

# Challenges in modelling the effects of PFAS remediation measures

Insights from monitoring a colloidal activated carbon barrier in  
Örnsköldsvik, Sweden

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# Introduction

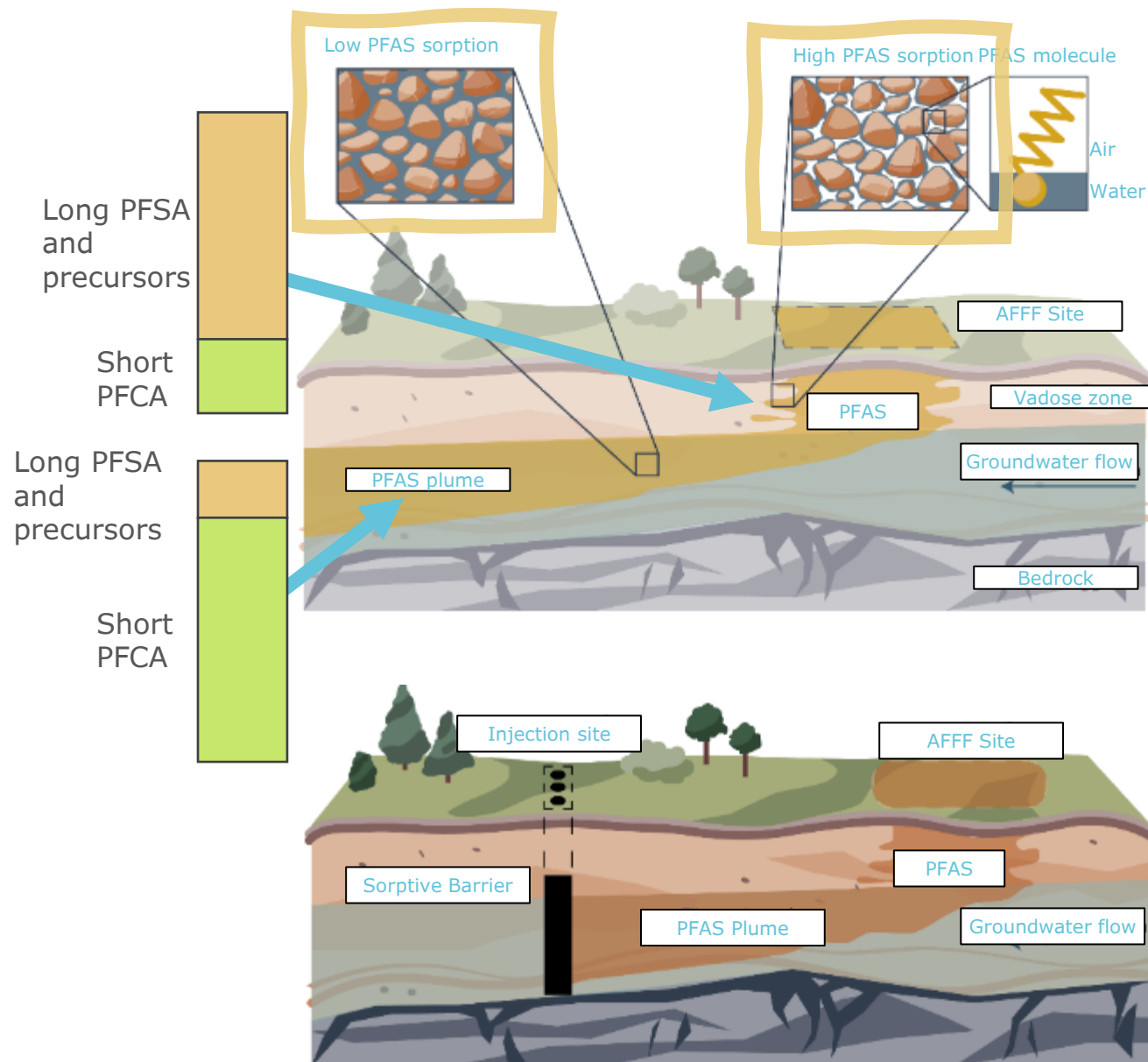
Many PFAS substances are very mobile in groundwater and considerably less mobile above the groundwater surface.

Air-water interface plays a significant role in the duration and timing of the impact.

Differences in the distribution of PFAS in soil versus groundwater may indicate that the composition of PFAS in groundwater will be different in the future.

SGI has an ongoing government assignment to develop/test remedial methods to increase the pace of remediation of PFAS-contaminated areas.

Among other things, the assignment tests stabilization with activated carbon. The results from three demonstration-scale pilot tests are currently being evaluated and reported.





## Focus today: AFFF site at Örnköldsvik Airport

Active fire-training site where AFFF was used from mid-1990's to 2008. **Case study site within PHISHES project.**

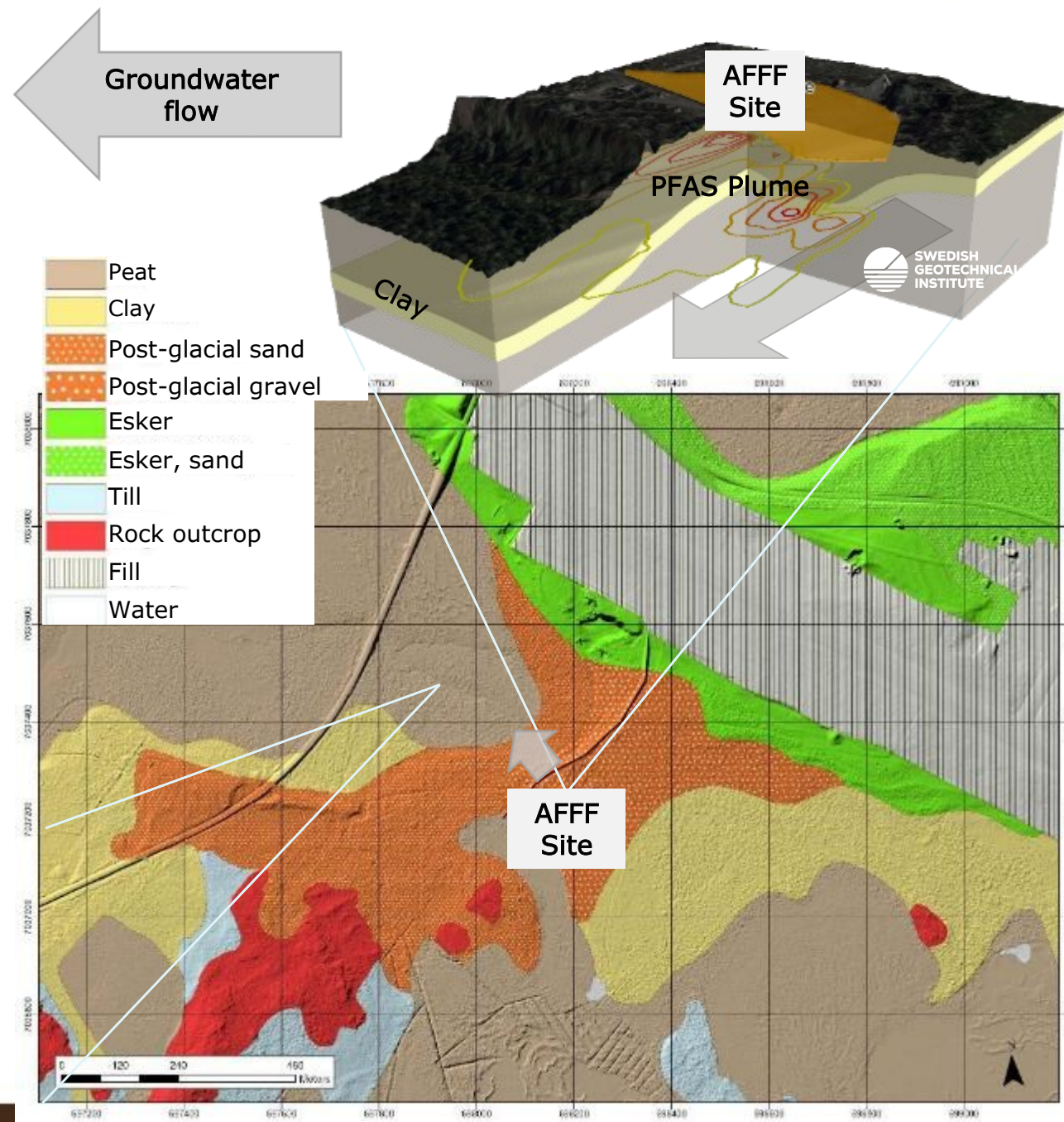
Site consists of glacial and post-glacial deposits with a complex but predictable hydrogeological setting.

