Spatio-Temporal Data Analysis as a Tool for Understanding Complex PFAS Plumes

Erik Ribeli
NIRAS Sweden AB

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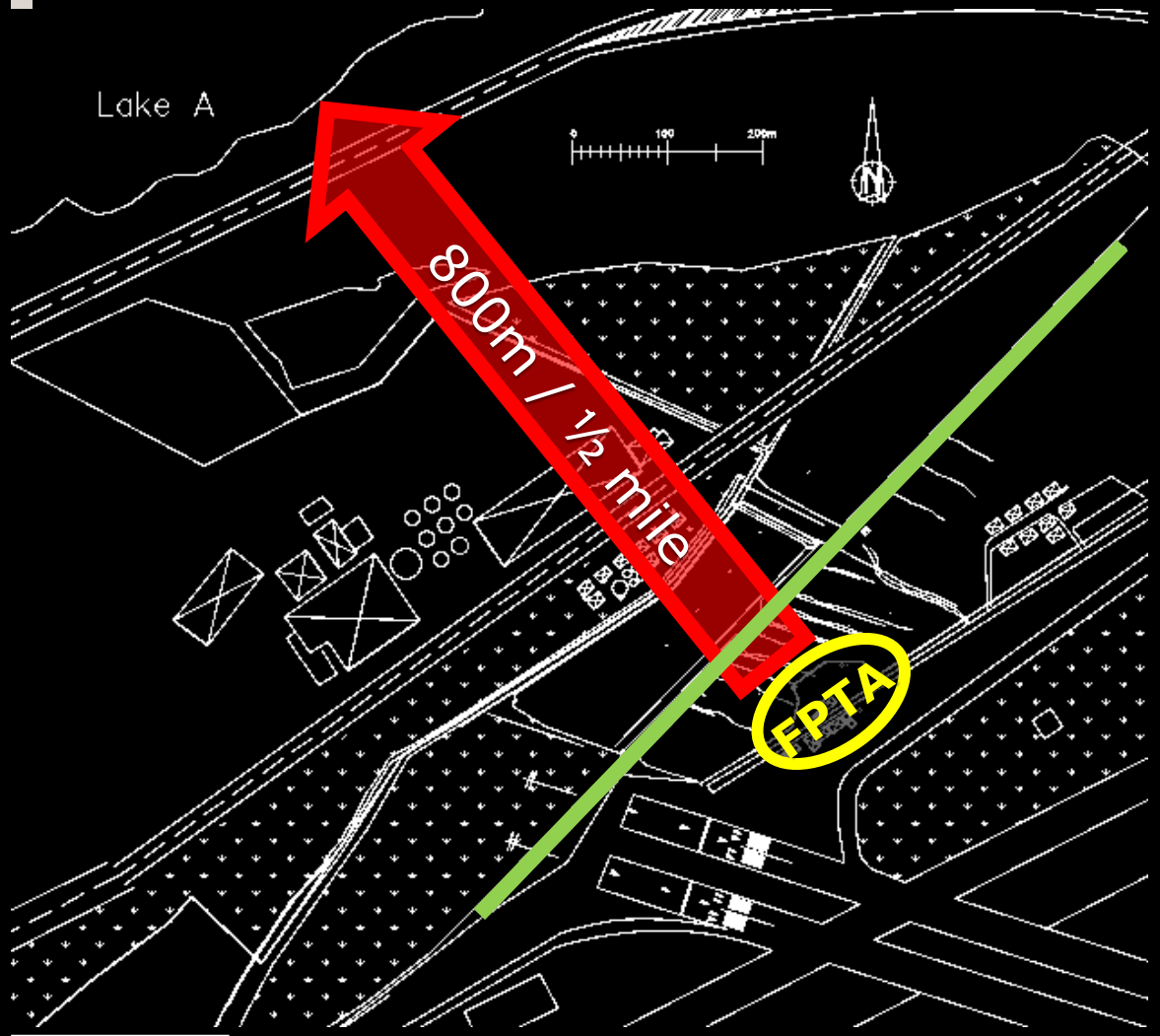
Presentation outline

- Project background
- Design of the groundwater monitoring programme
- Usage of Spatio-Temporal Data Analysis tool
- Results
- Future works
- Questions and answers

Project background – PFAS situation

- Gravel pitch used as a fire protection training area (FPTA), 1970s-1990s
- Site inactive between 1990s-2004
- Property owned by a confidential client today
- High PFAS levels observed in groundwater (GW) samples in 2014
- GW monitoring (GWM) conducted in several episodes, before starting up a four year lasting GWM programme in 2017 (ongoing)

