

New concept for in-situ remediation of PFAS plumes

Can a treatment zone with colloidal activated carbon reduce the mass flux?

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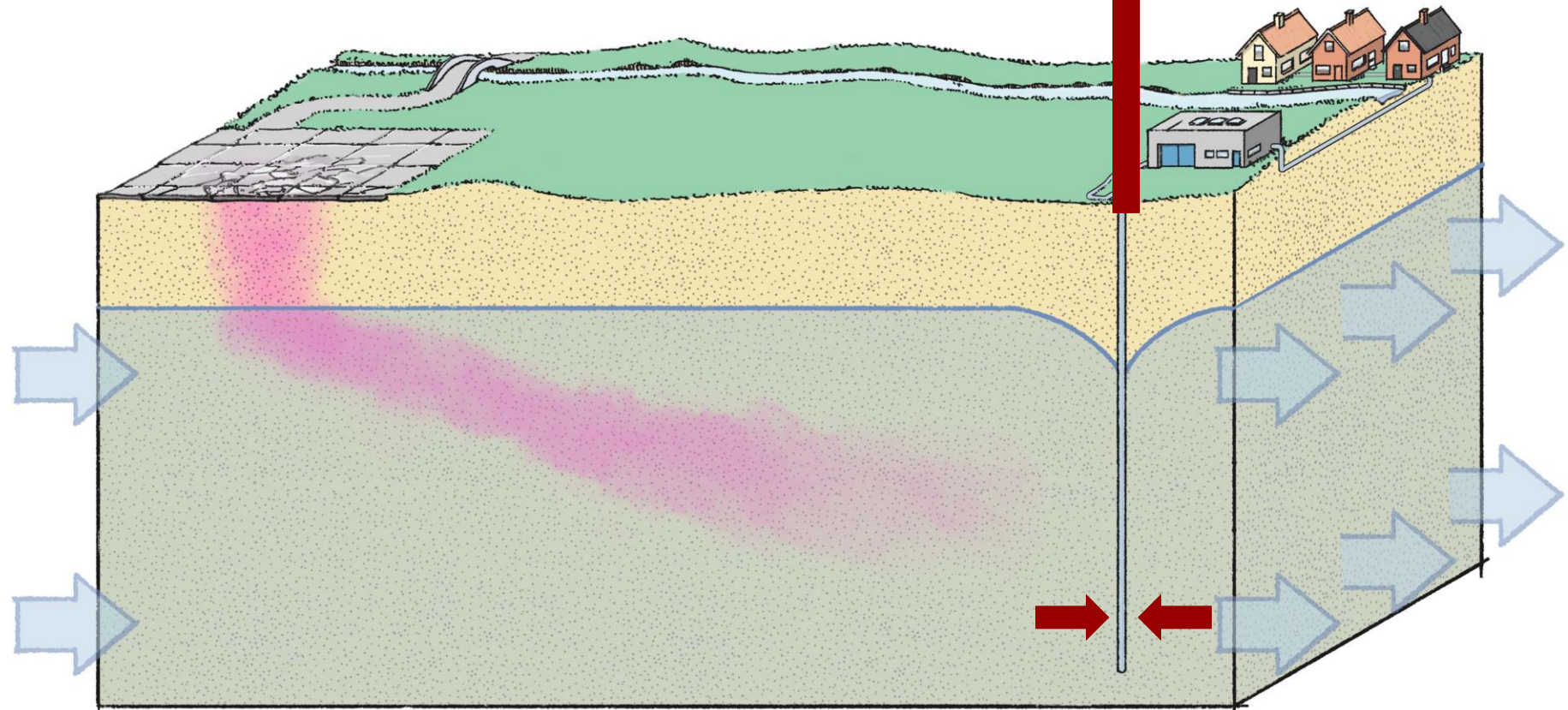
¹ Technical University of Denmark (DTU Sustain)

² Capital Region of Denmark

Clean drinking water is at risk

Q = Abstraction [m^3/yr]
 C = Concentration [$\mu\text{g}/\text{L}$]
 J = Contaminant Mass Discharge [$\mu\text{g}/\text{yr}$]

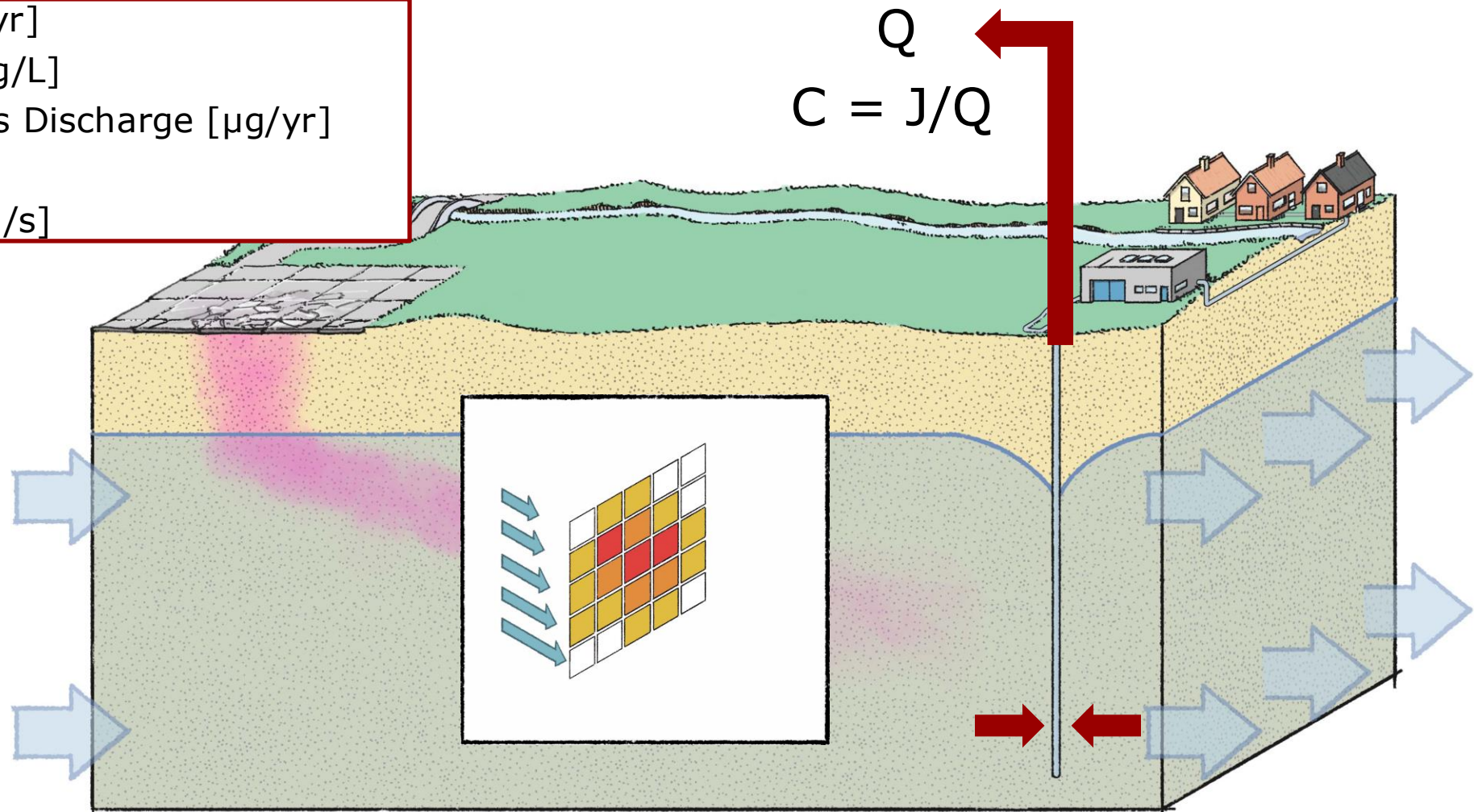
$$C = J/Q$$



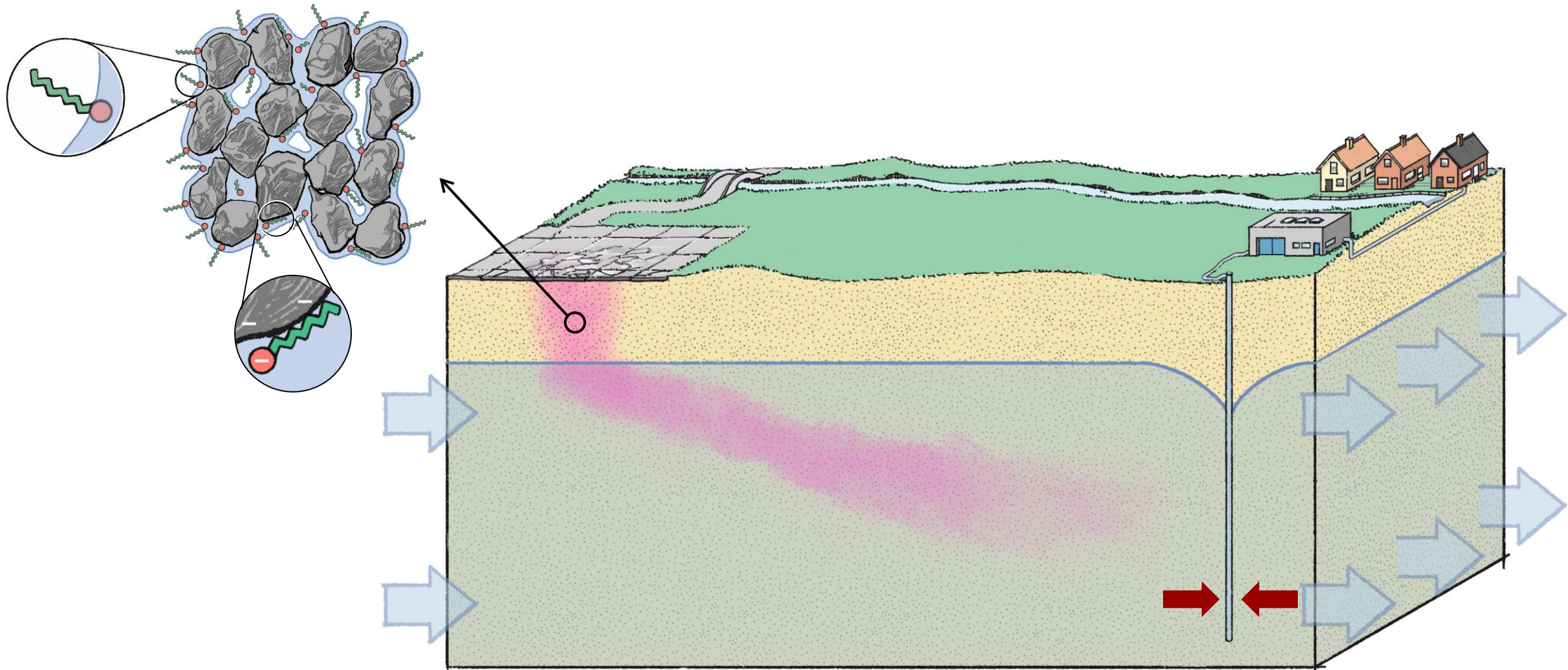
Clean drinking water is at risk

Q = Abstraction [m^3/yr]
 C = Concentration [$\mu\text{g}/\text{L}$]
 J = Contaminant Mass Discharge [$\mu\text{g}/\text{yr}$]
 A = Area [m^2]
 q = Darcy velocity [m/s]

