PFAS
PER- AND POLY-FLUOROALKYL SUBSTANCES
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Gestion des Risques Environnementaux & Sanitaires

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

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

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Context

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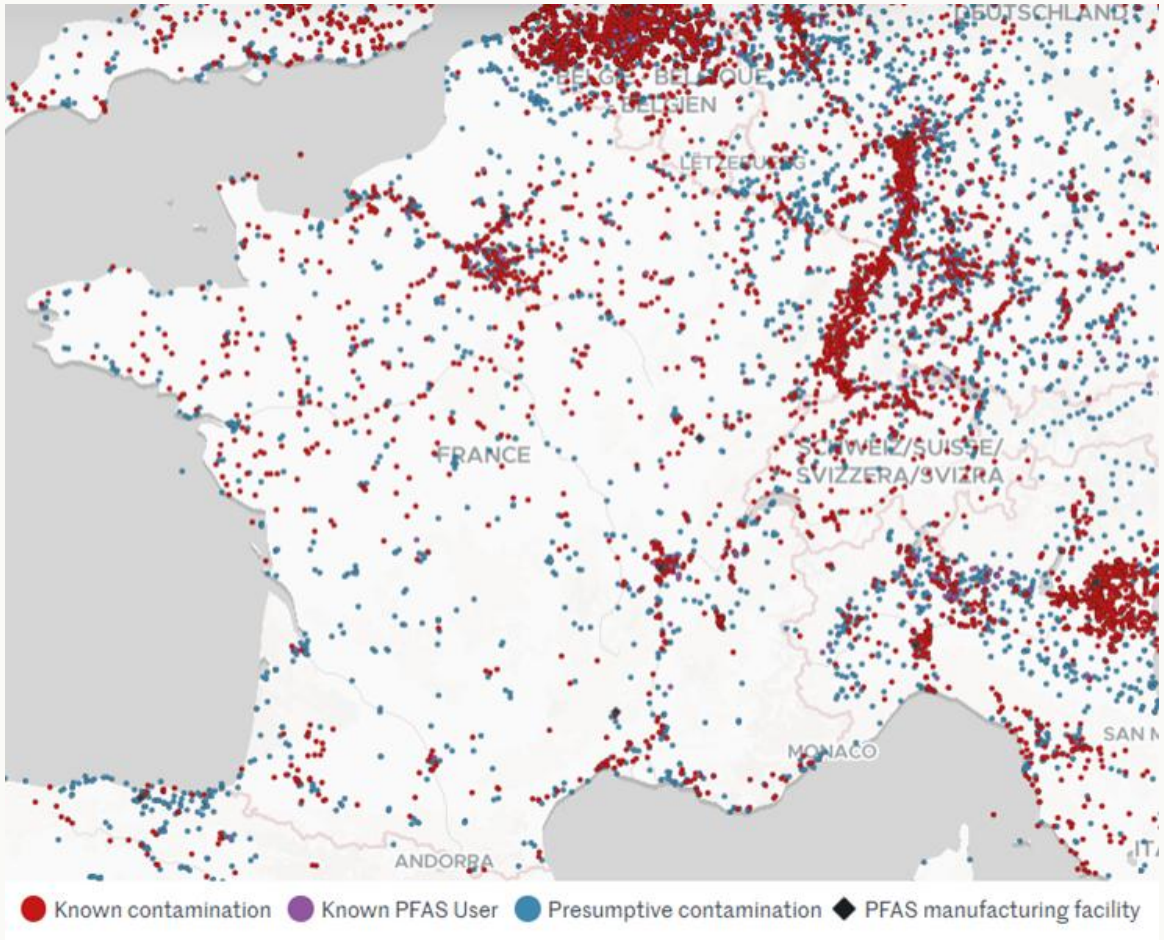
- PFAS : Very large family, more than **10,000** species, characterized by fluorinated bound :
  - Uses: emulsifiers, **fire-fighting foams**, surface treatment, etc.
  - Health concern: carcinogenic, hepatotoxic, endocrine disruptor, etc.
  - Absent or limited natural degradation process:
    - ➢ **«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