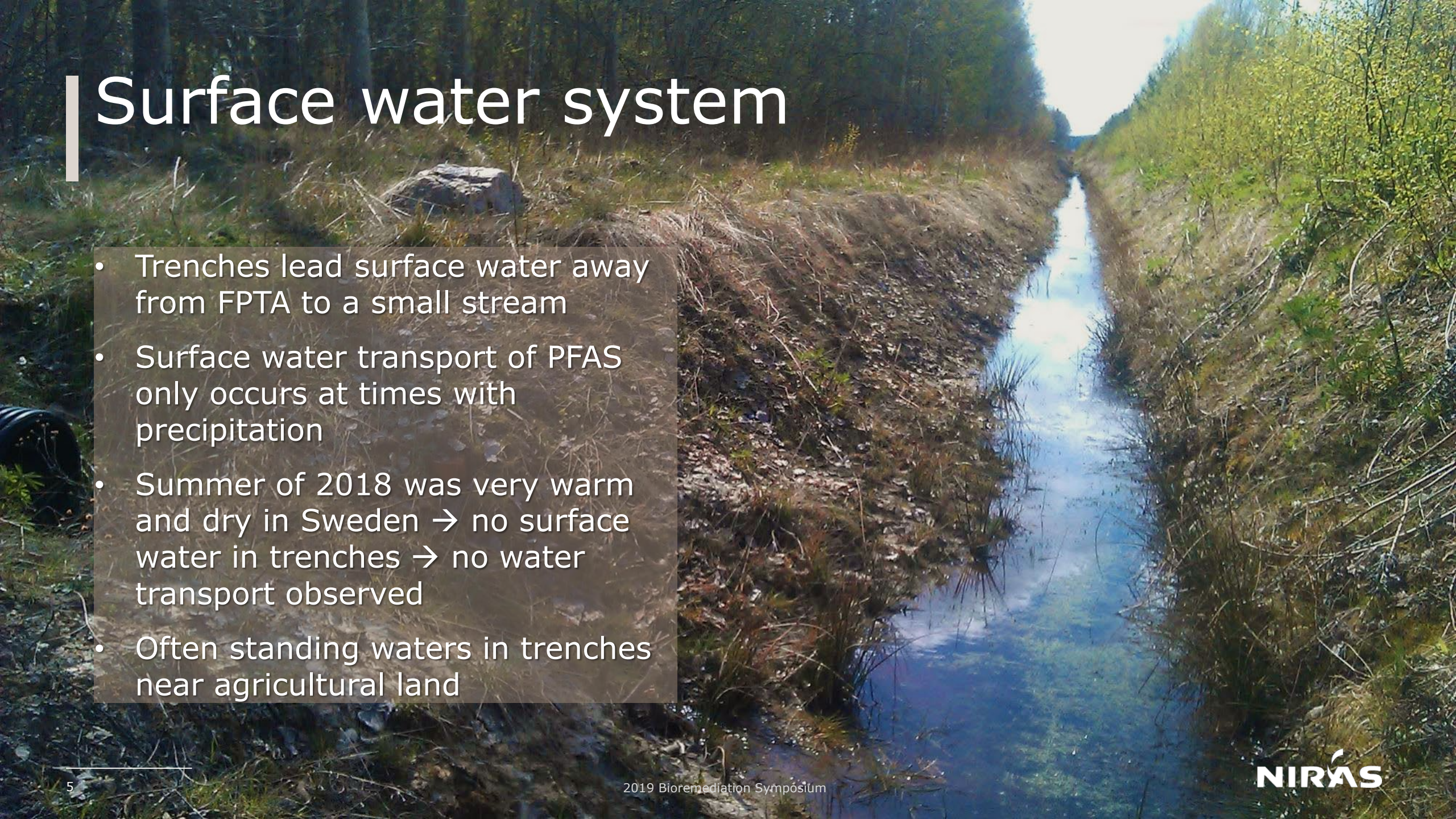
Area description – Land use



- FPTA adjacent to a formerly used airfield.
- Nearest surface water body (Lake A) is used as a drinking water source.
- System of trenches can speed up pollutant transport at times with intense precipitation.
- Railroad tracks (built in 1876) crossing the investigated area. Railroad inactive today.

Surface water system

- Trenches lead surface water away from FPTA to a small stream
- Surface water transport of PFAS only occurs at times with precipitation
- Summer of 2018 was very warm and dry in Sweden → no surface water in trenches → no water transport observed
- Often standing waters in trenches near agricultural land



Geological & hydrological conditions

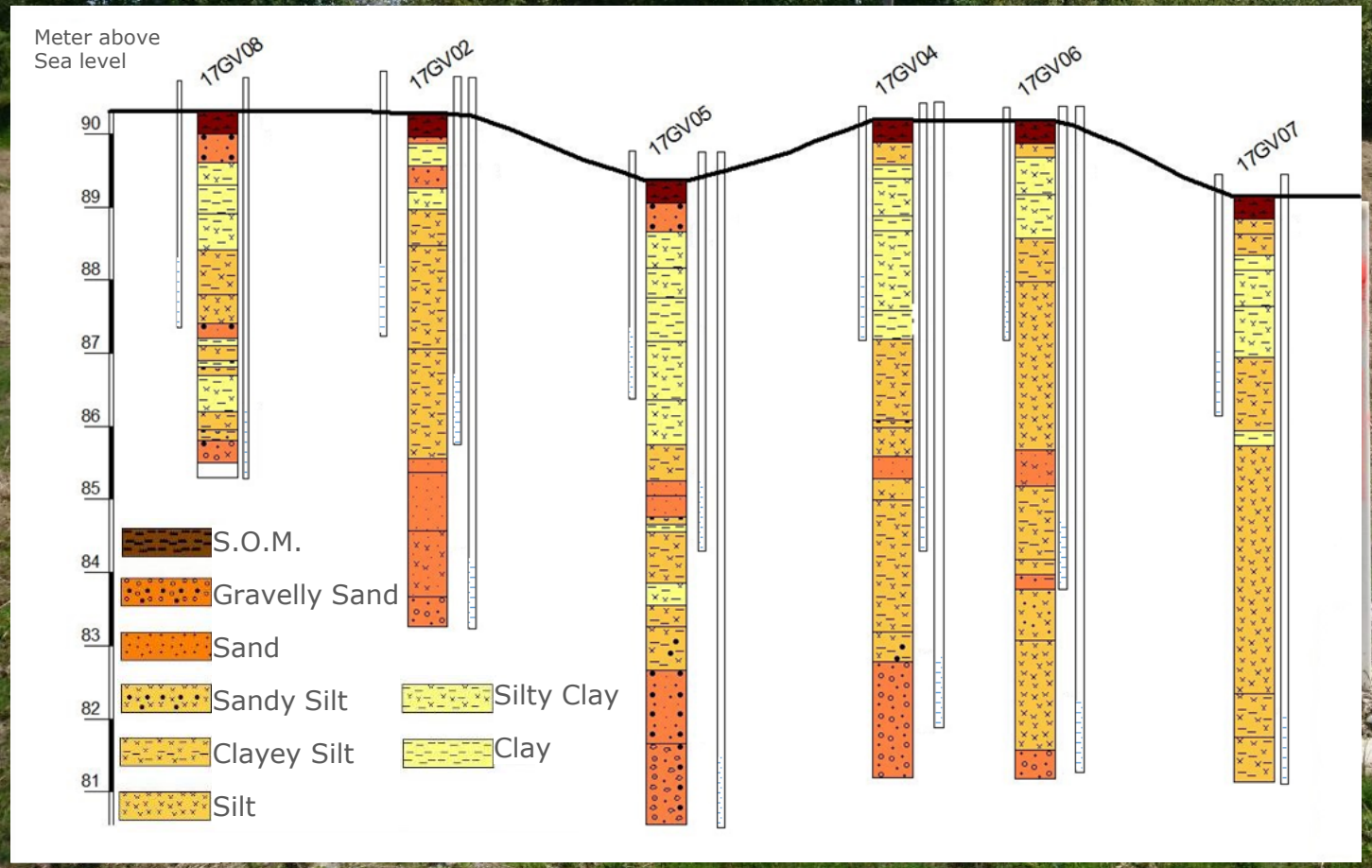
Complex soil matrix:

- Rural land (dominating soil type: Till)
- Agricultural land (mostly Clay)
- Track ballast, gravel and hard packed silt at railroad tracks

Groundwater flow:

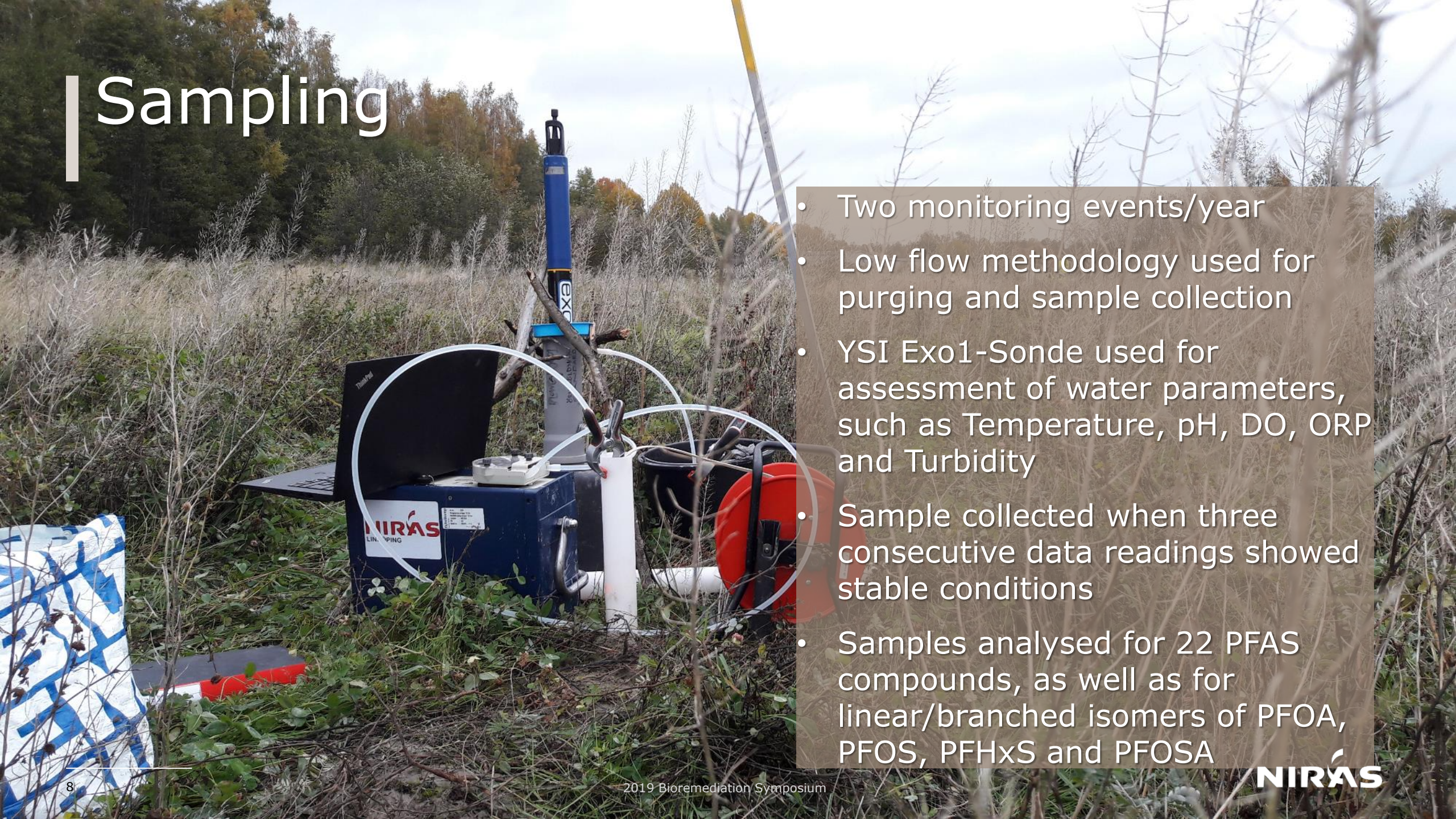
- Generally low hydraulic conductivity north of the railroad tracks
- Possibly high(er) hydraulic conductivity in soil near bedrock throughout the area

Groundwater monitoring



- 30 GWM wells installed at three different depths, so-called three theoretical aquifers (A, B and C)
- Aquifer A: shallow GW
  Aquifer B: intermediate GW
  Aquifer C: deep GW
- Aquifers analyzed separately

