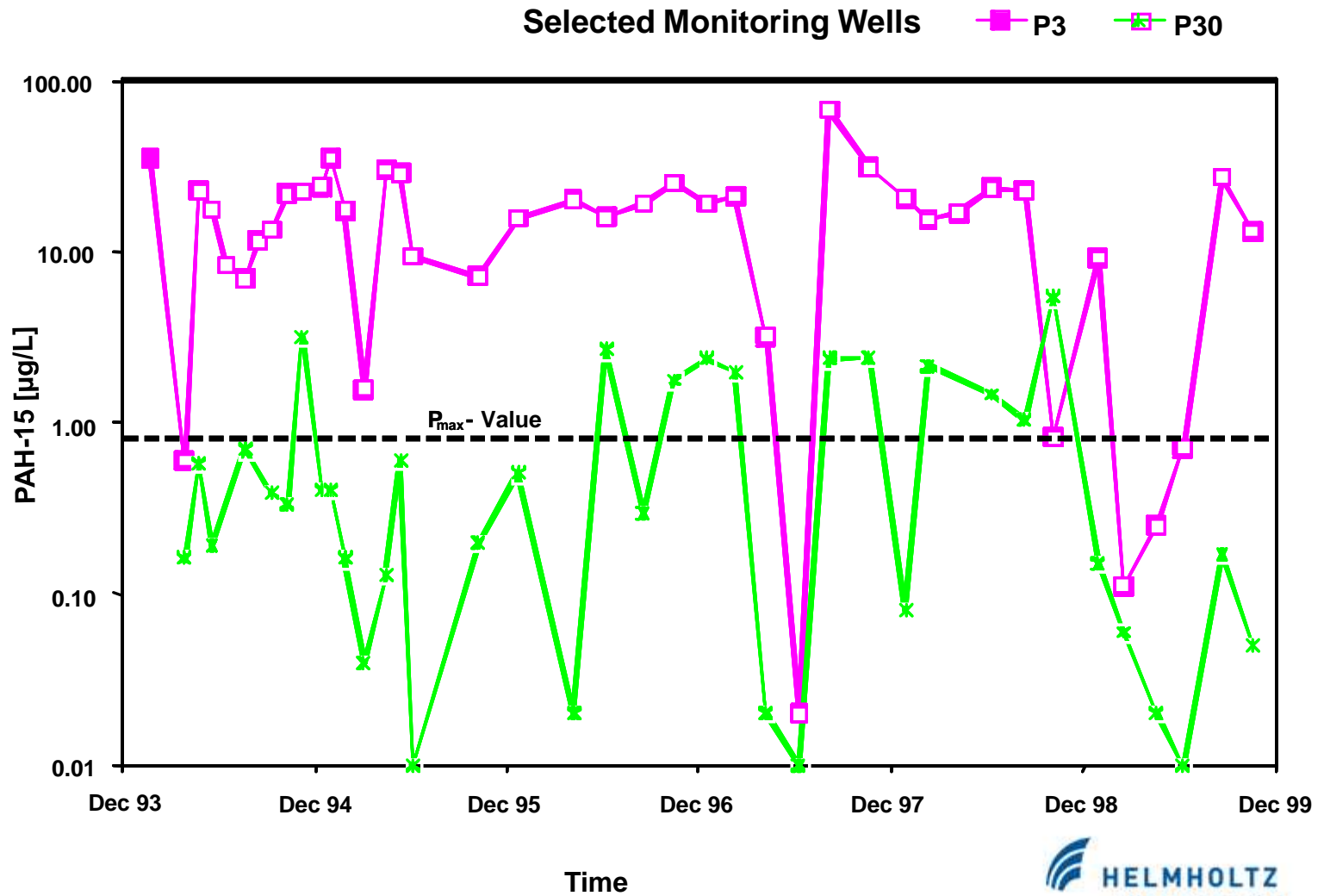


Life cycle of groundwater observation wells

Purposes for well installation

- observation of groundwater quantity (head)
- observation of groundwater quality

Temporal variability



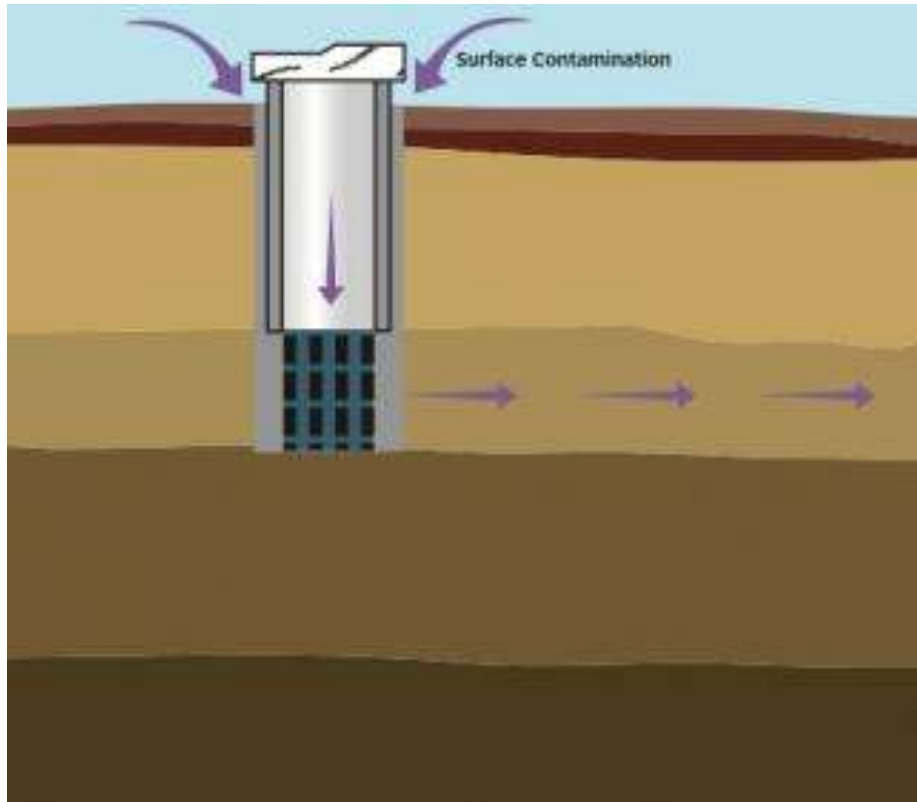
Purposes for well installation

- observation of groundwater quantity (head)
- observation of groundwater quality
- pumping for water supply
- pumping for geotechnical purposes
- aquifer recharge
- injection of substances for remediation
- injection of substances for geotechnical purposes