Primary plume transported in unconfined aquifer consisting of post-glacial sand. PFAS concentrations affect water several kilometres downgradient.

A pilot site for limiting the spread of PFAS with an activated carbon barrier. Further site characterisation carried out during 2024.

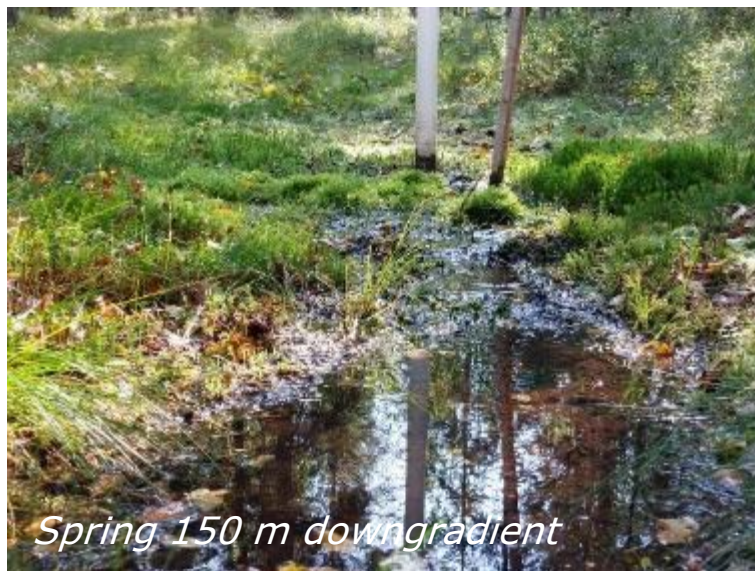


Photo: SGI, R. Earon





*Platform*



*Spring 150 m downgradient*



*Peatland*



*Training Area from south*



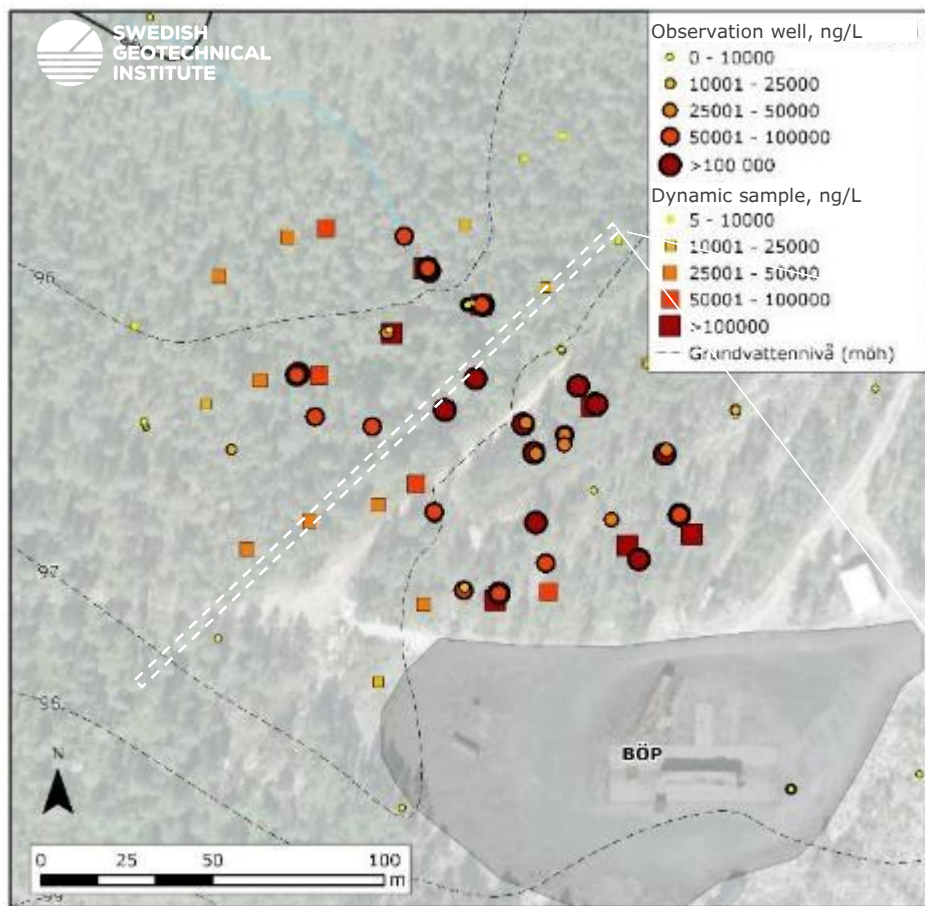
*Platform*



*Peatland*

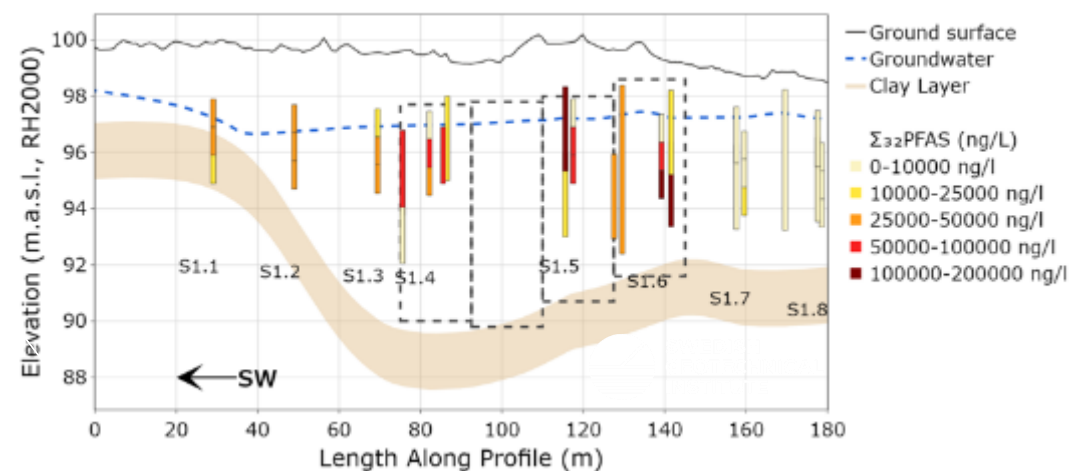


# Groundwater prior to Activated carbon injection



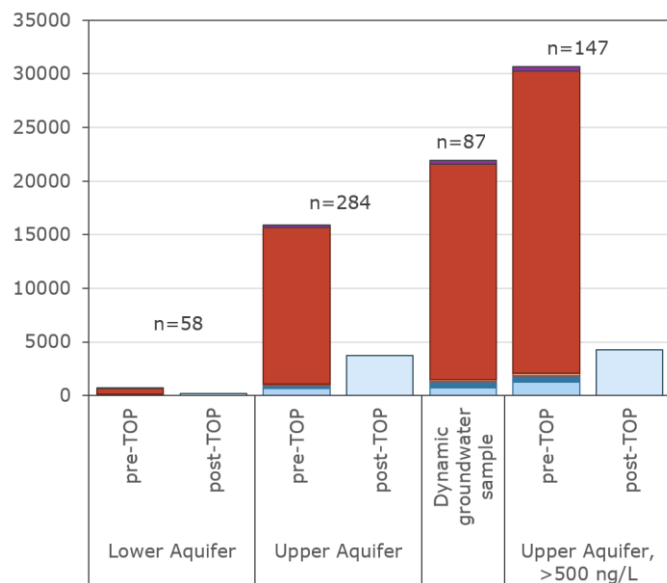
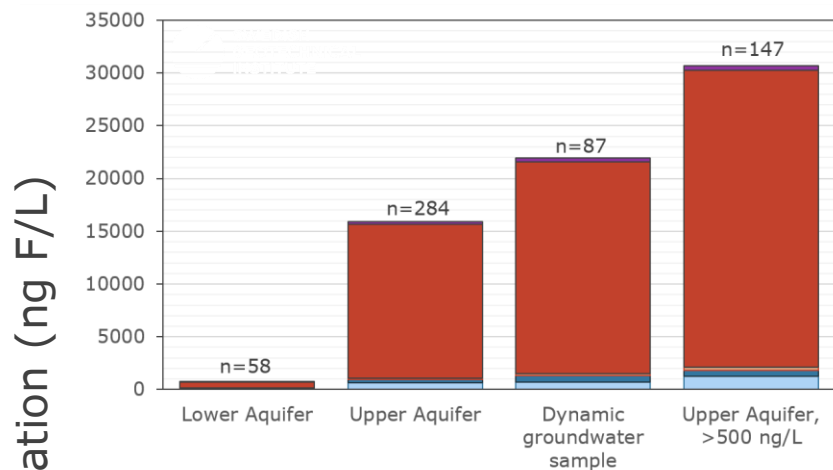
Groundwater concentrations over  
**200 000 ng/L  $\Sigma_{32}$ PFAS.**

Average concentrations approximately  
>45 000 ng/L in plume.





