

Retour d'expérience : Évaluation du transfert des PFAS en zone non saturée et en zone saturée et stratégie de dépollution

Feedback: Assessment of PFAS transfer in unsaturated and saturated zones and remediation strategy

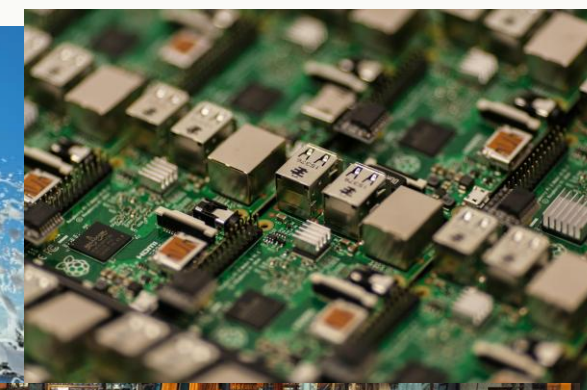
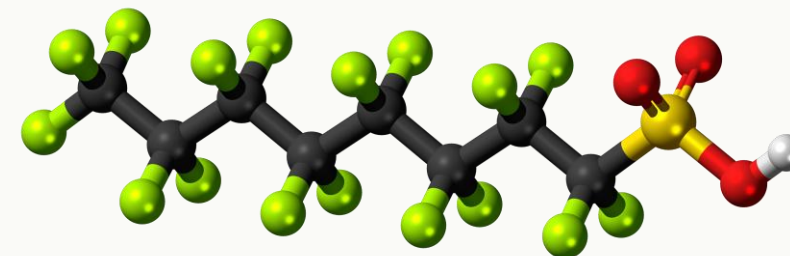
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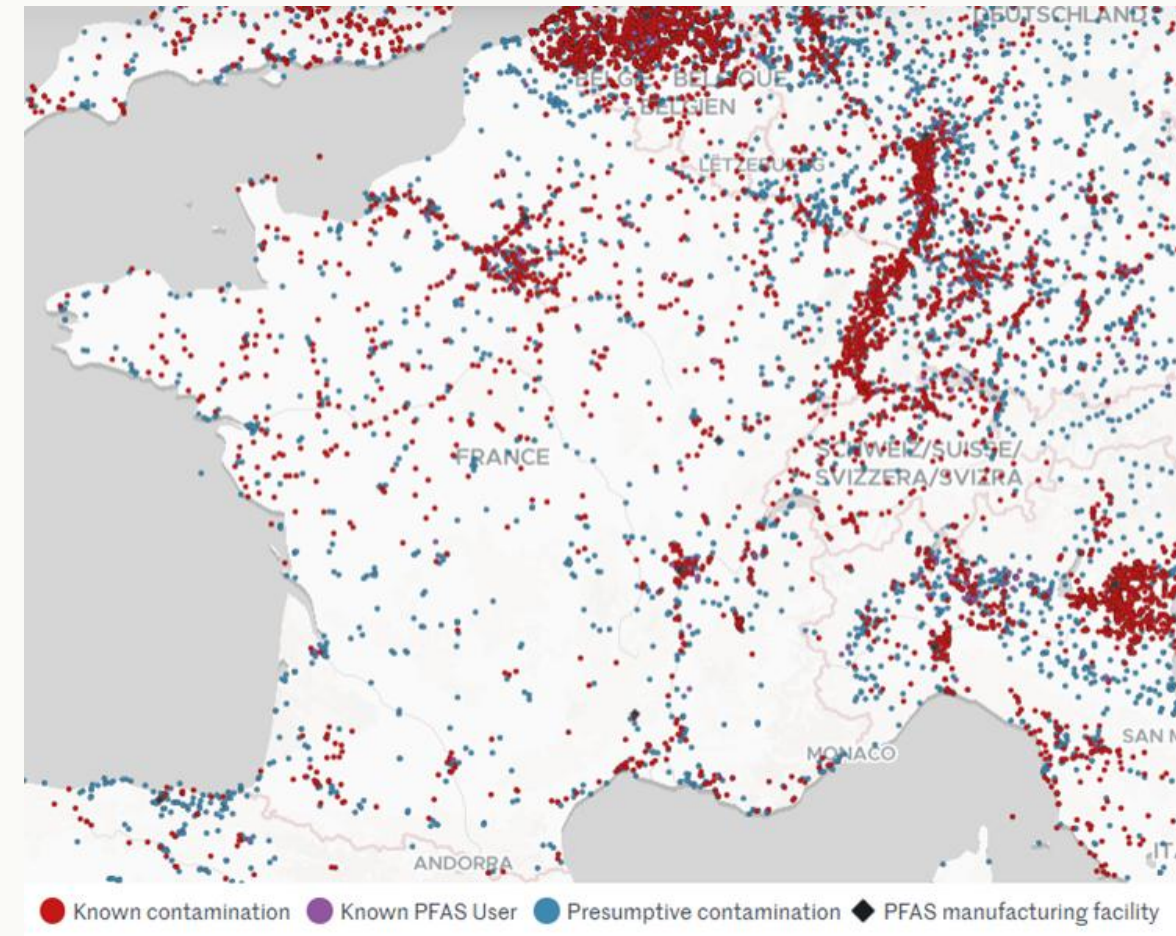
Context