Potential risk caused by wells

- access point for contamination

Contamination from well

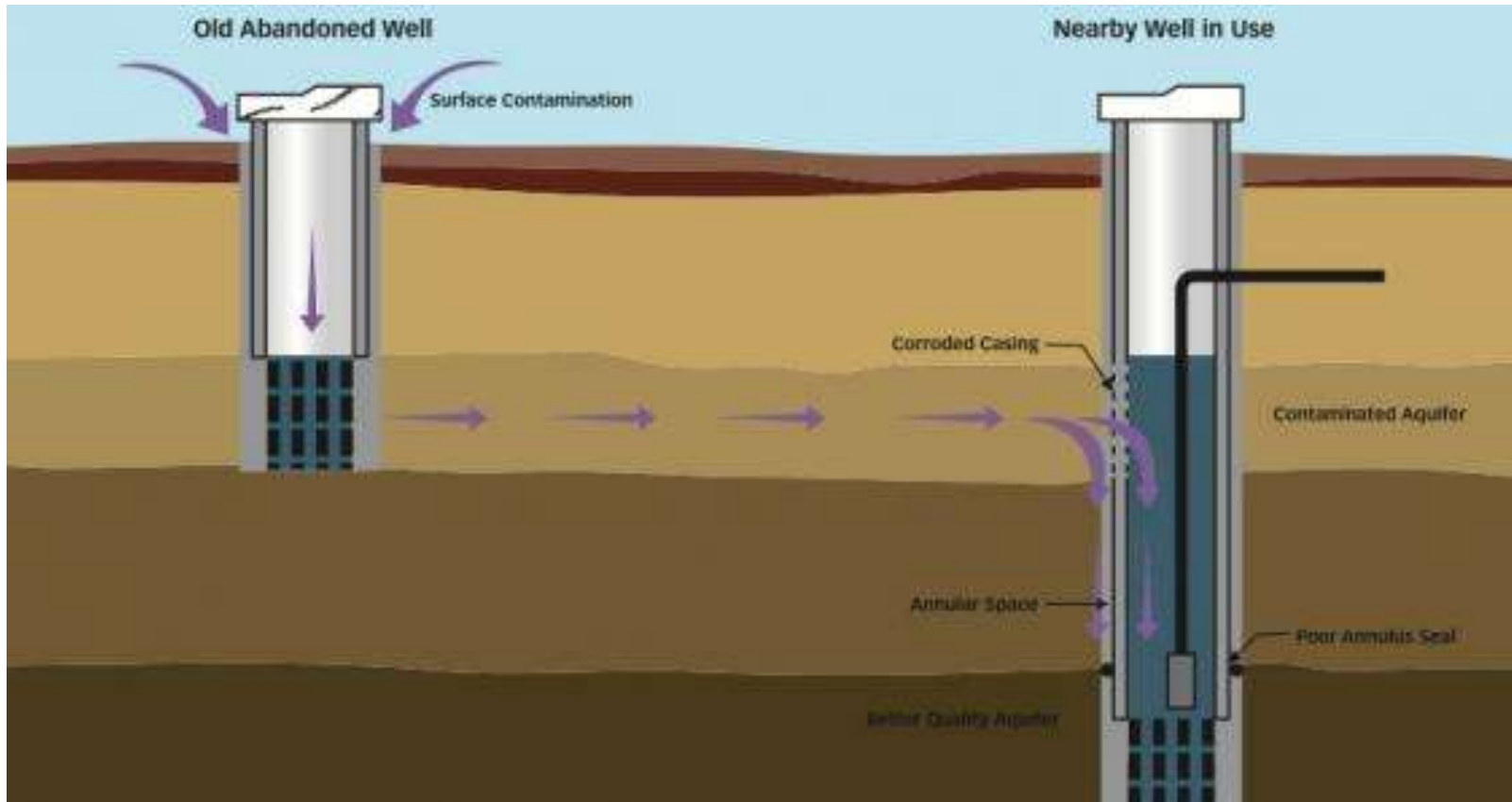


<http://www.sswm.info/category/implementation-tools/water-sources/hardware/surface-water-sources/water-source-protection>

Potential risk caused by wells

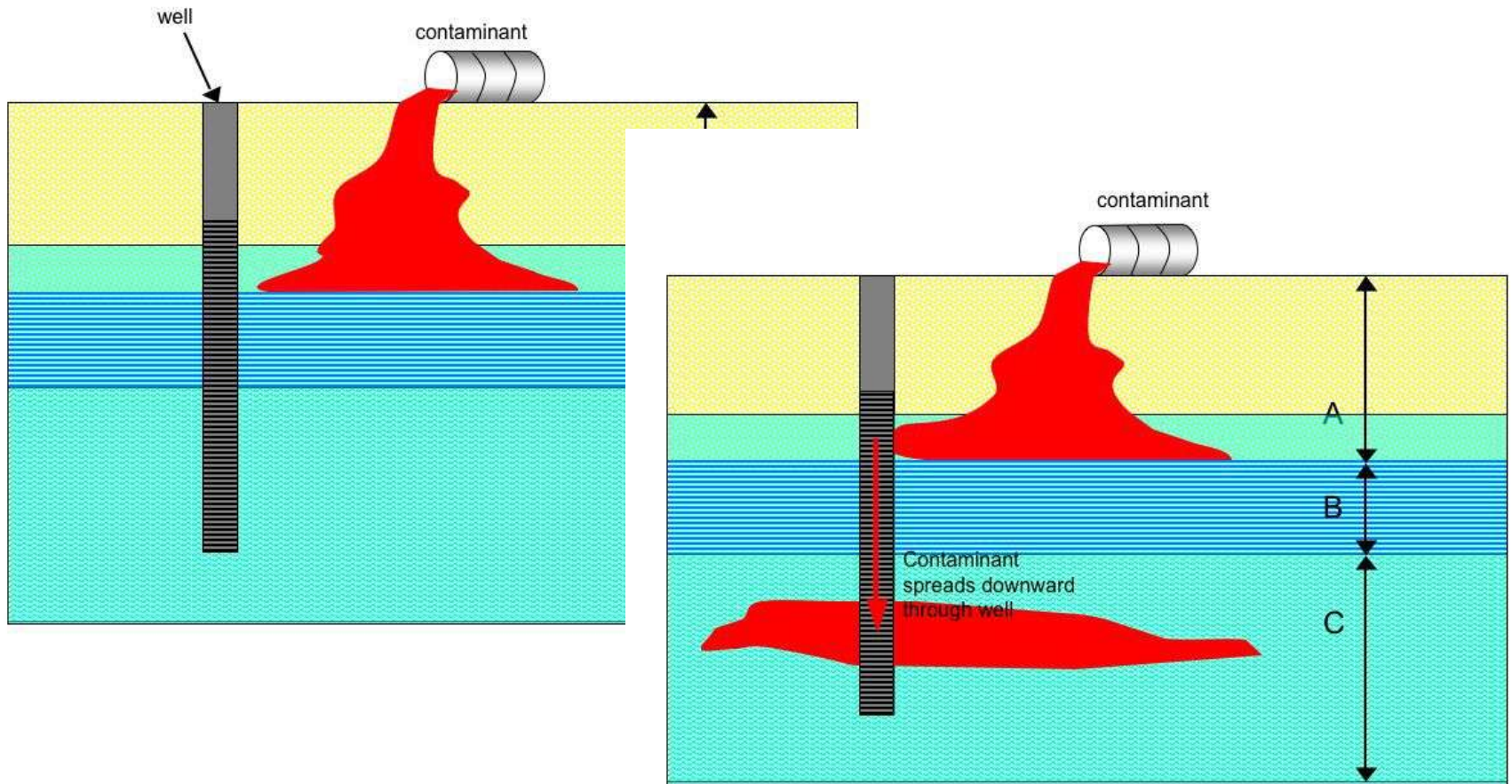
- access point for contamination
- connection of different aquifers
 - cross contamination
 - disturbance of hydraulic conditions