# Groundwater prior to Activated carbon injection



Groundwater concentrations over **200 000 ng/L  $\Sigma_{32}$ PFAS**.

Average concentrations approximately **>45 000 ng/L** in plume.

**>90% long PFSA, 4% short PFCA.**

Evidence of non-target precursors in groundwater.

- Short-chain PFCA
- Long-chain PFCA
- Short-chain PFSA
- Long-chain PFSA
- Target Precursor
- ΔPFCA (C4-C8)



# Installation of CAC Barrier

Barrier installed as a pilot test using colloidal activated carbon (diameter 2  $\mu\text{m}$ ) with high affinity for PFAS injected through direct push techniques.

Injection carried out between 20 Sept and 21 Nov 2023.

Barrier constructed with 3 rows injectate and 1 row “parking agent” ( $\text{CaCl}_2$ ).

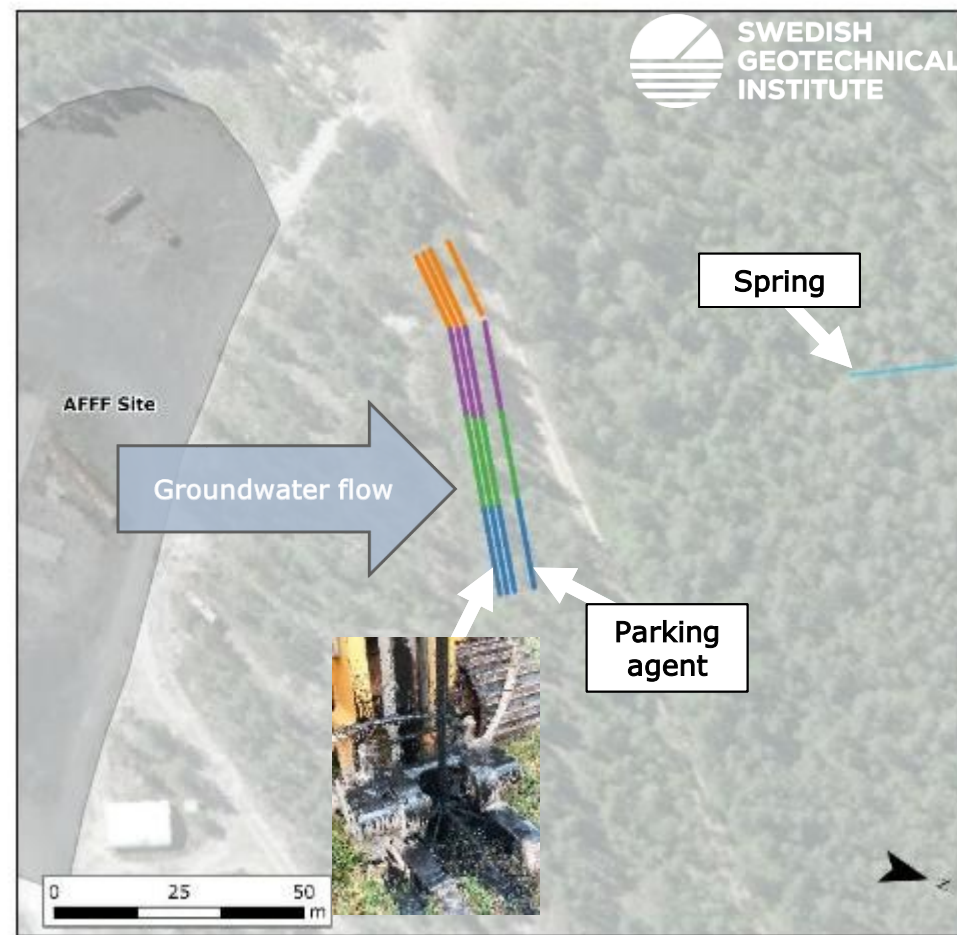
- 1.5 m point spacing, 47 pts/row.

