Comparison of purge and no-purge sampling strategies for deep groundwater

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Imagine the result

Presentation outline

1. No-purge groundwater sampling:
    1. What is it?
    2. Types
    3. Advantages
    4. Use
2. Use for contaminant distribution
    2 case studies
3. Use for long term monitoring
    1 case study
4. Conclusions

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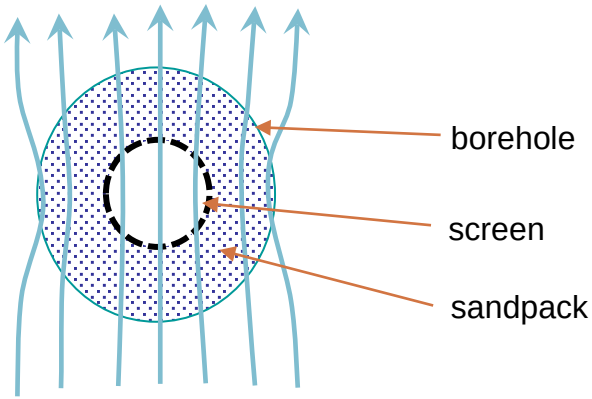
No-purge groundwater sampling

No-purge GW sampling

What is it?



- GW sampling without pumping or purging
- Sampling at a specific depth
- Widely accepted and used in the US for long term monitoring
- 2 types:
  - Passive diffusion bags
  - Hydrasleeve™
- More? ITRC, Feb 2007: *'Protocol for use of five passive samplers to sample for a variety of contaminants in groundwater'*

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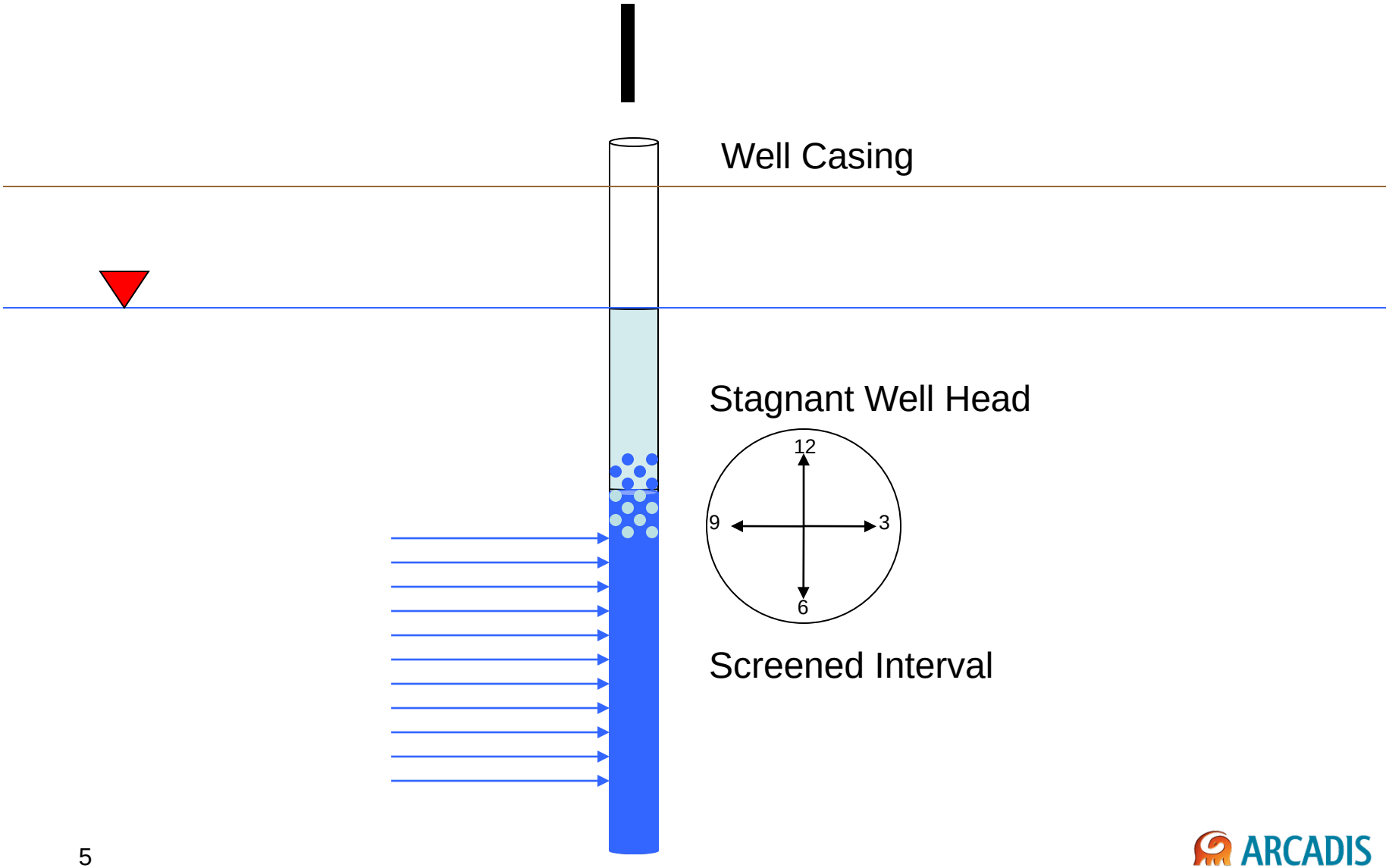
Passive sampling



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No-purge GW sampling

Types

Passive diffusion bags (PDB)

- Equilibration time of 2 weeks
- Only apolar compounds diffuse
- Diffusion through bag with distilled water

