

Passive *In-Situ-Sealed* **SNAP Sampling** for Improved Sampling Consistency

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Groundwater sampling "Black Box"

Why purge?

- Regulatory requirement?
- "Representativeness?"
- Tradition?
- We like to work hard?

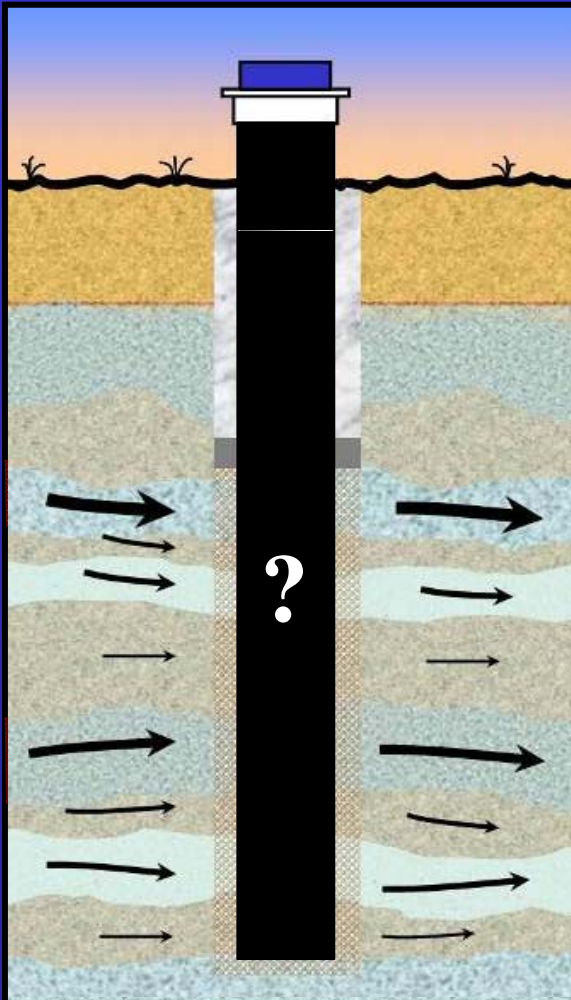


We do know some things about wells....

We do know that ...

HYDRAULICS CONTROLS FLOW...

Water does flow through...



Robin and Gillham, 1987, Field Evaluation of Well Purging Procedures.



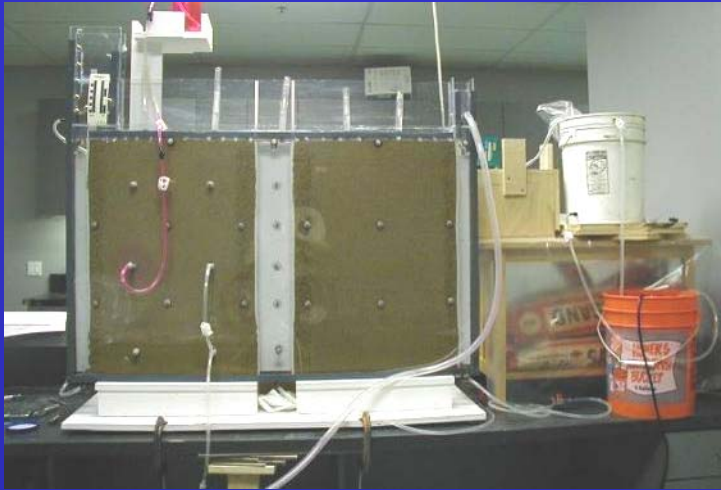
Puls and Barcelona, 1996, Low-Flow Groundwater Sampling Procedures



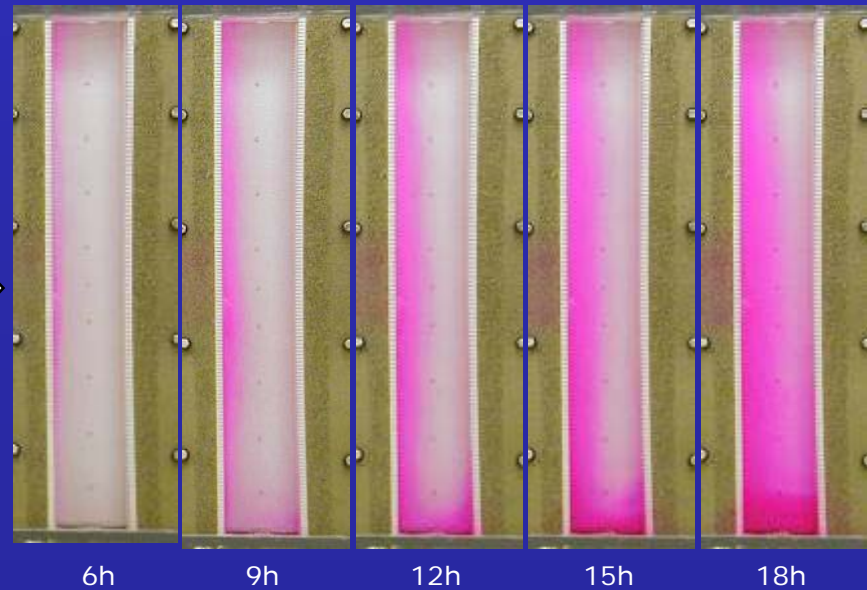
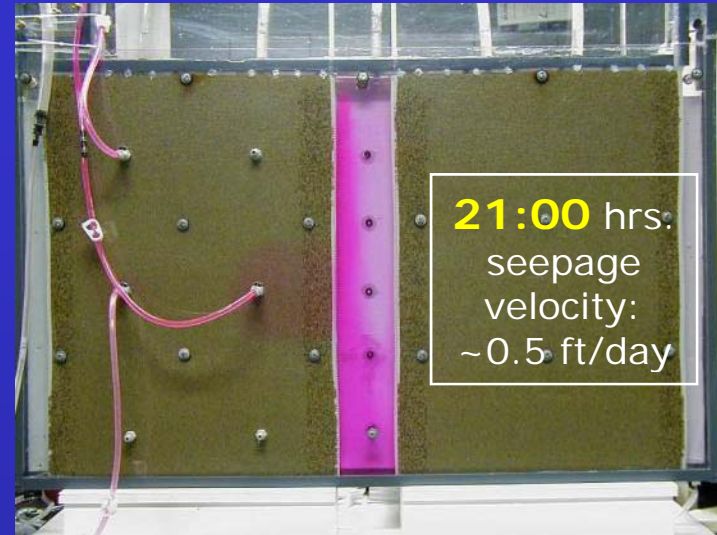
ITRC, 2004, 2007, Passive Groundwater Sampling Protocols

In-Well mixing/homogenization

Many if not most wells mix to some degree....



