

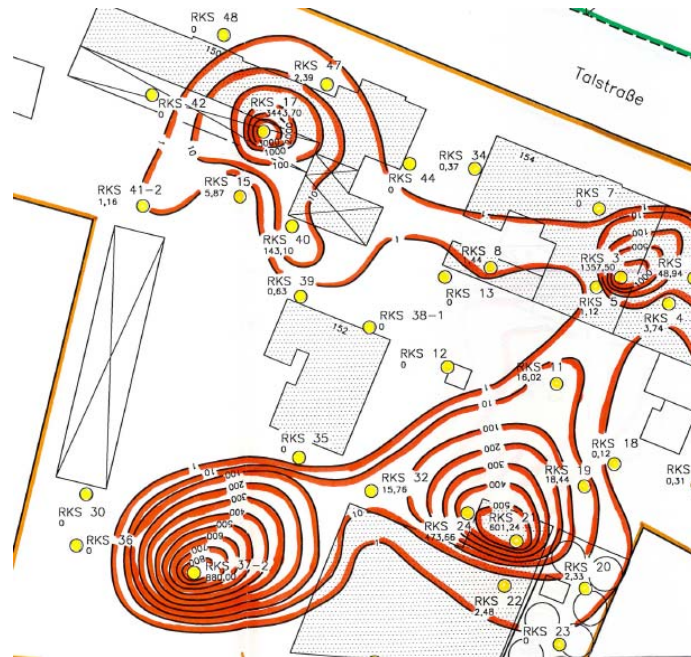
IN-SITU TREATMENT SYSTEMS for ORGANIC CONTAMINANTS