Cross contamination from well



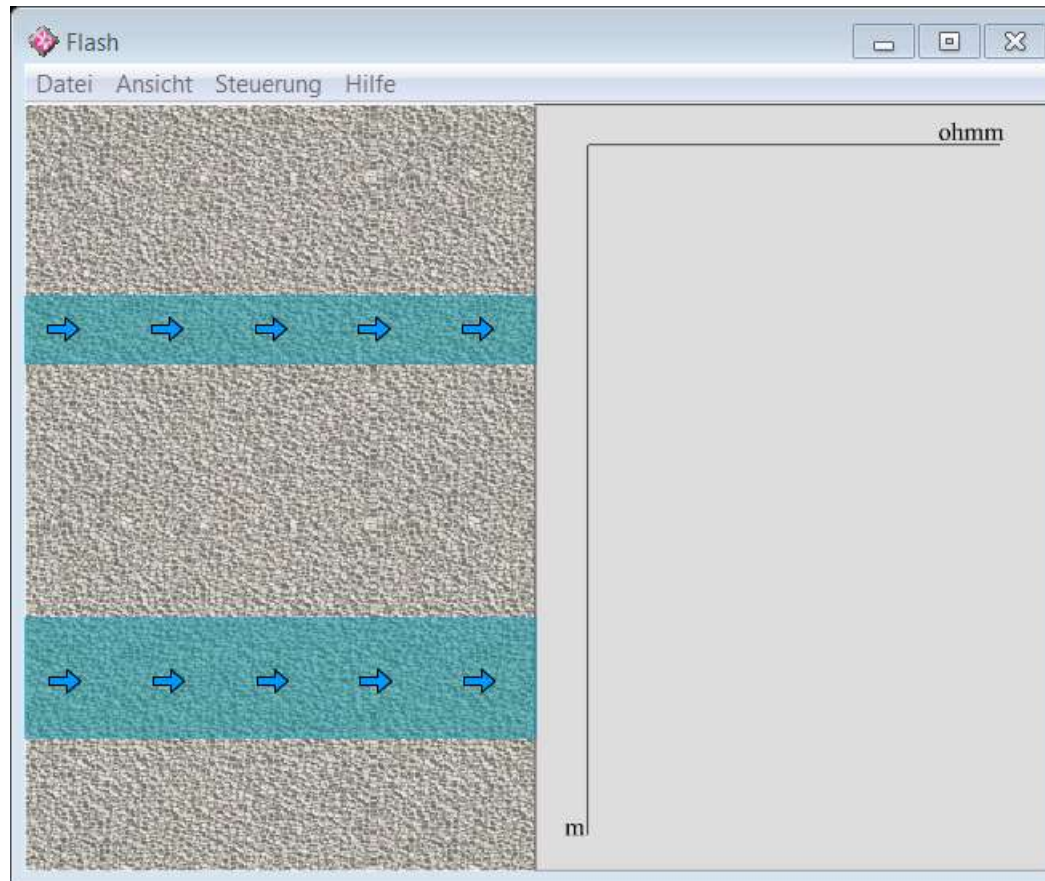
<http://www.sswm.info/category/implementation-tools/water-sources/hardware/surface-water-sources/water-source-protection>

Cross contamination from well



<https://lodore.wordpress.com/2010/10/24/water-wells-and-groundwater-contamination/>

Connection of aquifers



dillution/

Potential risk caused by wells

- access point for contamination
- connection of different aquifers
 - cross contamination
 - disturbance of hydraulic conditions
- watering due to pressure release of artesian aquifer
- induced solution of geological material

Potential risk caused by wells



Photo: DPA

Wiesbaden, geothermal drilling, November 2009



Photo: welt.de

Kamen, geothermal drilling, July 2009

Life cycle of a well

- installation
- use & aging
- abandonment
- (reuse)
- decommissioning/removal

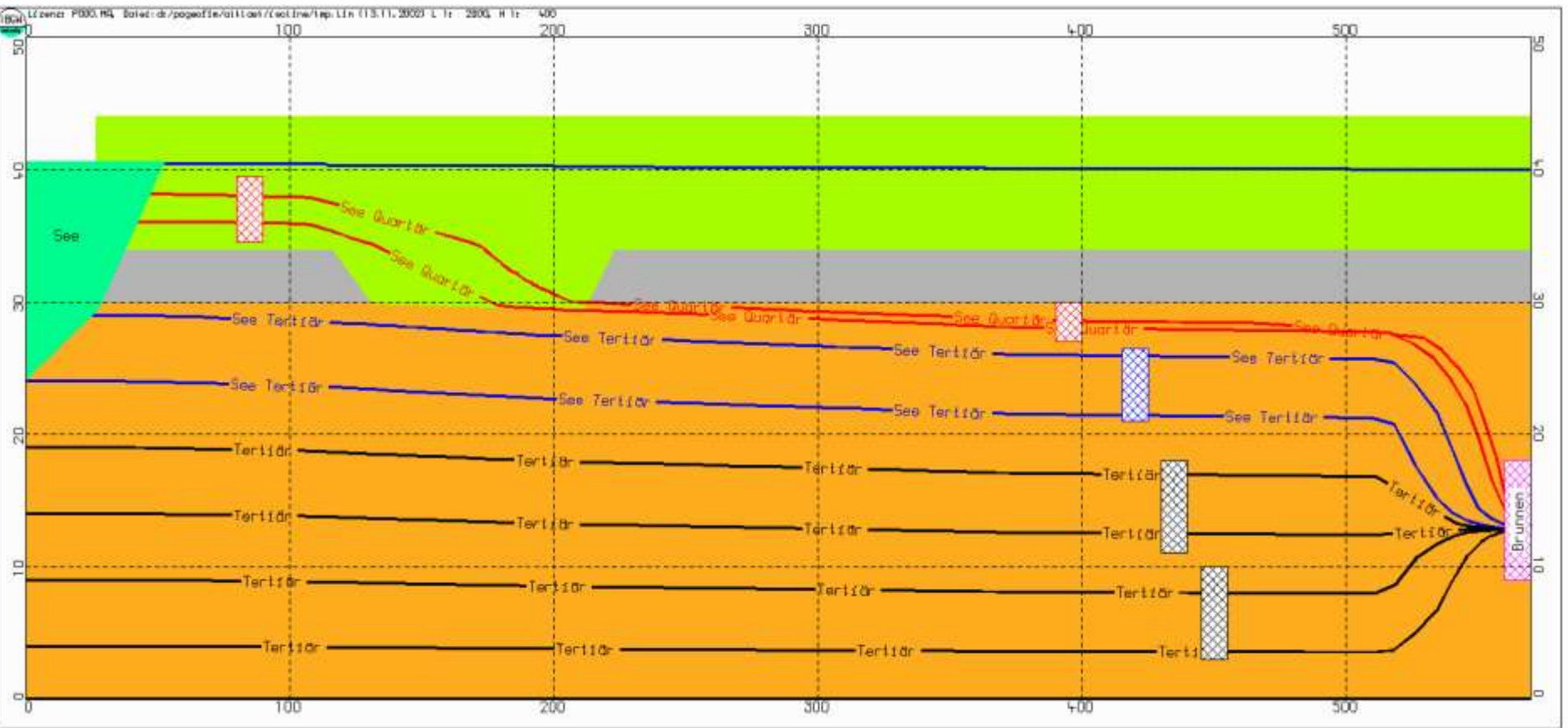
Installation of a well

For installation of a well should be considered

- purpose
- suitability/representativeness of location (model based)

View looking south of multilevel sampler array of the test site "Cape Cod" (LeBlanc et al. 1991)