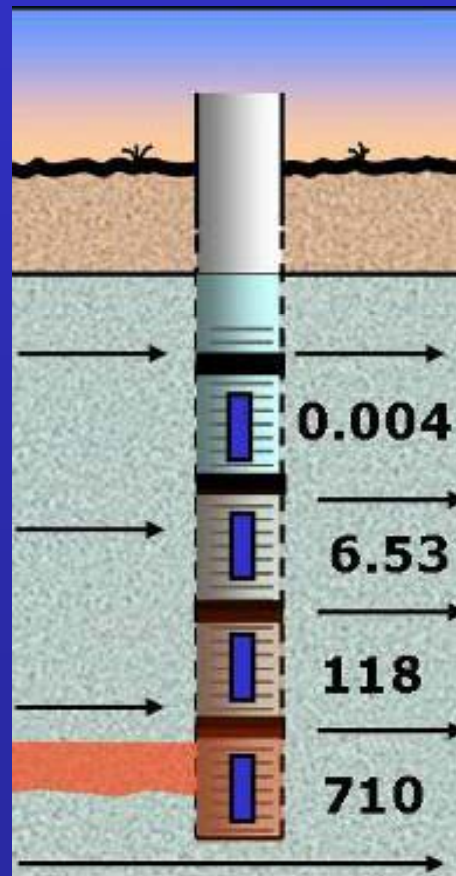
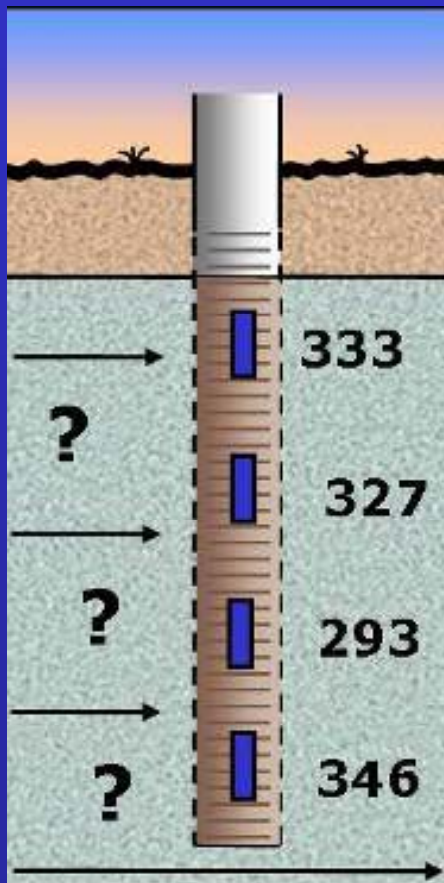
Britt, S.L., 2005, Testing the In-Well Horizontal Laminar Flow Assumption with a Sand-Tank Well Model, *Ground Water Monitoring and Remediation* 25(3): 73-81