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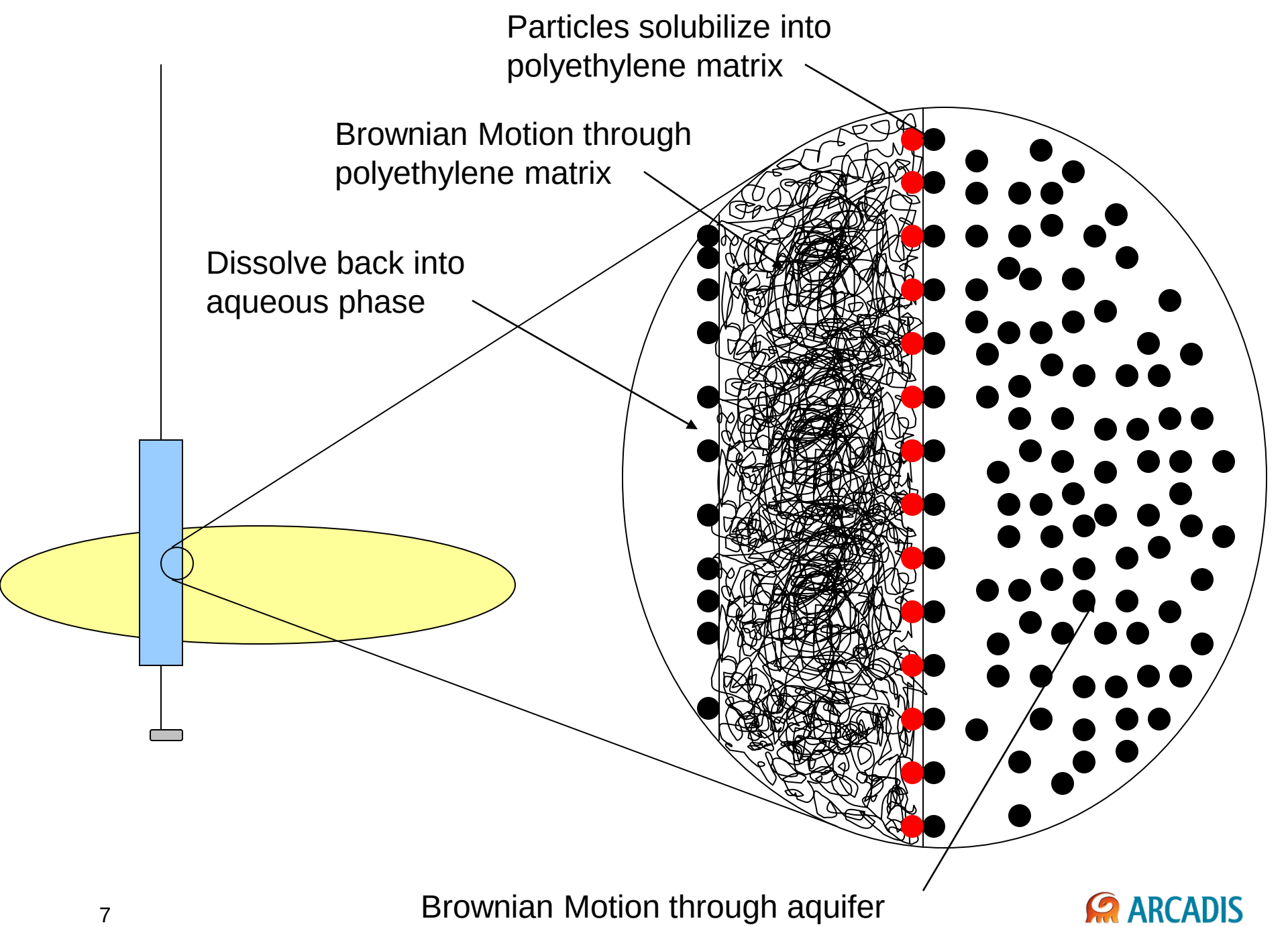
Particles solubilize into polyethylene matrix
Brownian Motion through polyethylene matrix
Dissolve back into aqueous phase
Brownian Motion through aquifer

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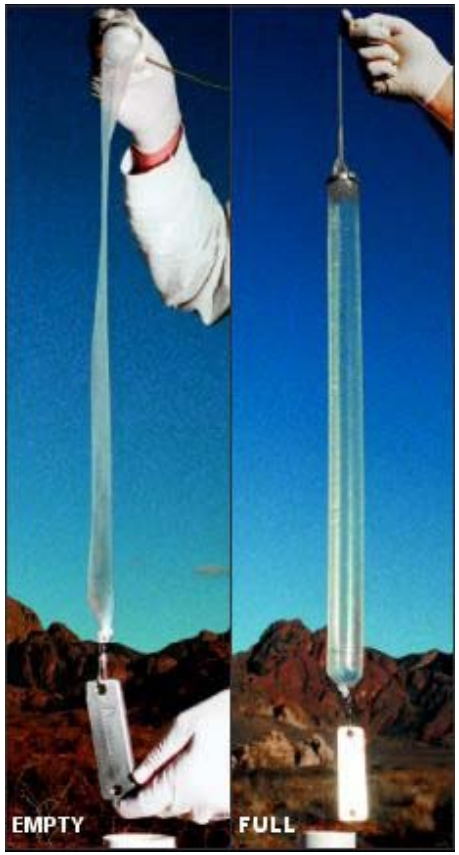
No-purge GW sampling

Types



Hydrasleeve™ (HS)

- No equilibration time needed
- Both polar and apolar compounds
- Grab sample = ‘snap shot’ in space and time