APPROPRIATE APPLICATION

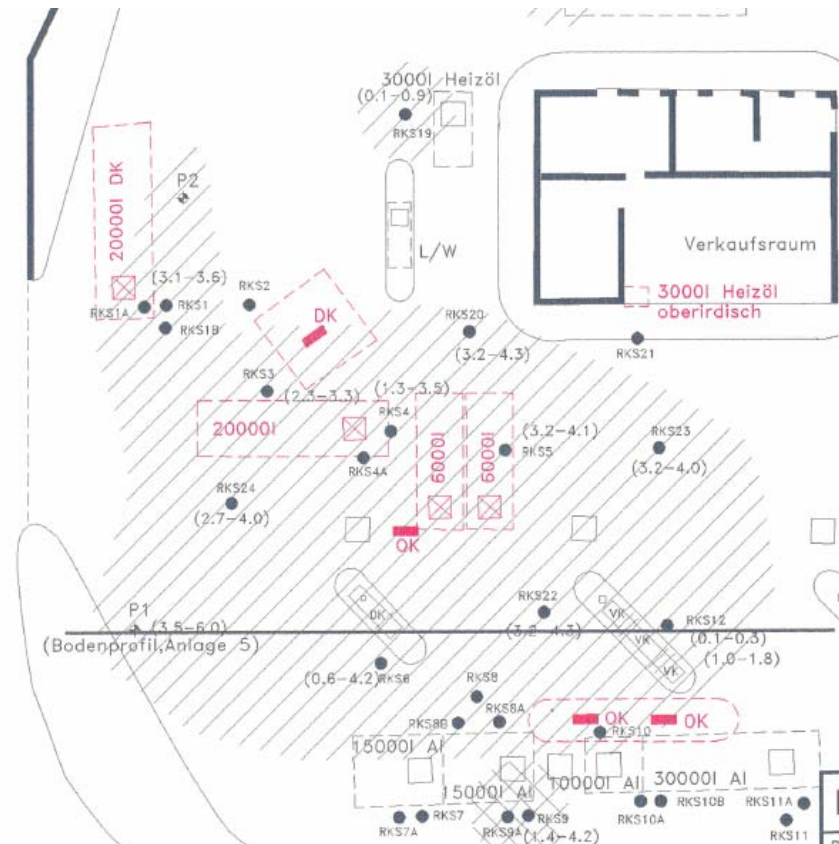


UNSERE LEISTUNG UND ERFAHRUNG SIND IHRE LÖSUNG

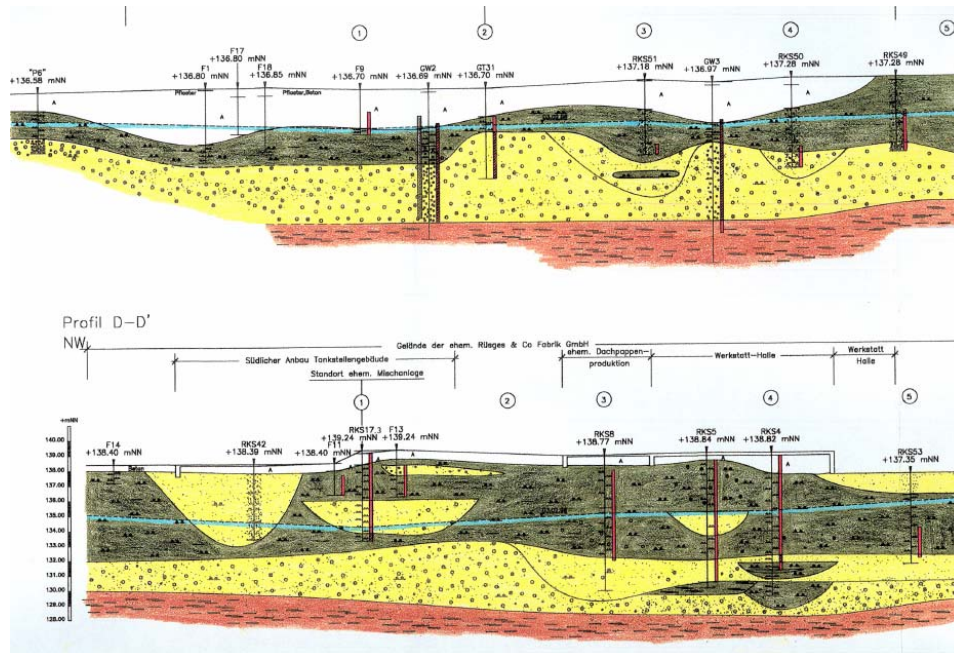
Evaluation of Investigation Results



Results from punctual drillings
are projected to the whole site



Evaluation of Investigation Results

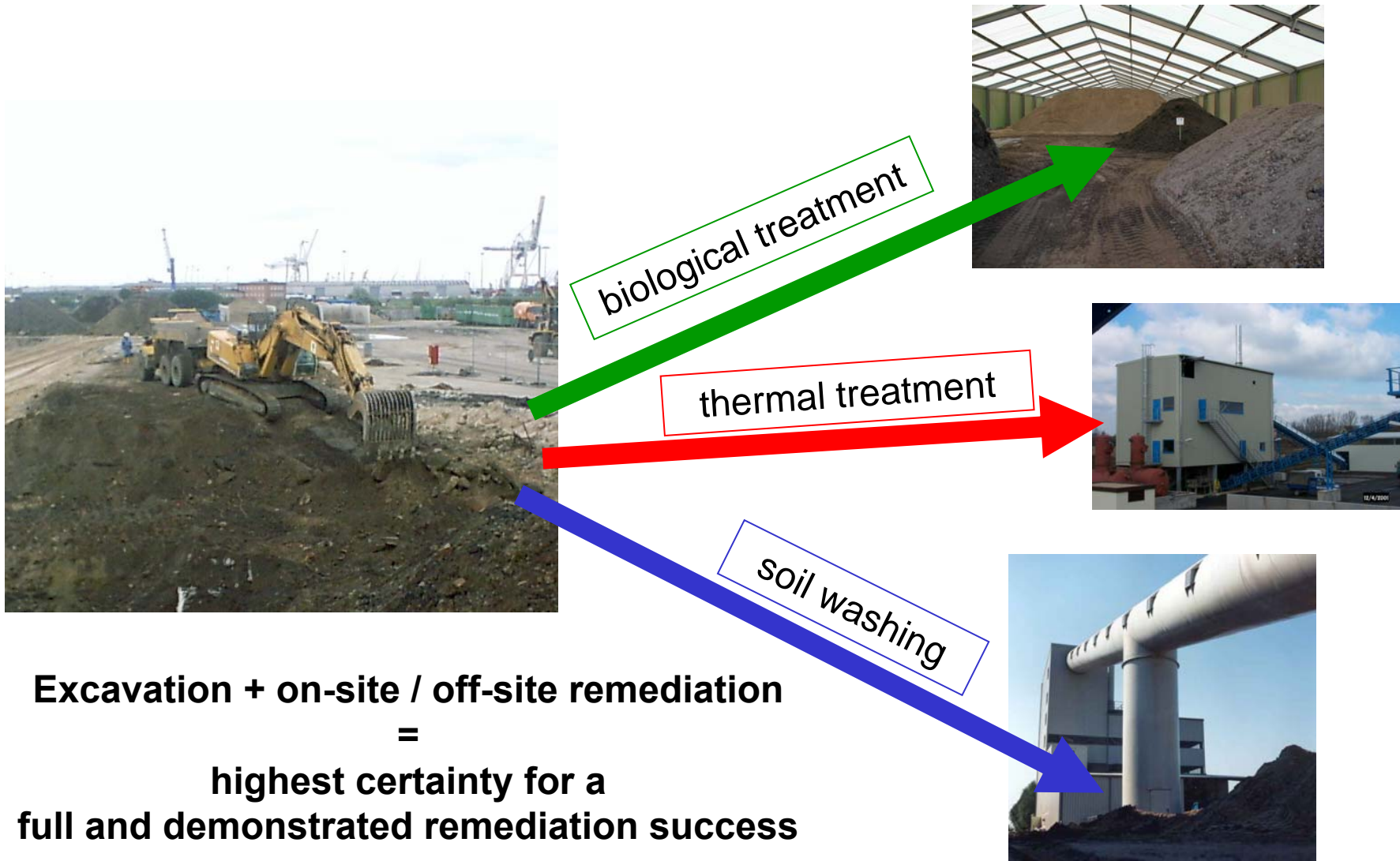


Cross-sections help with the understanding and extrapolation



Surprises are not unlikely

Ex-situ Remediation



Investigation of Soil after In-situ Treatment



Soil gas: clean
Groundwater: no detectable pollutants
Soil: still contaminated

In-situ treatment ≠ cost-saving alternative for excavation

Application range:

1. excavation not possible

- no access
- very deep, very wide
- stability risks for
 - * buildings
 - * streets
 - * pipe work
- no interruption of
 - * production
 - * sale



Application range:

2. pre-treatment before excavation to avoid

- explosions
 - fire
 - health risks for workers
 - emissions
-
- mixing with
 - * fresh soil
 - * groundwater



Application range:

3. prevention of further extension

- by free flowing product
- with the groundwater
- evaporation into the atmosphere

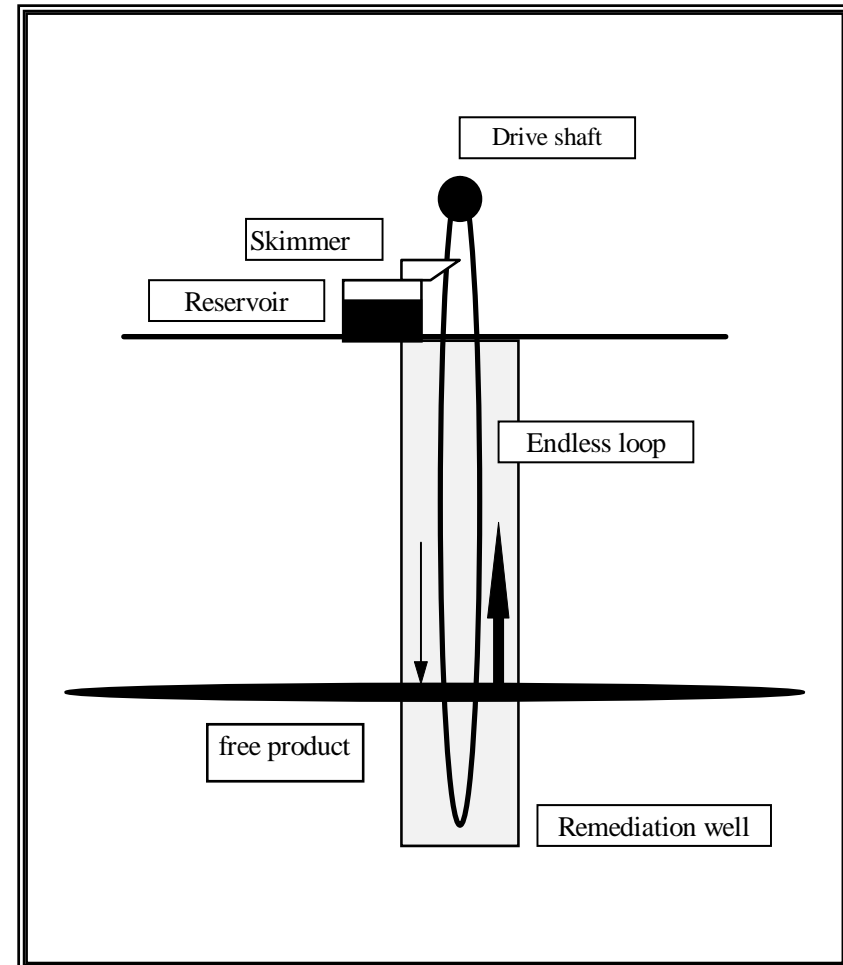
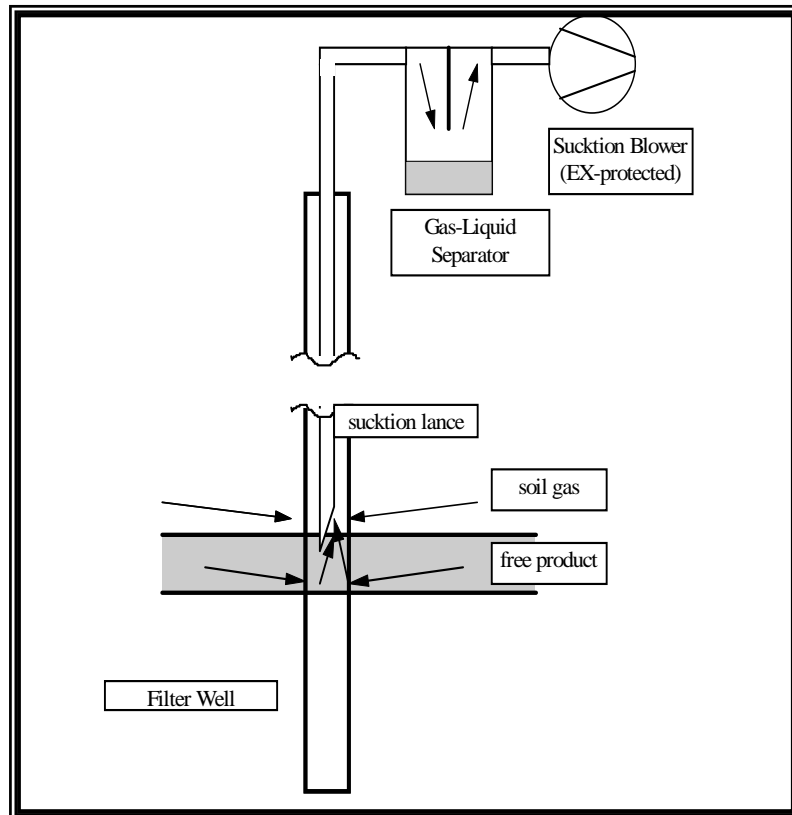