Open vs. isolated zone sampling

...Illustrates flow-weighted mixing concept

May also allow multilevel sampling in open wells



**In-well baffle device/
Mixing inhibitor**

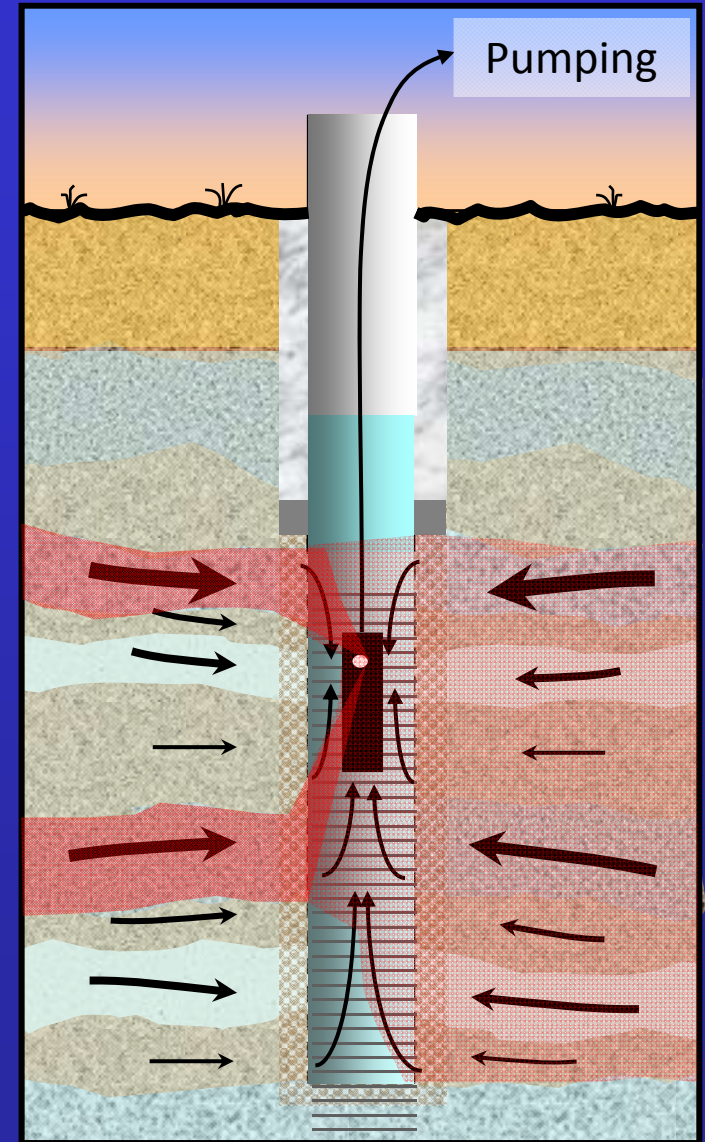
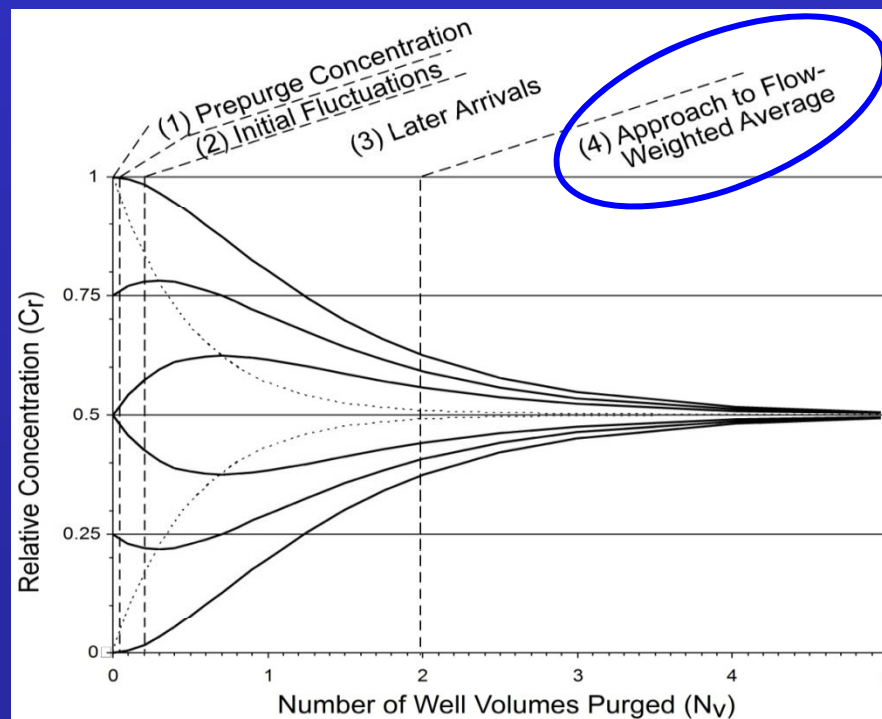
Britt, SL and Calabria M, 2008, Baffles may allow effecting multilevel monitoring in traditional monitoring wells, Battelle Chlorcon Conference, Monterey California, May 2008

Purging creates a flow-weighting effect too...

What controls flow-weighting during pumping?

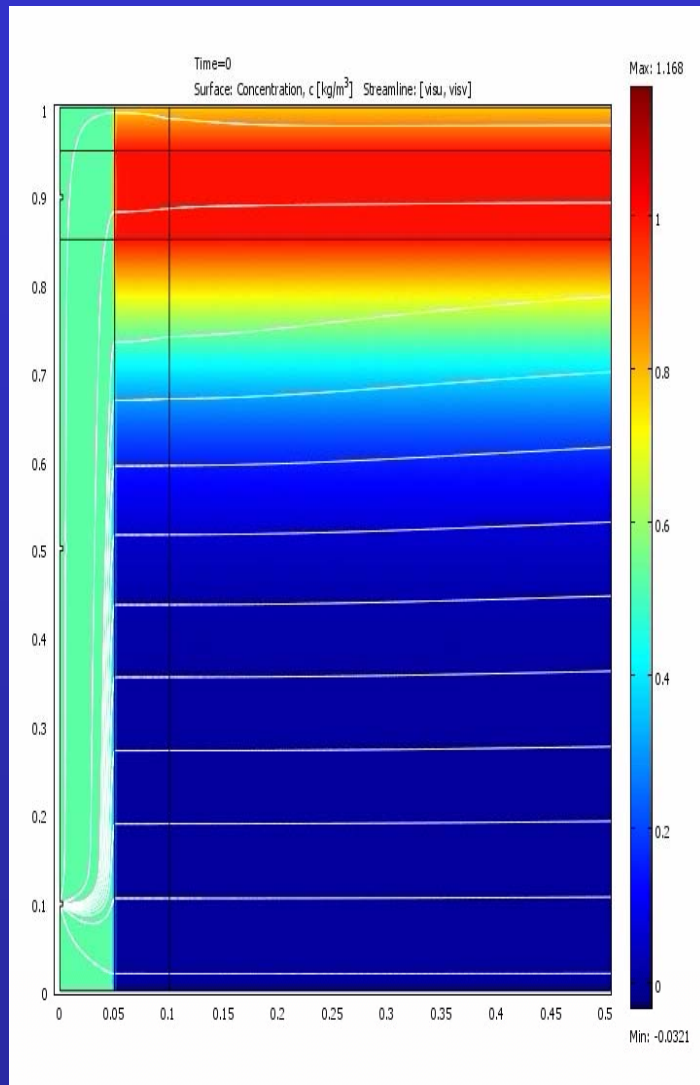
- Contaminant stratification
- Inflow location
- Pump position relative to stratification