- PFAS : Very large family, more than **10,000** species, characterized by fluorinated bound :
 - Uses: emulsifiers, **fire-fighting foams**, surface treatment, etc.
 - Health concern: carcinogenic, hepatotoxic, endocrine disruptor, etc.
 - Absent or limited natural degradation process:
 - « **Eternal pollutants** »
- Global pollution in Europe



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Regulation

International

- Currently 3 PFAS (PFOS, PFOA, and PFHxS) considered as Persistent Organic Pollutants (POPs): restriction of production and usage

European Union

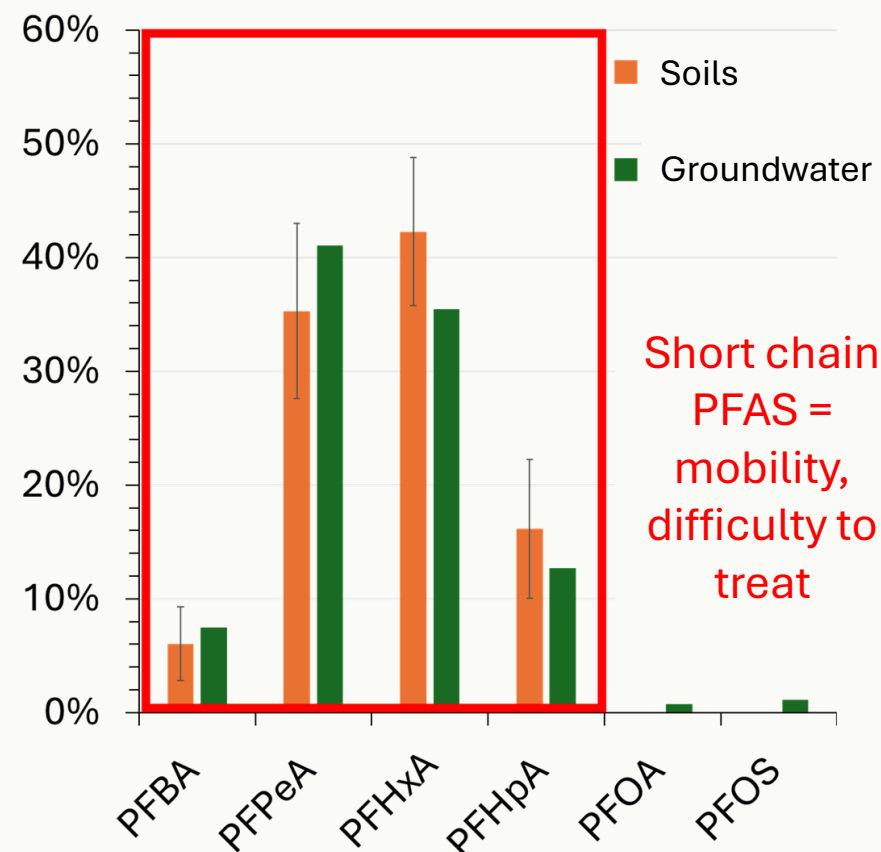
- Directive on the quality of water intended for human consumption
 - By 2026, values of **0.1 ug/L for the sum of 20 PFAS** or 0.5 ug/L for total PFAS.
- **REACH** Regulation
 - Proposal of restriction for more than 10,000 PFAS