Useful Effects

as
contaminant is

- | | |
|---------------------|----------------------------------|
| 1. pumpable | ➔ pumping systems |
| 2. adsorbent | ➔ adsorber systems |
| 3. volatile | ➔ extraction / stripping systems |
| 4. soluble | ➔ hydraulic systems |
| 5. bio-degradable | ➔ bio-systems |
| 6. chemo-degradable | ➔ chemical systems |

Product Recovery Systems



Product Recovery Systems



▲ Suction Unit



▲ Belt Skimmer

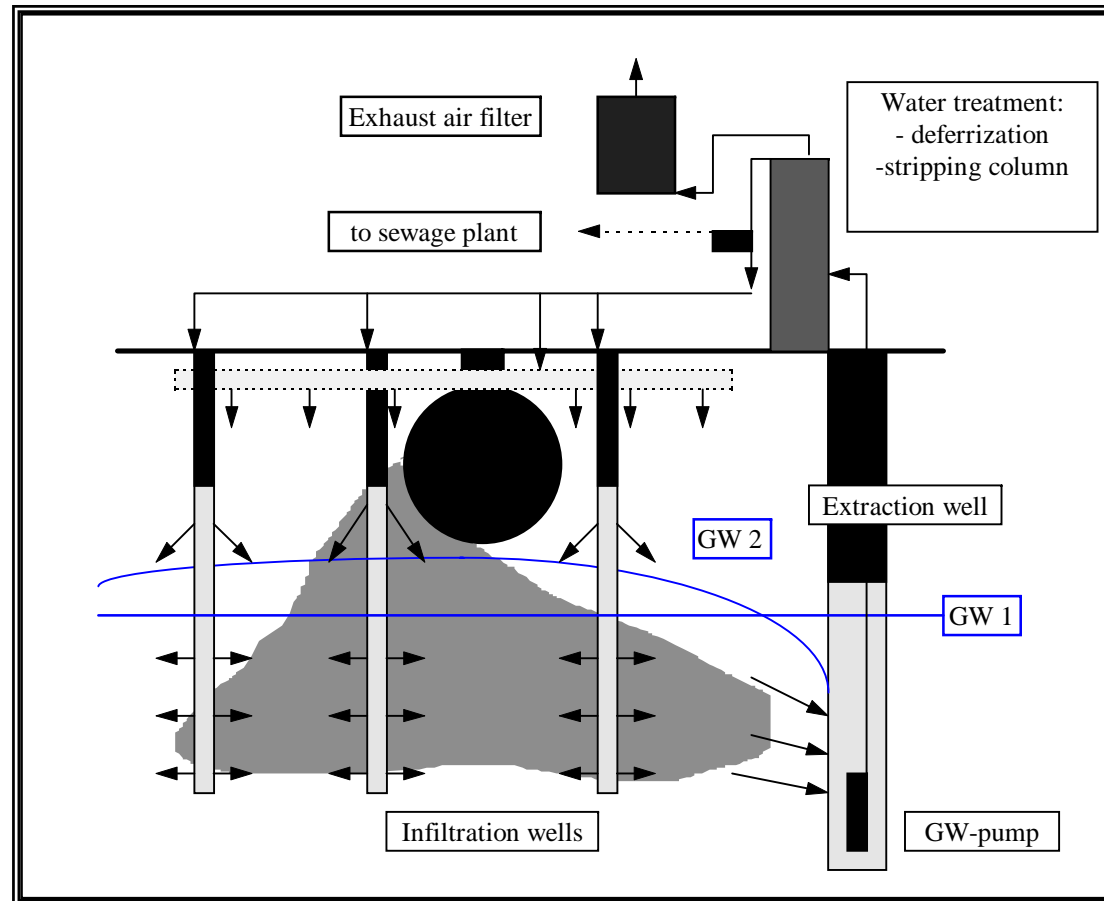
Application

- To remove free Gasoline, Diesel, Lubricants, Crude
 - to avoid pollution of soil during excavation
 - as first step before further treatment
 - to stop further extension of product
- Flow rates 1 ltr/h to > 10 ltr/h
- Duration 6 month and more

Limitations

- Product entry into well
- Free product covered by groundwater
- Blocking of wells and screens
- High viscosity products
- Removal of fine films from groundwater
- Processing of pumped water/product mixture