Zero volume purge and late-time purge often closest to FWA



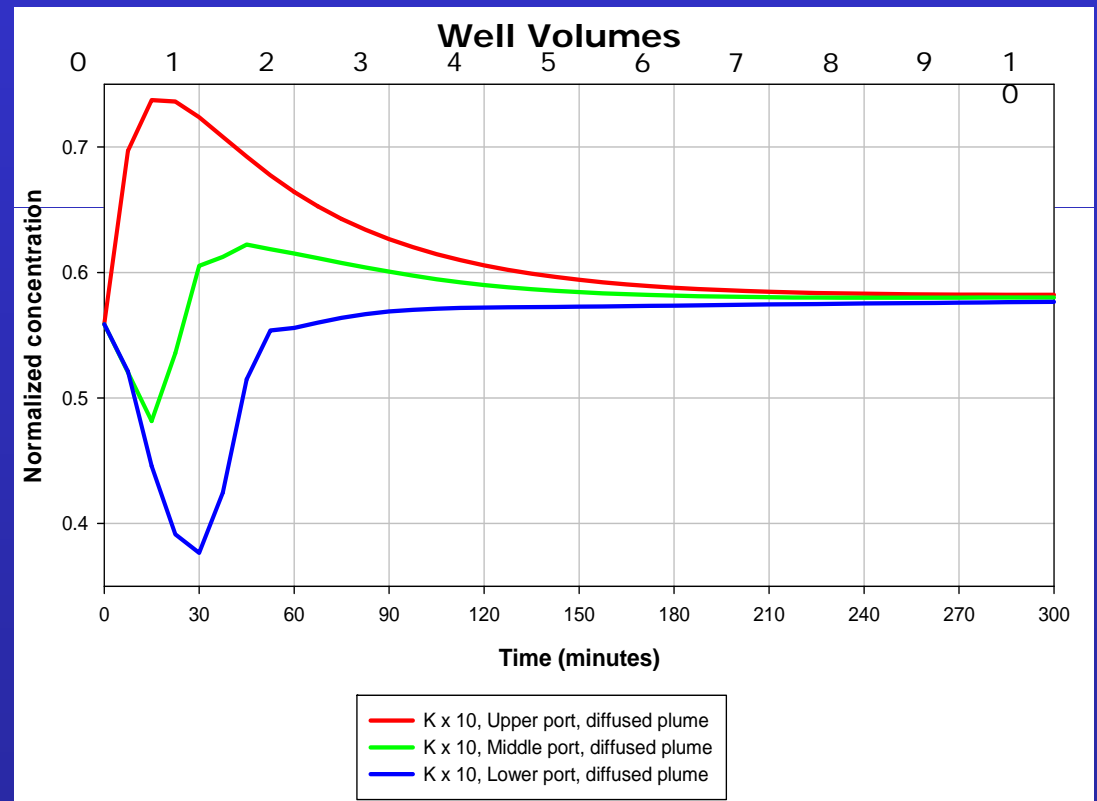
Martin-Hayden, 2000, Sample Concentration Response to Laminar Wellbore Flow: Implications to Ground Water Data Variability. *Ground Water* 38, no. 1: 12-19.

Purging creates a flow-weighting effect too...



When do you achieve a flow weighted average?

What are early concentrations in pump discharge



1 meter long, 10cm screen

250ml/minute pump rate

$K = 1 \times 10^{-2}$ cm/sec in contaminated zone, 1×10^{-3} in remaining aquifer

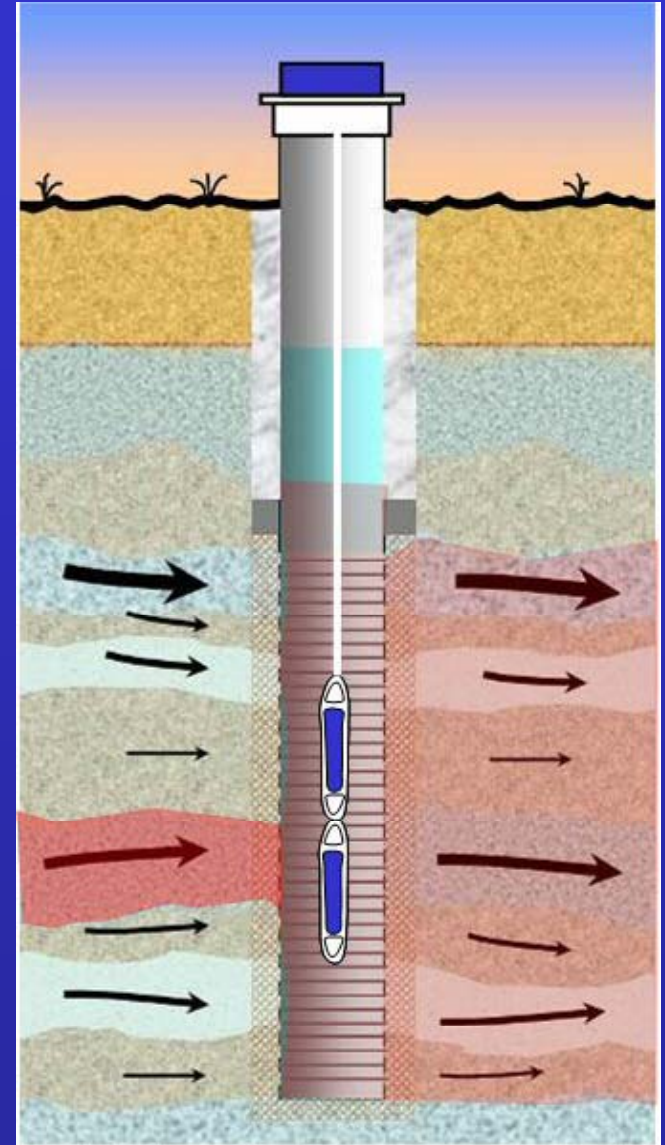
Pump located 10cm from bottom position

The Take Away?

Done correctly, passive equilibration is often very similar to purge sampling

- Natural flow delivered to well
- Ambient / passive mixing according to native flow dynamics
- Flow-weighted averaging effect

A dedicated passive sampling system can take advantage of this phenomenon



Several passive sampling systems are currently on the market

Diffusion-based Passive samplers

- Polyethylene Diffusion Sampler
- Regenerated Cellulose Diffusion Sampler
- Rigid Porous Pipe Sampler



Grab-Type Passive Samplers

- Hydrasleeve
- Snap Sampler

Sorptive Passive Samplers

- Gore Module



There are some convenient advantages...

