PFAS

Practical experiences on soil investigation and remediation from a site in Amsterdam

Paul Verhaagen
www.hmvt.eu

Introduction

Paul Verhaagen

- 30 years experience working as senior consultant and contractor
- Projects in Belgium, The Netherlands, Germany, France, Sweden, Denmark, Japan

HMVT

- Over 30 years experience in environmental engineering, from the start focus on innovative technologies
- Main activities are related to in-situ soil remediation, water treatment, vapour treatment
- Projects in Belgium, The Netherlands, France and Germany

Amsterdam project (2016 – 2019)

- Historical use of the site
- Soil investigation PFAS (2016-2017)
- Definition of remediation targets and remediation approach (2017)
- Remediation (2018-2019)
- Lessons learned – future outlook for PFAS remediation

Historical background and use of the site

- Former marshland in the eastern part of Amsterdam
- First industrial use (timber yard) start in 1925
- Later: processing asbestos materials (1934-1970)
- 1970-2016. Fire protection materials
- 2016. End of industrial activities - redevelopment

Now: development into a residential area

Soil investigation, focus on PFAS

- Key: how was the PFAS used on the site ?
- Find the source areas of PFAS
- Understand the hydrological system on the site (drainage – geohydrology)
- Only then: start actual soil investigation
- Always look into the impact on water (groundwater/ nearby surface waters)
- Do not jump to conclusions after a few analyses

Soil investigation PFAS some results

- PFAS on the site consisted for more than >90% of PFOS

- If PFAS are found: both soil + groundwater contain PFAS. Exception: in coarse sand layers only groundwater was impacted.

- Maximum levels in soil samples PFOS: 3.000 mg/kg
- Maximum levels groundwater PFOS: 6.500 µg/l

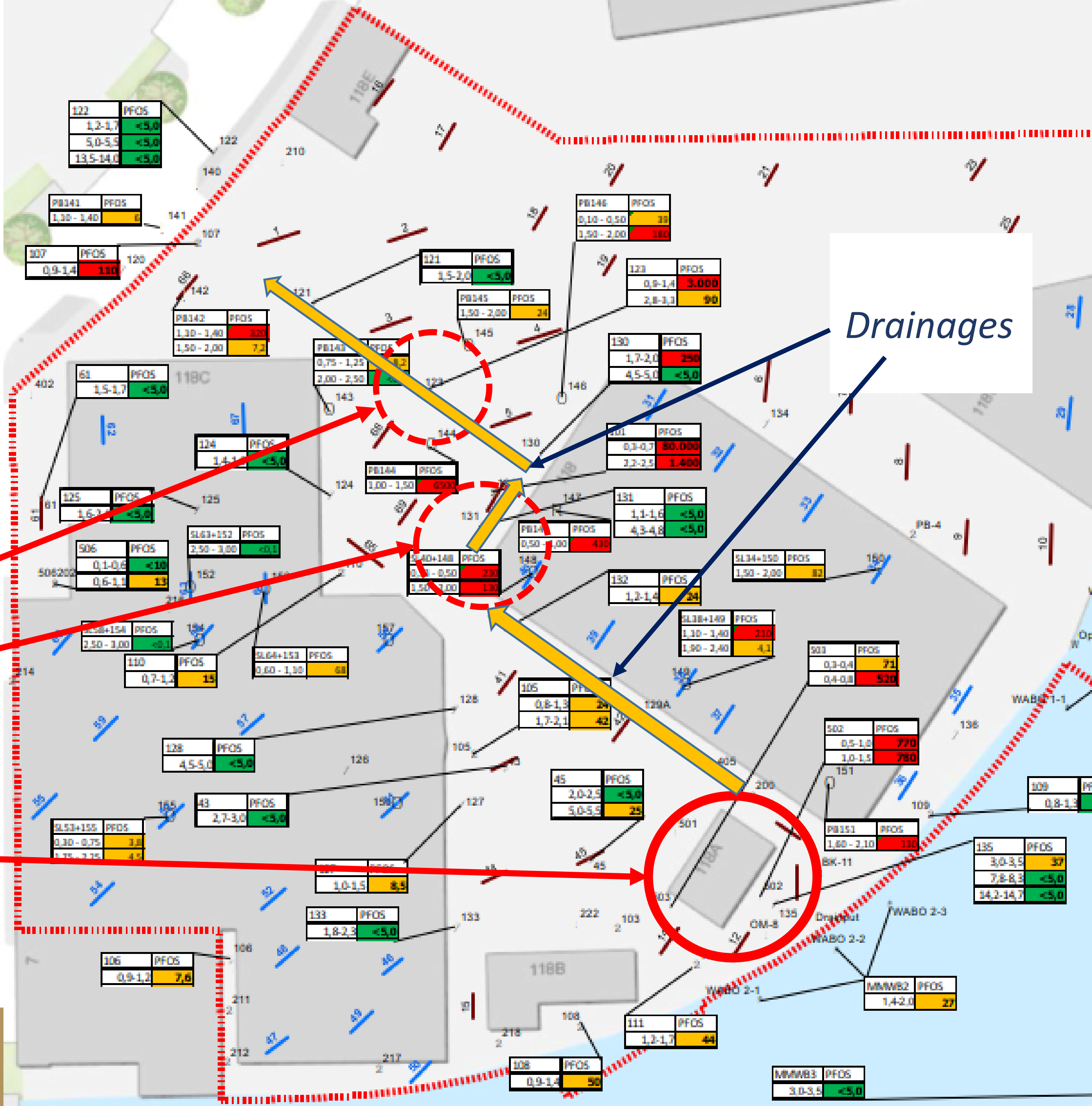
- The results confirm that hydrological system governs the spreading of PFAS into the soil

