REMTEC

REMEDIATION TECHNOLOGY SUMMIT

THE FUTURE OF REMEDIATION TECHNOLOGY

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Thursday Track 3

Technical Solution for the Removal of PFAS in Water

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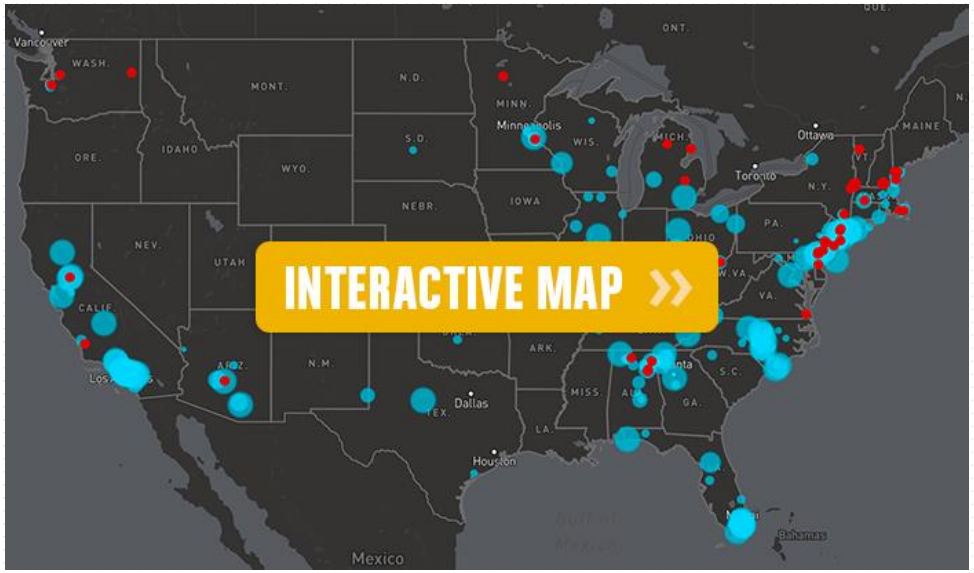
PFAS – Importance



PFAS in TAP Water and at Sites (red)
Source: www.EWG.org

State	PFOS	PFOA	PFAS	Sum of X
CA	13	14		
CT			70	5
ME	70			
MA			70	5
MI	70			
MN	27	35	27	PFHxS
NH	70			
NJ	13	14	13	PFNA
VT	20			

- Low birth rates
- liver damage
- Chronic kidney disease
- Etc.

Topics

- Background
- Remediation
- New Approach
- Site data
- Conclusions

Background - PFAS

- PFAS per- & polyfluorinated alkyl substances
- high stability (thermal, chemical)
- poor adsorption (GAC, extended plumes)
- large group (>6000)

12	Dodecyl			PFDoA
11	Undecyl			PFUnA
10	Decyl	PFDeS	8:2 FTS	PFDeA [1,2]
9	Nonyl	PFNoS		PFNoA [1,2]
8	Octyl	PFOS [1,2]	6:2 FTS [2]	PFOA [1,2]
7	Heptyl	PFHpS [2]		PFHpA [1,2]
6	Hexyl	PFHxS [1,2]	4:2 FTS	PFHxA [1,2]
5	Pentyl	PFPeS [2]		PFPeA [1,2]
4	Butyl	PFBS [1,2]		PFBA [1,2]

Remediation Tools

Water

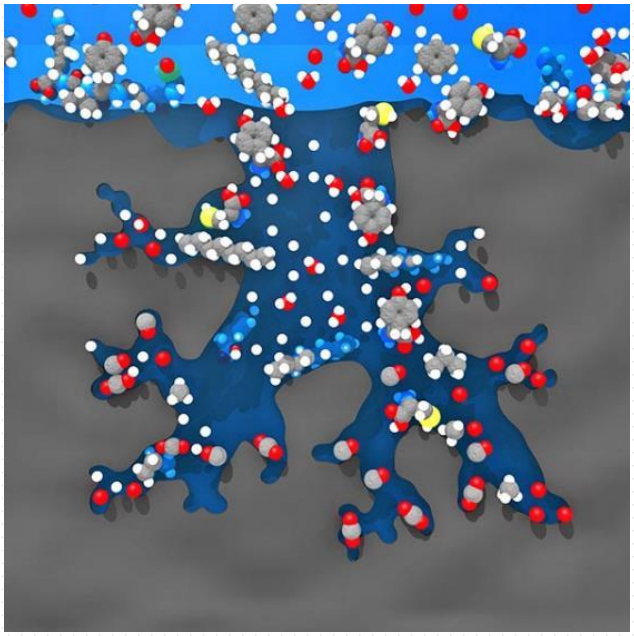
- GAC (granular activated carbon)
- IX (ion exchanger)
- RO (reverse osmosis)
- Precipitation/Flocc. (PerfluorAd)

Soil

- Incineration (high temperature)
- Soil washing (gravel, sand) – **water**
- Immobilisation
- Heating (?)