...you can sample by yourself...

...without the large vehicle...

...and with almost none
of this equipment...

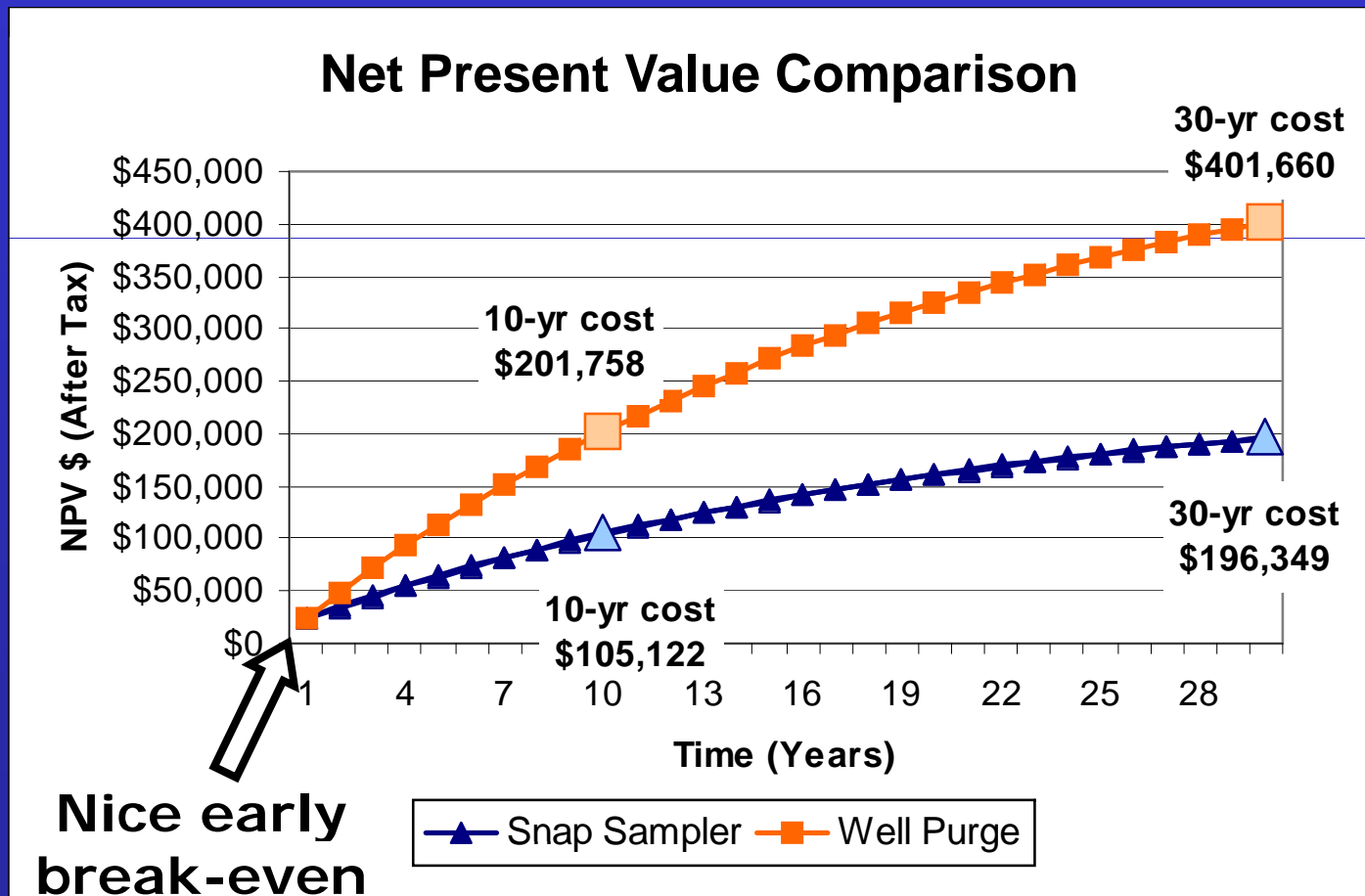


Safety is improved

- No drums
- No generator
- No compressed gas
- No fuel
- Shorter time at the well and in the field

SAVE 50% or more on sampling costs

NO waste disposal, sample 15-20 wells a day



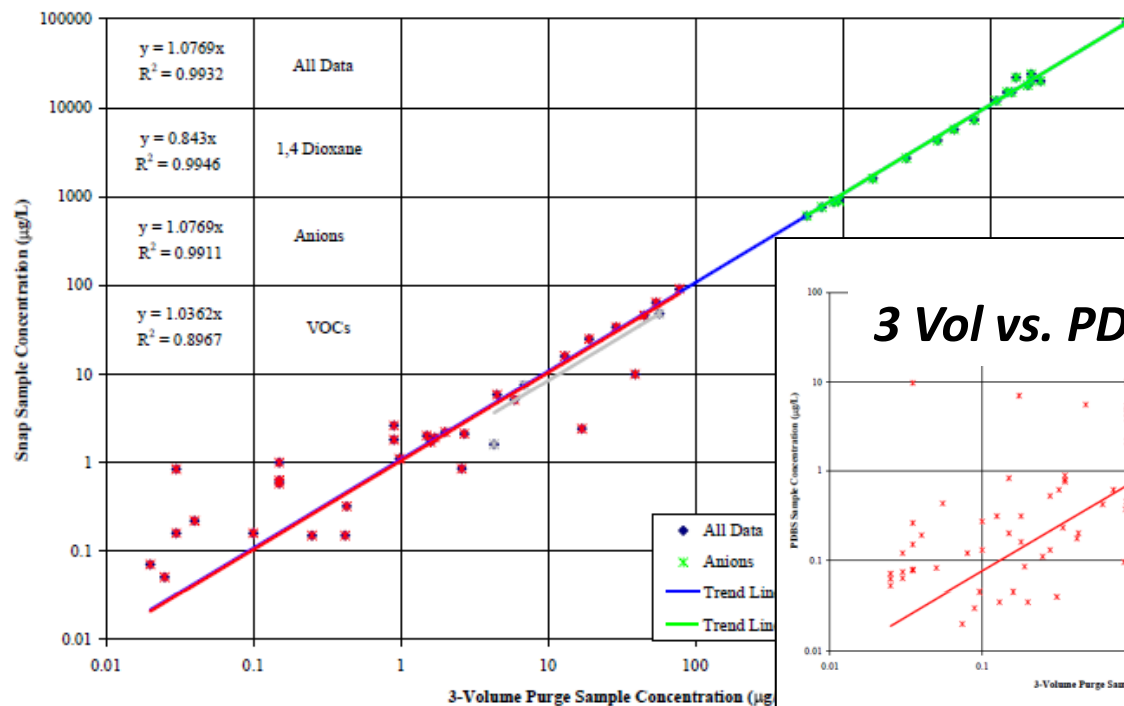
Is there consistency among all passive methods?