Lack of regulation values in soils

Description of the site

- Industrial site burned
 - PFAS contamination by **firefighting foams**
- Currently PFAS impacts detected in:
 - **Soils**
 - **Groundwater**
- PFAS pollution of moderate intensity:
 - Groundwater contamination max 15µg/L for the sum of 20 PFAS
 - Pollution mainly composed of **short chains**

% of contamination



Objectives



In the absence of regulation values for soils, should PFAS contamination of soils be treated?

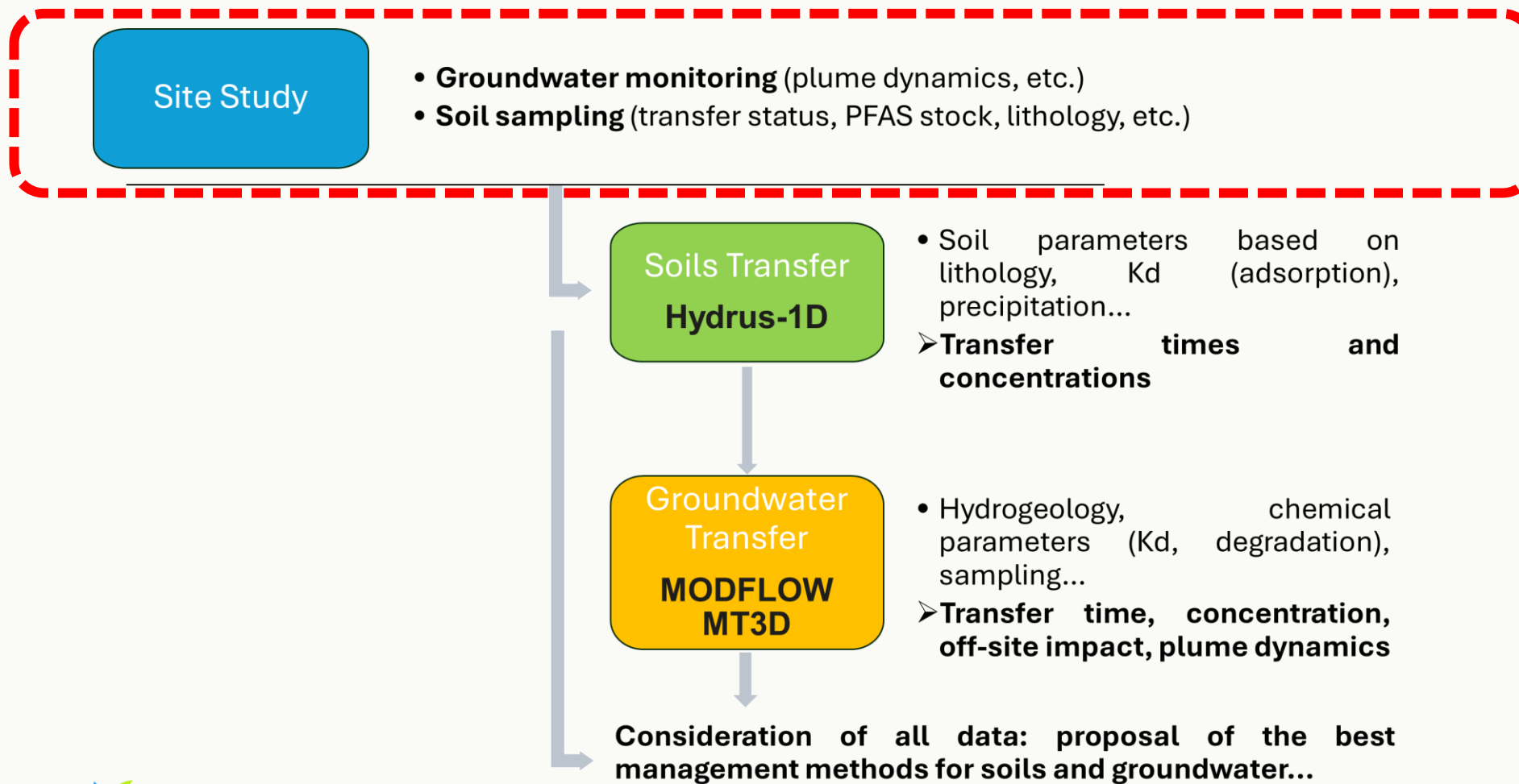


Determine the risks of off-site transfer of the aquifer to determine the permissible concentration values on site



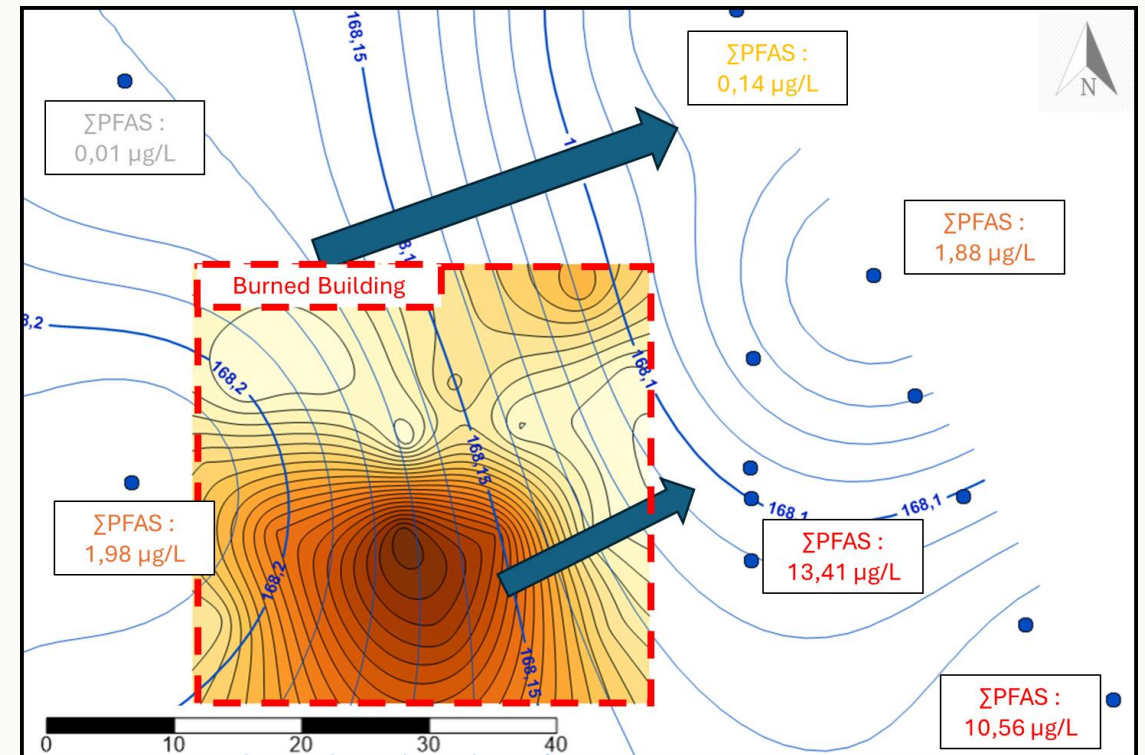
Study the transfer in the soils and the aquifer to determine if soils require treatment