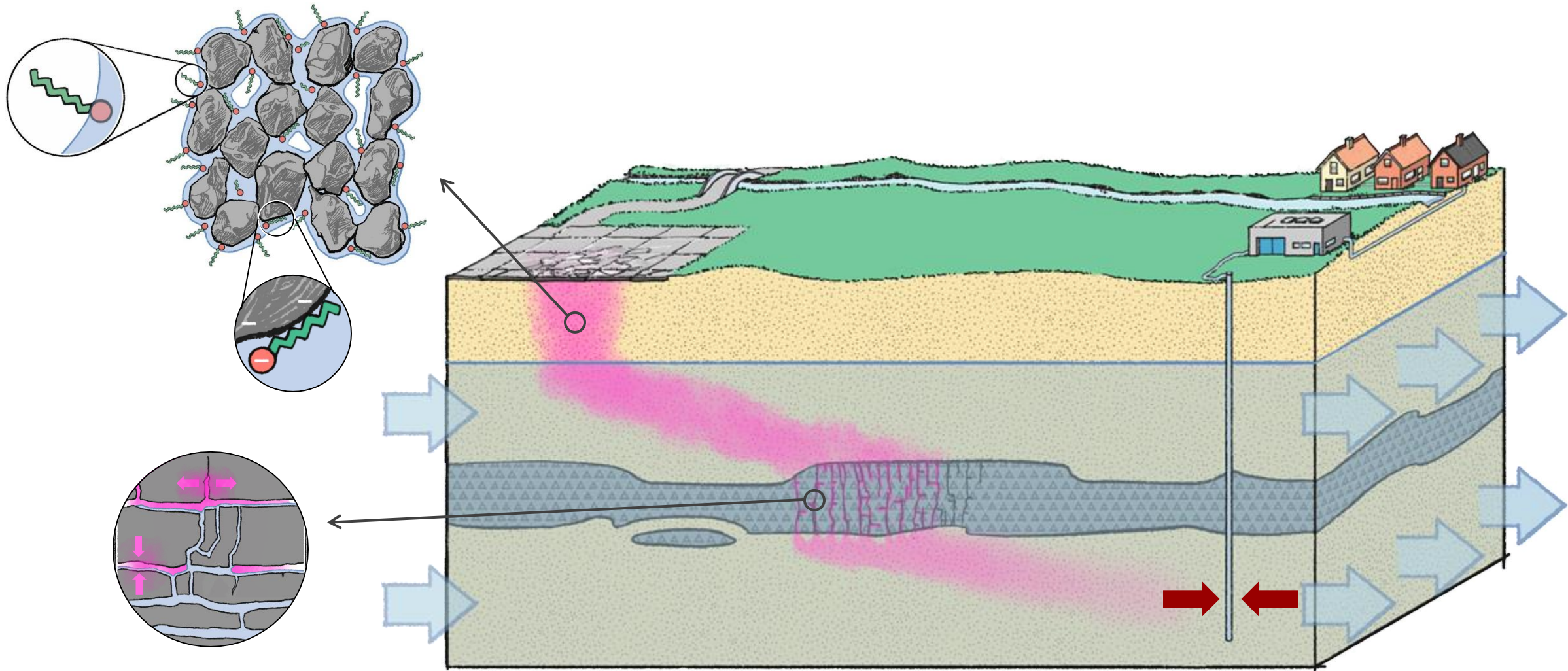
$$J = \sum_{i=1}^n C_i \cdot A_i \cdot q_i$$



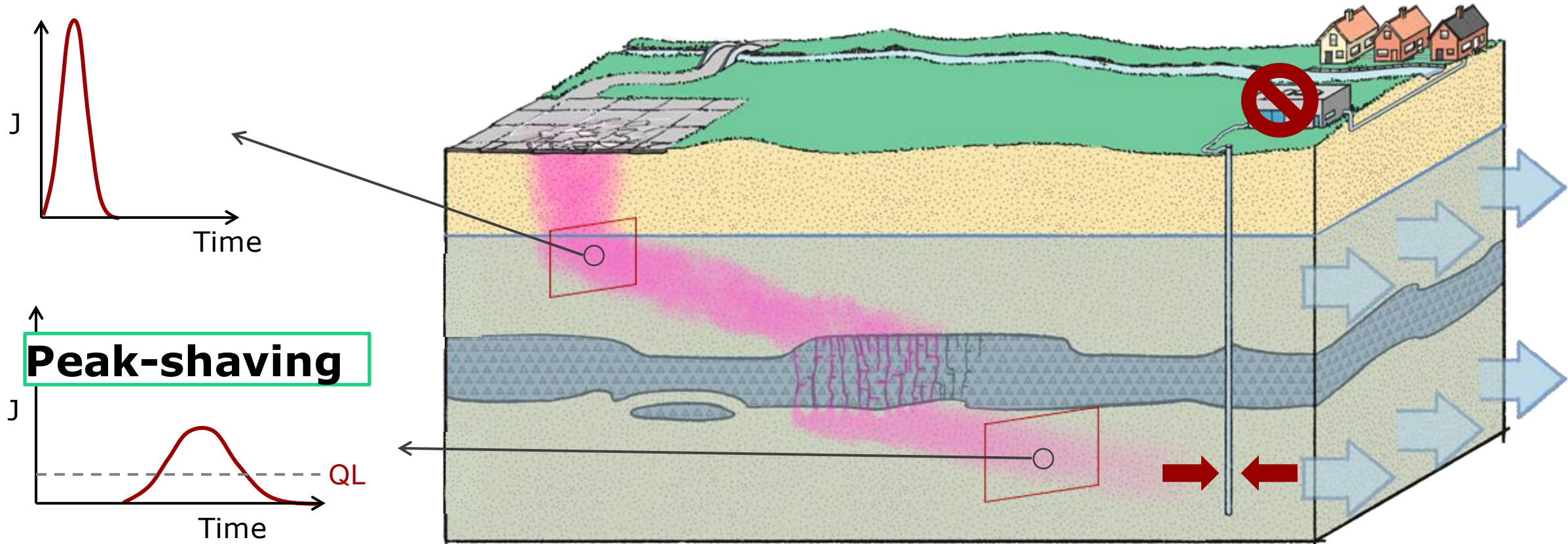
Natural retention of PFAS



Natural retention of PFAS

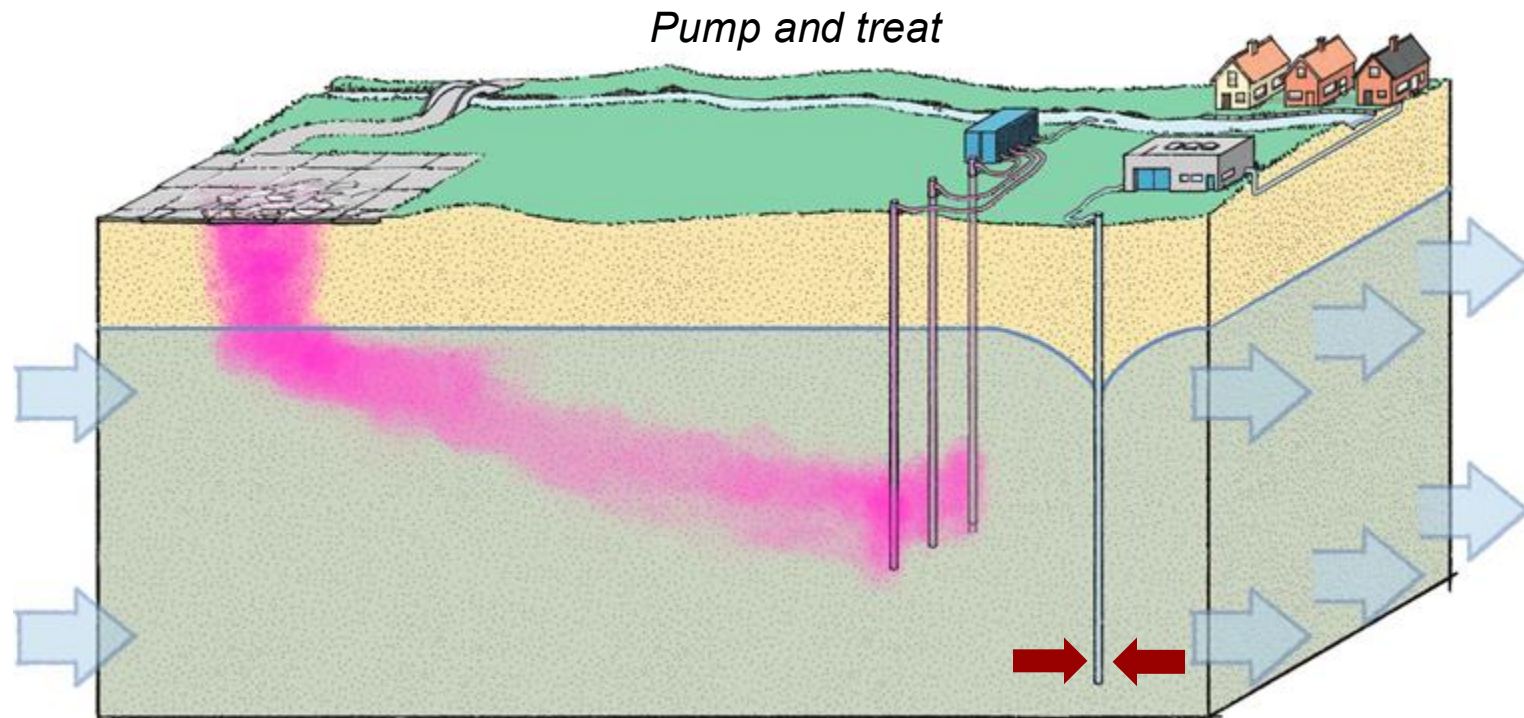
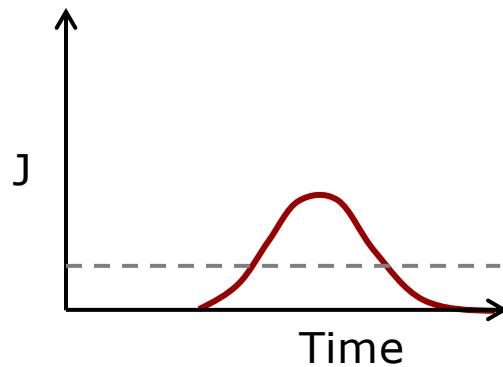