Examples from McClellan Air Force Base Study

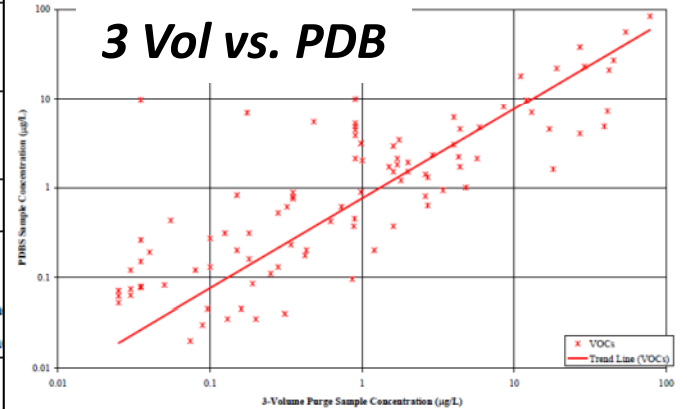
(some methods noisy, some consistent; some biased quite low)

3 vol purge vs:	Y-slope (RECOVERY)	R ² (SCATTER)
SS	1.04	0.90
PDB	0.75	0.58
RPPS	0.63	0.70
HS	0.59	0.50

3 Vol vs. Snap Sampler



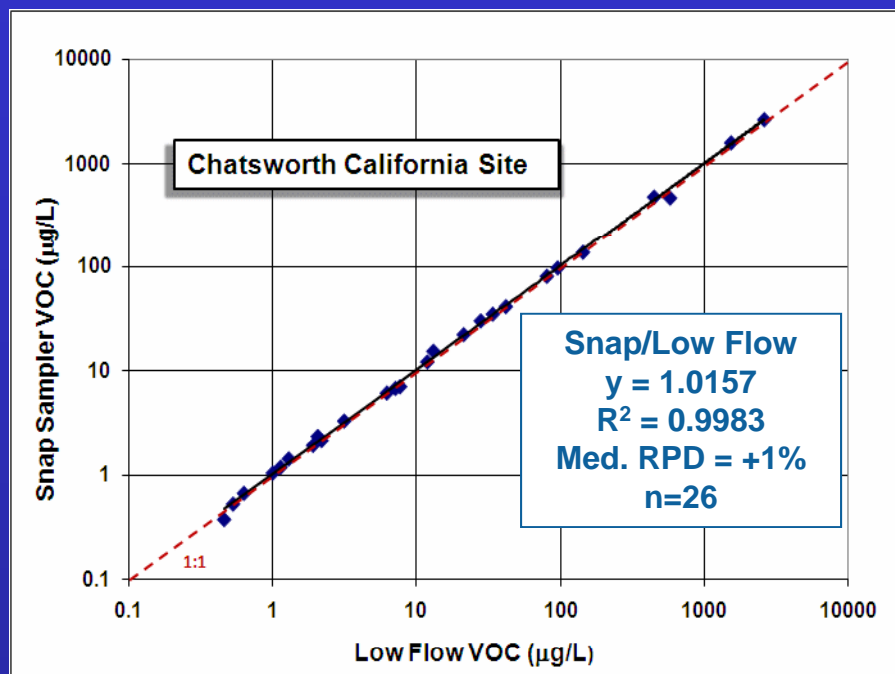
3 Vol vs. PDB



Comparability to purging can be at odds...

Example from SSFL

(Snap and LF almost exactly the same)



Britt, SL, Parker, BL, and Cherry, JA, 2010, A Downhole Passive Sampling System to Avoid Bias and Error in Groundwater Sample Handling, *Environmental Science and Technology*, v.44 p 4917-4923

Example from Hill AFB

(HS -40% RPD for TCE compared to 3vol)

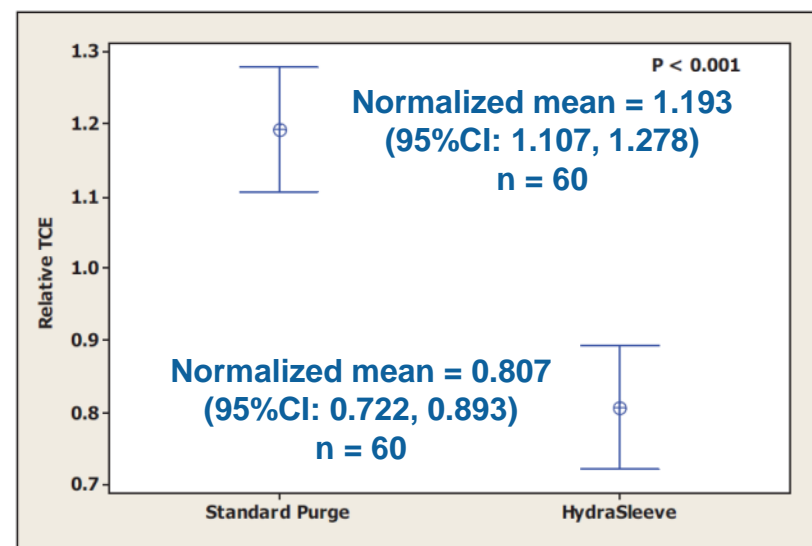


Figure 3. Difference between Average Relative TCE Concentrations Obtained with SP and HydraSleeve