Regulation

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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
  - PFOA and PFOS restriction in firefighting foam
  - Restriction of the use and marketing of chain PFAS between 9 and 14 C
  - Proposal of restriction for more than 10,000 PFAS

Lack of regulation values in soils

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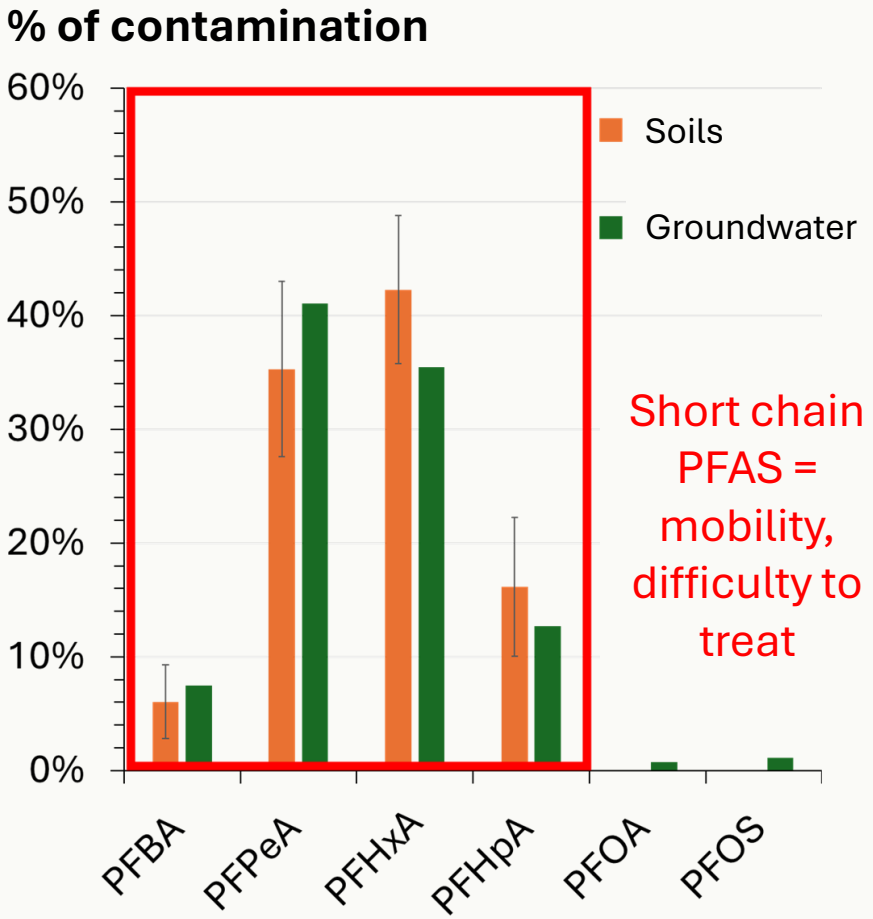
Description of the site

- 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**



Objectives

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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 ZNS and ZS to determine **threshold values for the soil treatment**, considering the duration of the treatment

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Methodology

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Site Study

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

Soils Transfer
Hydrus-1D

- Soil parameters based on lithology, Kd (adsorption), precipitation…
- ➢ **Transfer times and concentrations**

Groundwater Transfer
MODFLOW MT3D

- Hydrogeology, chemical parameters (Kd, degradation), sampling…
- ➢ **Transfer time, concentration, off-site impact, plume dynamics**

Consideration of all data: proposal of the best management methods for soils and groundwater…