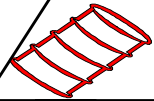


potential locations for well screens

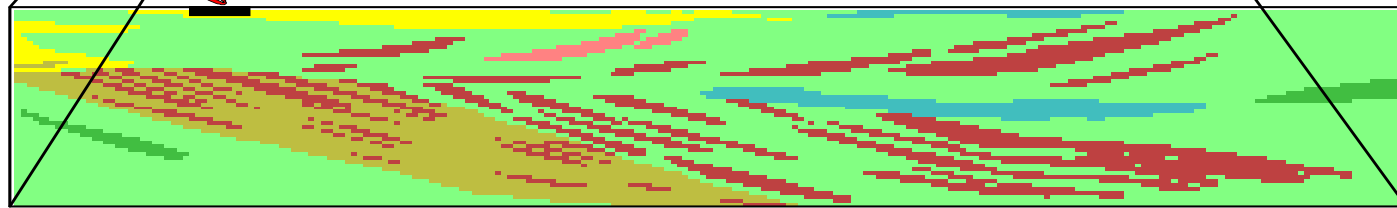
Courtesy of C. Nitsche

For installation of a well should be considered

- purpose
- suitability/representativeness of location (model based)
- required permits and clearances
- local (vertical) hydrogeological situation

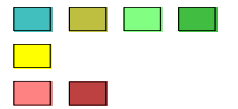


TCE-Input: 100 Liter / day
(2 days)