Spreading the mass: Peak-shaving



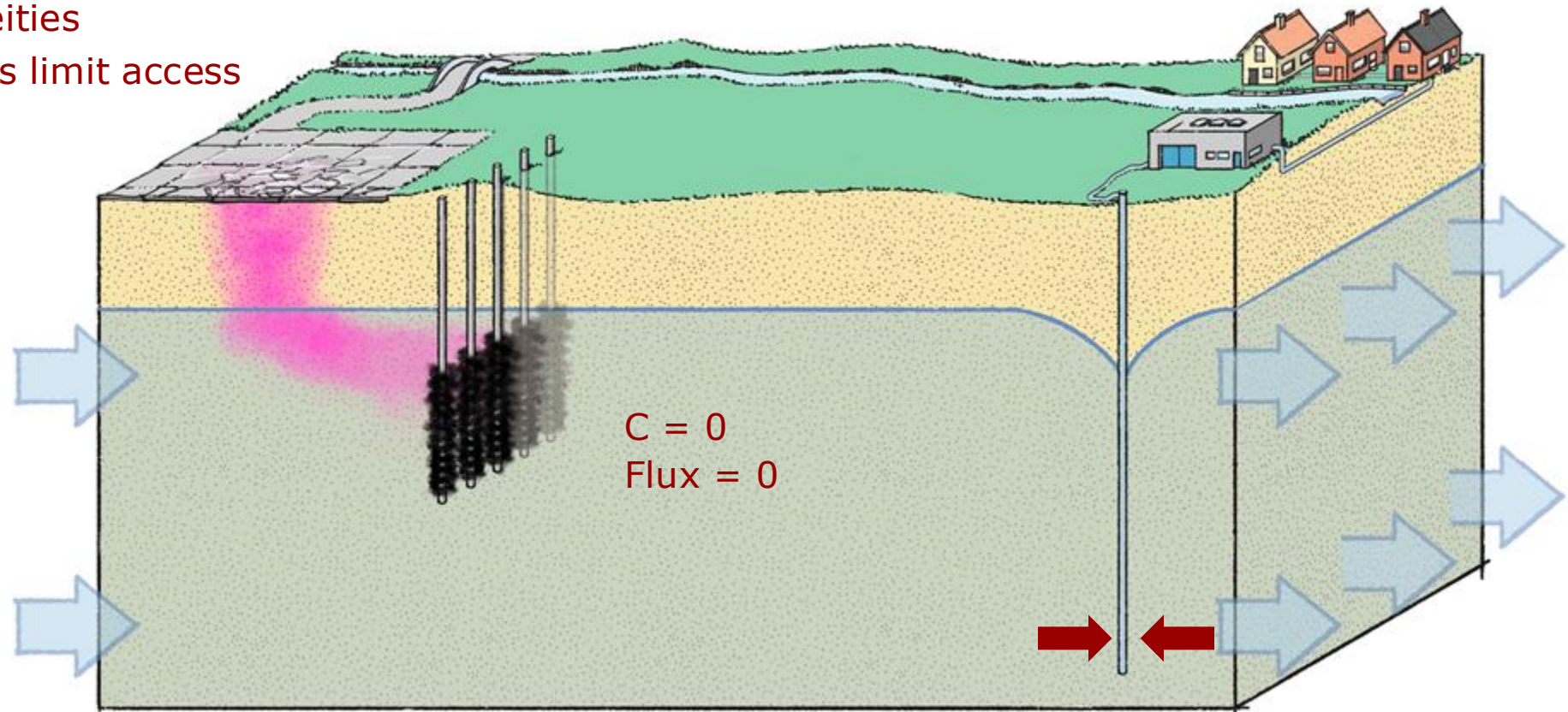
Some of the solutions to the challenge

- Treatment of water at water works
- Remediation: Pump and treat



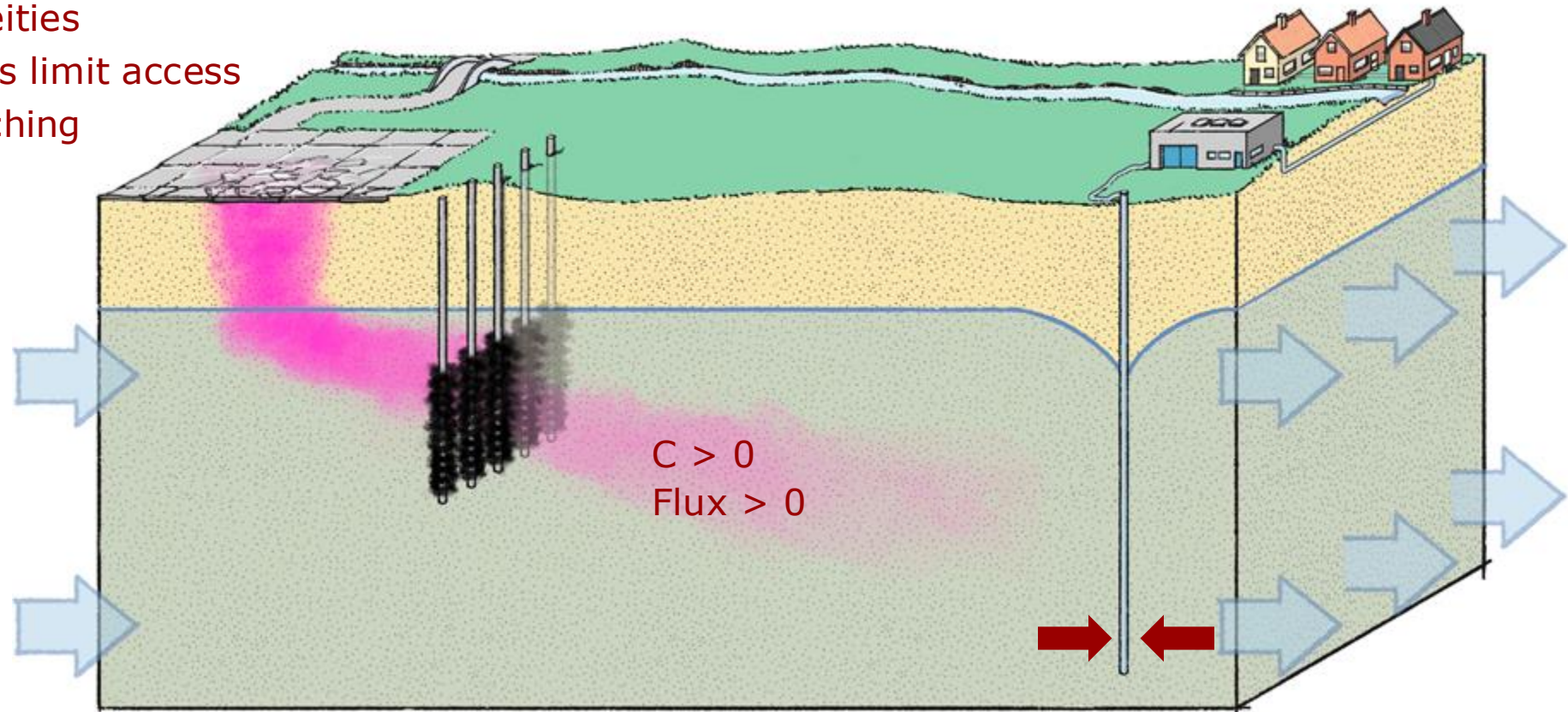
Stabilization of PFAS with permeable barriers in-situ

- ✓ Protects the abstraction well
- ✓ No/low maintenance
- PFAS is not removed
- Heterogeneities
- Urban areas limit access