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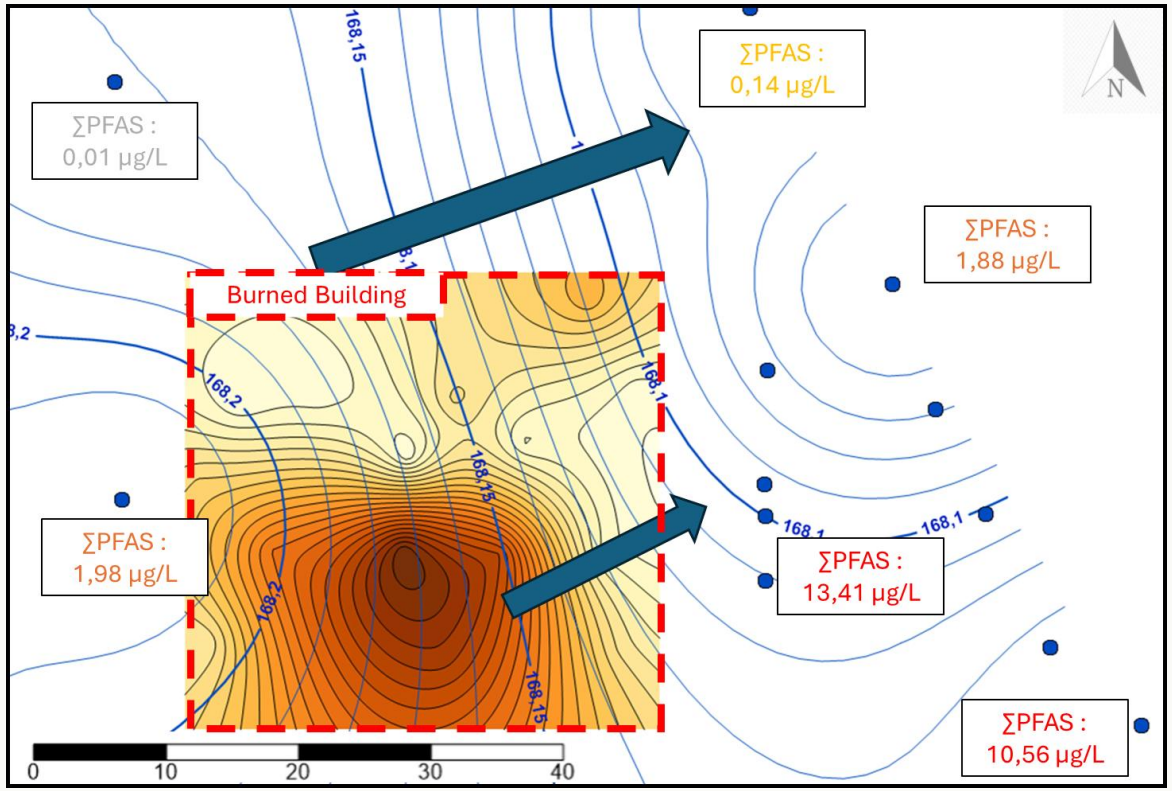
Site study