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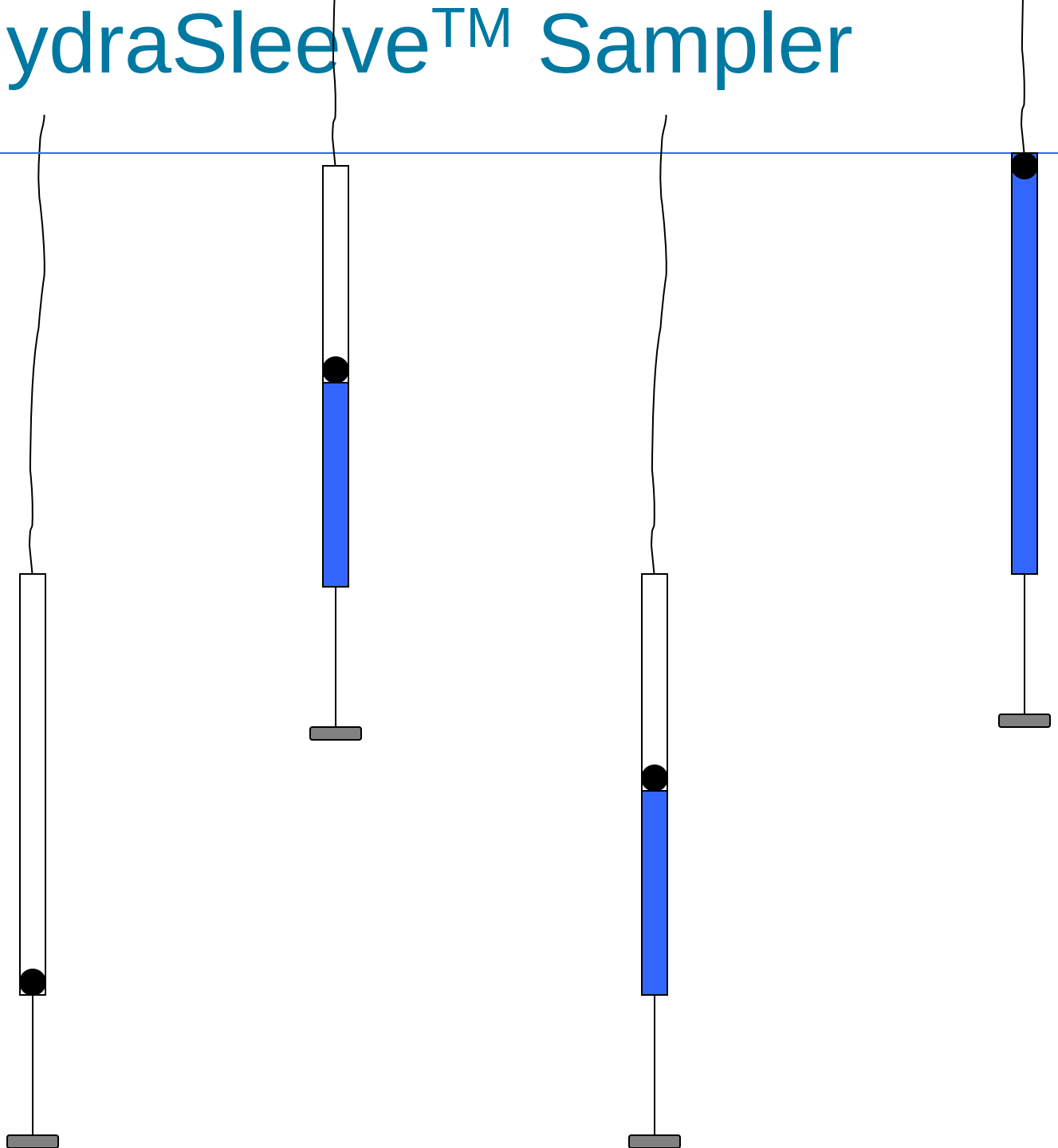
HydraSleeve™ Sampler



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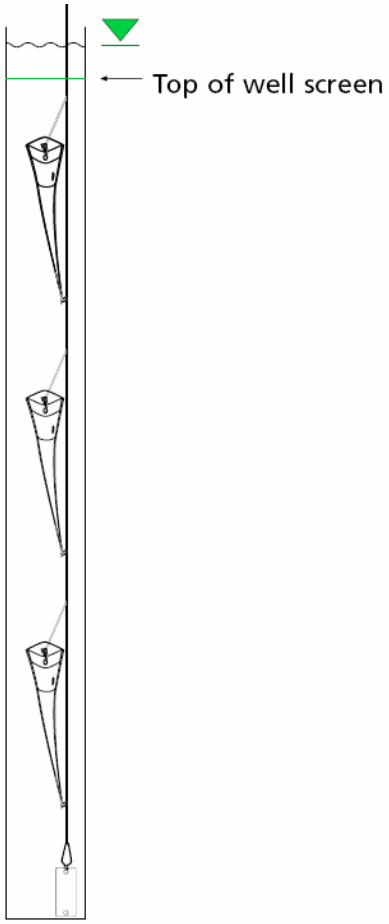
Advantages

- No purge water
- No decontamination necessary
- Limit time on site
- Cheaper (~ 50%) than purged samples
- Safer (limited exposure to groundwater)