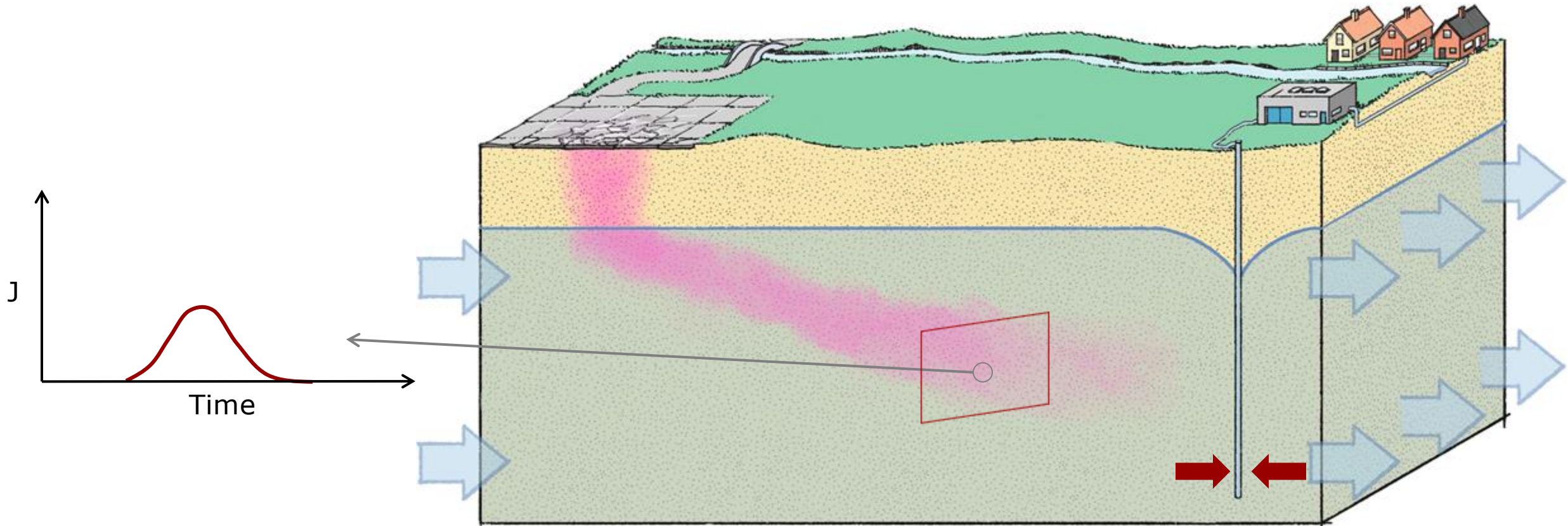


Stabilization of PFAS with permeable barriers in-situ

- ✓ Protects the abstraction well
- ✓ No/low maintenance
- PFAS is not removed
- Heterogeneities
- Urban areas limit access
- Risk of leaching

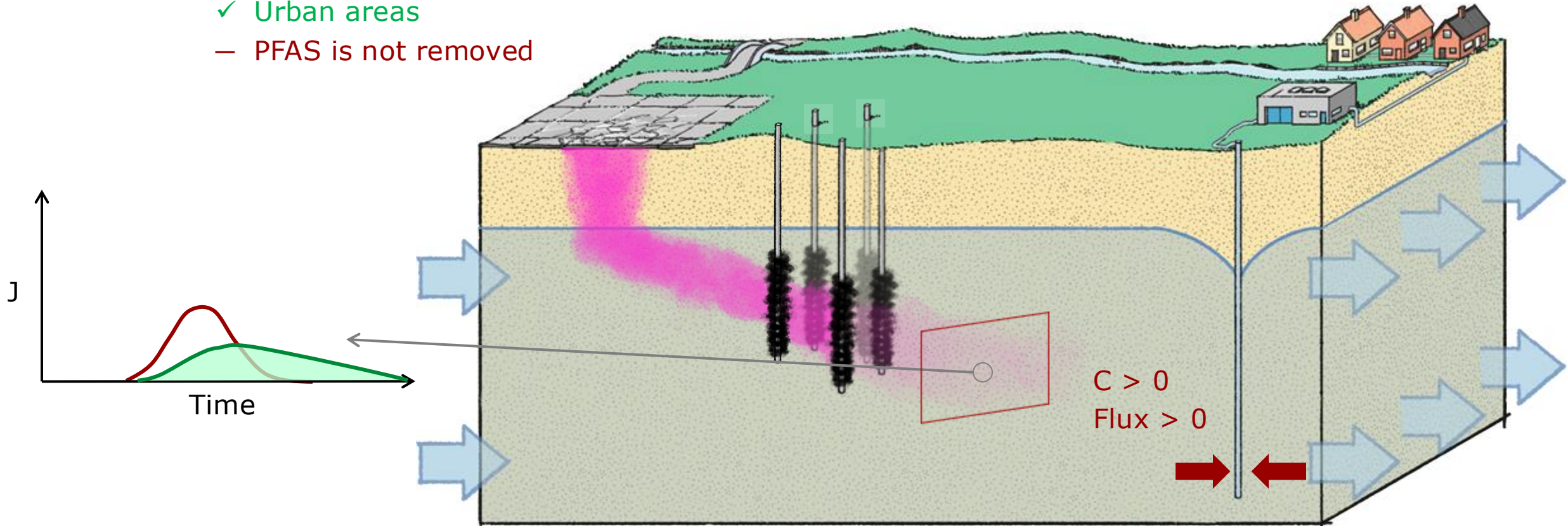


New concept: Is Flux Control the solution?

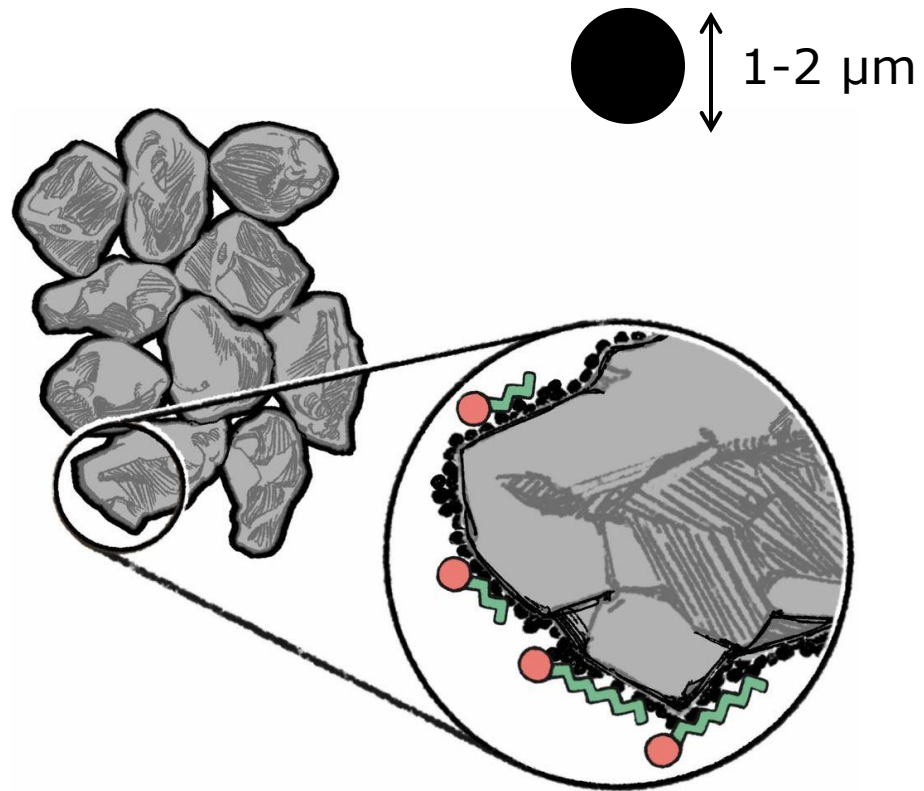


New concept: Is Flux Control the solution?

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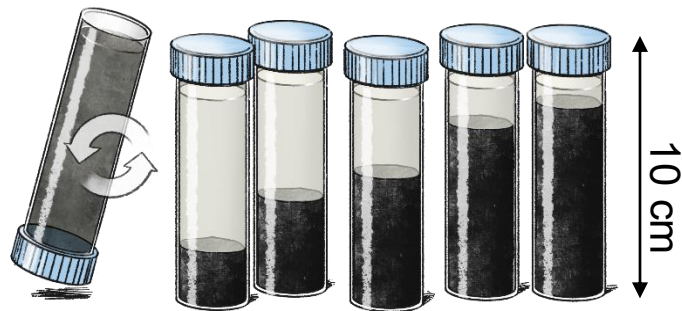


What is colloidal activated carbon (CAC)?



