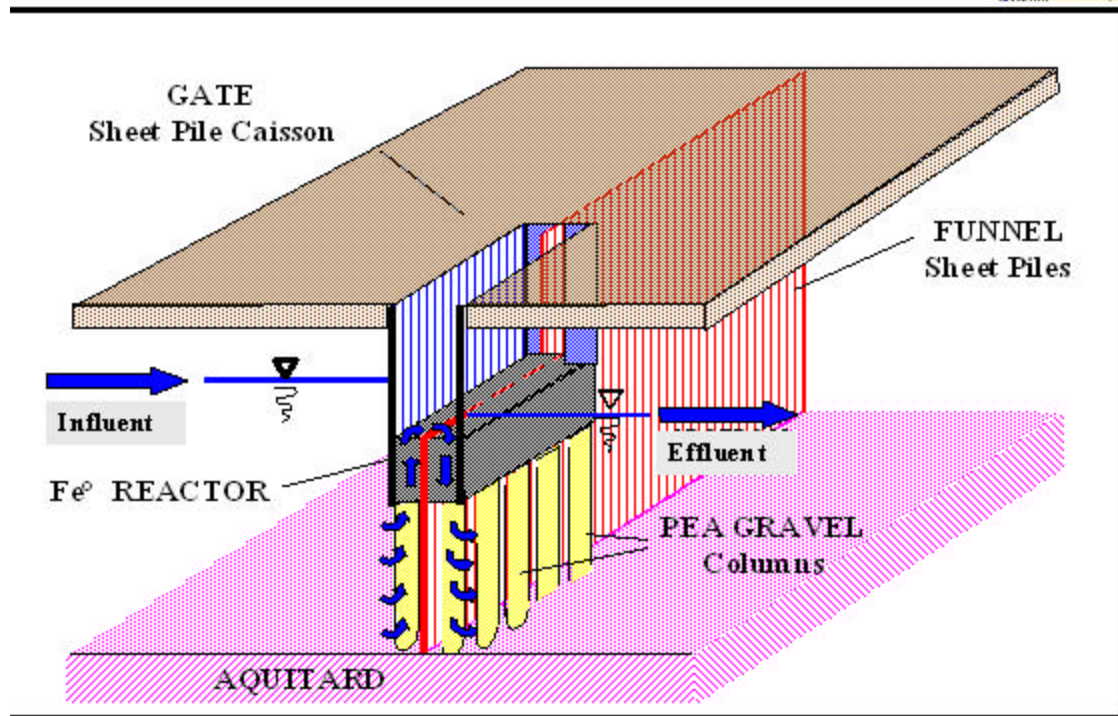
Edenkoben

- Six identical gates, each constructed as a sheet pile caisson (open at its bottom)
- Funnel: continuous sheet pile wall, 430 m long, 14 m deep
- Funnel also runs through every gate, thus separating each of them into two chambers
- Inside the gates the sheet pile wall was buried down to 1 m below the lowest groundwater level anticipated
= overflow weir between the chambers