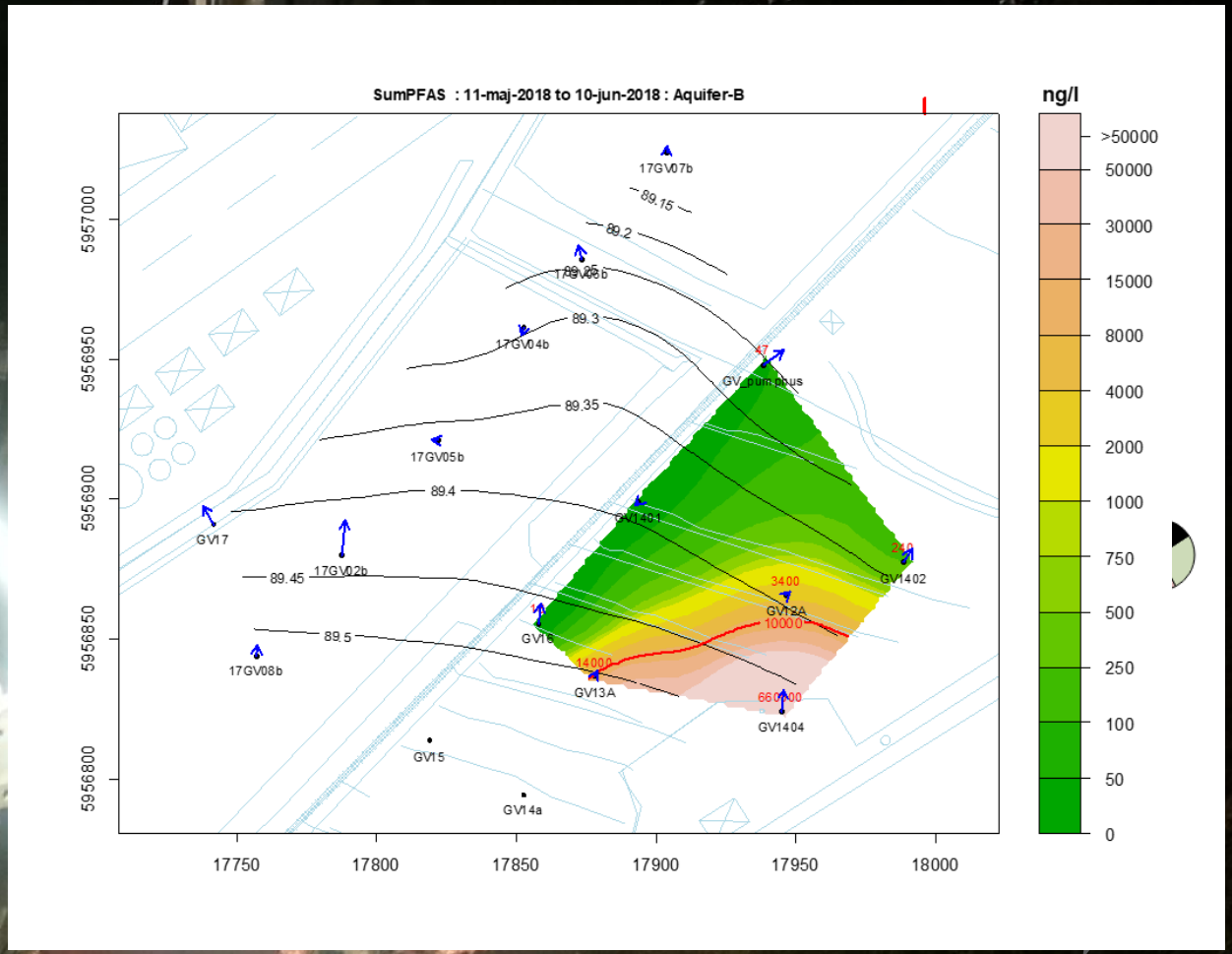
Sampling



- Two monitoring events/year
- Low flow methodology used for purging and sample collection
- YSI Exo1-Sonde used for assessment of water parameters, such as Temperature, pH, DO, ORP and Turbidity
- Sample collected when three consecutive data readings showed stable conditions
- Samples analysed for 22 PFAS compounds, as well as for linear/branched isomers of PFOA, PFOS, PFHxS and PFOSA

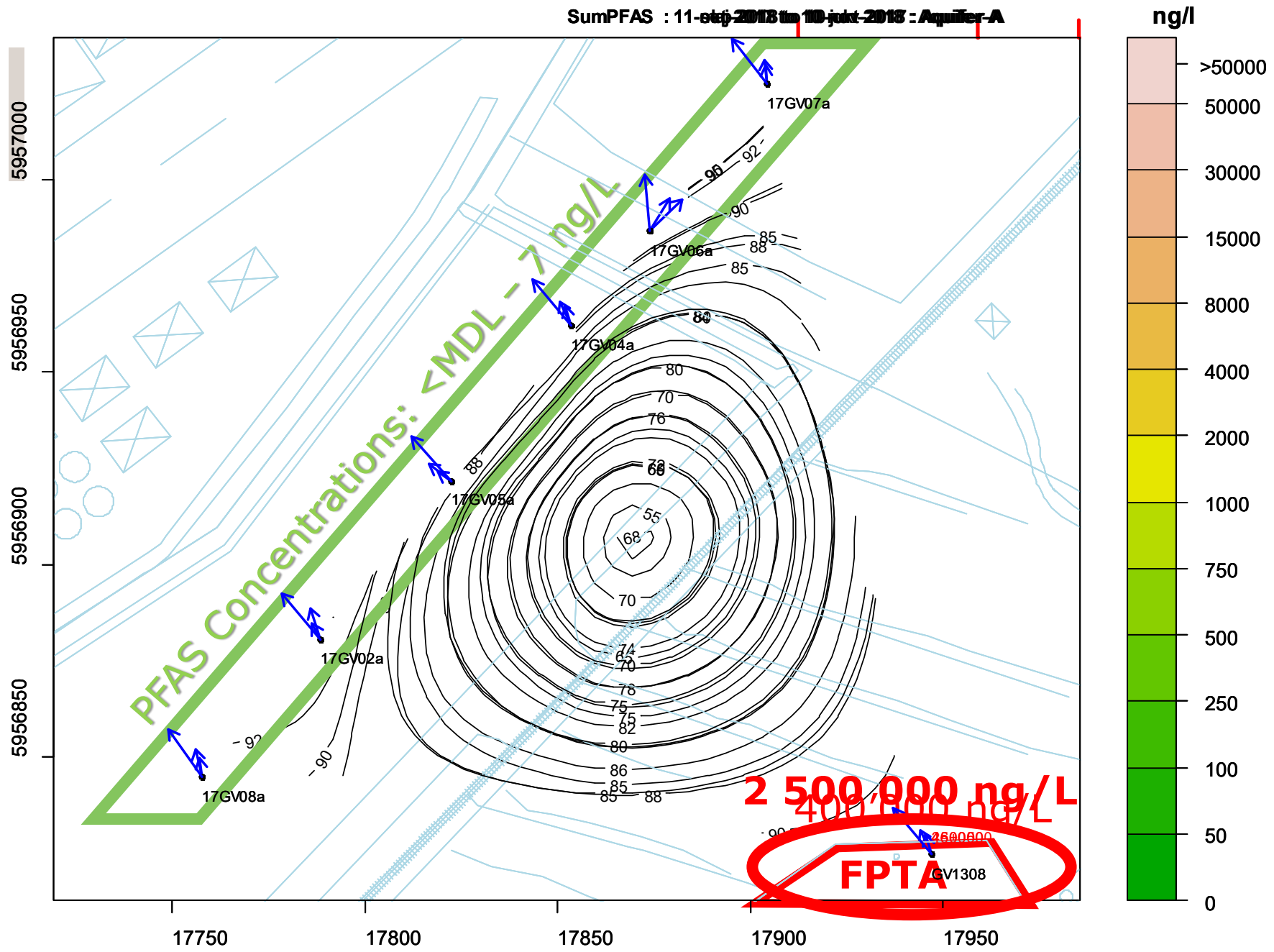
Result analysis using GWSDat

- Developped by Shell Global Solutions in 2004
- In this project, v2.1 was used (developed in 2009)
- Helps visualize trends in GWM data
- Uses Microsoft Excel as primary interface and R for statistical calculations and graphical output