- 4 injection zones.

- 5-6 m treatment horizon.

- 500-600 kg PlumeStop/pt.

76.7 tons PlumeStop injected



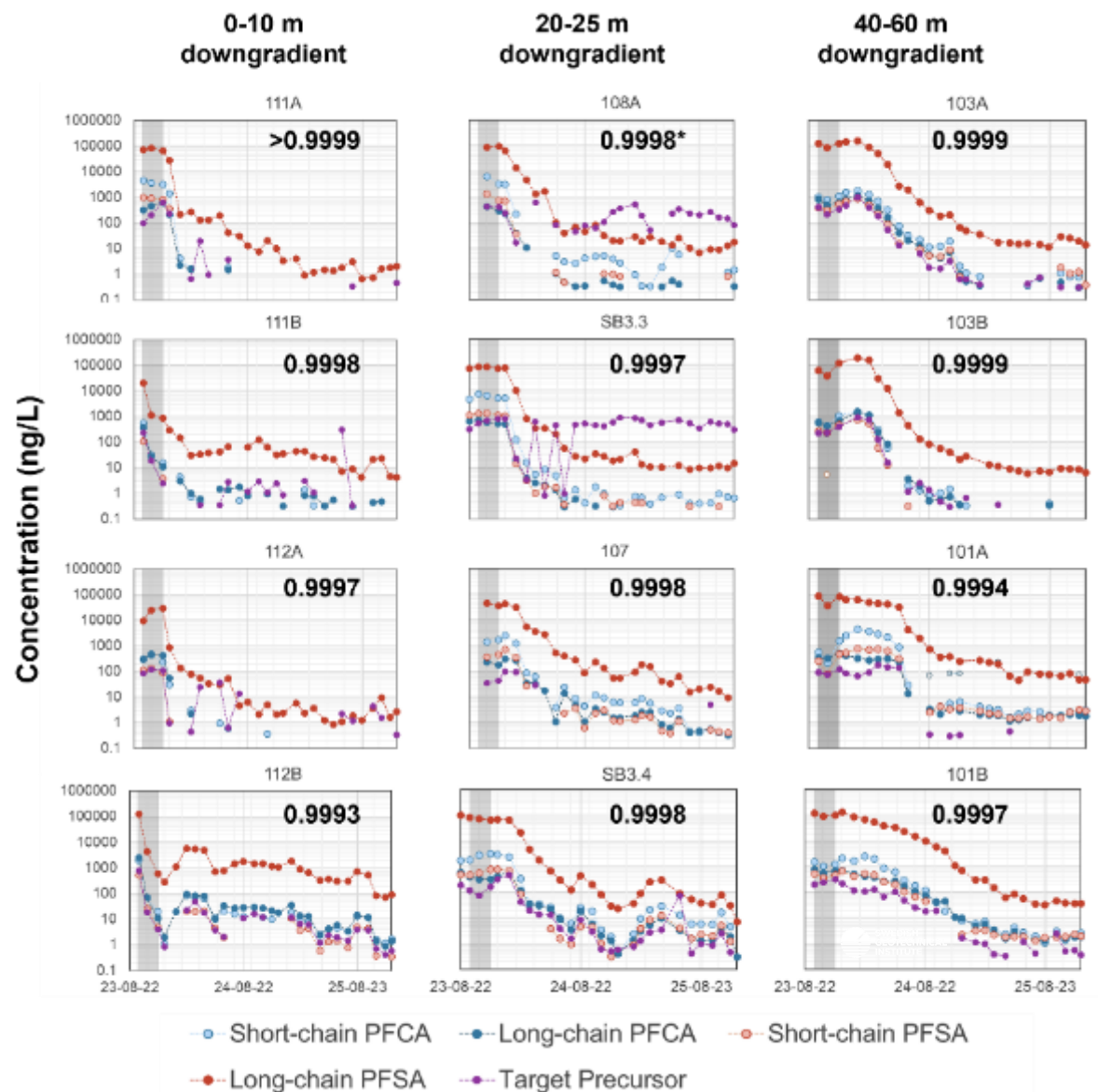
SWEREF 99 TM, Background: Lantmäteriet





## Effect of the barrier downstream

- The response is delayed, with timing dependent on distance.
- All monitoring wells expected to be impacted by the pilot test show **>99% reduction** in  $\sum_{32}$  PFAS compared with concentrations before barrier injection.
- Secondary sources may influence the observed effect downstream of the barrier.





## Seasonal variation

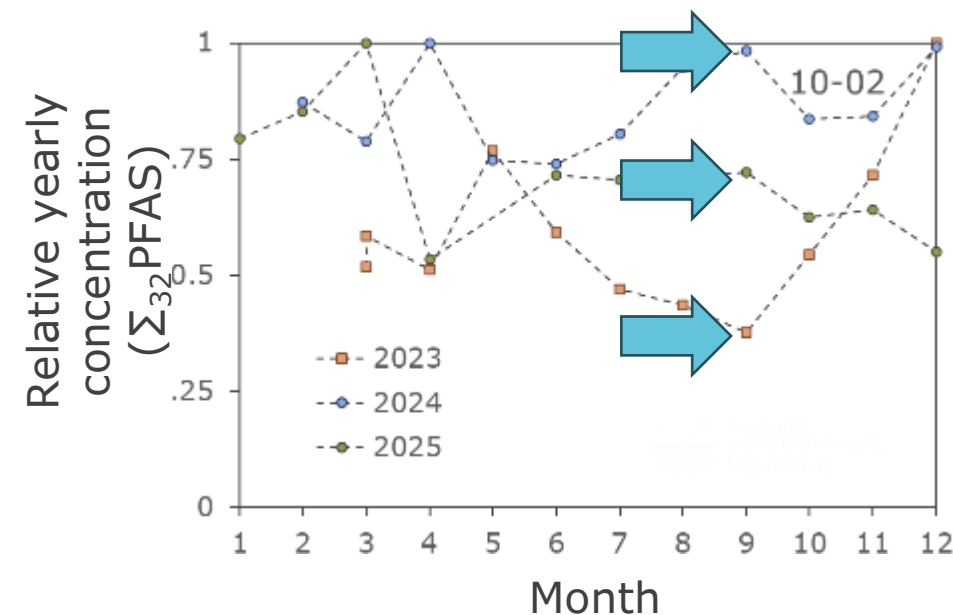
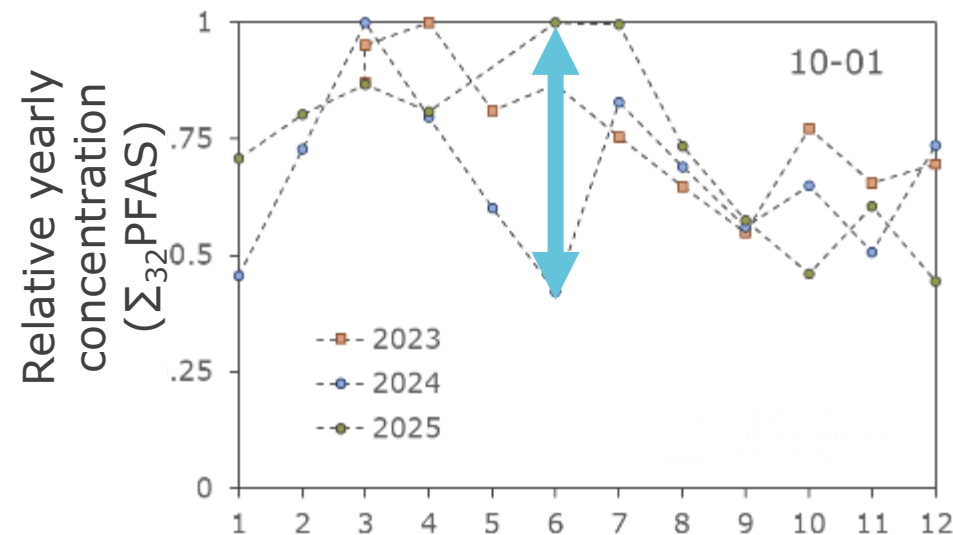
All observation wells show seasonality in groundwater PFAS concentrations