Edenkoben

Position and shape
of the F&G PRB

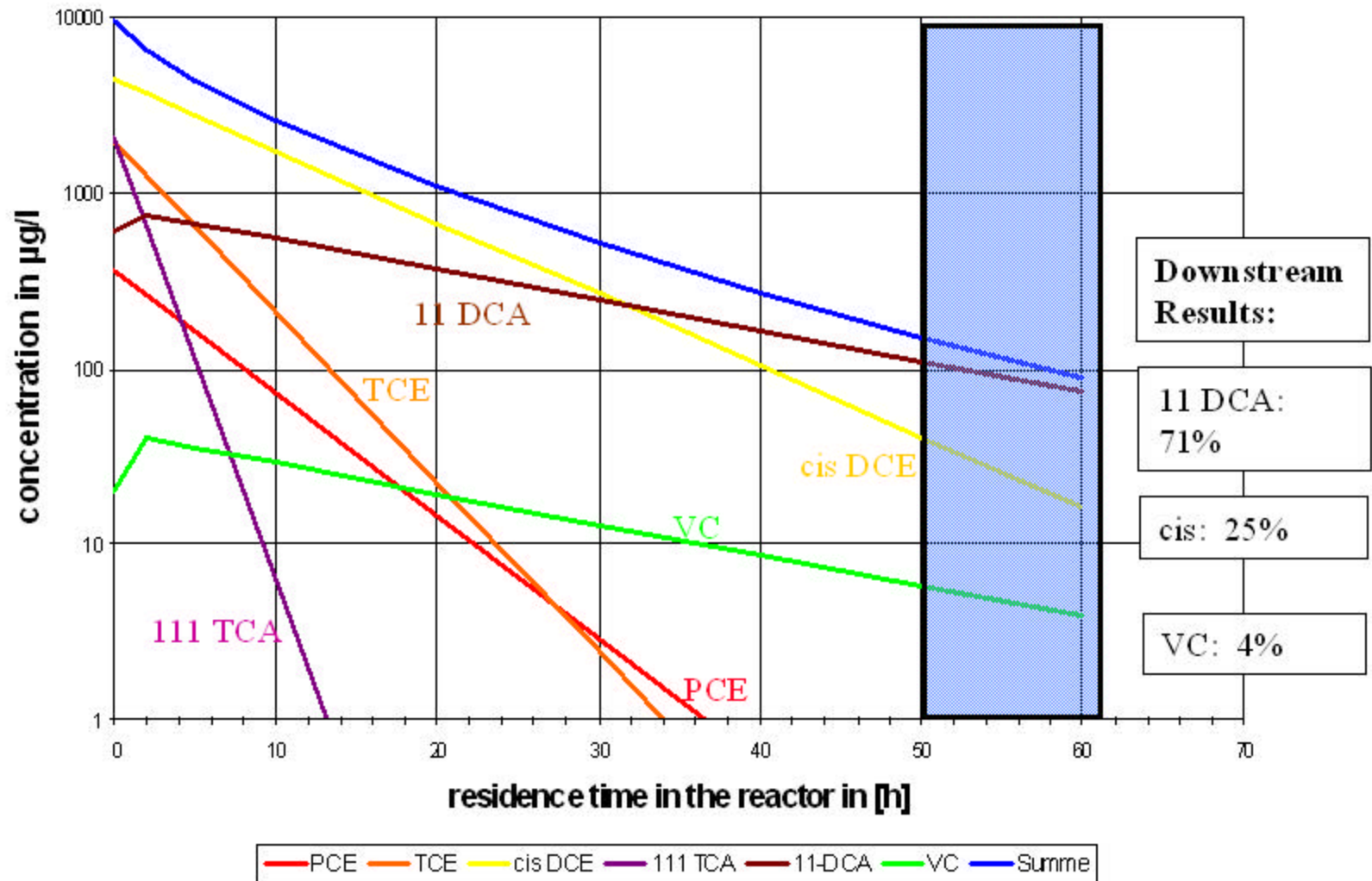
Gate design



1.500 ft.



Edenkoben



Validation of cVOC degradation
six months after installing the pilot gate

Karlsruhe

- 2000/2001: full-scale F&G packed with granular activated carbon (GAC, 150 tons) to treat PAHs and BTEX
- Funnel consists of sheet piles (200 m long, 17 m deep)
- Eight gates consisting of specifically perforated steel; cylindrical steel tubes were lowered into previously set up, large diameter boreholes (2.5 m)

Karlsruhe



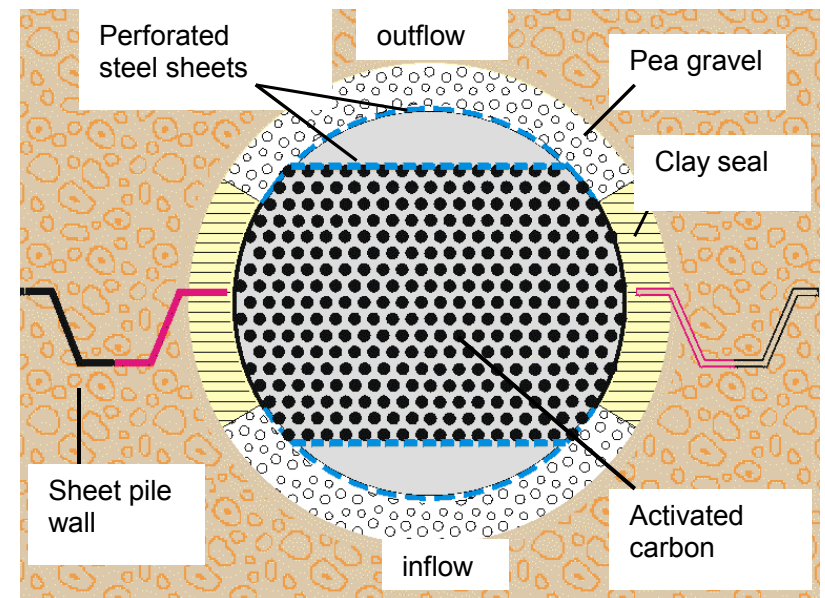
Former gas works plant



Overview of the full-scale F&G PRB

Karlsruhe

- Pea gravel, serving as a filter medium and for homogenizing the flow through the gates, was packed at the inflow and outflow zone
- Free space left between the steel tubes and the adjacent funnel segments was sealed off using clay