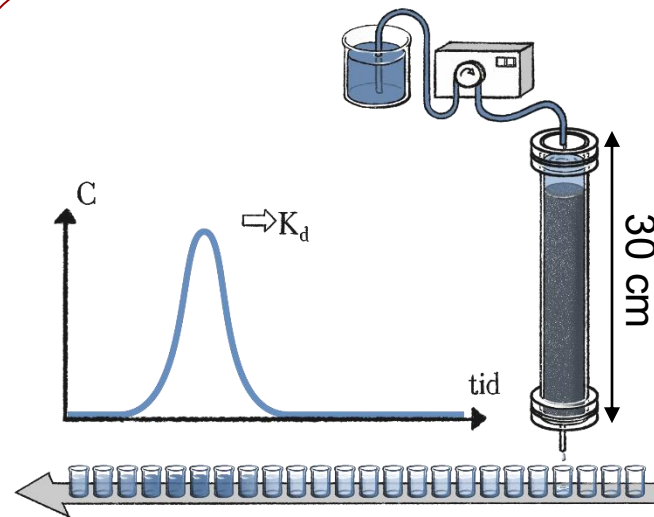
Data collected in the laboratory

Batch experiment



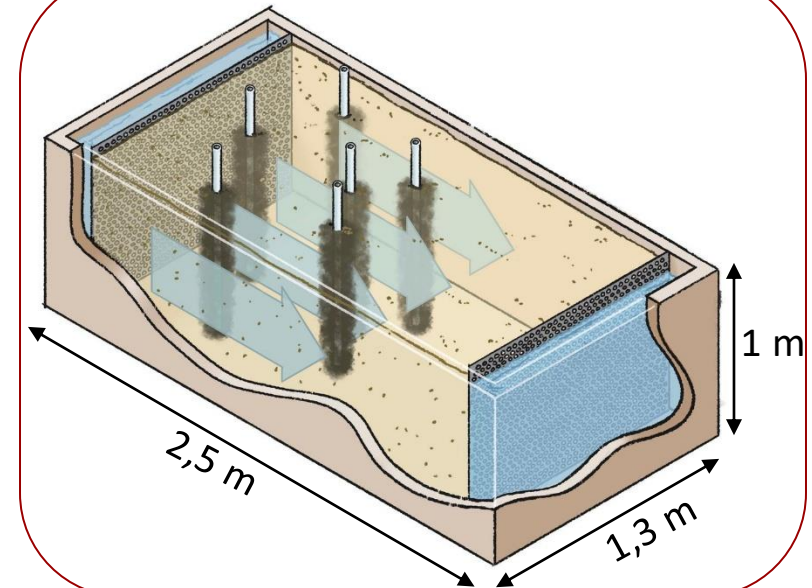
0D – no transport

Column experiment



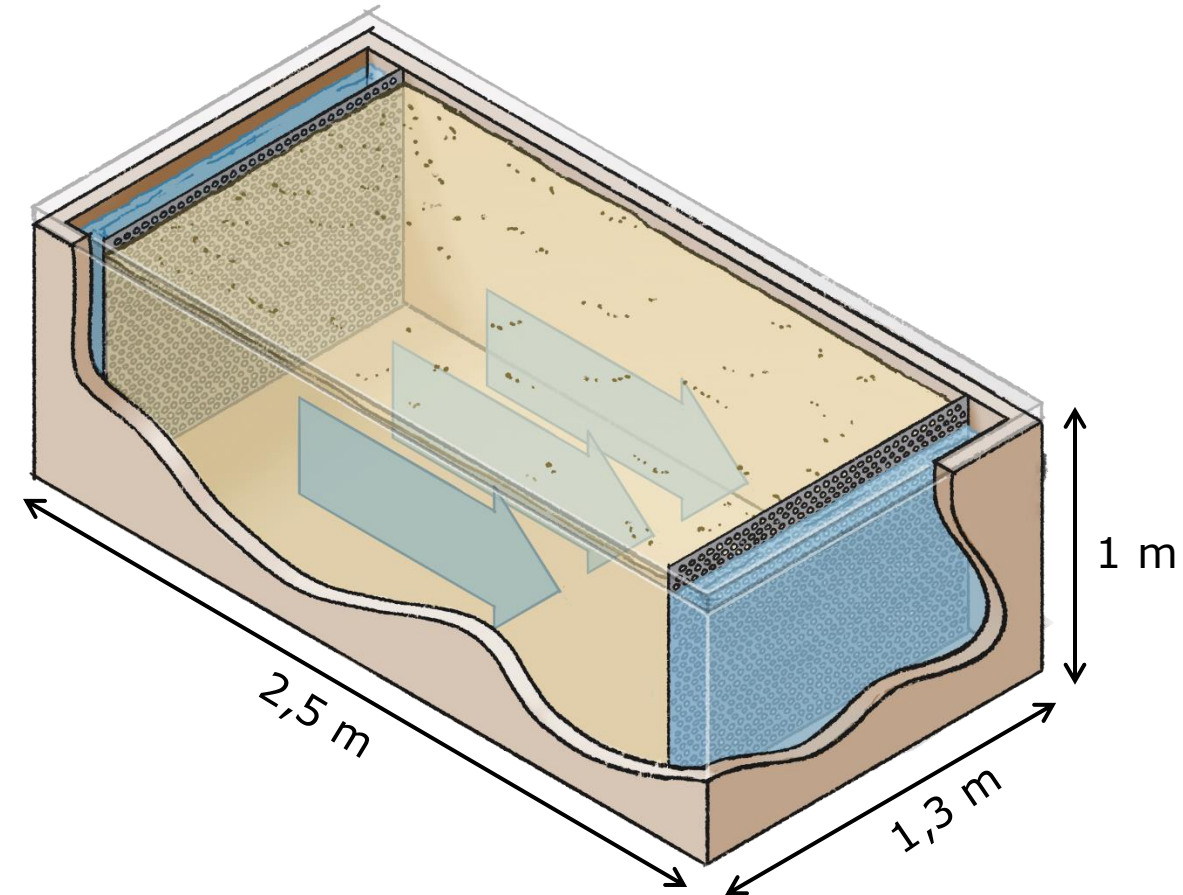
1D – transport

Tank experiment

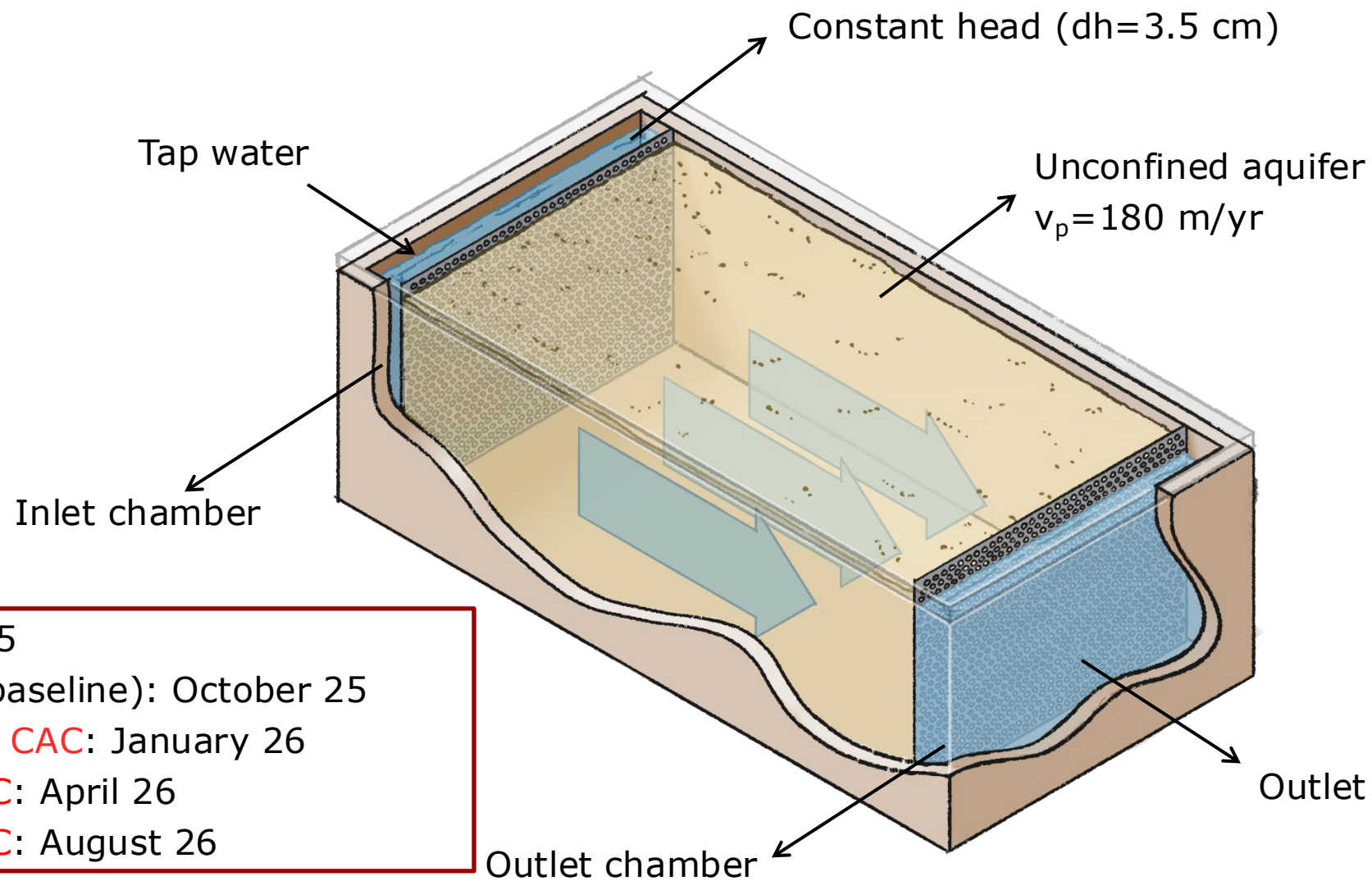


3D – transport

Test of the concept in a tank experiment



Experimental setup



- Br: September 25
- Br + PFAS mix (baseline): October 25
- Br + PFAS mix + CAC: January 26
- Br + PFOA + CAC: April 26
- Br + PFOS + CAC: August 26

Experimental setup



Inlet chamber

Constant head ($dh=3.5$ cm)

Unconfined aquifer
 $v_p=180$ m/yr

Outlet

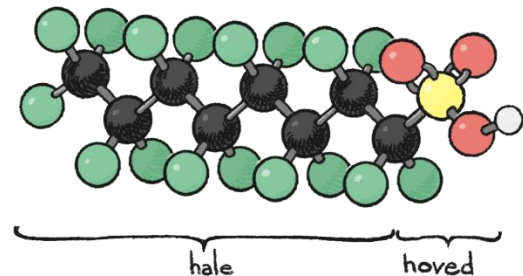
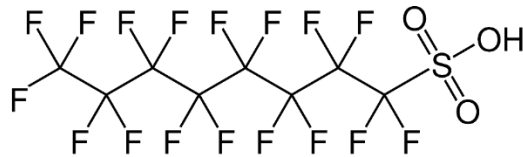
Outlet chamber

- Br: September 25
- Br + PFAS mix (baseline): October 25
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- Br + PFOA + CAC: April 26
- Br + PFOS + CAC: August 26

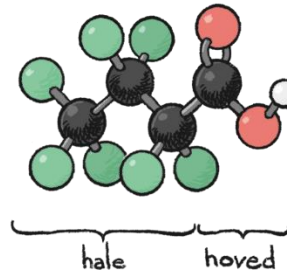
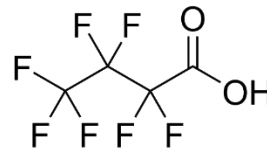
Selected compounds and concentration intervals