Methodology



Site study

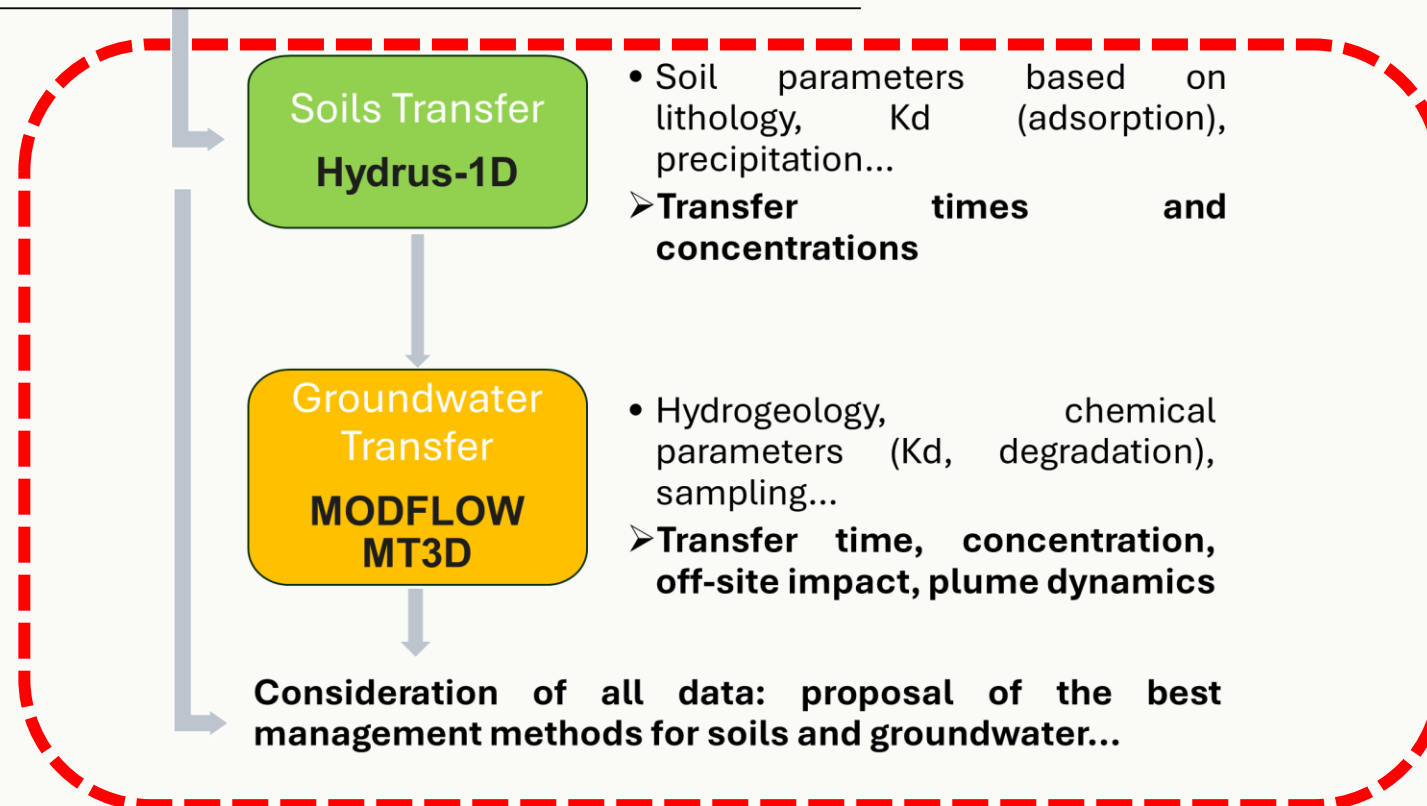
- Heterogeneous soils with alternating silty-clay complexes with clayey-sandy horizons, and the presence of gravelly, sandy passes
- **A rapid transfer path** to the aquifer through sandy heterogeneities
- **A slower transfer path** to the aquifer through clayed horizons
- Significant concentrations of PFAS in the soil in the **first 4 meters**
- Distribution in accordance with the groundwater direction to the northeast