Concentrations can vary by a factor of 2 over the year.

Seasonal variations not consistent between years or between PFAS.

Recharge, flow, distance from source all impact the seasonality, but even wells equidistant from the source differ in impact.

*To right: relative concentration over the three-year observation period in two groundwater wells.*





## Seasonal variation

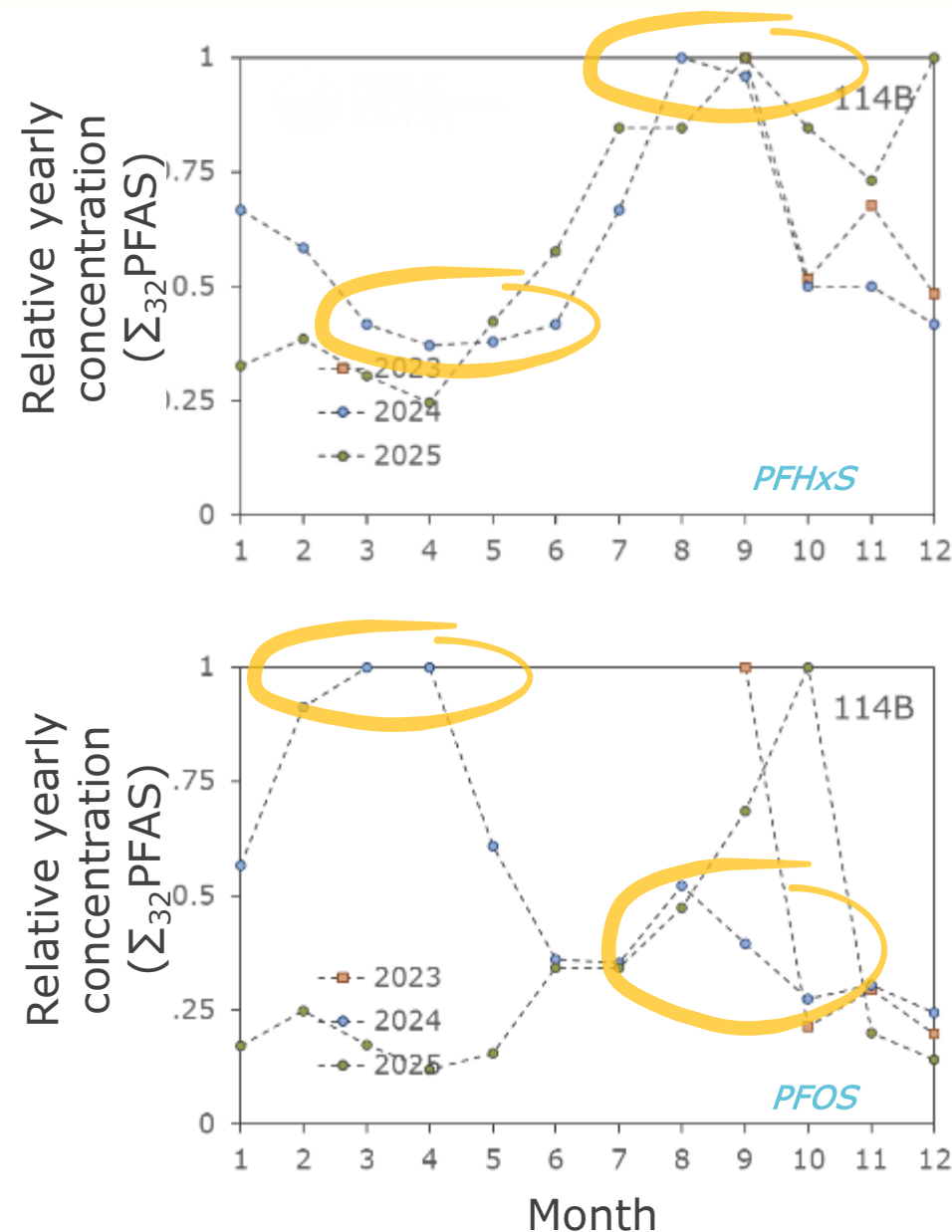
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*To right: relative concentration over the three-year observation period in two groundwater wells.*