Karlsruhe

Packing the gate
with granular
activated carbon



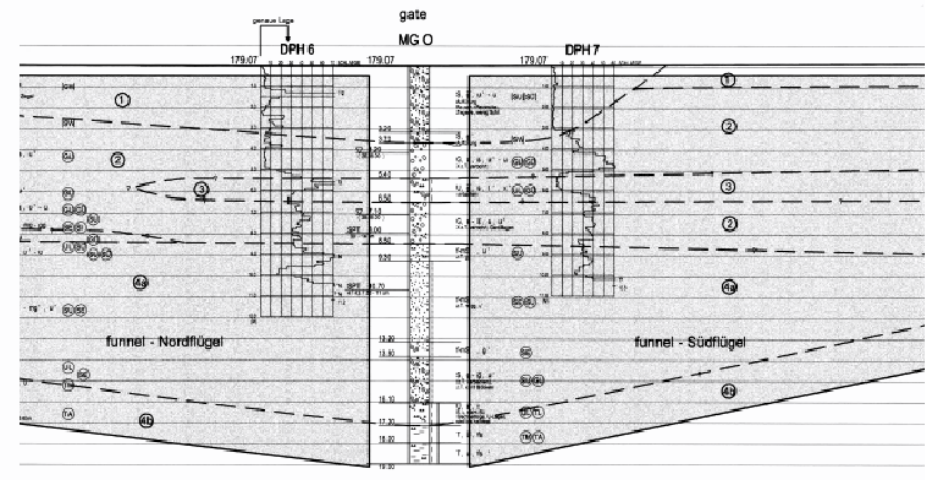
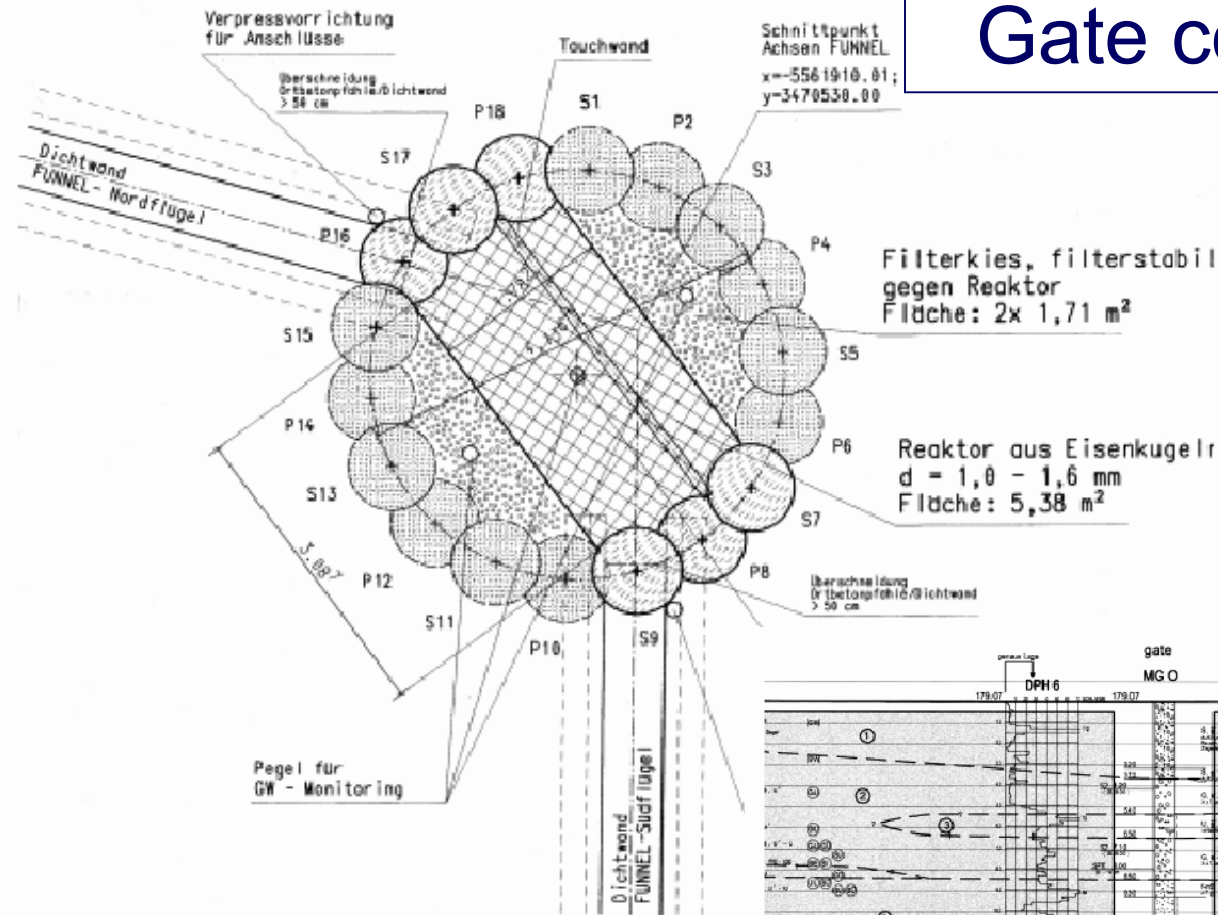
Sheet piles were pressed
into the ground using the
“silent piler”-technique

Oberursel

- cVOC contamination treated with ZVI at the BOSTIK site (TOTALFINAELF)
- L-shaped F&G equipped with one gate
- Gate shaped like a wide annulus:
 - ◆ Diameter 3.3 m, 13 m deep
 - ◆ Overlapping boreholes cast with concrete forming the annulus
(at the inflow/outflow zone, permeable concrete was cast)
- Funnel (slurry wall): 175 m long, 4-19 m deep, 0.6 m thick

Oberursel

Gate construction



Oberursel

Gate construction,
shape of the F&G