- Mix of short- and long chained PFCAs and PFSA's
- Concentration between 5-50 µg/L

PFOS



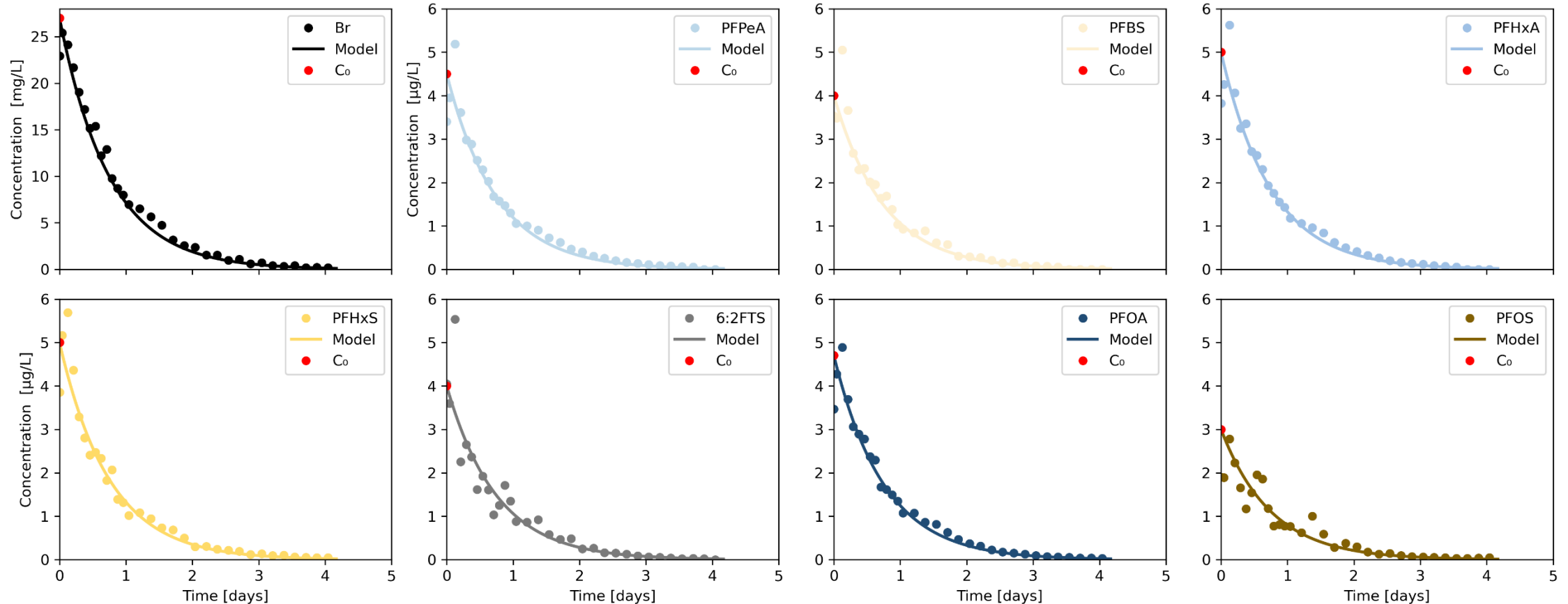
PFBA



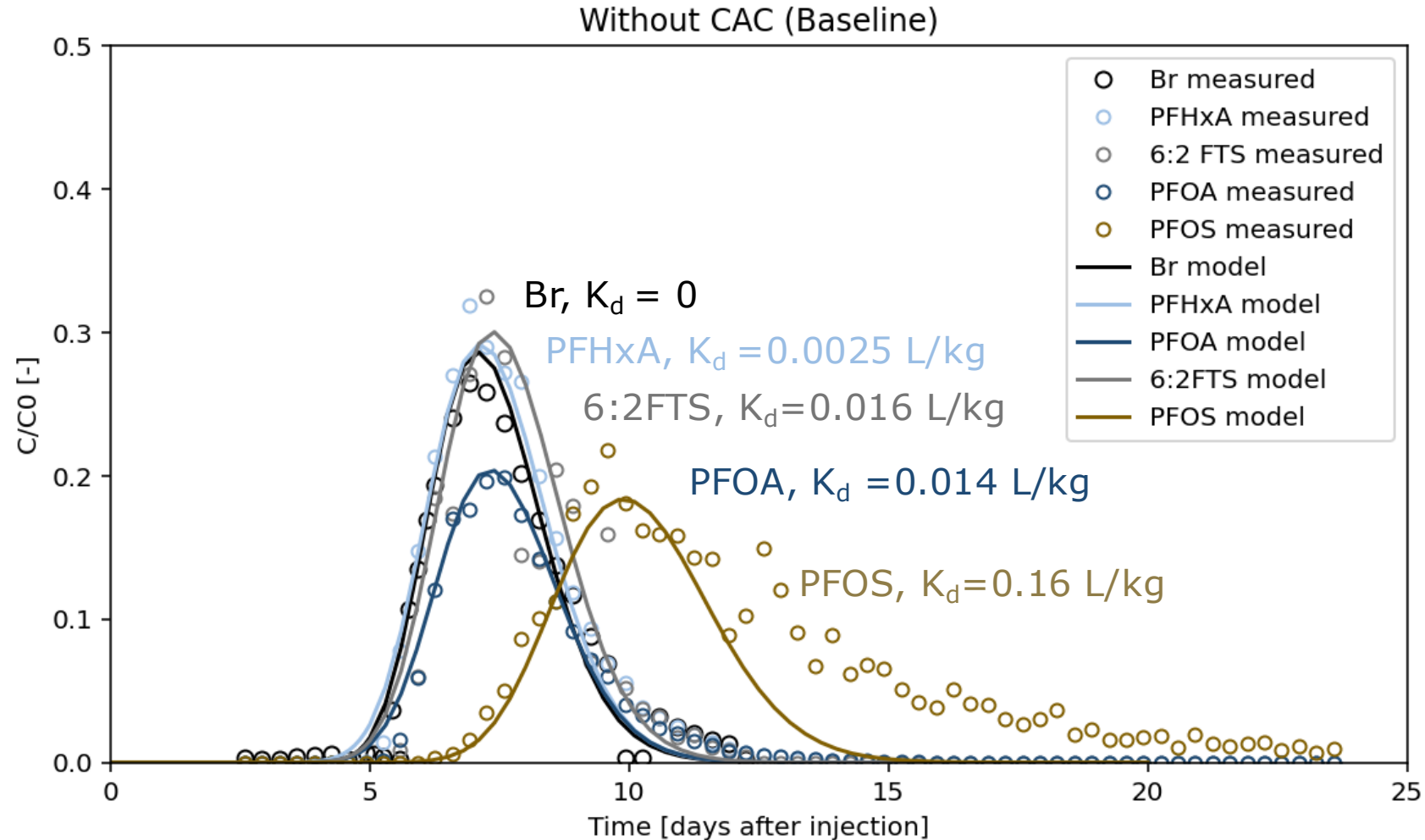
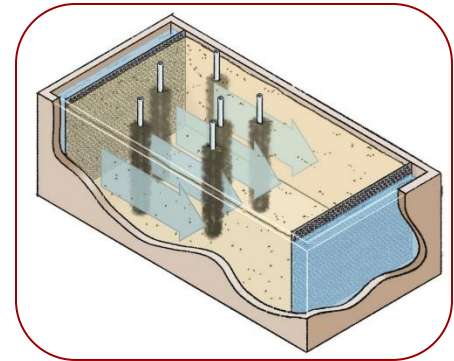
Compound	Chain length
Br	-
PFPeA	CF ₄
PFHxA	CF ₅
PFOA	CF ₇
PFBS	CF ₄
PFHxS	CF ₆
PFOS	CF ₈
6:2 FTS (precursor)	CF ₆ (C ₈)

Results from the inlet chamber

- Model = completely mixed flow reactor (CMFR)