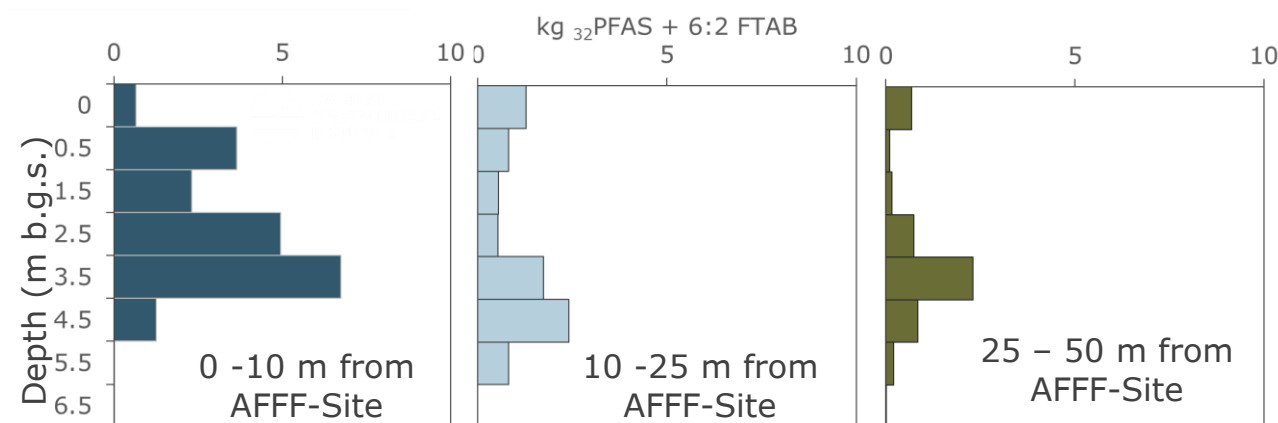
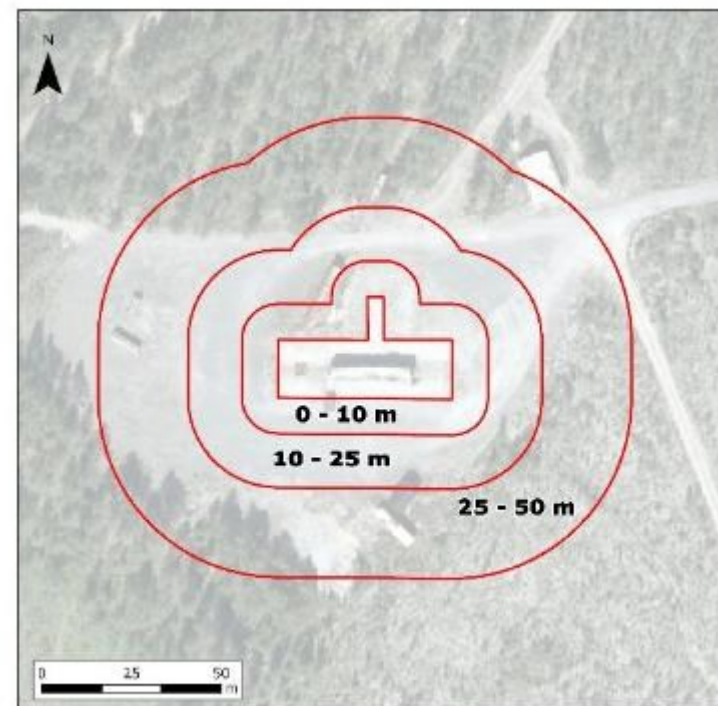
# Soil concentrations and their interactions with groundwater

Analyses of soil cores collected 2024.

~85% of identified PFAS mass within 25 m from concrete platform.

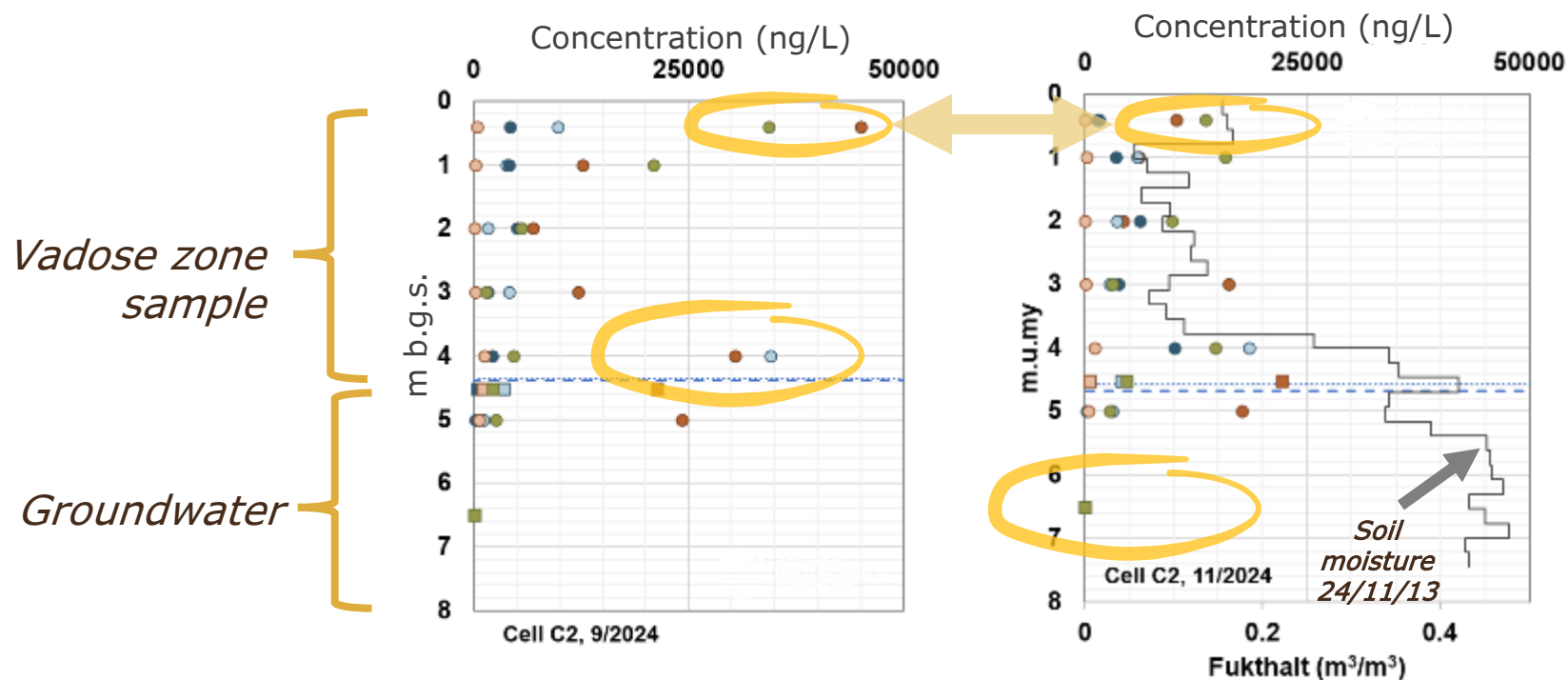
Roughly 50% of mass target precursors (compared with single-digit percent in groundwater).

PFAS concentrations decrease rapidly between 4-6 mbgs as saturated conditions rapidly mobilise and transport PFAS.