GWSDat-results

- On the following slides, GWSDat-results are shown, one event and aquifer at the time
- Aquifer summary after 3 events
- Compilation summary after all results
- Only plume of SumPFAS (22 compounds) shown due to time restrictions



Aquifer	Mon. Event 1	Mon. Event 2	Mon. Event 3
A (2-4 m bgl)	Oct 2017	May 2018	Oct 2018
B (4-8 m bgl)	Oct 2017	May 2018	Oct 2018
C (8-10 m bgl)	Oct 2017	May 2018	Oct 2018

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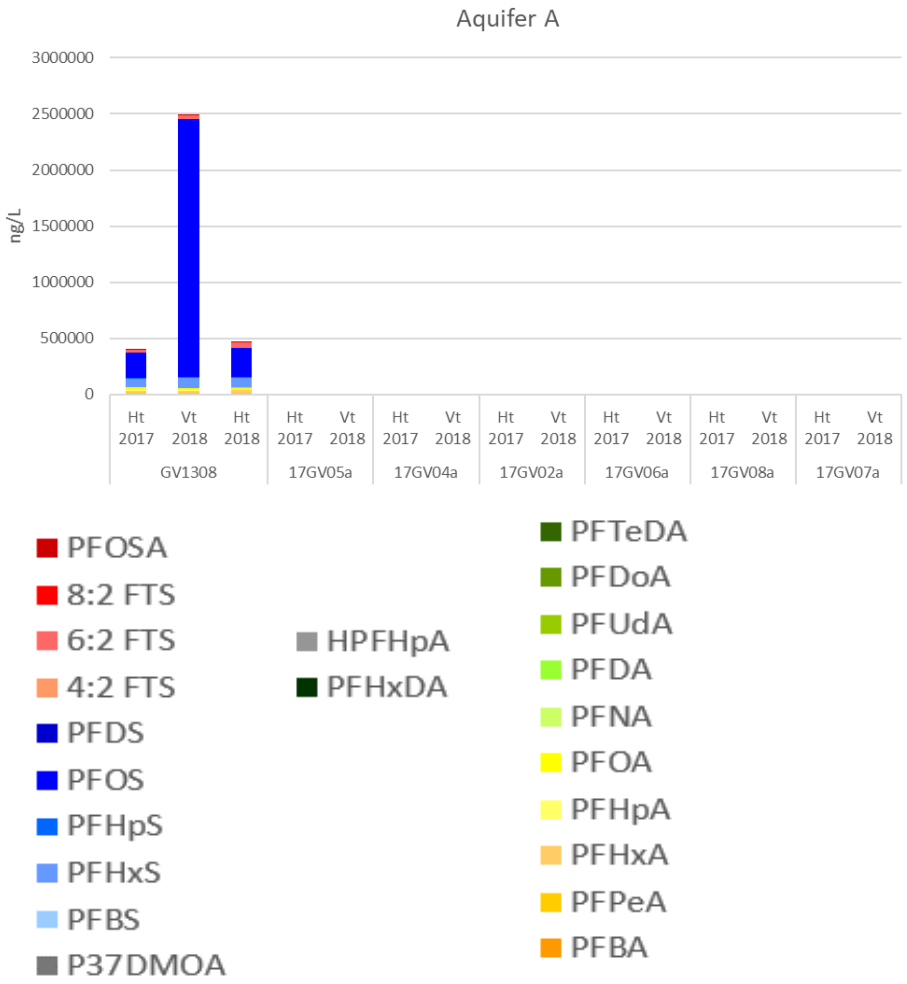
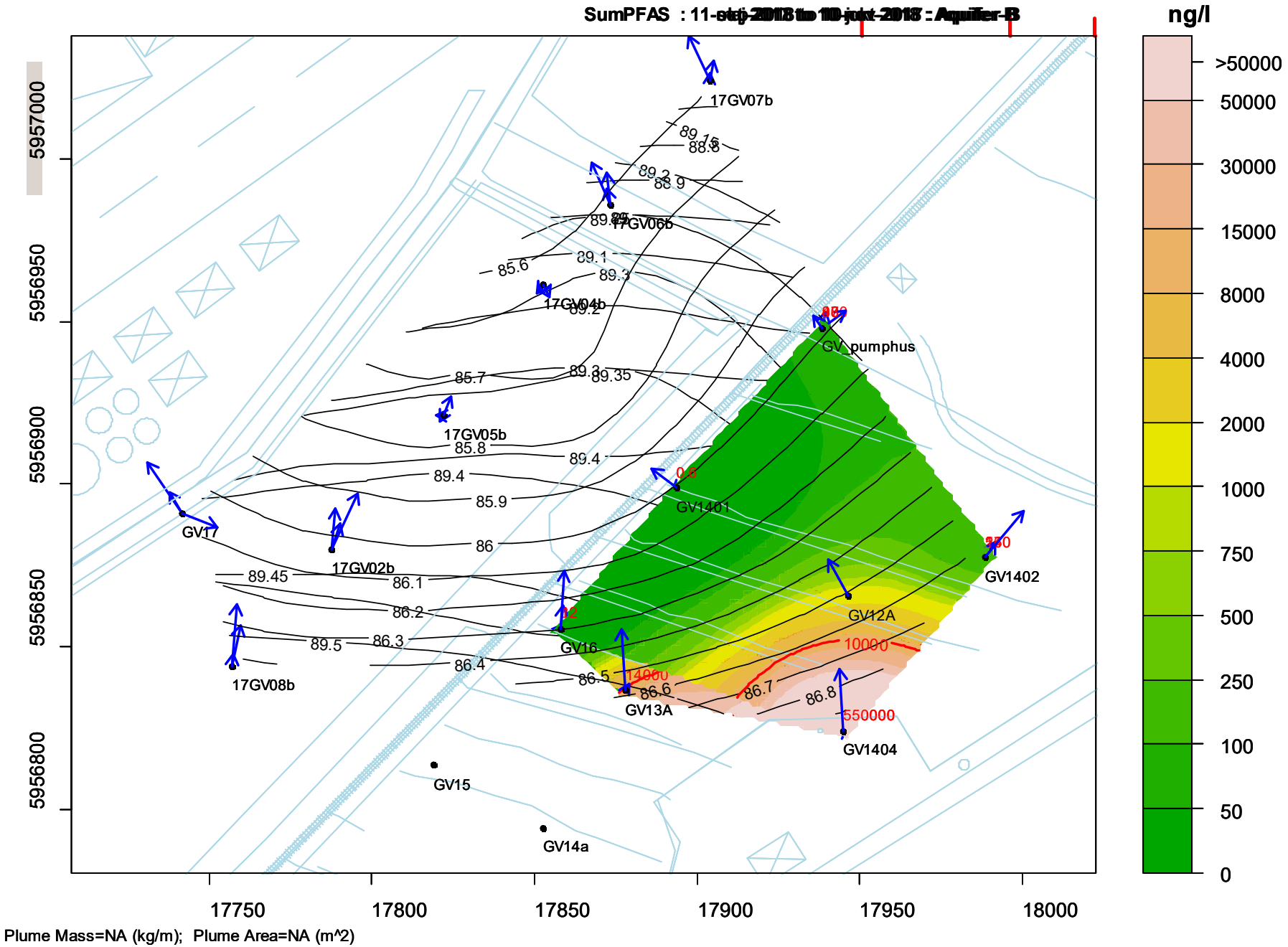
Summary of results, Aquifer A