No-purge GW sampling

Use



1. Contaminant distribution
    - Profiling
    - Comparison with purged samples
2. Long term monitoring

NOT recommended for one time sampling

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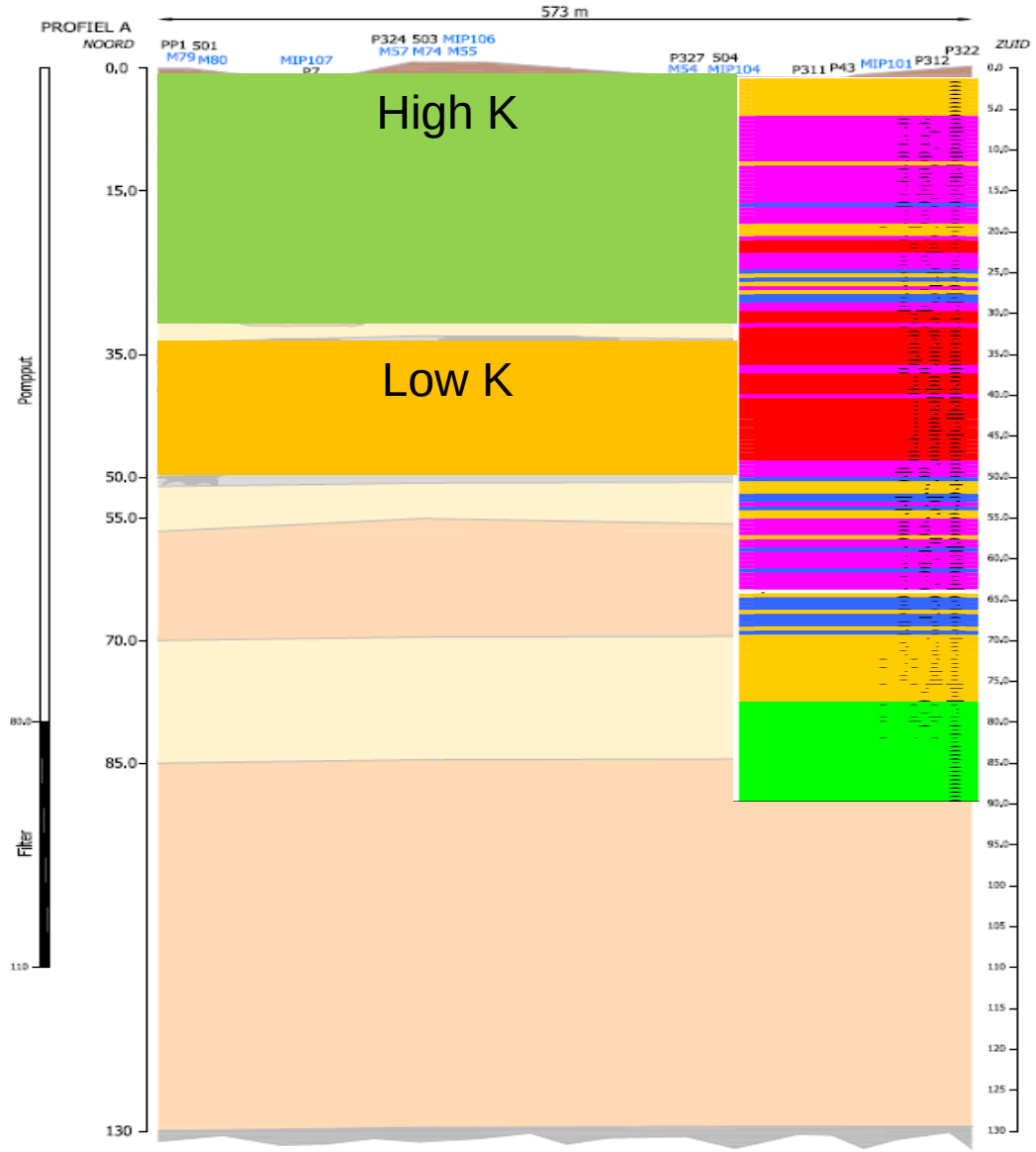
Use for contaminant distribution

Site 1

Executed tests

1. Comparison high volume purge, low flow sampling, PDB and HS
    1. High K zones
    2. Low K zones
2. Vertical profiling

General overview conceptual site model



PID :
0 ppm
< 5 ppm
< 10 ppm
< 100 ppm
> 100 ppm

Legende:
- verstoorde zone
- zand, middelmatig tot grof
- zand, middelmatig tot fijn
- zand, fijn
- zeer fijn zand, kleihoudend
- zandhoudende klei

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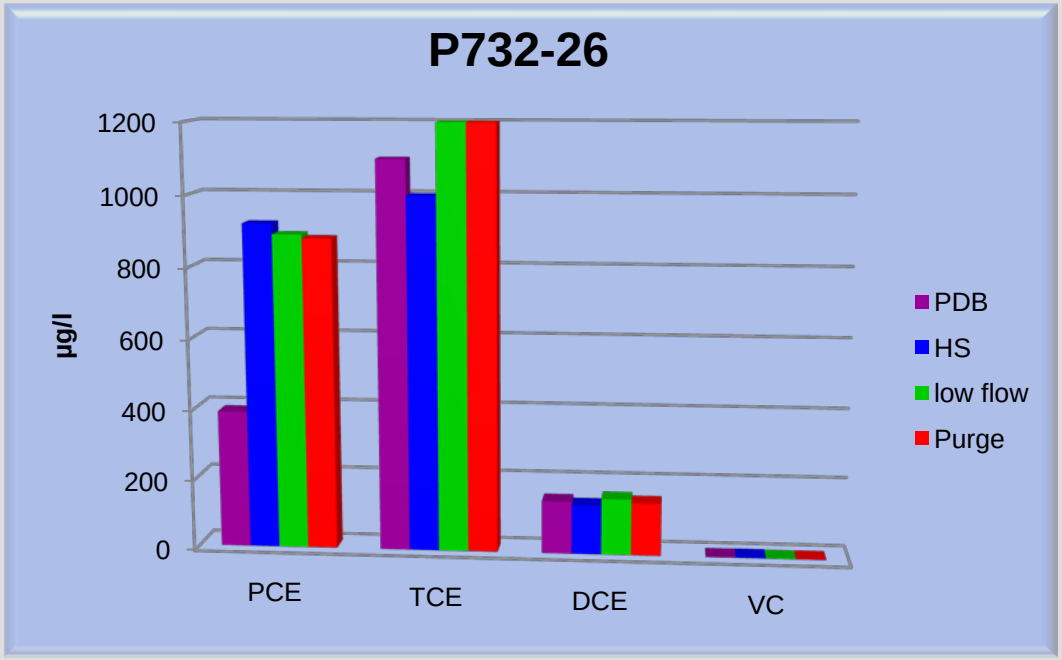
Contaminant distribution