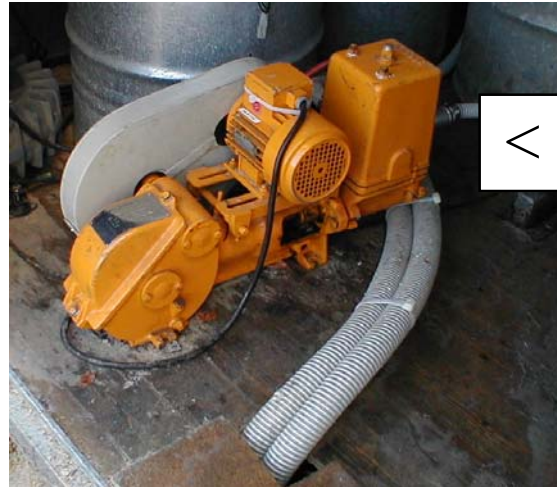
Pump and Treat Systems



Pump and Treat Systems



$> 50 \text{ m}^3/\text{h}$



$< 5 \text{ m}^3/\text{h}$



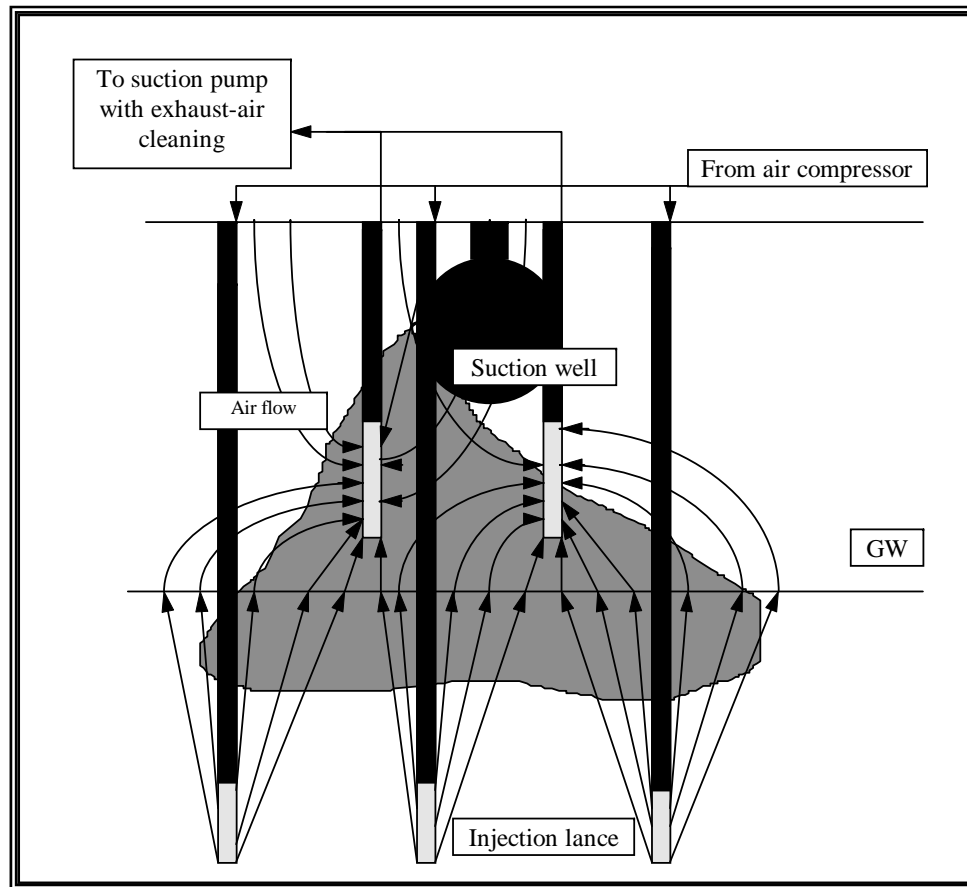
Application

- Groundwater capturing
- Groundwater lowering
- Downstream protection
- Combination with mobilising systems
 - airsparging

Limitations

- Decreasing access to polluted soil areas
 - Shrinking yield of contaminants
 - at constant costs
- Corrosion, blockings, frost
- Immediate re-rise of pollutant concentrations after stop of plant