- High to very high PFAS concentrations at former FPTA
- Low to non-detect PFAS concentrations at other wells
- No transport in shallow groundwater over large distances observed
- Shallow groundwater might end up as surface water in trenches
- PFAS fingerprint dominated by PFOS



Plume Mass=NA (kg/m); Plume Area=NA (m^2)

Aquifer	Mon. Event 1	Mon. Event 2	Mon. Event 3
A (2-4 m bgl)	Oct 2017	May 2018	Oct 2018
B (4-8 m bgl)	Oct 2017	May 2018	Oct 2018
C (8-10 m bgl)	Oct 2017	May 2018	Oct 2018

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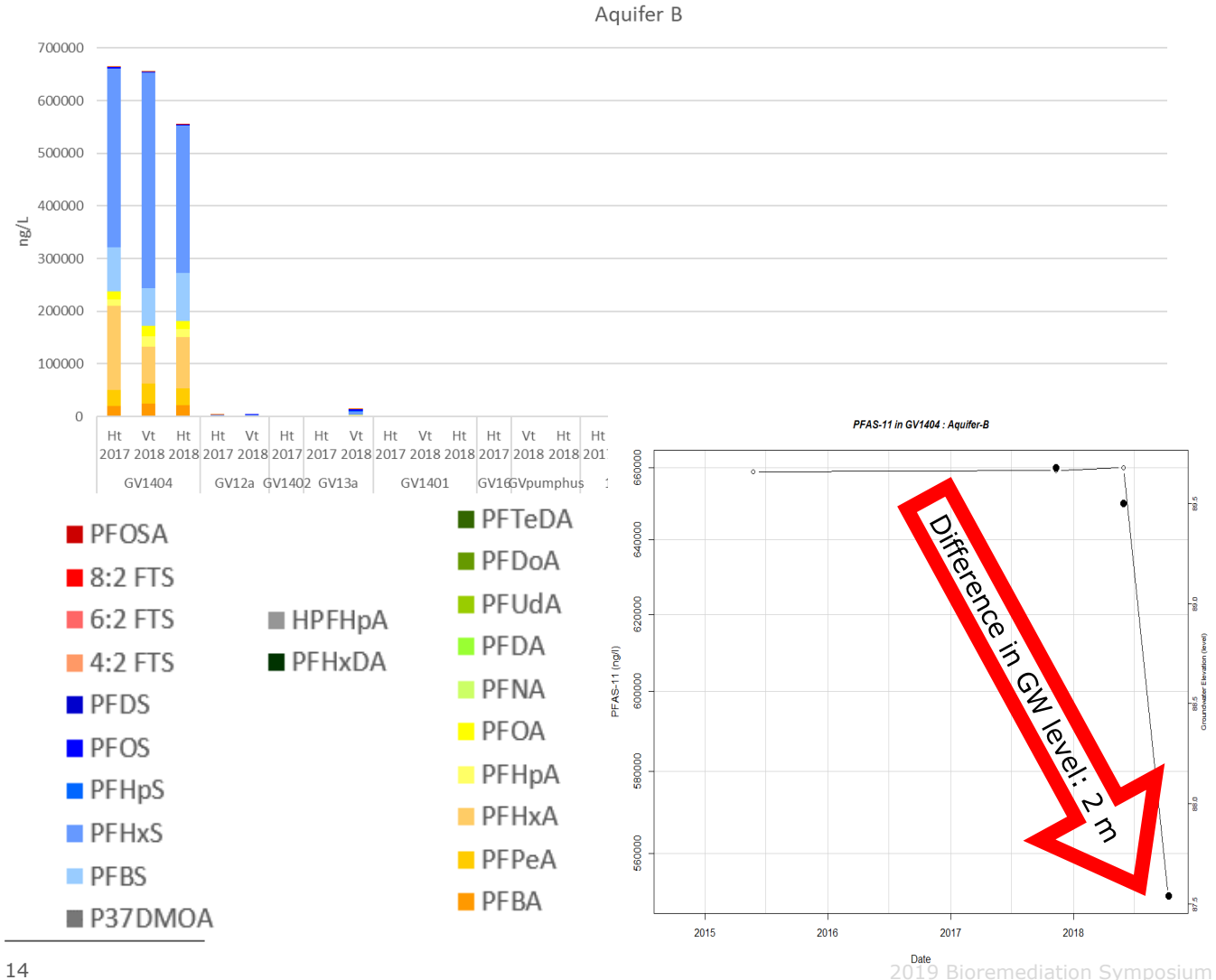