Methodology

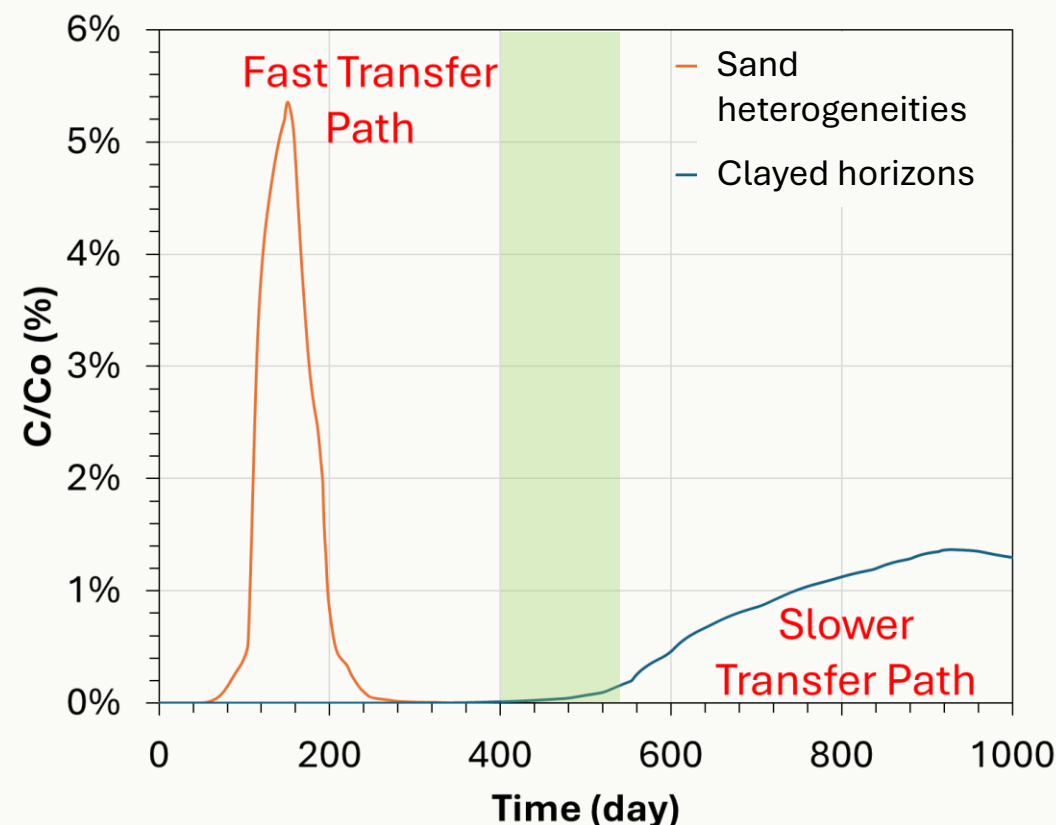
Site Study

- **Groundwater monitoring** (plume dynamics, etc.)
- **Soil sampling** (transfer status, PFAS stock, lithology, etc.)