Site 1

1. Comparison high volume purge, low flow sampling, PDB and HS
    1. High K zones

Good correlation



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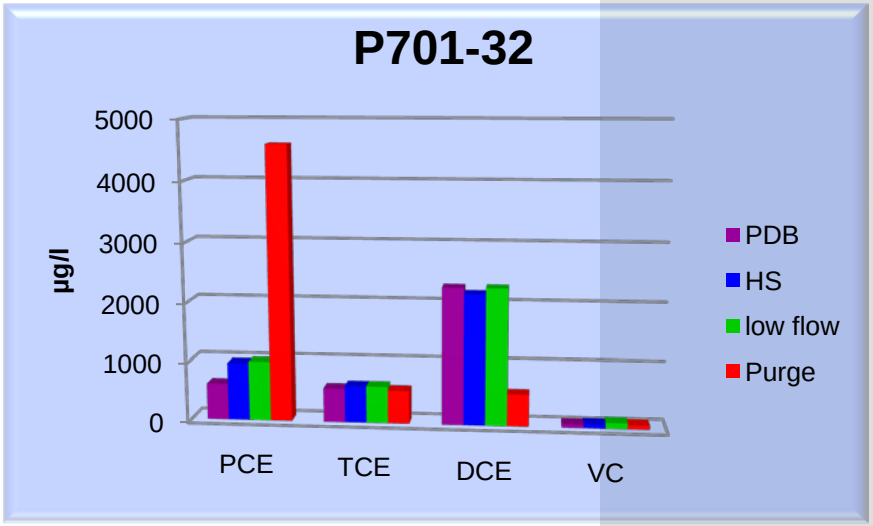
Contaminant distribution

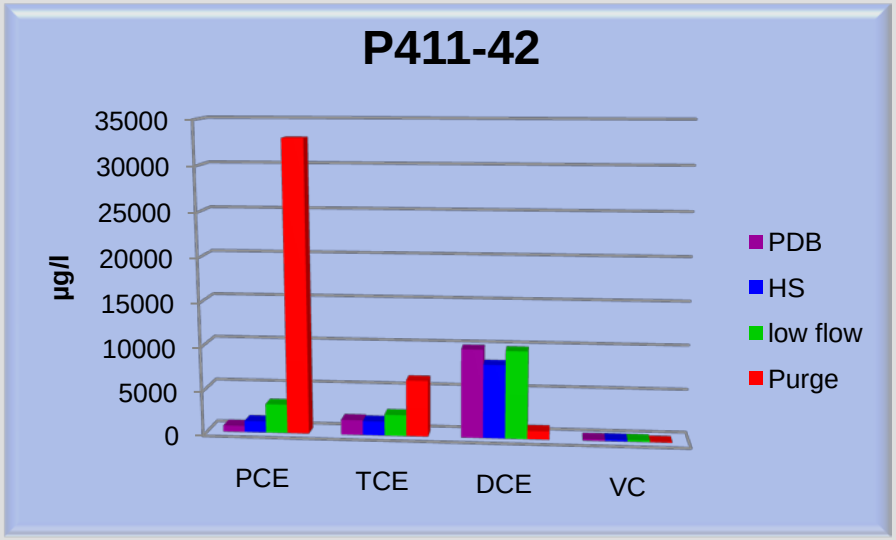
Site 1

1. Comparison high volume purge, low flow sampling, PDB and HS
    2. Low K zones

Bad correlation with high volume purge

- Higher PCE
- Lower DCE





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Site 1

2. Profiling with PDB's

- Well P411-42
- No significant differences across screen
- Does **NOT** give explanation for differences between high volume purge and passive sampling techniques

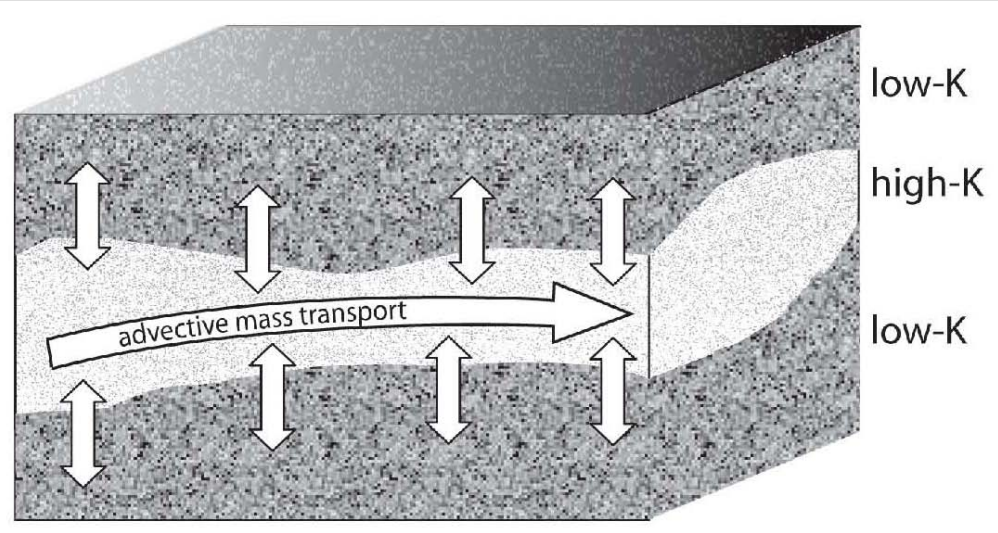
		PCE		TCE		cisDCE		VC	
Filter screen	Depth PDB	**PDB**	**conv**	**PDB**	**conv**	**PDB**	**conv**	**PDB**	**conv**
m-bgs	m-bgs	µg l-1		µg l-1		µg l-1		µg l-1	
38 - 42	38 - 38.5	76	54000	440	5800	6100	120	23	57
	39 - 39.5	250		58		16000		19	
	40.5 - 41	570		200		11000		13	
	40.5 - 41	240		240		14000		23	
	41.5 - 42	190		140		14000		22	