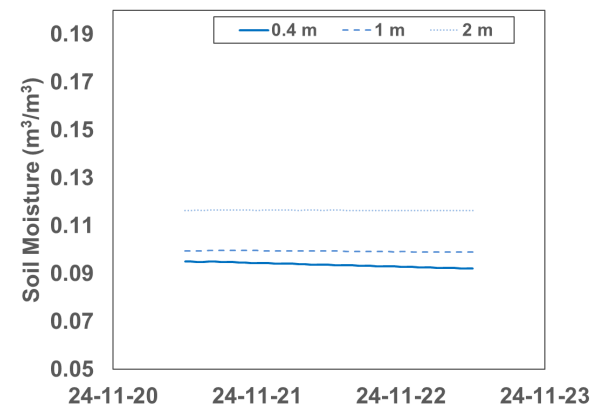
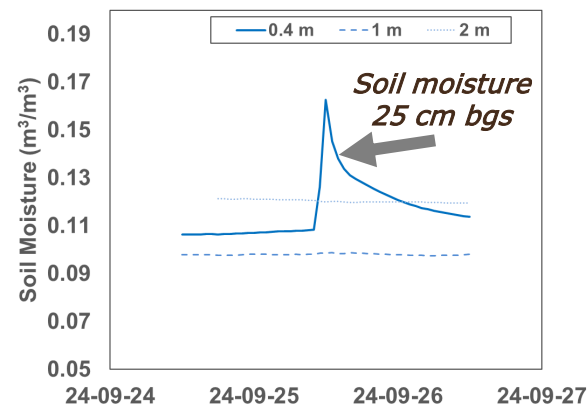




# Effect of soil moisture on PFAS concentration

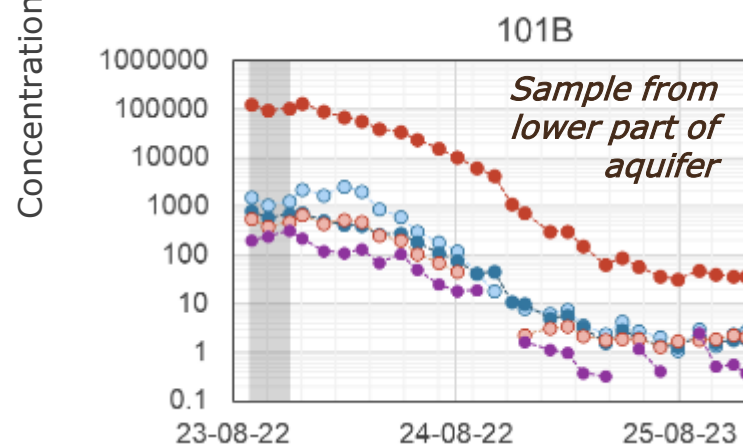
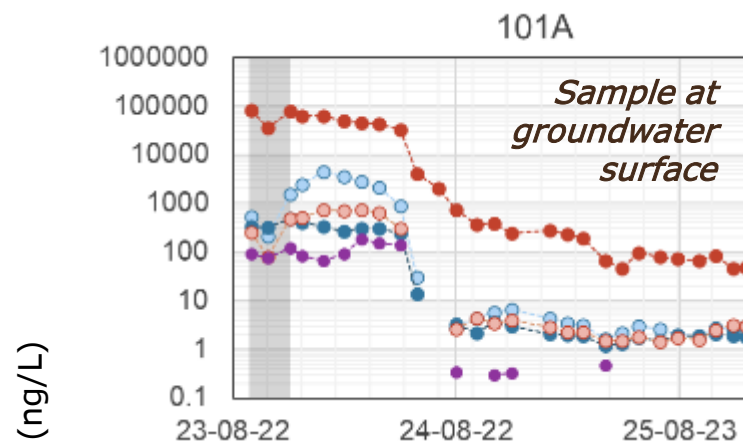


Soil moisture  
two days after  
pressurization  
of lysimeters

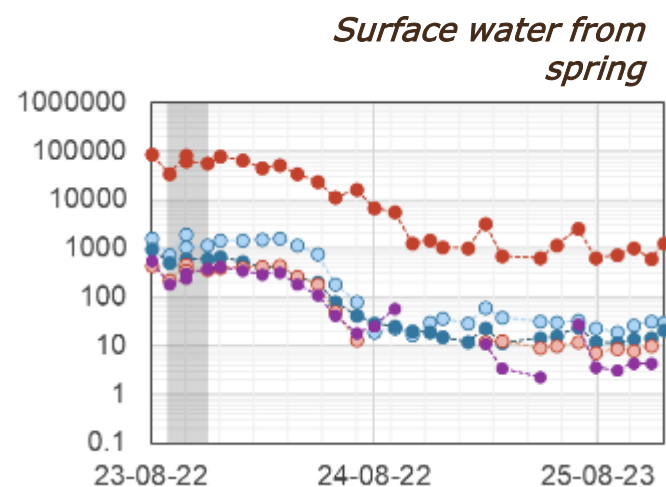




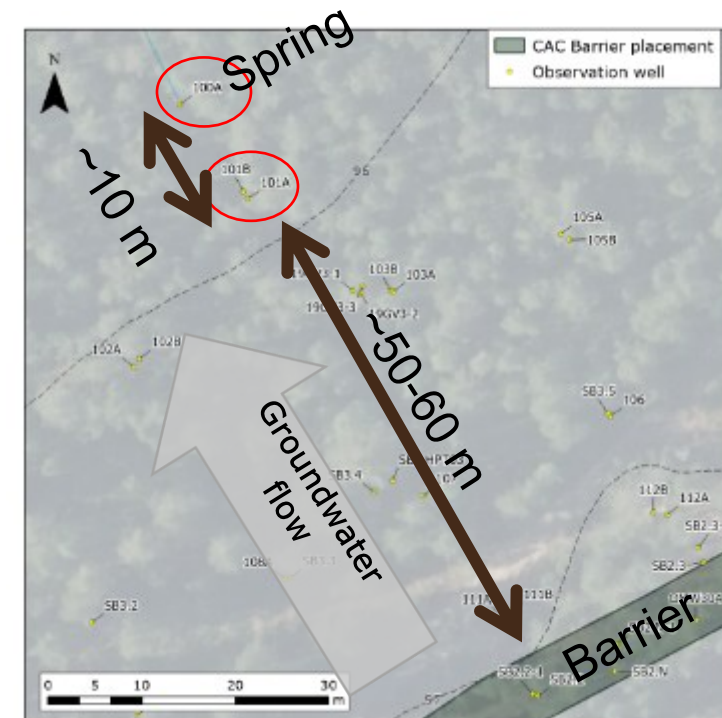
# The history of the plume in one slide



Groundwater



Surface water

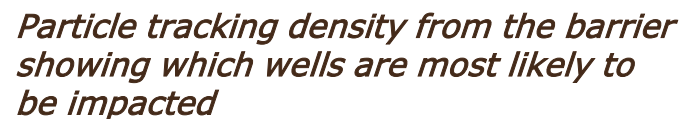


SWEREF 99 TM, Background: the Swedish mapping, cadastral and land registration authority

- Short-chain PFCA
- Long-chain PFCA
- Short-chain PFSA
- Long-chain PFSA
- Target Precursor



*Particle tracking density from the source zone showing how the barrier will interact with the plume.*