PFAS in the soil

Due to drainage on the site, multiple source areas have developed in the subsoil

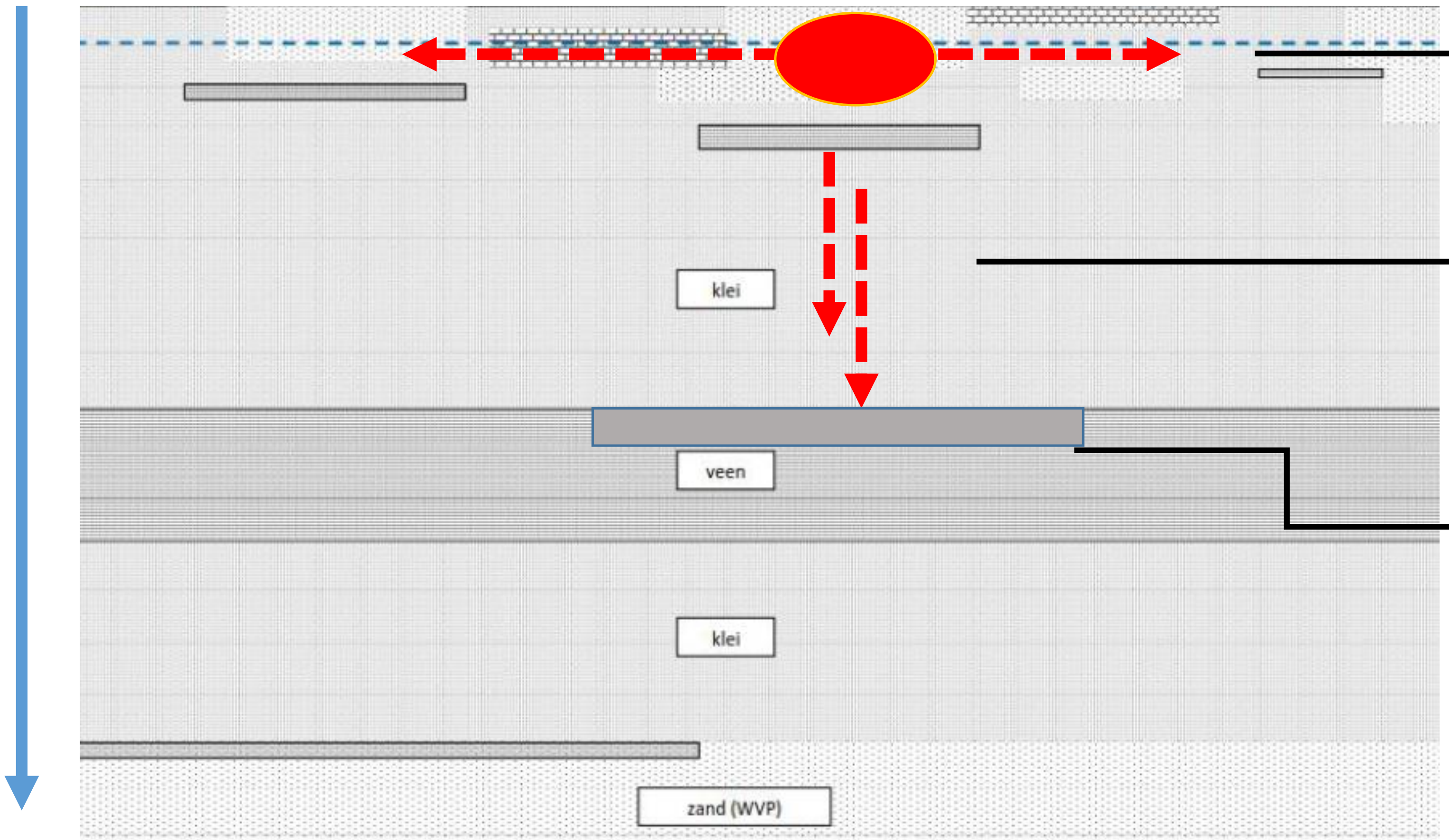
Source area's related to drainage

Source area related to testing



Impact soil structure on PFAS spreading

infiltration



Horizontal spreading (via rubble layers, via drainage etc.)

Vertical spreading at source areas (clay no hinderance for spreading)

Peat is a hinderance for vertical spreading

This is site specific

Definition of remediation targets PFAS

- In 2016: no set values for remediation PFAS.

- So, start with the basics: what is the aim of the remediation ? To make the redevelopment of the site possible. No remediation – no redevelopment.

- Remediation target is the elimination of risks related to a contamination. So, in this case the soil remediation has to remove risks in relation to the future use of the site.

- For this site the situation after remediation:
    - No risks for humans (installing a clean layer of soil –'leeflaag', use of the site – apartments, no private garden area's)
    - No ecological risks (clean soil layer)
    - No risk for spreading (removal of source areas)

Remediation targets

2017 accepted remediation targets site:

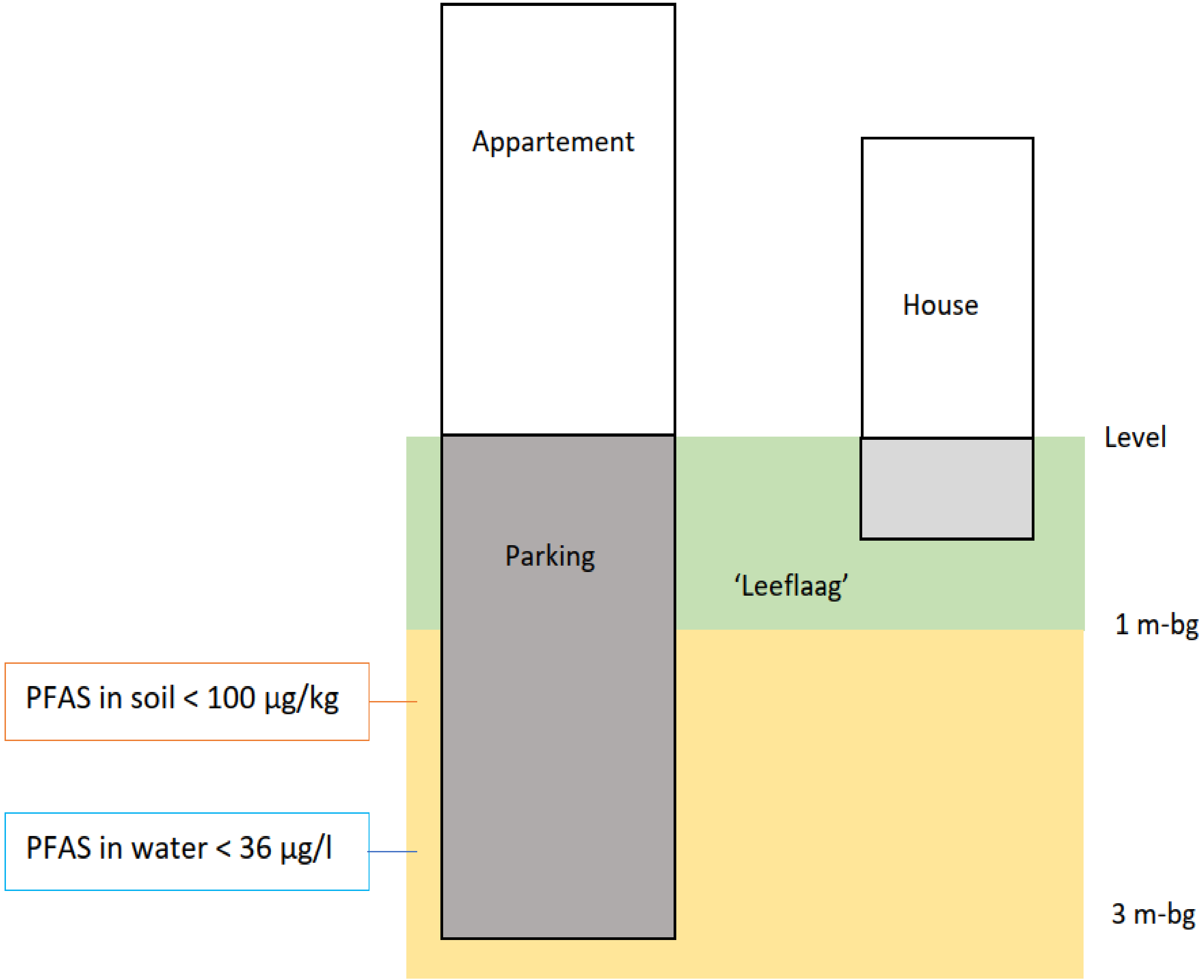
- Soil 100 µg/kg
- Groundwater: 36 µg/l

How did we get there?

Soil: Use of existing values for a ‘neglectable impact on surrounding soil – water quality’

Groundwater: use of the set level for water Emissions.

Most important: the remediation results in the removal of 97% of the PFOS.



Comparison with PFAS remediation targets (June 2020)

Compound			
	Soil (µg/kg)	Groundwater (µg/l) (incl. drinking water)	Groundwater (µg/l) (excl. drinking water)
PFOS	110	0,20	56
PFOA	1100	0,39	170
GenX	97	0,66	140

For the project in 2017: 100 µg/kg

For the project in 2017: 36 µg/l

Remediation of PFAS

- **Safety issues** for staff during remediation PFAS are basic.