Site 1

Explanation: heterogeneity

Subsurface (and also low K zones) consist of higher and lower K zones

- Advective transport through high-K zones
- Diffusive interaction with low-K zones



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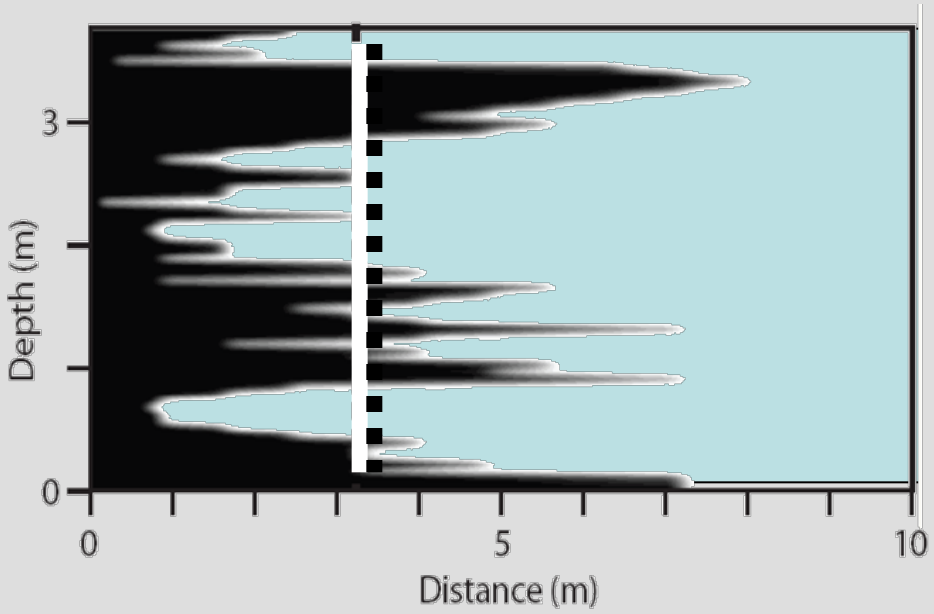
Every Monitoring Well Sampling Method Yields Strongly Biased Results



Tracer Studies Reveal Dramatic Variability In the Delivery of Groundwater, Reagents & Contaminants to Wells

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Contaminant distribution

Site 1

High PCE and TCE in pumped samples?

- Sampling of higher K zones around the well under pumping conditions
- During sampling: GW decrease of 7 m causes increase of natural hydraulic gradient by > 100 x

⇒ Shear forces mobilize residual DNAPL in high K-zones

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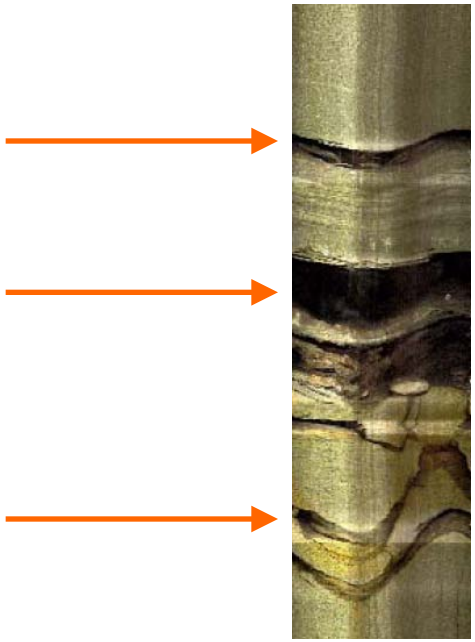
Contaminant distribution

Site 1



High DCE in passive samples?

- Limited flushing of the well by natural groundwater flow and limited # high K zones

⇒ passive sampling shows concentrations in lower K zones

- Different geochemistry of high and low K-zones
  - More organic material in lower K-zones
  - More food for CVOC reducing bacteria
  - Higher degradation in lower K zones

⇒ More DCE

Site 1

Conclusions

High K, dissolved concentrations zones:

- Passive sampling ~ purged samples

Low K, DNAPL zones:

- Passive sampling more representative for dissolved fraction
- Purged sampling shows presence of residual DNAPL

Site 2

Executed test:

Comparison high volume purge and PDB

- good correlation in high K-zones
- well W3 in lower K zone: higher TCE conc
- Best correlation in high K-zones