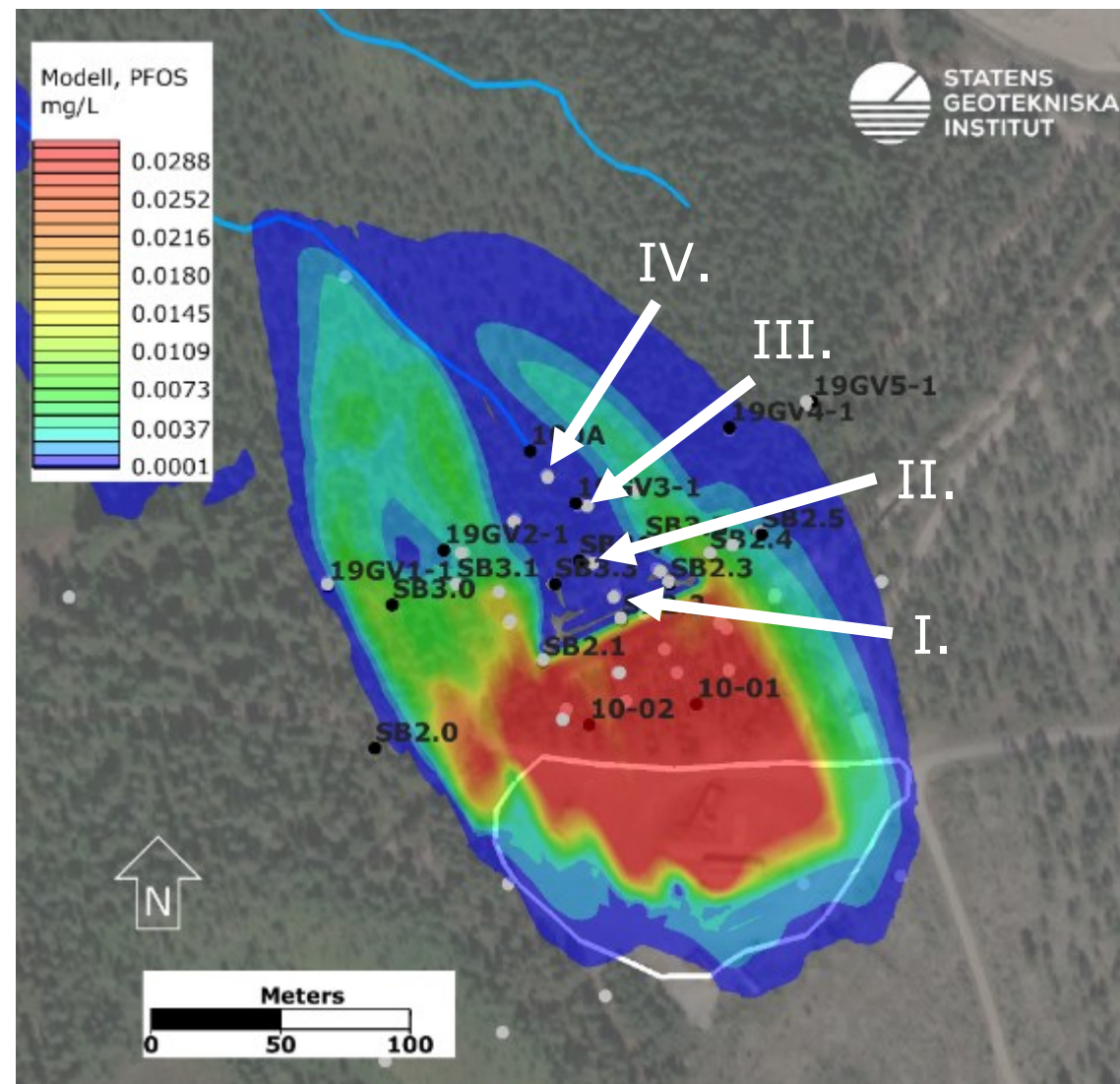
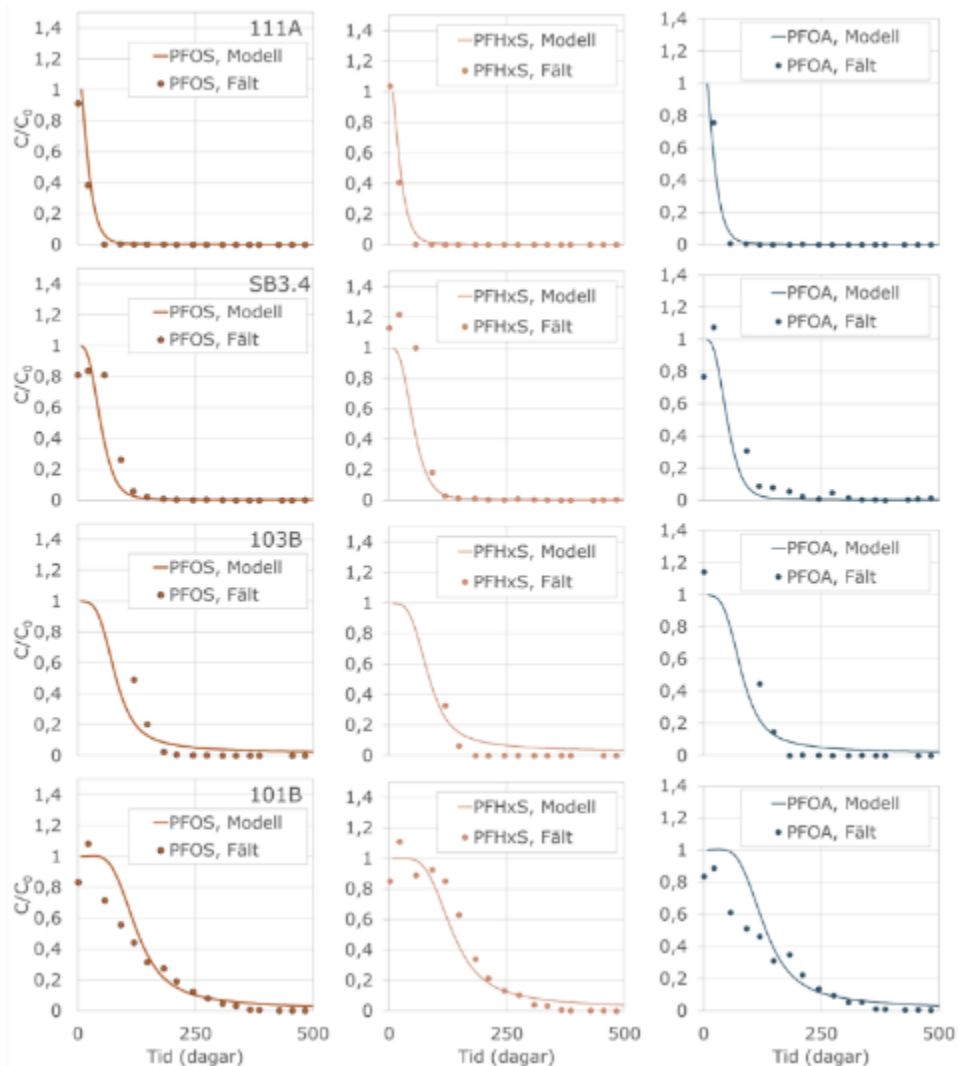


I.

II.

III.

IV.





## Lessons Learned from CAC Barrier in Örnsköldsvik

Activated carbon demonstrated to be an effective remediation technology to mitigate the spread of PFAS in groundwater.

The importance of attempting to quantify a holistic perspective of the contaminated site.

Verification and an iterative approach to site descriptive modelling increases likelihood of successful remediation.

Impact of spatial and temporal heterogeneity of great importance.

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