2,5 m

Increasing permeability

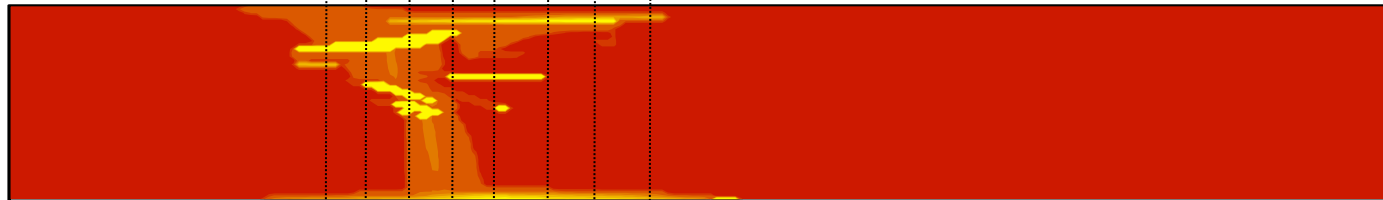


Gravels, Sandy Gravels
Sand
Open Framework Gravels

$v_a = 1$ m/day

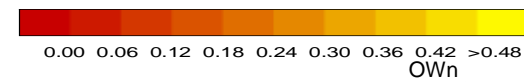
P1

Pn



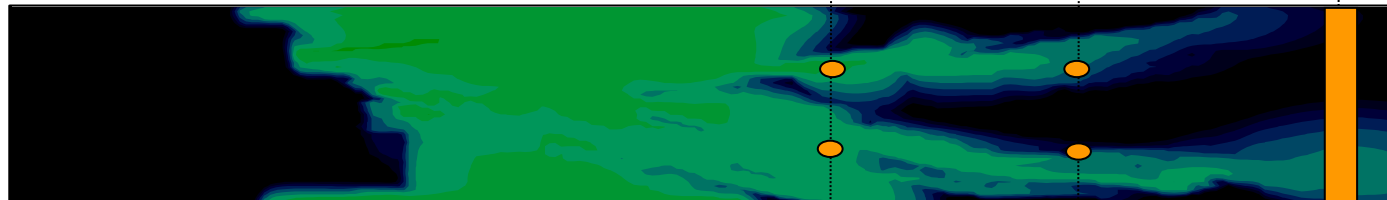
TCE saturation

S_o



OW1

OWn



TCE molar fraction in water

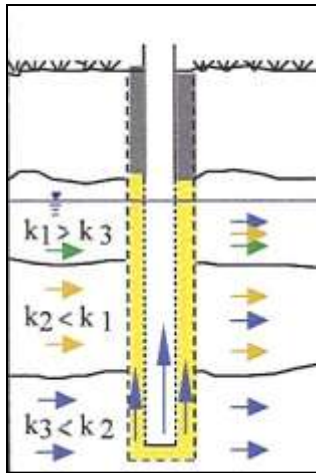
$\log\left(\frac{x}{x_{sat}}\right)$



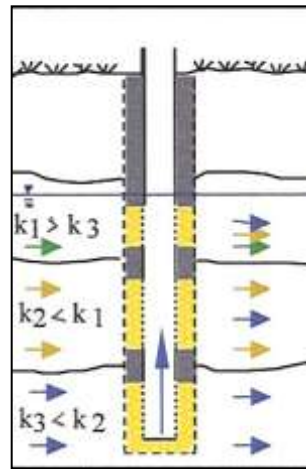
Whittaker
et al., 1998

Types of groundwater observation wells

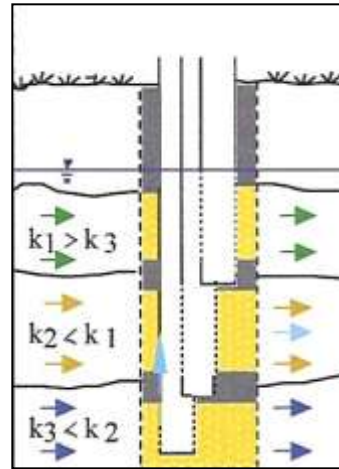
completely screened well



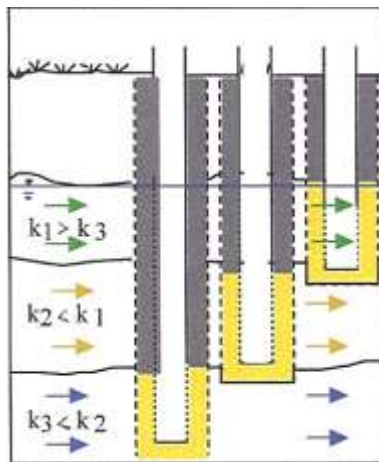
multiple screened well



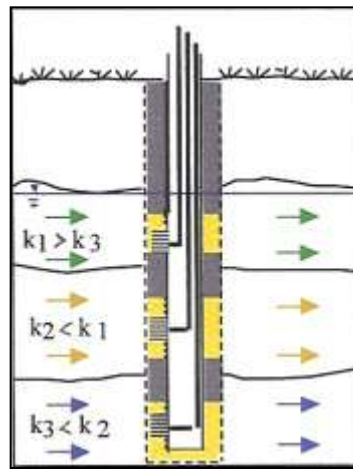
bundle of well



group of wells



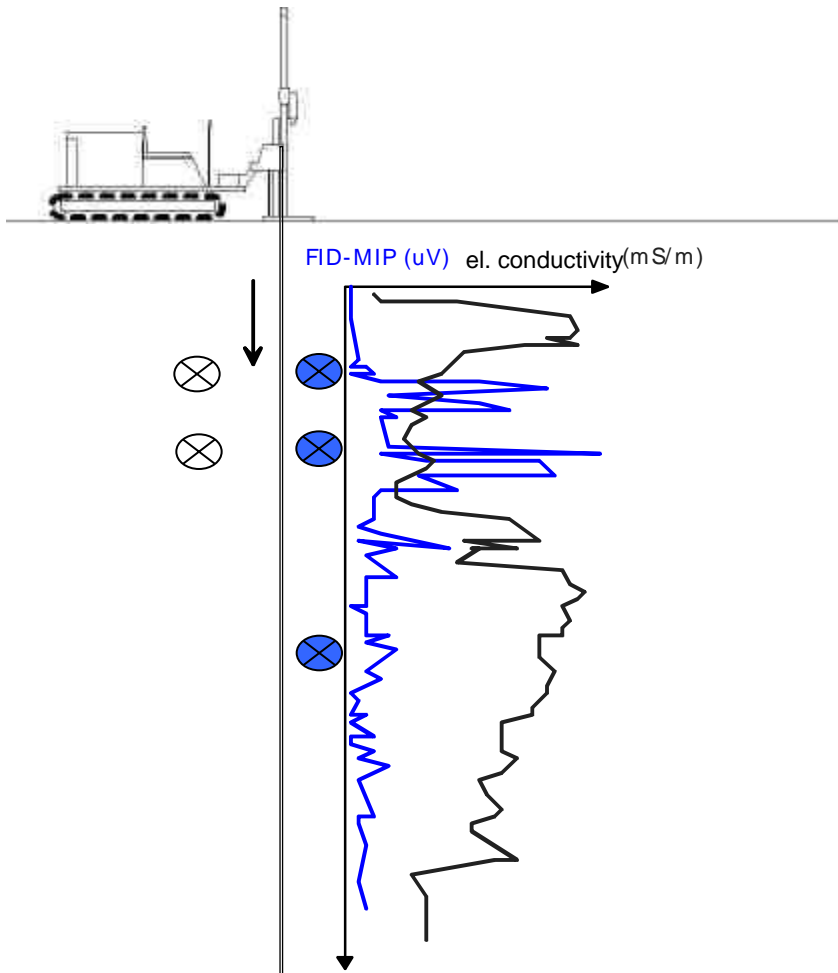
special designed well



For installation of a well should be considered

- purpose
- suitability/representativeness of location (model based)
- required permits and clearances
- local (vertical) hydrogeological situation
- duration of operation
- risks of operation
- decommissioning/removal option and cost

Use of "Direct Push" - technology



- **profile measurements**

- electrical conductivity
- contaminant parameter
- hydraulic conductivity
- ..