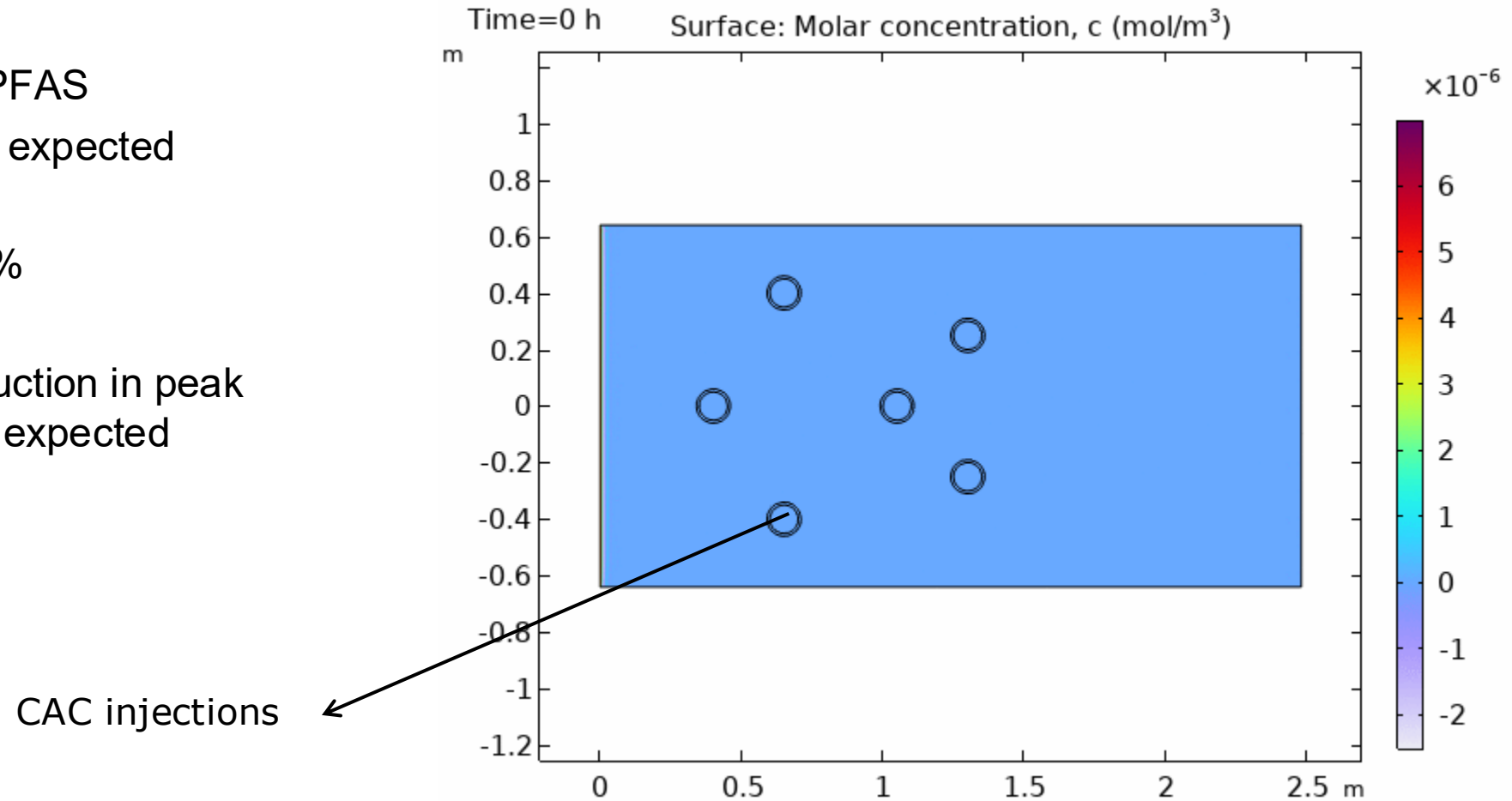


Results from the outlet chamber – without CAC

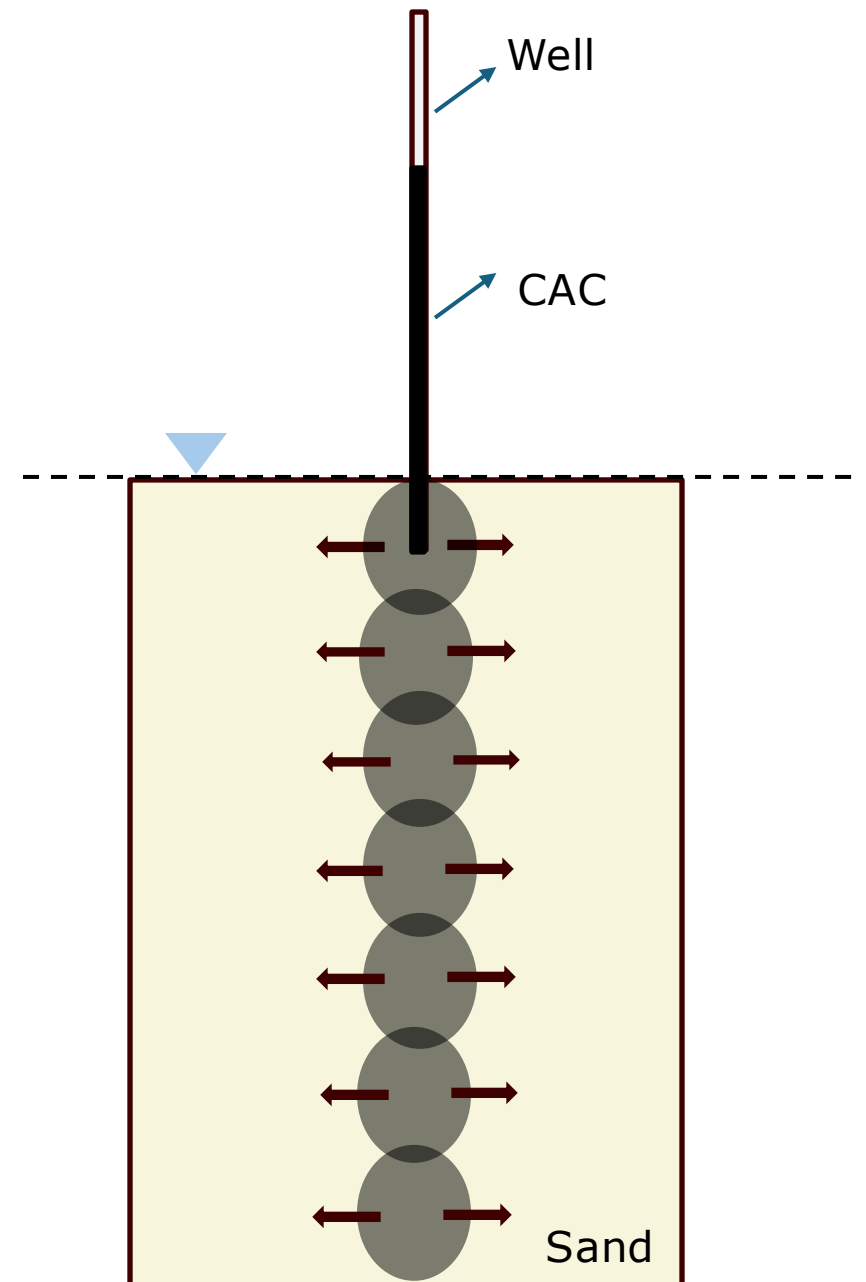
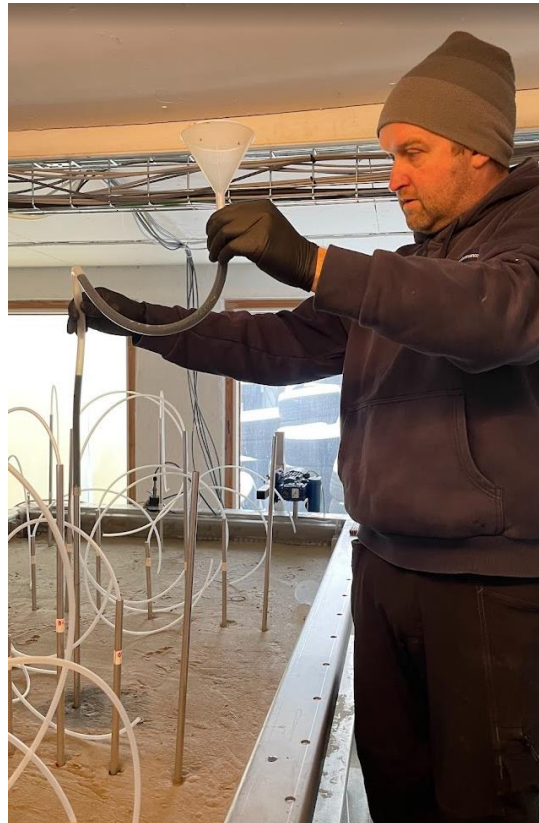


Final design with CAC

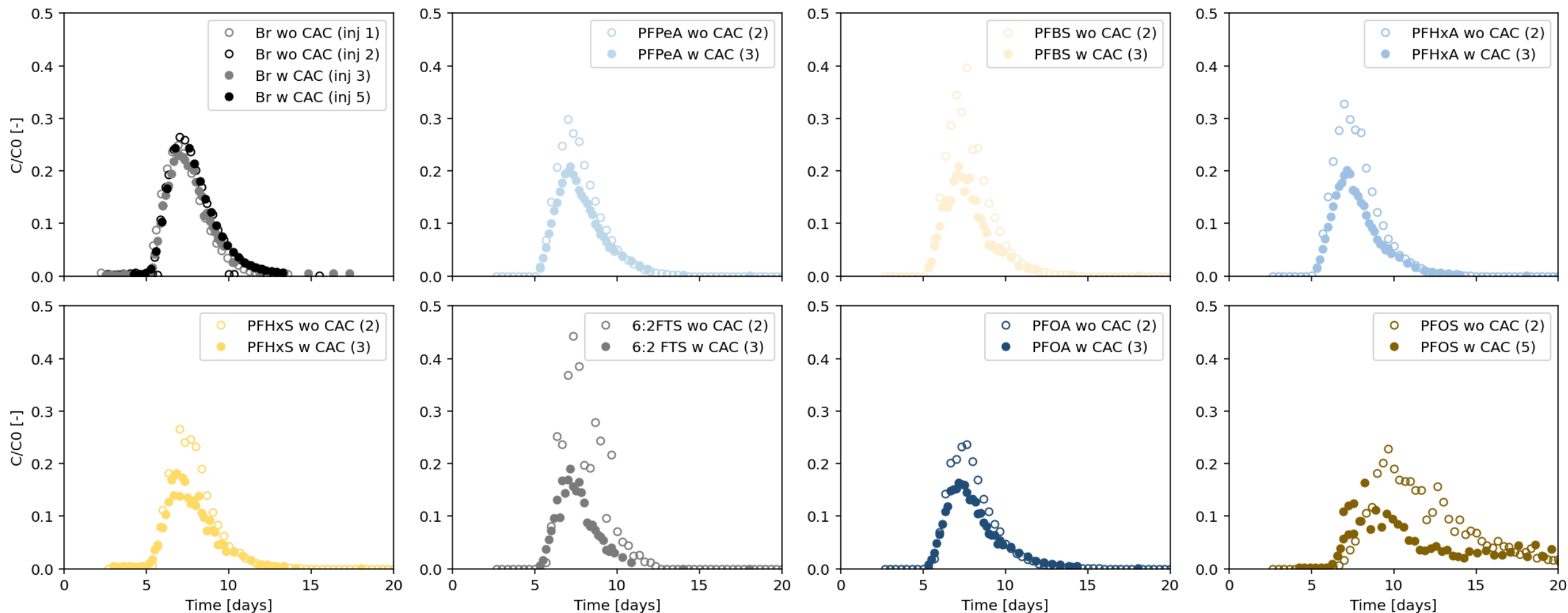
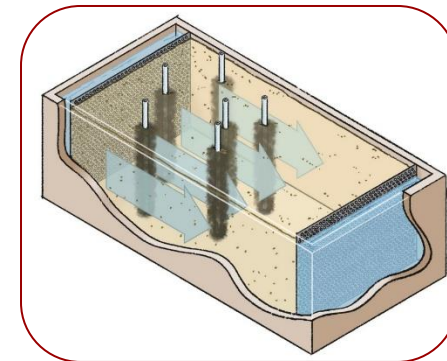
- $C_0 = 5 \mu\text{g/L}$ of 7 PFAS
 - Max sorption is expected
- Target $f_{\text{CAC}} = 0.01\%$
- Approx. 50% reduction in peak concentrations is expected