Well	Filter depth	trichloroethylene		cis-1,2-dichloroethylene		vinylchlorine	
		PDB µg l^{-1}	conv. µg l^{-1}	PDB µg l^{-1}	conv. µg l^{-1}	PDB µg l^{-1}	conv. µg l^{-1}
W1	20 - 22	<0.29	<0.29	3.85	19.7	1.16	3.92
W2	20 - 22	<0.29	<0.29	4.9	8.34	5.31	5.37
W3	4.4 -6.4	299	2040	49	173	5.76	7.33
W4	9.4 - 11.4	16	0.37	27.1	28	74.9	61.2
W5	9.8 - 11.8	33.4	55.7	2.56	1.18	<0.78	<0.78
W6	15 - 17	58.6	47.2	265	201	1.37	1.7
W7	15.5 - 17.5	32.2	47.3	301	384	1.94	1.79
W8	10 - 12	2.34	2.72	1520	1810	206	208
W9	31 - 33	<0.29	<0.29	7.34	6.77	1.83	1.57

Use for long term monitoring

Long term monitoring

Site 1

Criterium for long term monitoring:

- Consistency in time
- Similarity to purged samples is **NOT** a good criterium (see previous testing)

Executed test:

Comparison PDB and HS consistency in time

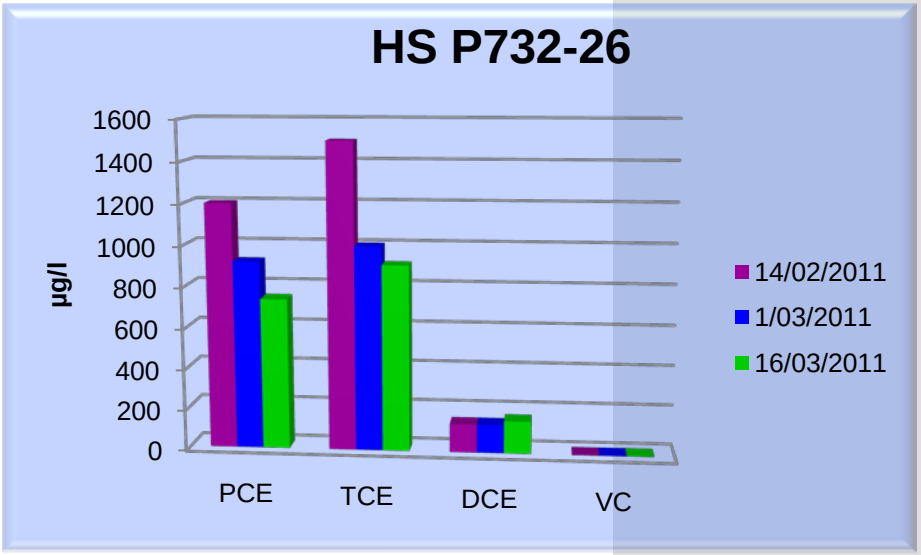
1. High K zones
2. Low K zones

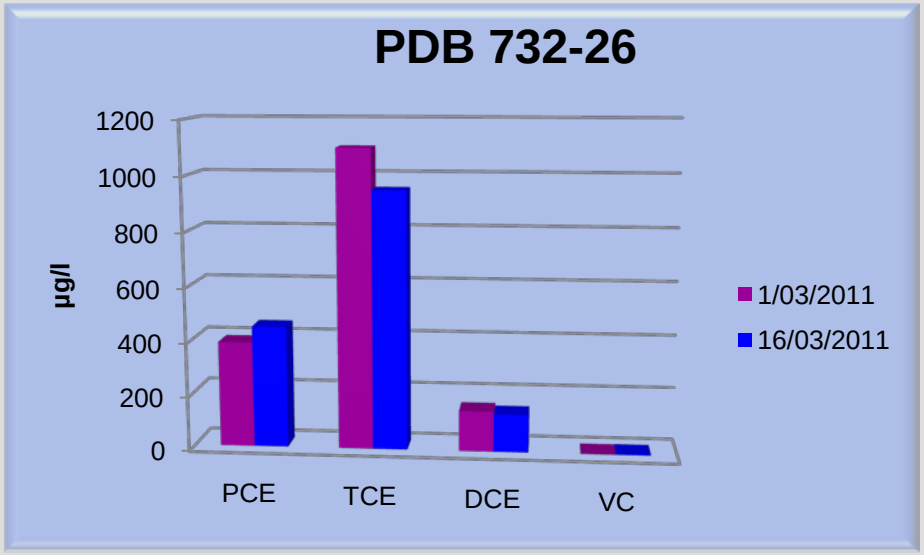
Site 1

Comparison PDB and HS consistency in time

1. High K zones

- Results are stable in time





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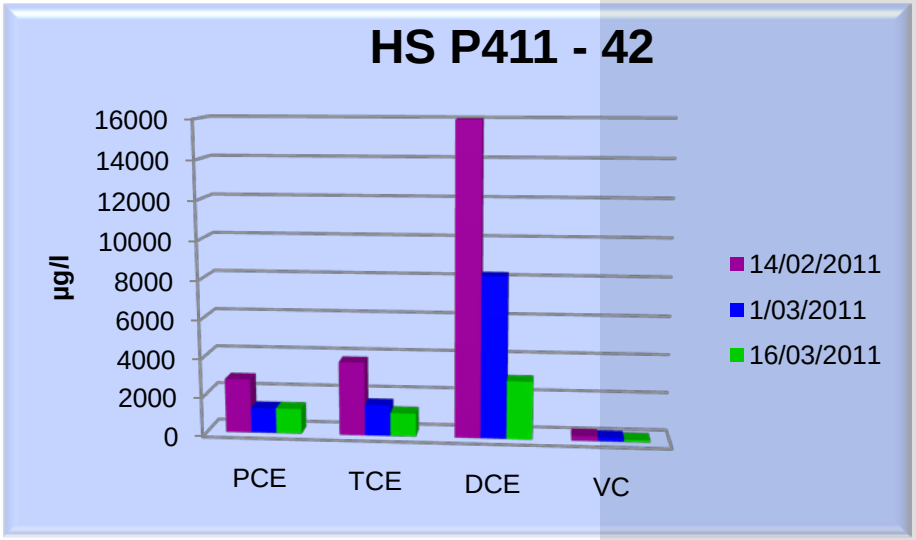
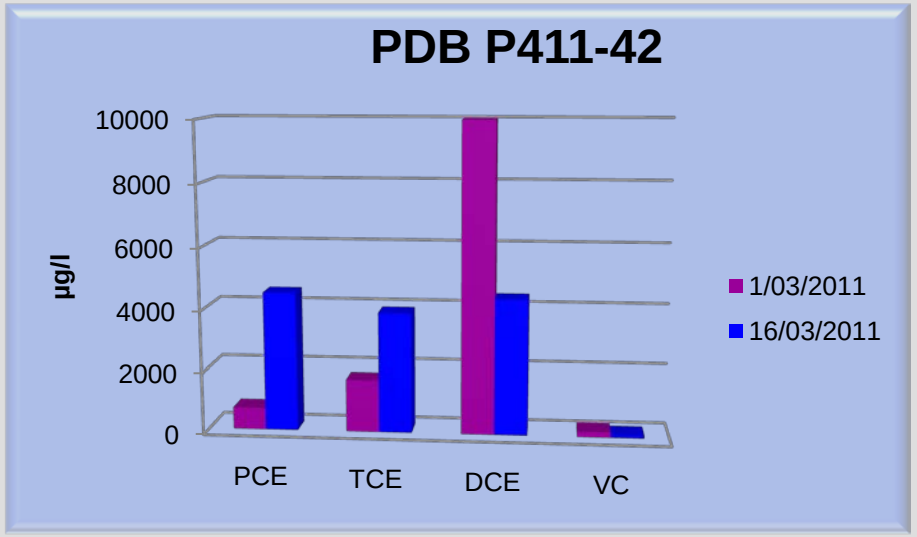
Comparison PDB and HS consistency in time

2. Low K zones

- Results are variable in time
- BUT influence of purging on March 1, 2011 between sampling events!





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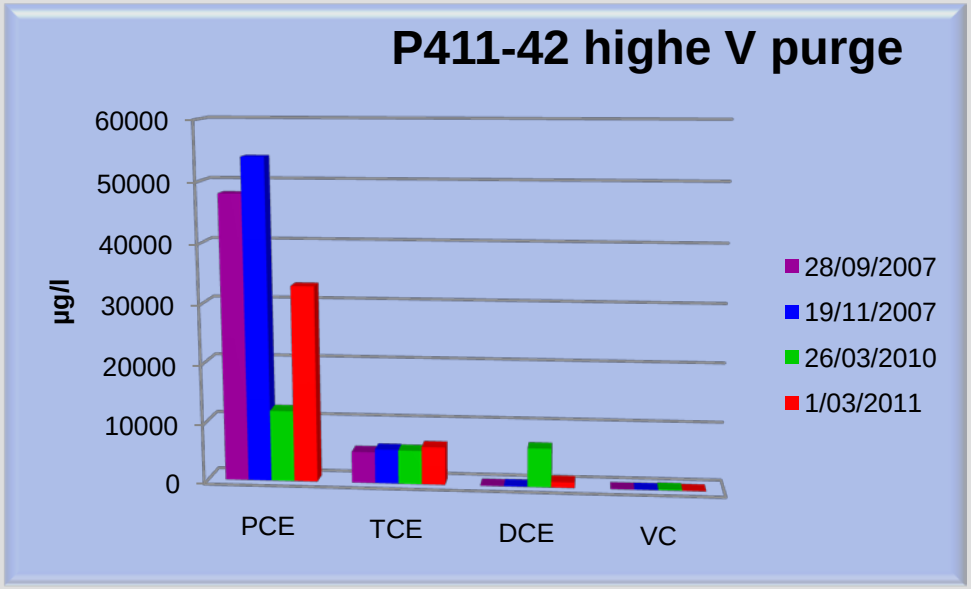
Comparison PDB and HS consistency in time

2. Low K zones

- Results from purged samples could also vary in time



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Site 1

Cost savings