Airsparging Systems



Airsparging Systems



Application

- Stripping of volatile products
- Mobilization of contaminants

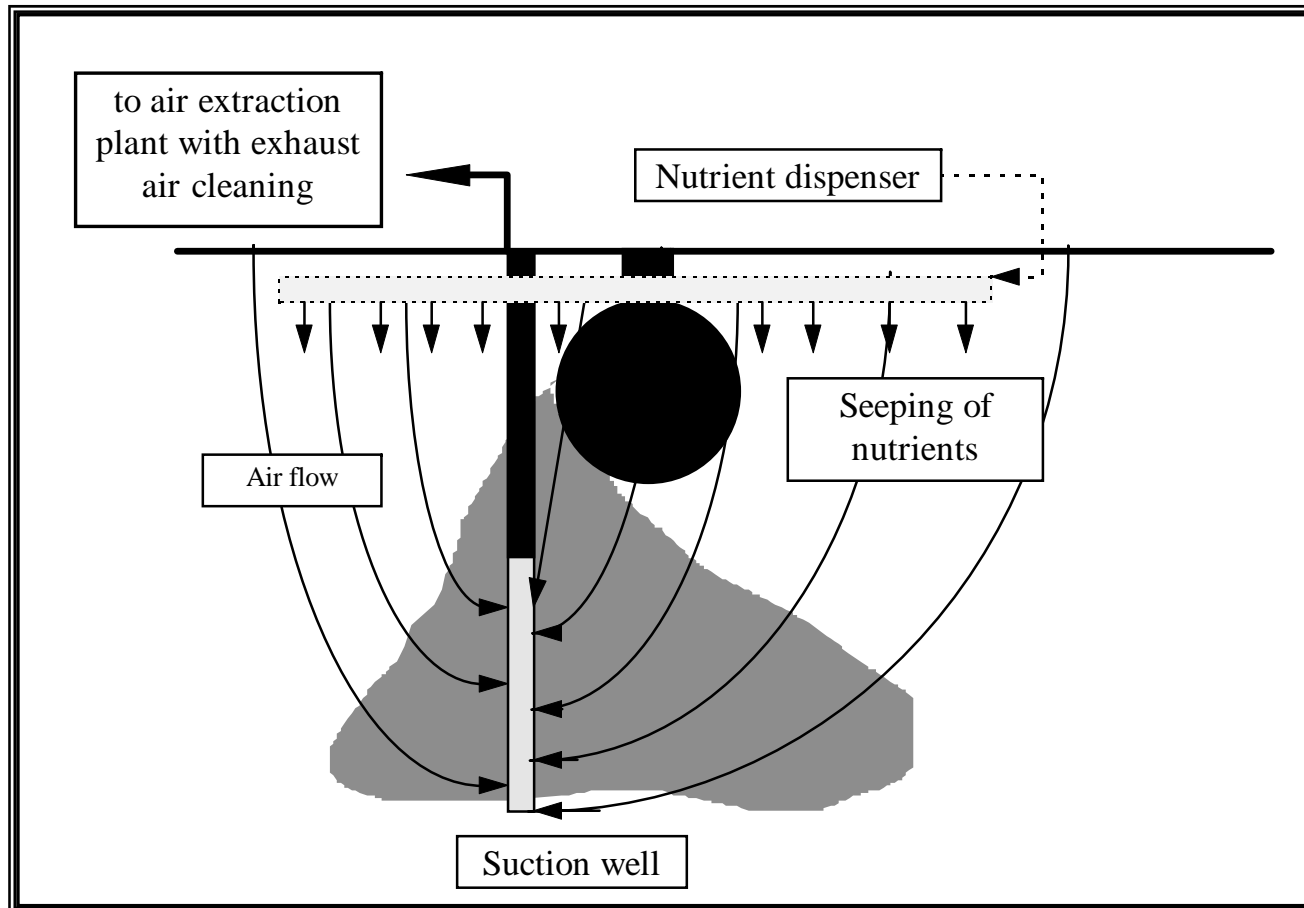
Combination with

- Soil gas extraction + vacuum extraction
- Pump & Treat + Soil gas extraction
- Product recovery + vacuum extraction
- Biodegradation + water capturing

Limitations

- Overestimation of effective radius
- Volatility of products (Diesel: no !)
- Dispersion of air (preferred channels)
- Covered free product