- 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

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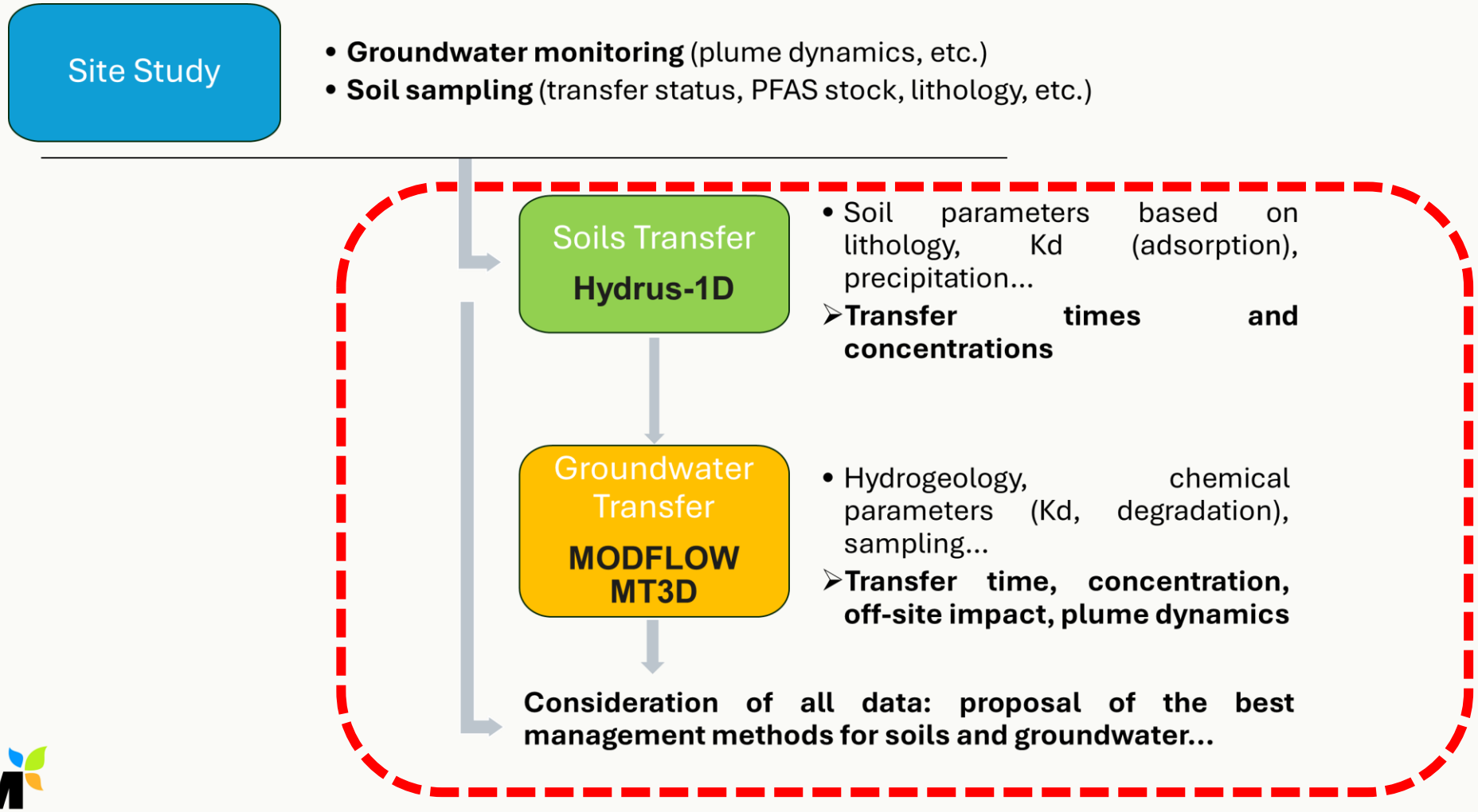

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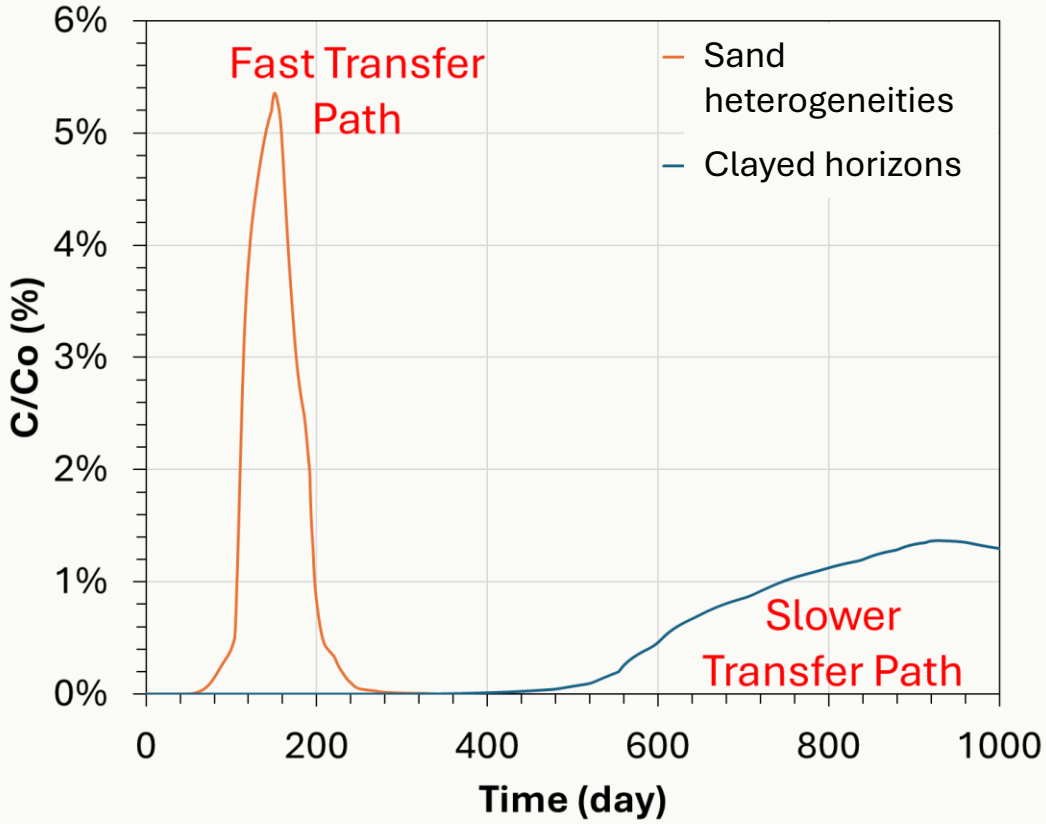
Soils transfer