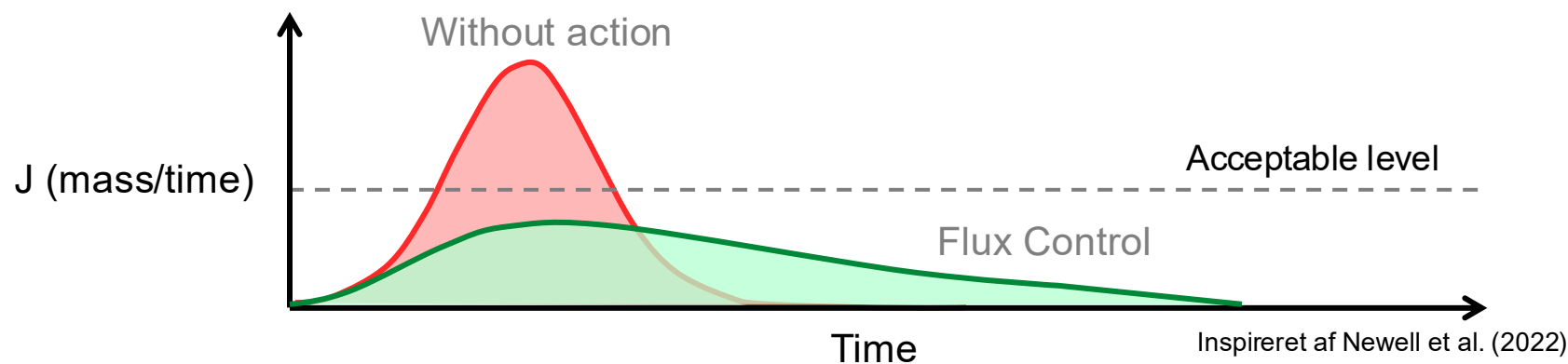
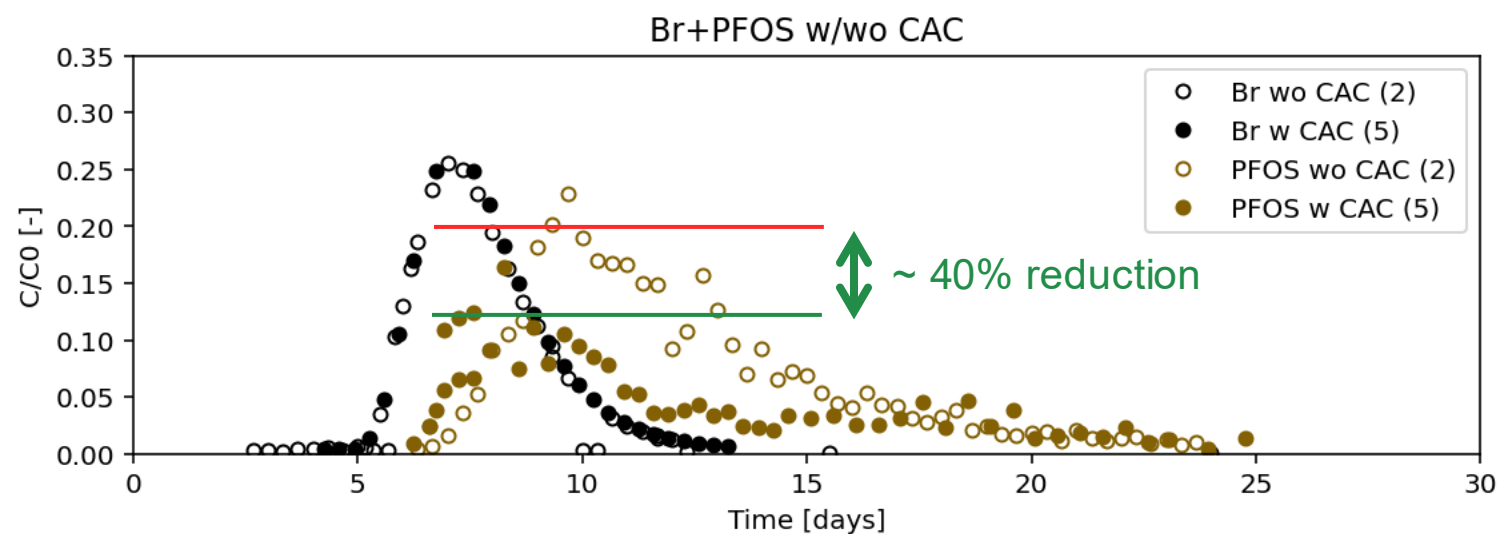
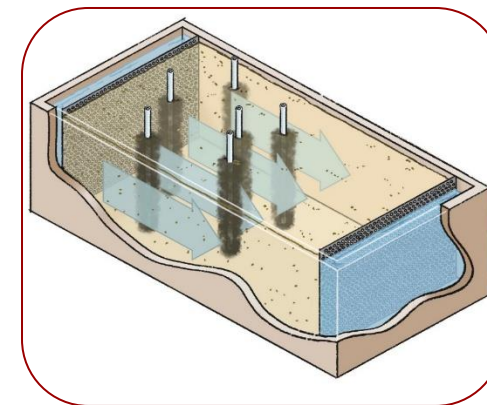
Injection of CAC – direct push



Results from the outlet chamber - with and without CAC

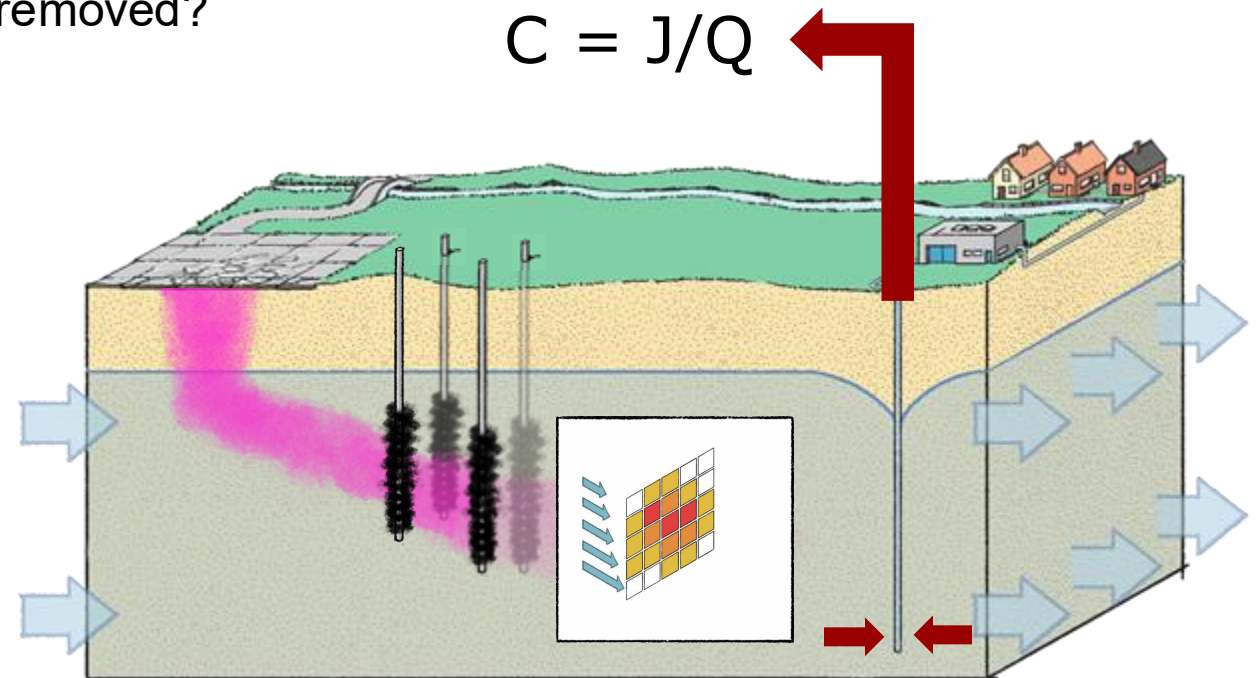


Breakthrough curves with CAC in the tank



Flux Control can reduce peak mass discharges

- PFAS is persistent in groundwater
- Enhanced retention can influence how they are transported
- Approximately 40% reduction in peak was observed
- Flux Control does not apply for all sites
- Can we accept that PFAS is not removed?



Thank you for listening!

Support

Simon Hansen (Region Hovedstaden)
Kim Franck Larsen (Region Hovedstaden)
Jens Schaarup Sørensen (DTU Sustain)

Funding

PFAS Center
The Capital Region

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if you are interested in knowing more.



Literature

- Adamson, D. T., Newell, C. J., Kulkarni, P., & Stroo, H. (2025). PFAS Monitored Retention: A Framework for Managing PFAS-Contaminated Groundwater Sites. *Groundwater Monitoring and Remediation*. <https://doi.org/10.1111/gwmr.70001>
- Newell, C. J., Javed, H., Li, Y., Johnson, N. W., Richardson, S. D., Connor, J. A., & Adamson, D. T. (2022). Enhanced attenuation (EA) to manage PFAS plumes in groundwater. *Remediation*, 32(4), 239–257. <https://doi.org/10.1002/rem.21731>
- “Vil spænde ben for PFAS før det når hanen”, 2026, nr 86, p. 18-21
https://issuu.com/dtudk/docs/dynamo_86?fr=sZmJjYzg3OTI3MTc (in Danish)