Soil Gas Extraction Systems



Soil Gas Extraction Systems



▲ Catalytic Combustion Unit

◀ Activated Carbon Filter

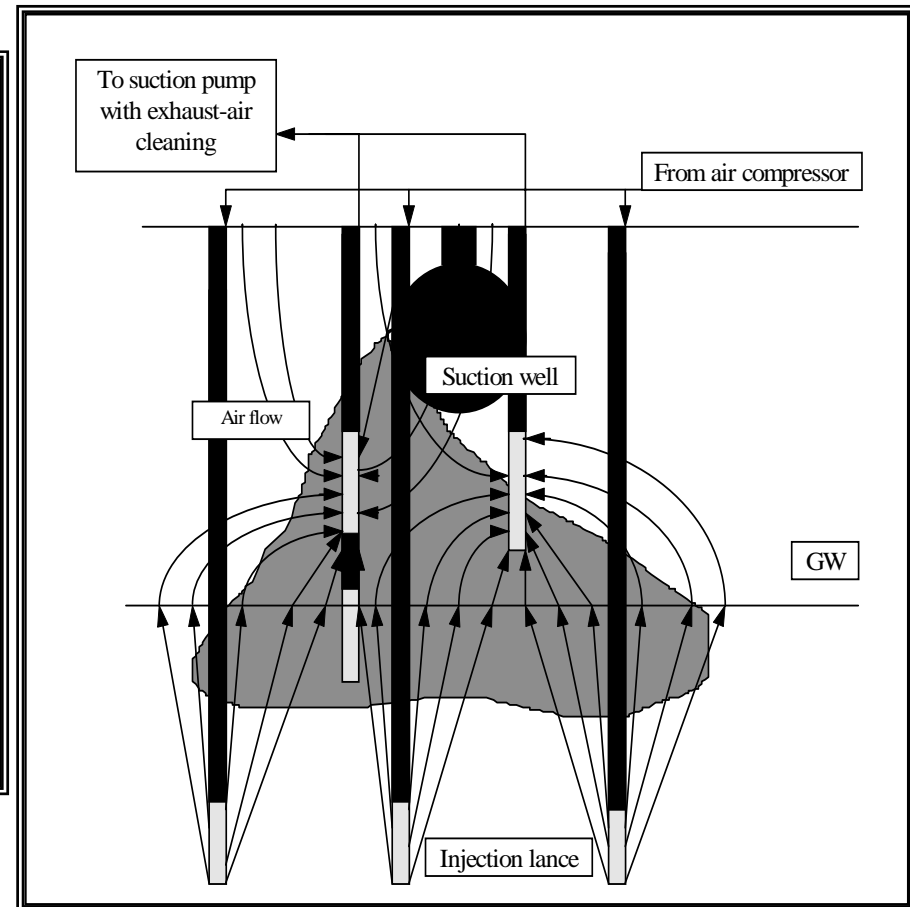
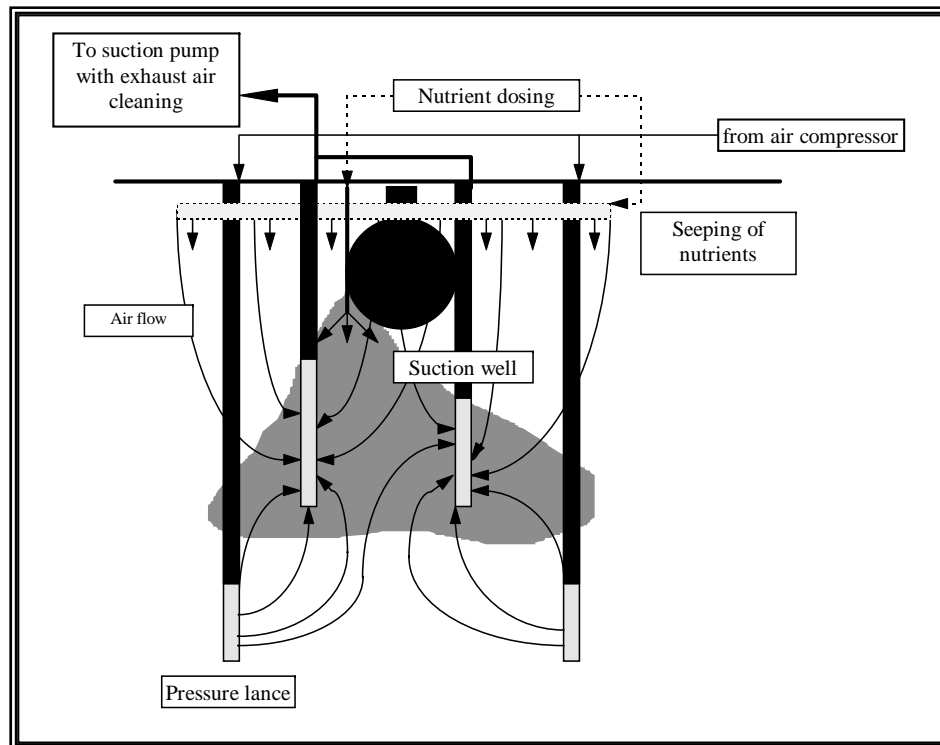
Application

- To remove volatiles: Gasoline, BTEX, MTBE, PCE, TCE, VC ...
 - to avoid emission to the atmosphere
 - to make the excavation safe
 - to clean the soil gas
- Air Flow per well 50-100 m³/h
- Effective radius in subsoil 5-60 m
- Duration up to 12 month

Limitations

- Permeability of soil
 - clay: slow, low effective radius
- EX-Risks e.g. by free products
- Volatility of products (Diesel: no !)
- Flow interruption by ditches and foundations

Biological Treatment Systems



Biological Treatment Systems



→ oxygen supply

air	techn.O ₂ ,	O ₂ in Water,	chem.-O ₂
21%	98%,	10 mg/ltr,	NO ₃ H ₂ O ₂

→ temperature

<< 10°C: ☹️

11°-15°C: 😐

16°-28°C: 😊

→ pH-value

<< 5,0: ☹️

5,1-6,0: 😐

6,1-8,9: 😊

>> 9,0: ☹️

→ soil permeability (m/s)

kf < 10⁻⁶: ☹️

= 10⁻⁵: 😐

> 10⁻⁴: 😊

- Application conditions
 - contamination dispersed in soil (no free oil!)
 - active micro organisms
 - nutrients
 - oxygen
 - temperature
 - time
- fast degradation
 - n-Alkanes, BTEX e.g. from Gasoline and Diesel
 - PAH from Diesel (max. 4 Rings)
- slow degradation
 - long chain a-Alkanes e.g. from lubricants
 - branched Alkanes (Iso-Alkanes)
 - MTBE
 - CHC