- **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
- Consitent with our monitoring
- Most of the transfer is still in progress (stock between 0-4 m)
  - ➢ **Possibility of treating the concentrated source in unsaturated zone to stop transfer to the groundwater**



Groundwater transfer

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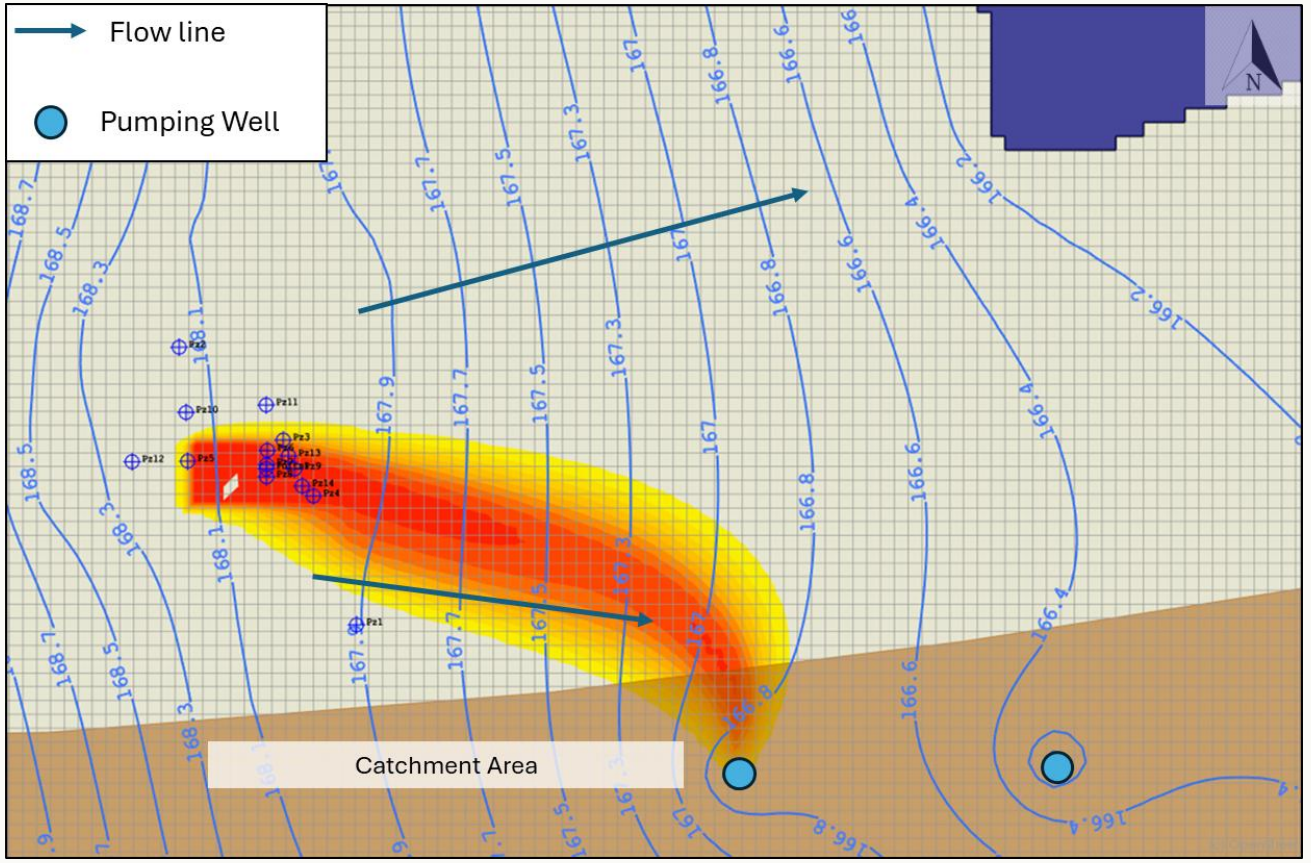
- Evaluation with **MODFLOW** of the off-site risk of transfer
- Weak mitigation of the PFAS plume => no degradation only diffusion and dilution
- **Drinking water catchment area** near the PFAS plume
  - **Displacement risk** of the PFAS plume near pumping area
  - **Action to avoid drinking water contamination**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