- **sampling** ⊗

- ground water samples
- soil samples
- soil gas samples

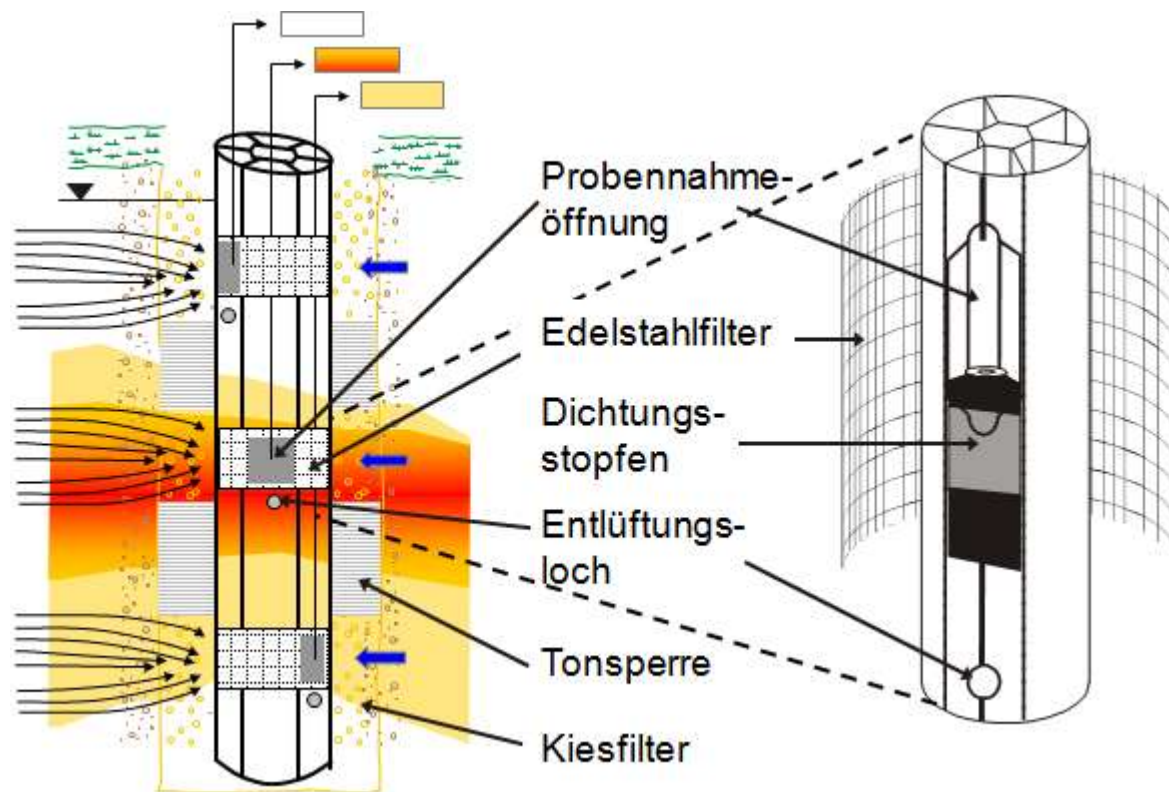
- **installation** ⊗

- sampling points
- dosimeter
- sensors

Direct Push Technologies

Temporary groundwater observation wells

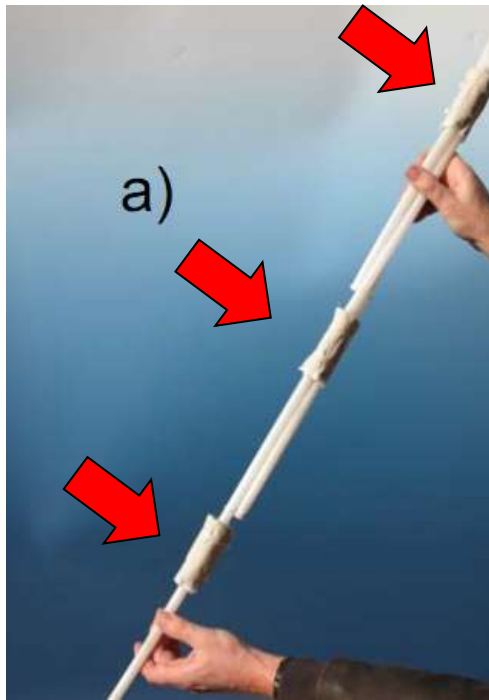
one and multi channel pipes



Direct Push Technologies

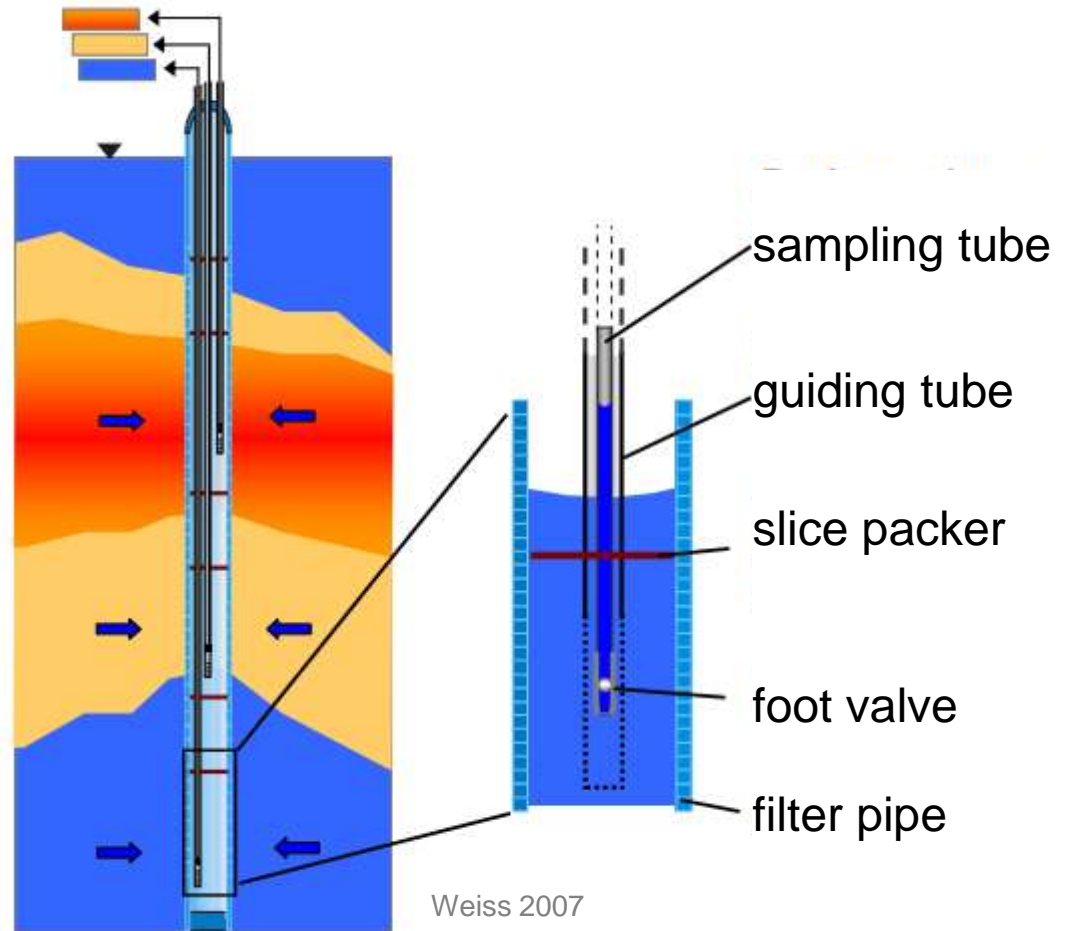
Temporary groundwater observation wells

Sealing



Körner 2007

one channel observation point bundle with bentonite sealing



one channel observation point bundle with slice packers

"Direct Push"-Technology: installation



IMW & Geomonitoring, 2001

Direct Push profiling



Results of insitu measurements



On site decision about depth of sampling points



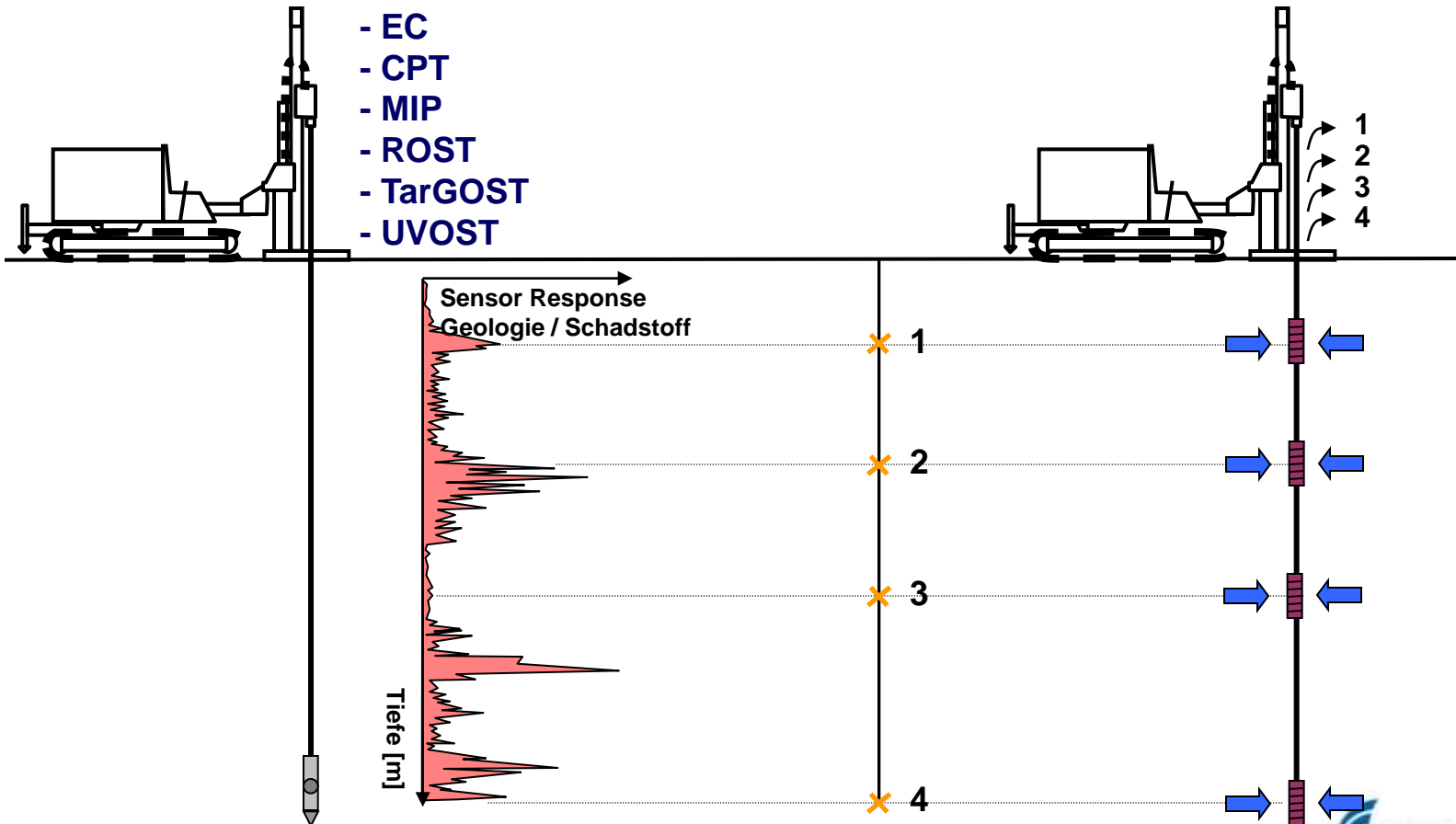
Depth oriented sampling or installation of sampling devices