Comparison of costs between high volume sampling and HS/PDB

- 1 sampling event
- 46 wells at depths between 6 and 69 m bgs on site 1
- Includes material and rental of equipment
- Does not include cost for treatment of pumped groundwater, lab analysis and reporting

Purge	Passive	Reduction
6.000 €	3.500 €	42%

Site 1

Conclusions

- High K, dissolved concentrations zones:
  - Passive sampling is consistent in time
- Low K, DNAPL zones:
  - Both passive and active sampling are variable in time
  - BUT purging may have influenced results of passive sampling

Conclusions

Conclusions

No-purge GW sampling…

- can be used for long term monitoring
  - Cheaper than purged samples
  - More cost effective for deep wells
  - Be aware of differences with purged samples

- can significantly differ from purged groundwater sampling
  - Low K zones
  - DNAPL zones

- can give a better insight into the distributio of the contamination
  - Profiling
  - Low and high K zones

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“Provocative” Conclusions

In plume zones : no matter which technique you choose

In source zones :

- For Risk assessment : use passive sampling
- For dimensioning the treatment installation : use purge samples
- For defining total mass, use at least purge samples,….but better core drillings

Extra slides

Comparison of boundary conditions

	high volume	PDB	HS
polar compounds	+	-	+
apolar compounds	+	+	+
field parameters	+	-	+
time for >30 m (hrs)	8	1	1
vertical profiling	-	+	-
waste generated	-	+	+
cost	-	+	+
materials needed	-	+	+
sample volume	+	-	-
small dia wells (< 2")	+	-	-