MWH, 2010, Final Alternative Sampling Study, Letter Summary Report, Hill Air Force Base, Ogden, Utah

...but variability is more important for LTM than 1:1 correspondence

Sample handling itself adds: random error

Pour test results from SERDP ER-1704 Research:

Table 1

Differences Between Bottle Fill Method
All analytes, normalized

Fill Method (BF vs SP)		Significance	p=
50BF > 50SP	-7%	Highly Sig.	7×10^{-6}
250BF > 250SP	-15%	Highly Sig.	0.0002
1000BF > 1000SP	-9%	Highly Sig.	0.001
Fill Method (SP vs TP)		Significance	p=
50SP > 50TP	-6%	Highly Sig.	0.0009
250SP < 250TP	+6%	not sig	0.176
1000SP < 1000TP	+4%	not sig	0.314
Fill Method (BF vs TP)		Significance	p=
50BF > 50TP	-12%	Highly Sig.	5×10^{-17}
250BF > 250TP	-10%	Highly Sig.	3×10^{-6}
1000BF > 1000TP	-6%	Highly Sig.	0.003

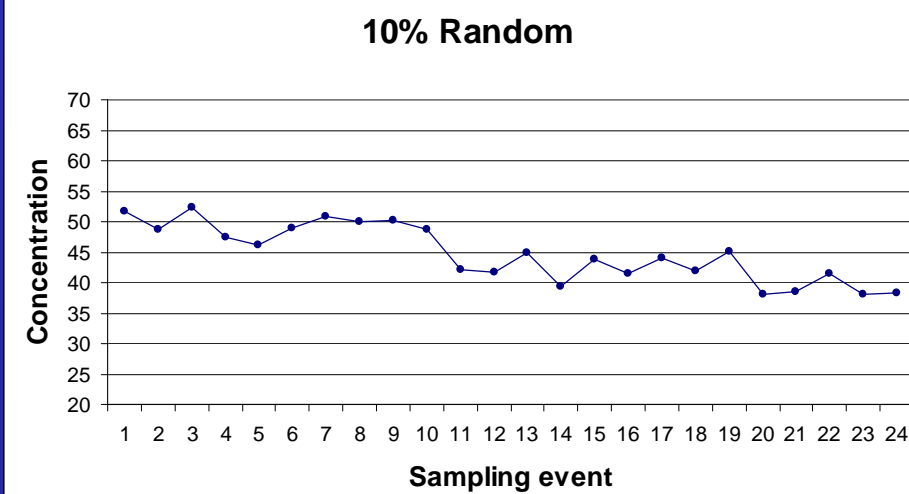
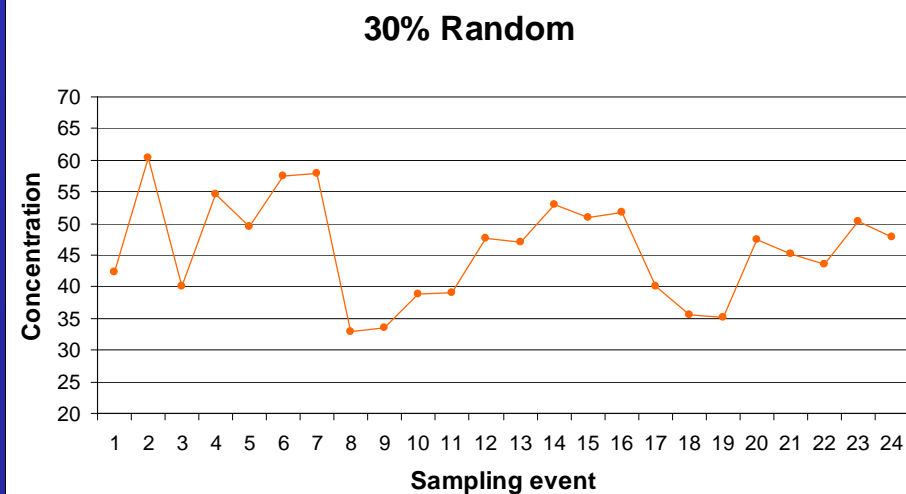
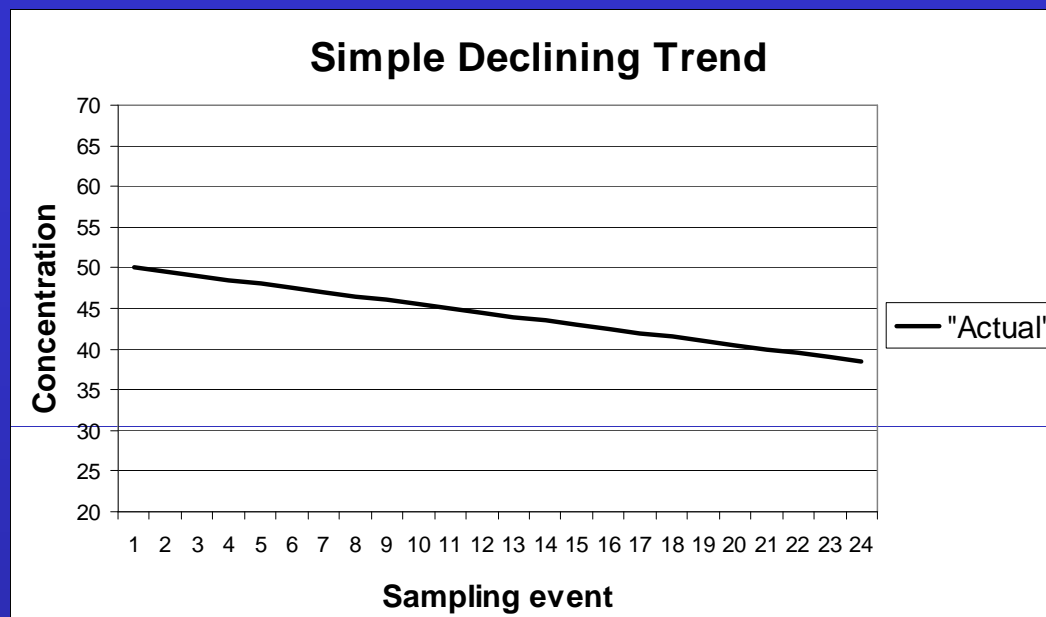
Table 2