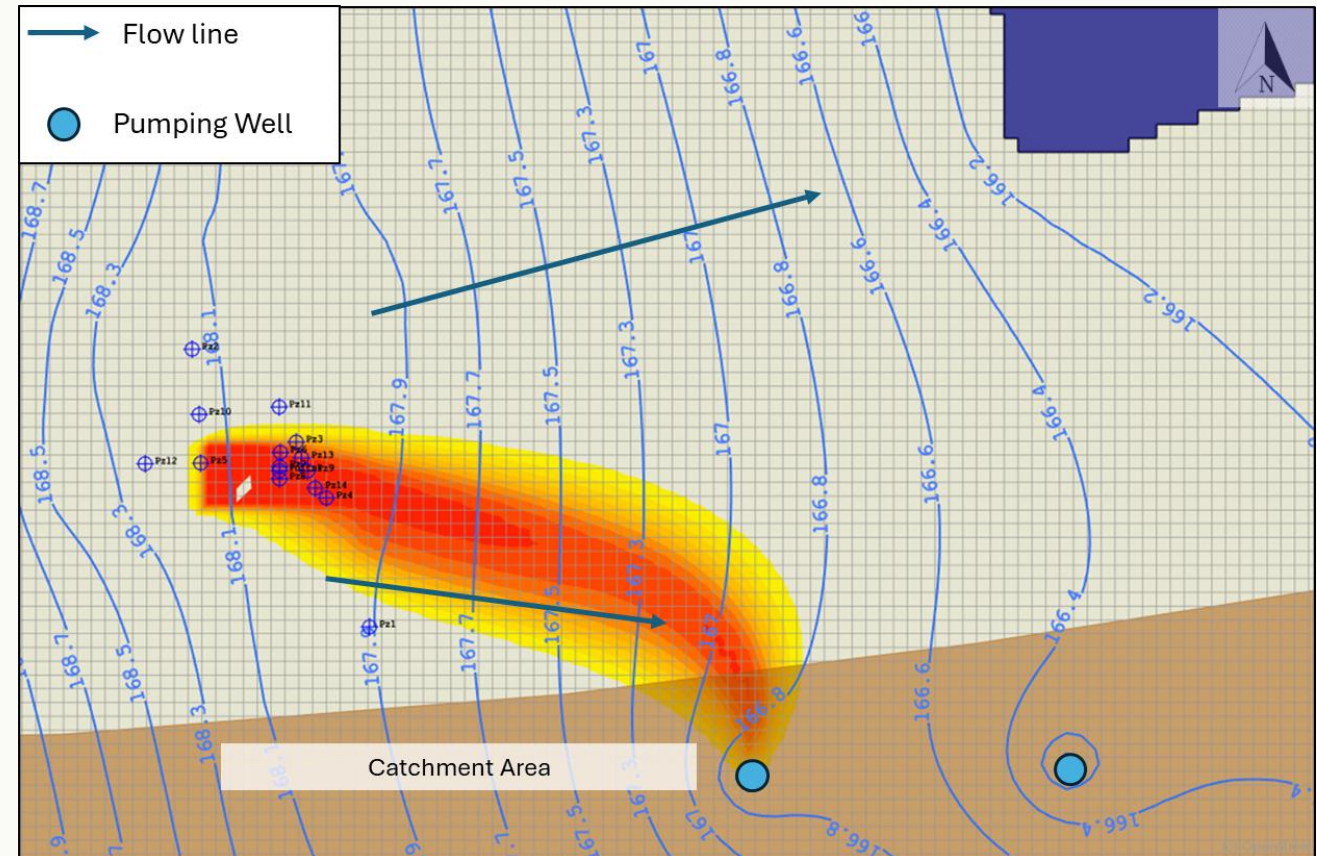
Soils transfer

- **Hydrus 1D** modelling of different soil profiles from soil drilling
 - Rapid transfer (< 1 year) through sandy heterogeneities
 - Slow transfer (> 3 years) through clay horizons, which may release pollutants over several years
- Consistent with our monitoring
- Most of the transfer is still in progress (stock between 0-4 m)
 - **Possibility of treating the concentrated source in soils to stop transfer to the groundwater**



Groundwater transfer

- Evaluation with **MODFLOW** of the off-site risk of transfer
- Weak mitigation of the PFAS plume => no degradation only diffusion and dilution
- **Drinking water catchment area** near the PFAS plume
 - **Displacement risk** of the PFAS plume near pumping area
 - **Action to avoid drinking water contamination**
 - Groundwater Pumping



Integration of results

Site Study

First rapid PFAS peak due to preferential transfer in sands

Slow diffusion over several years by migration through the clayed horizon

Risk Evaluation

High risk of off-site impact without treatment (presence of drinking water catchment areas)

Threshold value for the off-site groundwater : **0.1 µg/L for the sum of 20PFAS**