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Integration of results

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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**

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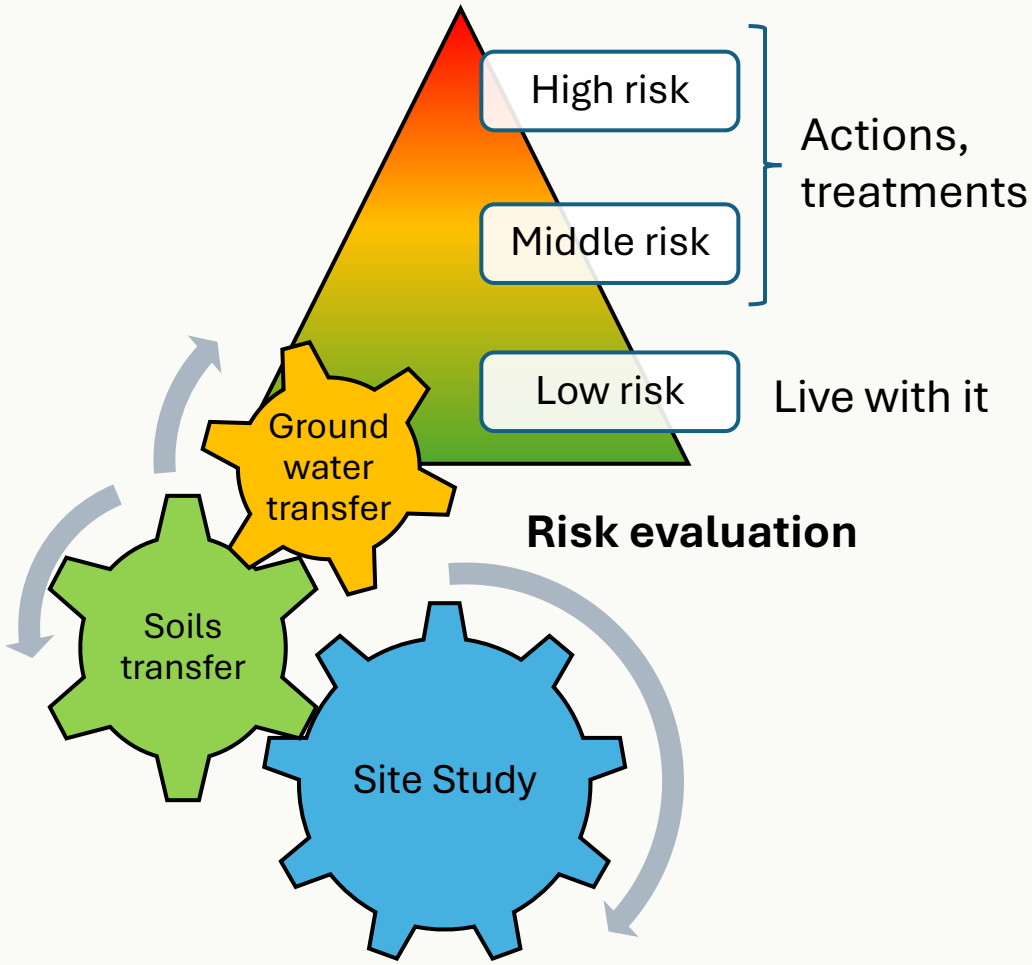
Conclusion

- 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

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- 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)**