DP probes

- EC
- CPT
- MIP
- ROST
- TarGOST
- UVOST

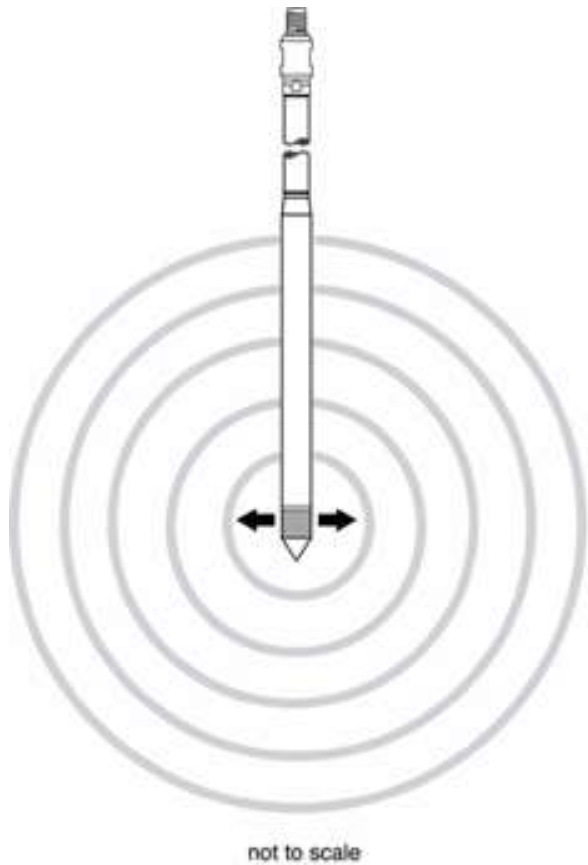
Sampling systems

- 1
- 2
- 3
- 4



Site Characterization – Hydraulic Profiling

Direct Push Injection Logger (DPIL)

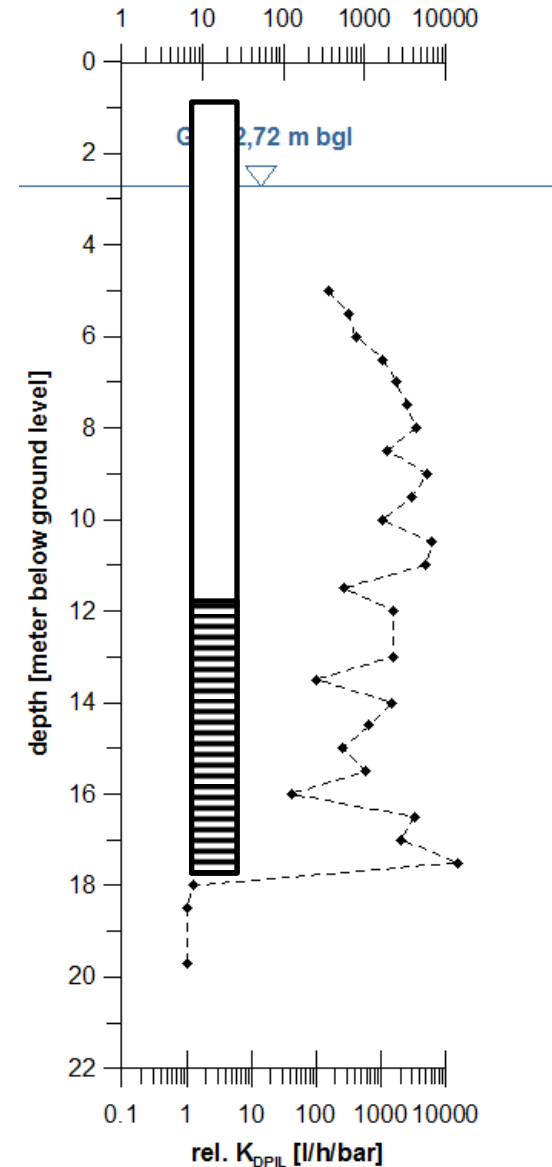


$$K_{\text{relative}} = f(Q, \Delta p, S)$$

Q = injection rate,

Δp = injection pressure

S – system parameters

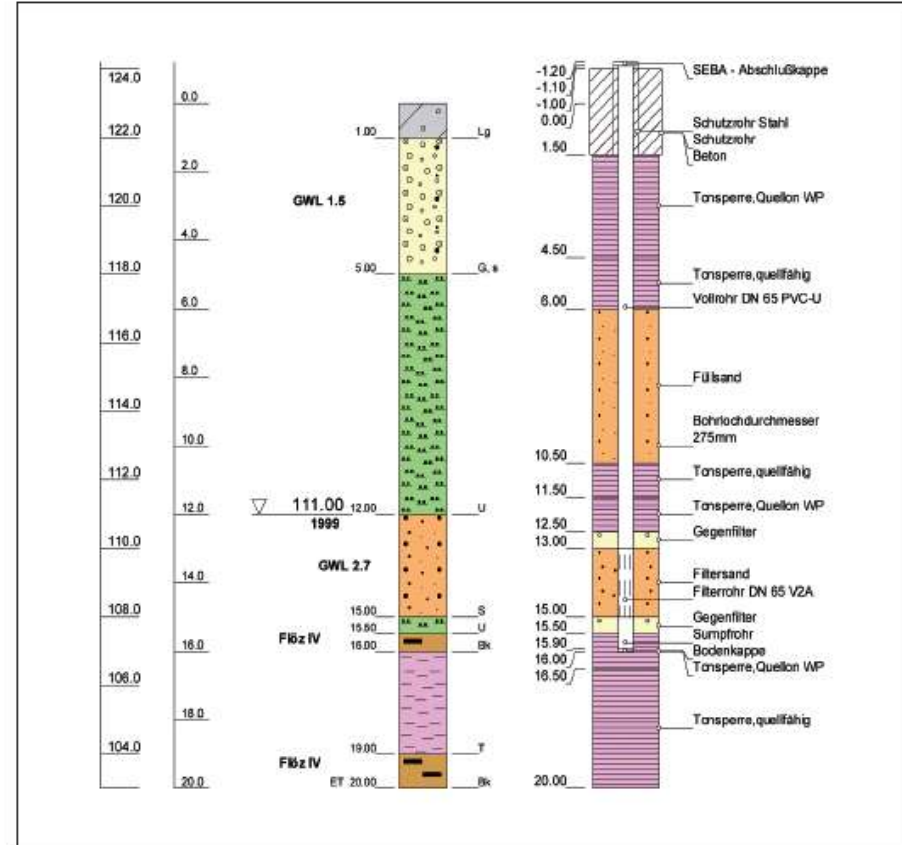


Dietrich et al. 2008

Documentation



Allgemeine Daten	Ergebnisse der Erstbeprobung
Rechtswert	Einbautiefe der Probennahmpumpe
Hochwert	Absenkung
Bohrverfahren	Abzupumpendes Wasservolumen
Bohrdurchmesser	pH-Wert
k_f -Wert Pumpversuch	Elektrische Leitfähigkeit
	Sauerstoffkonzentration
	Redoxspannung
	Temperatur
Datum	Datum
Stempel/Unterschrift des Auftraggebers	Stempel/Unterschrift der mit der Eignungsprüfung beauftragten Firma



Geologisches Profil und geprüfter Ausbau der Grundwassermeßstelle

Durchgeführte Reparatur- und Wartungsarbeiten

Datum				
Regenerierungsverfahren				
k_f -Wert des Pumpversuches				
Reparaturen				
Ausführende Firma				
Bemerkungen				
Unterschrift d. AG				

Operation of well

- use according to the purpose
- possible aging (clogging, corrosion, damages)
- well control