- **Limitations**

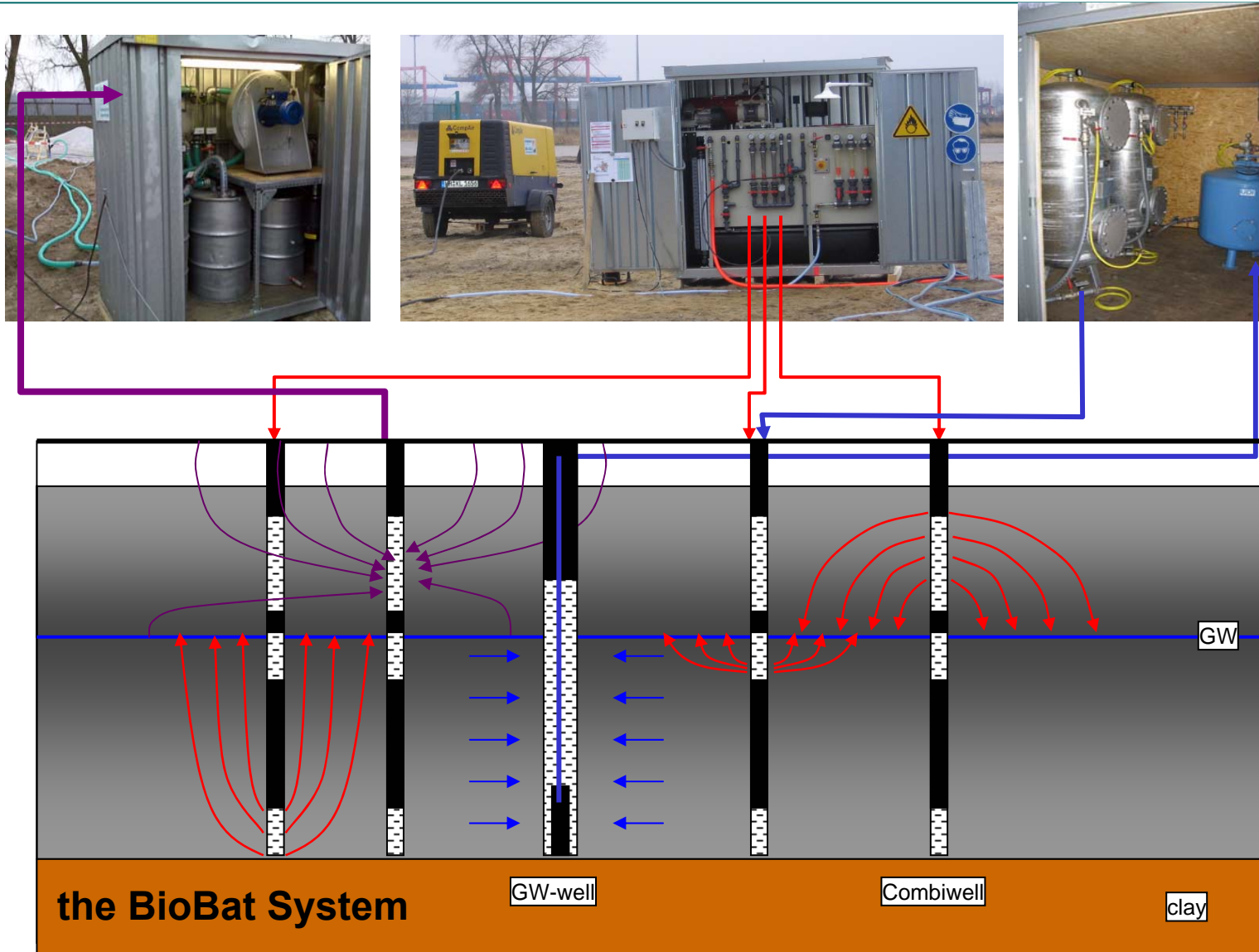
- free oil (emerged or covered)
- no access (clay, lumps etc.)
- extreme pH (e.g. concrete)
- too dry
- too cold
- non bio-degradable
 - heavy oil
 - asphalt
 - tar
 - 5-6 ring PAH

- **Chemical Oxidation**
 - Peroxide (H_2O_2)
 - Permanganate (KMnO_4)
- **Reductive Process**
 - Carbohydrates
 - Sugar polymers
 - Iron

Application

- Oxidation of
 - Gasoline, Diesel, Heating oil, Kerosine
 - BTEX, MTBE, Phenols
 - PAK, PCB, explosives, pesticides
- Reduction of
 - CHC

ISCO Systems



Limitations

- Dispersion / Transportation / Hidden Zones
 - Degradation effect only where Oxidants are
 - Within reaction period
- Auto degradation of Oxidant
 - short reaction time esp. of H_2O_2
- Mobilisation of products in groundwater
- Volatilisation of Hydrocarbons
- Safety issues (EX)
- Production of hazardous intermediate product (e.g. VC)

Suggestions to be “careful” with

- Electric Degradation of Hydrocarbons
- „Turbo“ strains of bacteria
- Pump & Treat as remediation system
- In-situ thermal systems ($> 120^{\circ}\text{C}$) e.g. at filling stations

and

- ANY BLACK BOX SYSTEM

Statements

- In-situ can not substitute ex-situ without the risk of leaving contaminated soils behind but
- In-situ can be used for pre-treatment to remove free product, EX-risks, problems at excavation
- In-situ can be used to remove volatiles from soil and dissolved contaminants from groundwater

That's all folks

Thanks

Questions now ?

Questions later ?

tcaro@caro-biotechnik.de