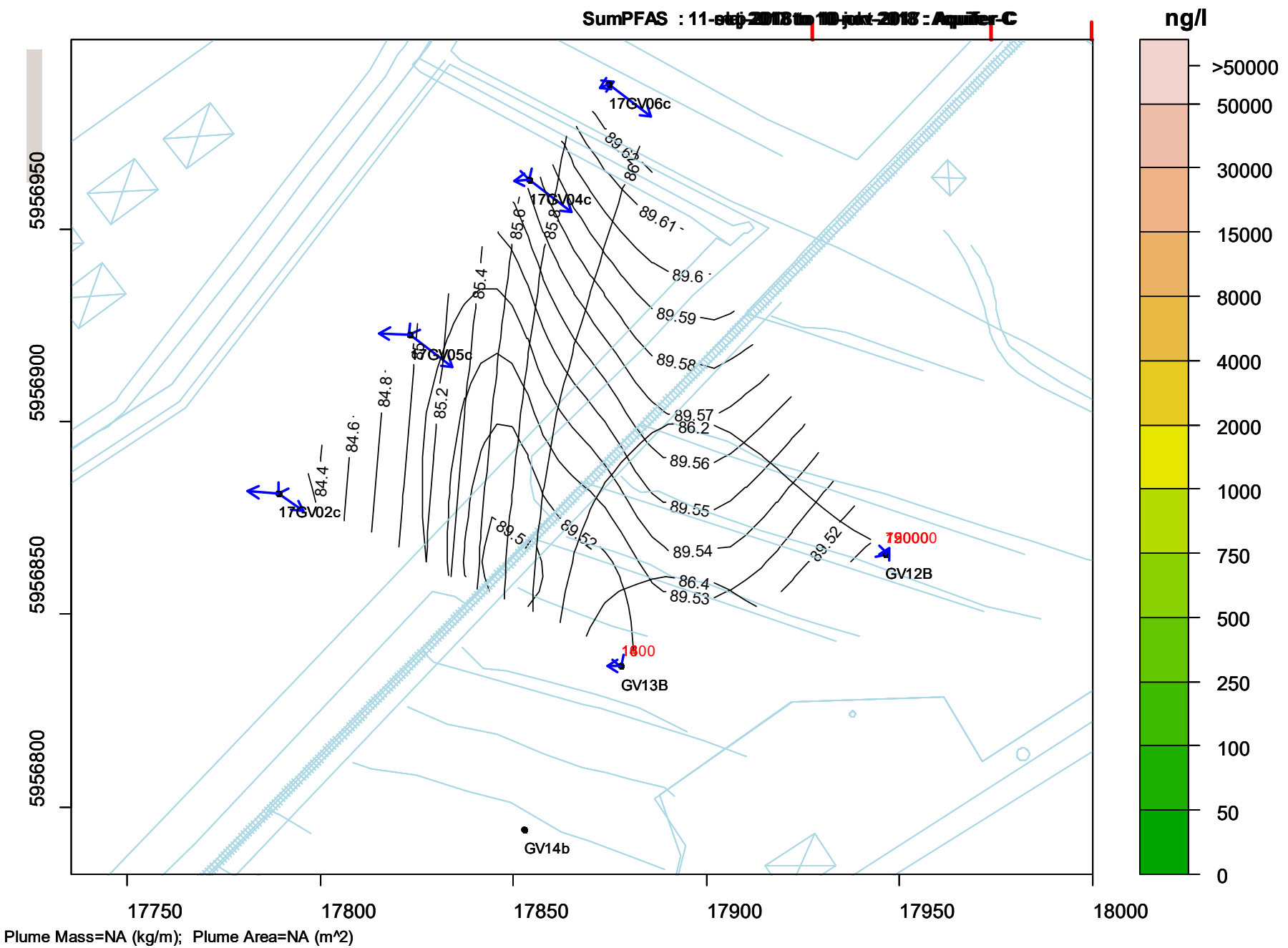
Summary of results, Aquifer B



- High concentrations at former FPTA
- Adjacent wells also affected
- Plume extent north of railroad tracks might be overestimated (noise, chromatography smear)
- Problems with low GW levels might underestimate plume extent near FPTA
- PFAS fingerprint dominated by PFHxS, PFHxA and PFBS, not PFOS.



Aquifer	Mon. Event 1	Mon. Event 2	Mon. Event 3
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Plume Mass=NA (kg/m); Plume Area=NA (m^2)