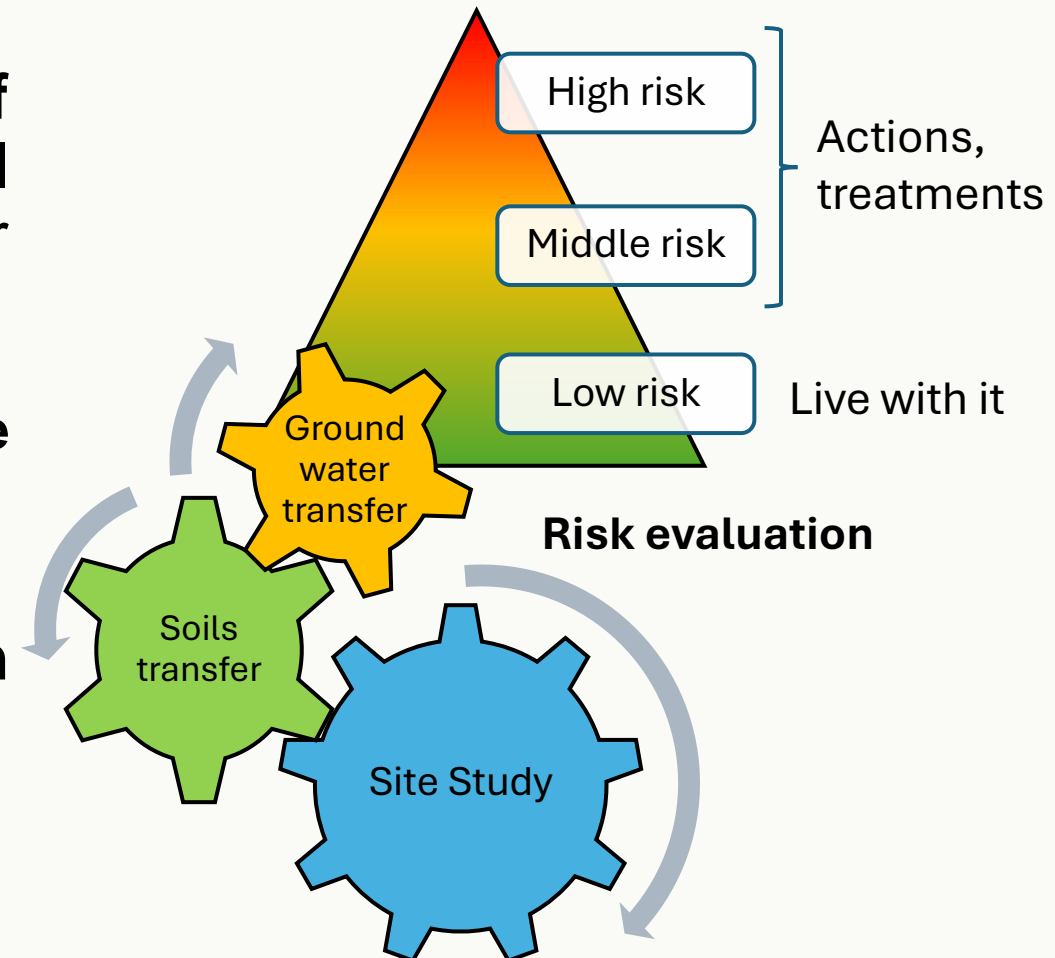
Risk of exceeding thresholds for many years

Recommendation

- **Groundwater pumping and treatment**
- **Treatment of concentrated sources in soil**

Conclusion

- Approach based on the **combination of field data acquisition and numerical modeling** of soils and groundwater transfers
 - **Choice of a threshold values based on the off-site targets identified (pumping well...)**
- Recommendation of treatment based on the evaluation of risk considering:
 - **Times of contamination**
 - **Concentration in groundwater**
 - **Off-site usage**



Perspectives

- Rapid changes in regulatory frameworks, acceptance thresholds for treatment processes...
 - At present, there are no PFAS reference values for soils, and remediation thresholds values are determined on a case-by-case basis according **the evaluation of the risks**
- Currently 20 PFAS monitored, but what about other molecules?
 - Limited analytical lists and costly analyses
 - **Possible evaluation by TOP assays (Oxidizable Precursors)**