- **PFAS analyses**: please consider in advance the required lab time

- The **technologies** for the remediation at this project were basic:
  - Excavation of contaminated soil
  - Extraction of contaminated groundwater

- **Treatment** (soil and groundwater) are very complex:
  - Treatment / final disposal of soil
  - Treatment - purification of the groundwater

Treatment of PFAS contaminated groundwater

- Water treatment applied at the site in Amsterdam
- Future outlook remediation technologies

Pilot treatment PFAS

Composition of the PFAS: appr. 85% is PFOS (comparable with soil investigation).

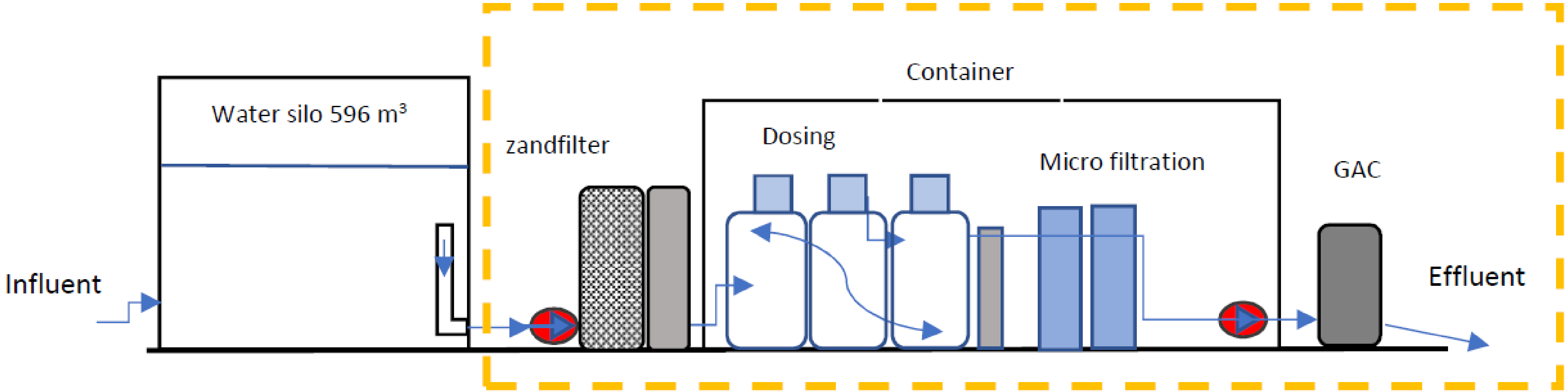
Level of PFAS is representative for the site