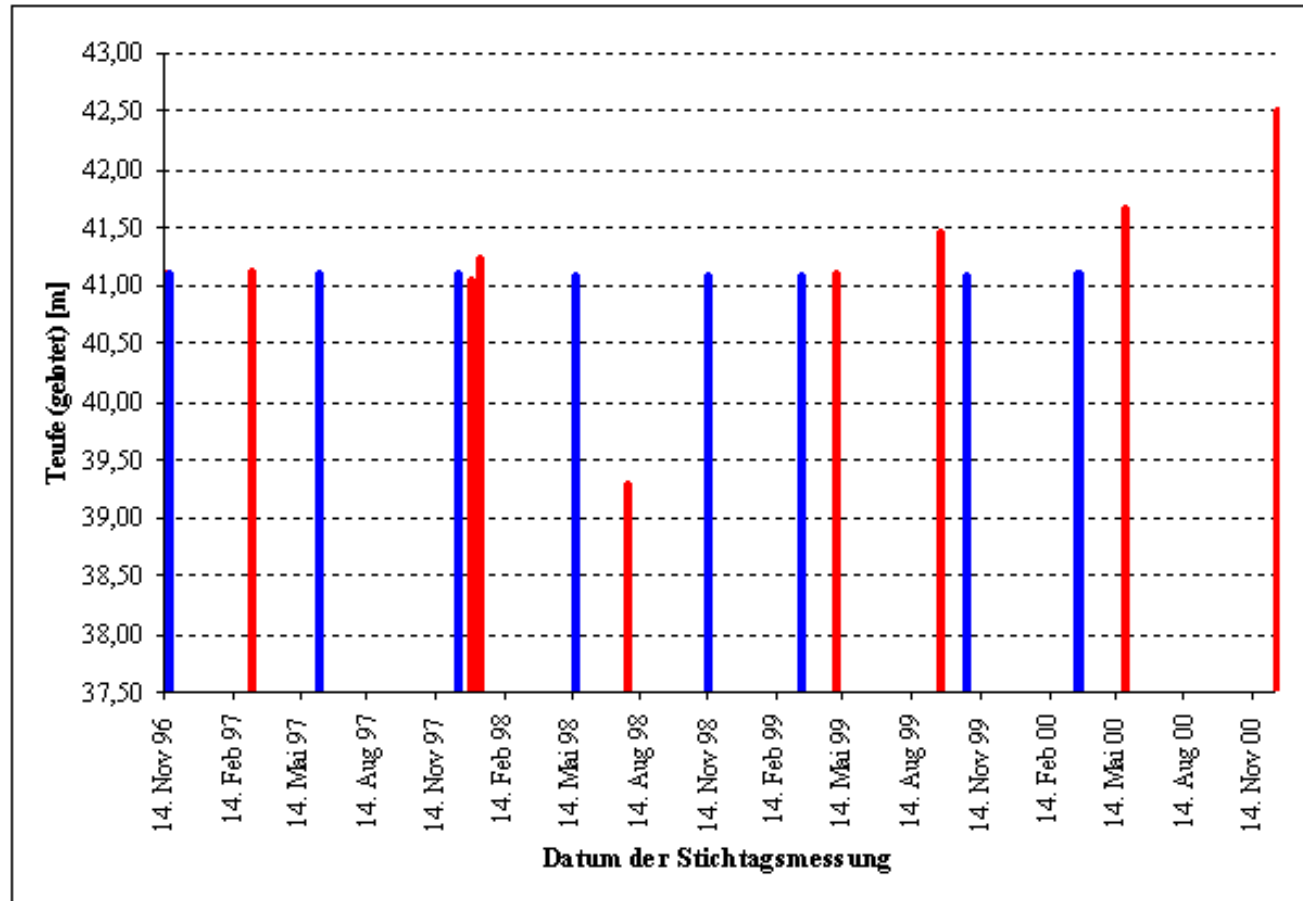
Well control

- take over from another owner
 - control of documentation
 - visit of the well
 - check of well construction

Well control

- take over from another owner
- during operation

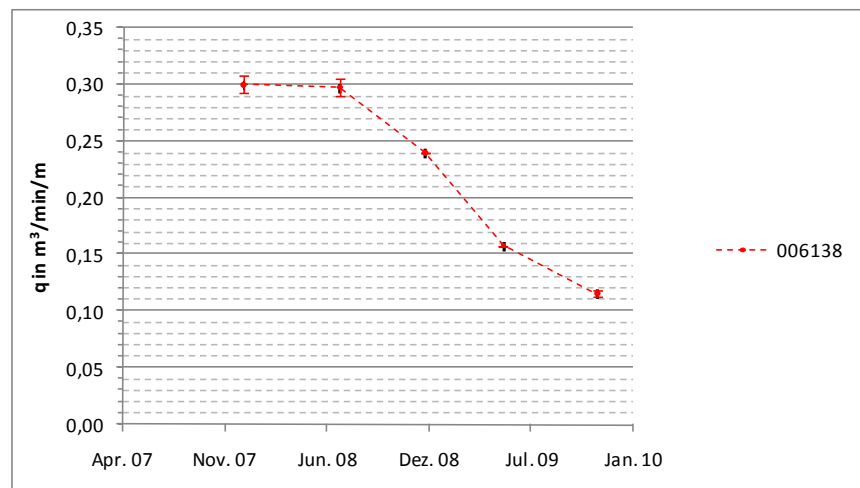
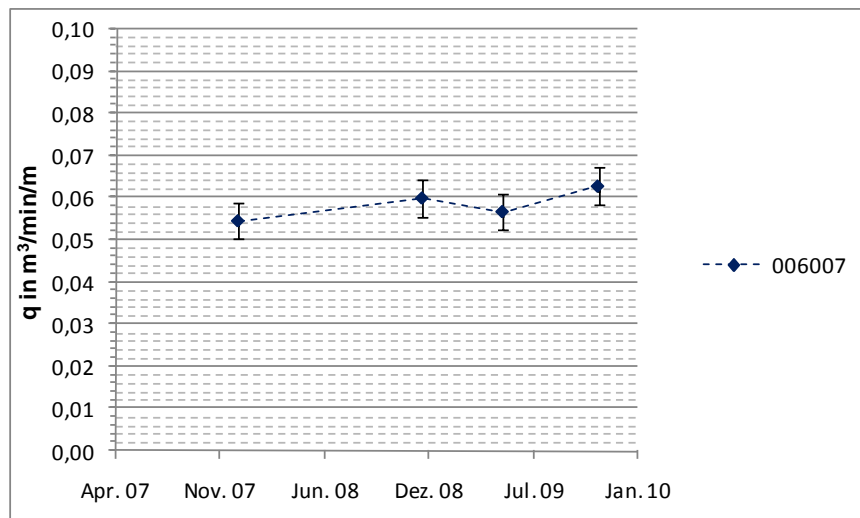
Well control - during operation



Courtesy of C. Nitsche

Well control - during operation

Specific yield



Courtesy of C. Nitsche

Well control

- take over from another owner
- during operation
- after certain time intervals
 - control of documentation
 - visit of the well
 - check of well construction

Reinstallation of a well

- removal of well equipment
- well characterization
- remove casing (if possible)
- filling and sealing

Summary and conclusion

- Wells are suitable for different purposes.
- Wells are a disturbance of the subsurface. They can cause cross contamination and changes of the hydraulic situation.
- Well installation should be adopted to purpose and the specific situation at the site.
- Well behavior can change with time.
(clogging, corrosion, damages)
- Well should be removed if they are not more in use.
- Cost for removal should be considered already in preparation of installation.