Combinations of Fill Rates and Fill Methods
All analytes, normalized

Fill rates and method		Significance	p=
50SP < 1000BF	+13%	Highly Sig.	1×10^{-10}
250SP < 1000BF	+19%	Highly Sig.	1×10^{-5}
50TP < 1000BF	+20%	Highly Sig.	5×10^{-28}
Fill rates and method		Significance	p=
50SP < 250BF	+11%	Highly Sig.	1×10^{-6}
50BF > 250SP	-12%	Highly Sig.	0.0008
1000TP > 250SP	-11%	Highly Sig.	0.01

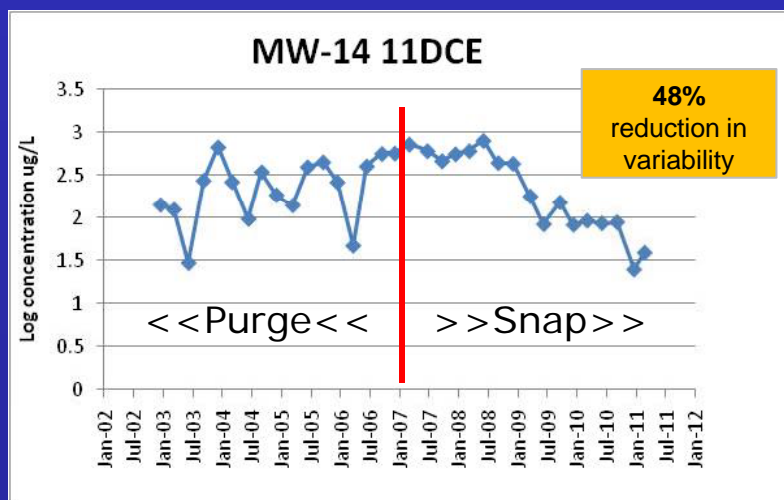
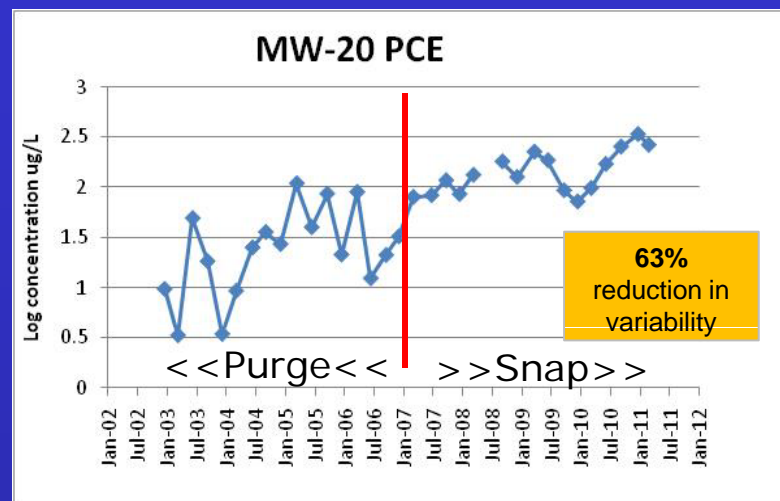
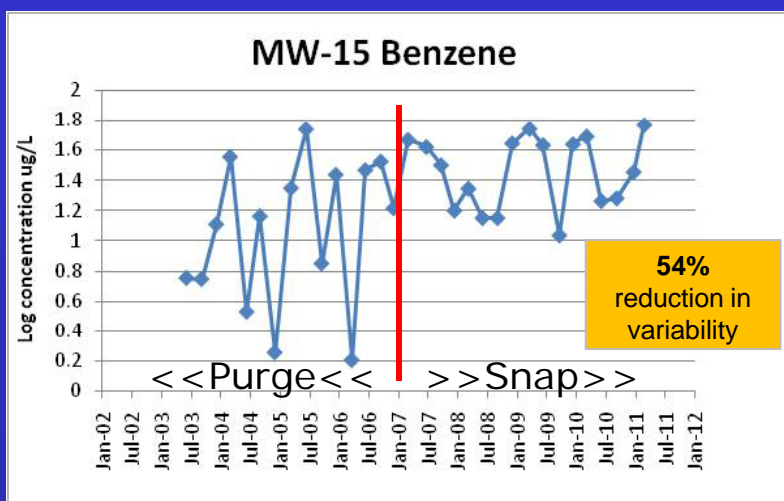
BF = Bottom Fill; SP = Side Pour; TP = Top Pour; numbers are flow rate in ml/min

Interpretation is easier with less random error



Illustration, not site data

Interpretation is easier with less random error



Data Noise Reduction

Value: Better Decisions

In summary...

Passive Sampling:

- Efficacy is largely proven
- Comparison tests still warranted for some devices, well completions
- Saves Money - 50% is common
- Improves Safety and Field Effort
- **In-Situ Sealed passive sampling also adds a variability-limiting effect that has been field demonstrated**