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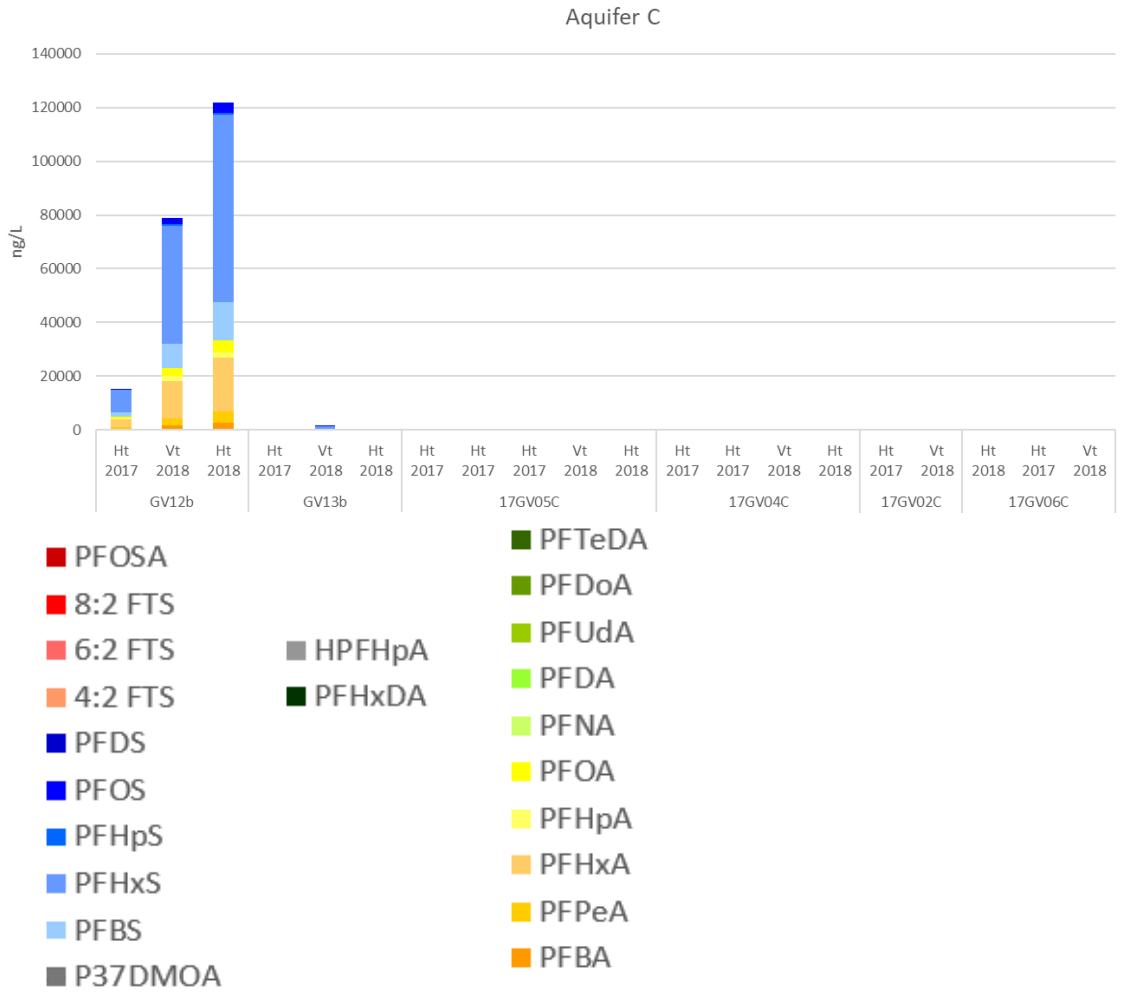
Summary of results, Aquifer C



- No wells in Aquifer C installed directly on the FPTA
- Increasing PFAS levels in GV12b
- PFAS plume dominated by PFHxS, PFHxA and PFBS, similar to observations in Aquifer B
- No contamination of Aquifer C observed north of railroad tracks

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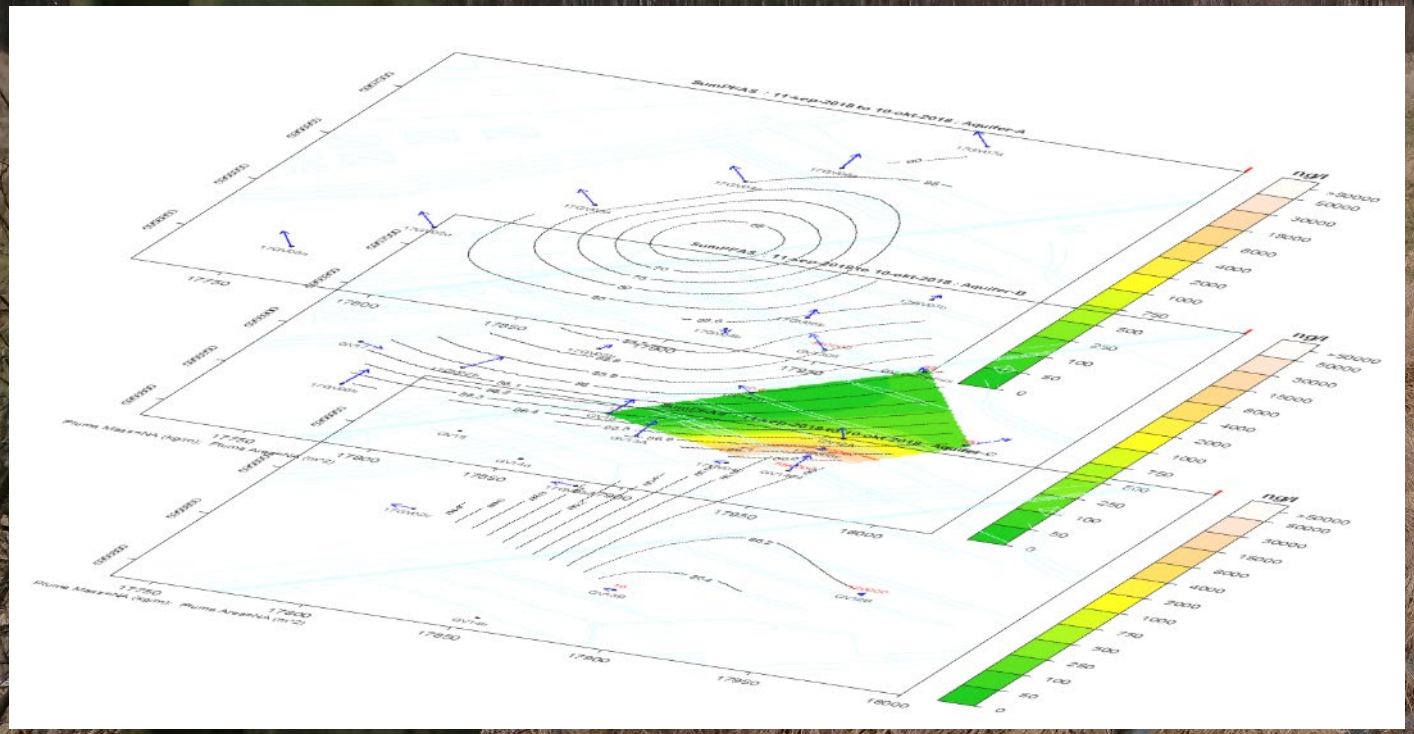
Summary



- PFAS plume movement in the nearby environment both horizontal and vertical
- Main PFAS plume in Aquifer B
- No plume movement past railroad tracks observed
- Trench system affects fate of PFAS at times with intense precipitation

Future works

- Monitoring programme to be continued until end of 2020
- Plume movement crucial for designing remedial activities in order to prevent contamination of nearby lake
- 3D visualization of plume extent might enhance understanding of movement

“We must use time as a tool, not as a couch”
- John F. Kennedy

THANK YOU

Erik Ribeli

erik.ribeli@niras.se

+46 70 981 02 16