Treatment efficiency = o.k.
Influence of PerfluorAd dosing rate is little

Project	Untreated	Treated		
PFC-Verbindung in µg/l	Rohwasser 0	Dosing rate PerfluorAd in mg/l 50	100	200
PFBA	0.3	0.3	0.2	0.08
PFBS	2.1	0.008	0.004	0.004
PFPeA	0.8	0.4	0.2	0.03
PFHxA	1.6	0.3	0.08	0.03
PFHxS	4.6	0.02	0.03	0.04
PFHpA	1.0	0.03	0.01	0.01
PFOA	2.2	0.03	0.03	0.03
PFOS	140	0.4	0.7	1.00
PFOSA	1.1	0.006	0.01	0.02
PFNA	0.07	<	<	0.001
PFDA	0.3	<	0.002	0.003
PFDS	<	<	<	<
PFUnA	0.03	<	<	<
PFDoA	<	<	<	<
PFHpS	1.6	0.005	0.01	0.01
PFPeS	1.3	0.003	0.004	0.005
4:2 FTS	0.05	0.006	0.003	0.001
6:2 FTS	5.1	0.2	0.1	0.2
8:2 FTS	1.2	0.007	0.02	0.04
Summe µg/l	**163.35**	**1.715**	**1.403**	**1.504**
Removal rate		**99%**	**99.10%**	**99%**

Water treatment: full scale approach for the site

- It is a groundwater remediation
- Flow rate 1,5-2,0 m3/h
- Emission level PFAS 1 µg/l (ppb)



Water treatment results

Start September 2018 – stop March 2019

INFLUENT	Inflow	ug/l					
						% share PFOS vs	
Date 2018	PFOS	PFOA	PFBS	PFHXa	PFHXs	PFAS	PFAS total
13-9-2018	20	1	0,39	1,9	3,5	72%	27,8
18-10-2018	7,6	0,67	0,48	1	3,2	55%	13,71
12-11-2018	8,7	0,78	1	1,6	4,3	50%	17,4

EFFLUENT	Outflow	ug/l							
						% share PFOS vs		Efficiency rate total	Efficiency rate
Date 2018	PFOS	PFOA	PFBS	PFHXa	PFHXs	PFAS	PFAS total	PFAS	PFOS
13-9-2018	1,4	0,32	0,18	1	0,56	34%	4,05	93%	93%
18-10-2018	0,94	0,34	0,3	1,1	0,41	25%	3,73	88%	88%
12-11-2018	0,99	0,8	1,2	4,3	0,93	10%	9,98	43%	89%

	Emisie na Aktief kool. PFAS total ug/l	
13-9-2018	0,7	
18-10-2018	5,25	GAC desorb
12-11-2018		emitting to the buffer
20-11-2018	0,25	new GAC

PFAS water treatment conclusions

Experiences with the selected approach and the technology:

- Emission requirement PFAS 1 µg/l is achievable
- Buffering (water silo) is important to homogenize PFAS levels
- Removal of suspended material from the water is essential

Future outlook on PFAS remediation

- Soil
- Water

PFAS remediation soil

No (in-situ) remediation technologies for soil treatment available.

In-situ remediation: next 1-3 years no expectations on a breakthrough of a (economical) technology. Bottlenecks:

- Properties PFAS (behaviour in soil)
- Remediation targets required (and potential for reuse of soil)

Treatment of soil (ex-situ). Good option can be washing of (sandy) soils followed by treatment of waste water from the plant.

PFAS remediation water

By 2021 various treatment technologies are available.

Selection of water treatment technologies are always site specific:

- Short remediation time / small flow / low levels: GAC
- Longer remediation time higher flow / higher levels: combination of technologies

Key issue is to prevent waste generated (GAC, others) that has to be incinerated or landfilled.

Thank you

Paul Verhaagen

HMVT
Postbus 174
6710 BD Ede
www.hmvt.nl