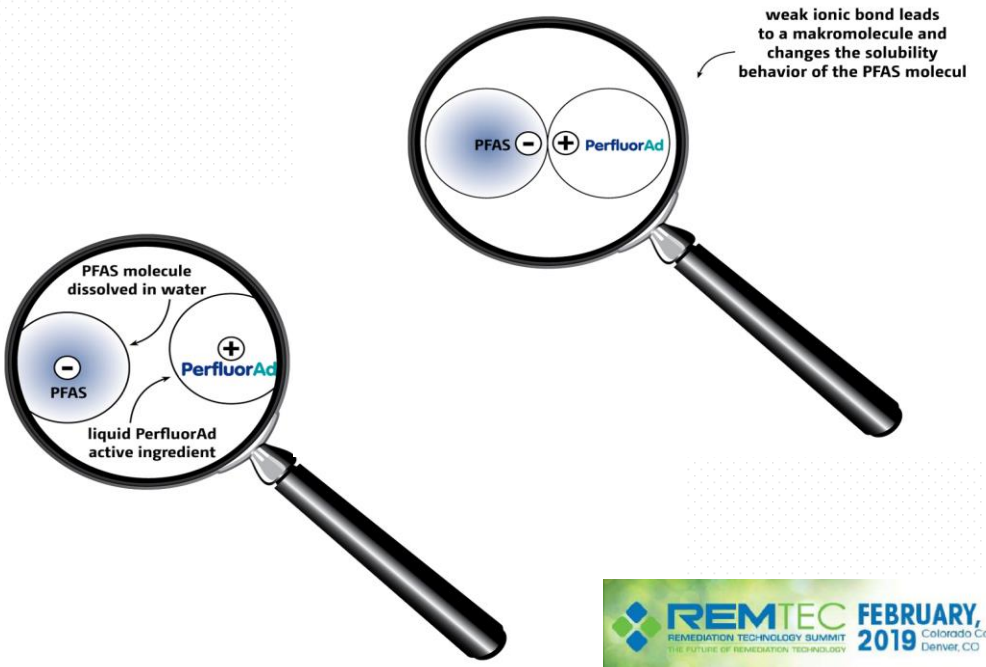
Remediation – GAC

- low adsorption rate (0.01%)
- long residence time (size)
- water chemistry (Fe, particles)
- contaminants/DOC
- competition
- carbon changes/disposal



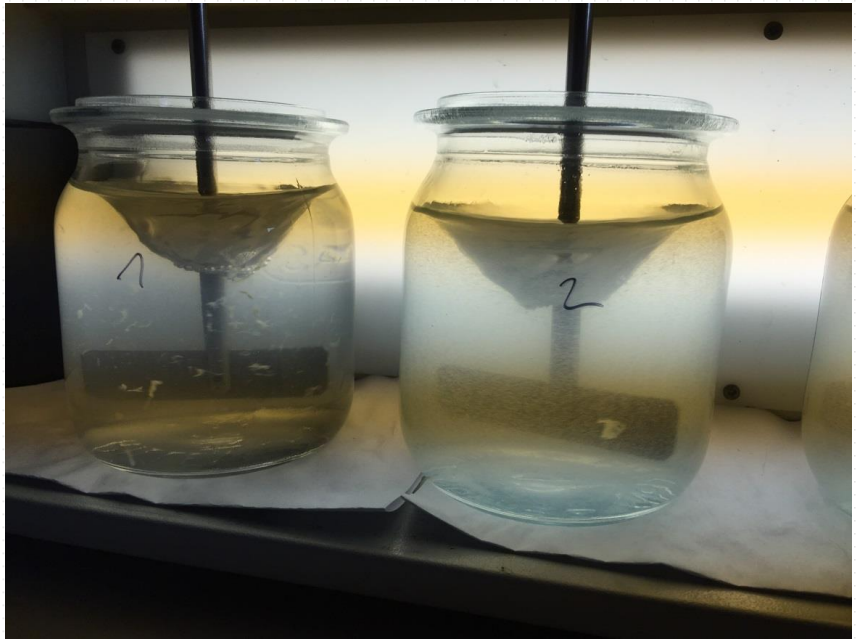
New Approach

- liquid is dosed
- difference in electrical charge
- connection with PFAS - micro flocs (PFAS)
- removable by filtration/precipitation
- ITRC listed



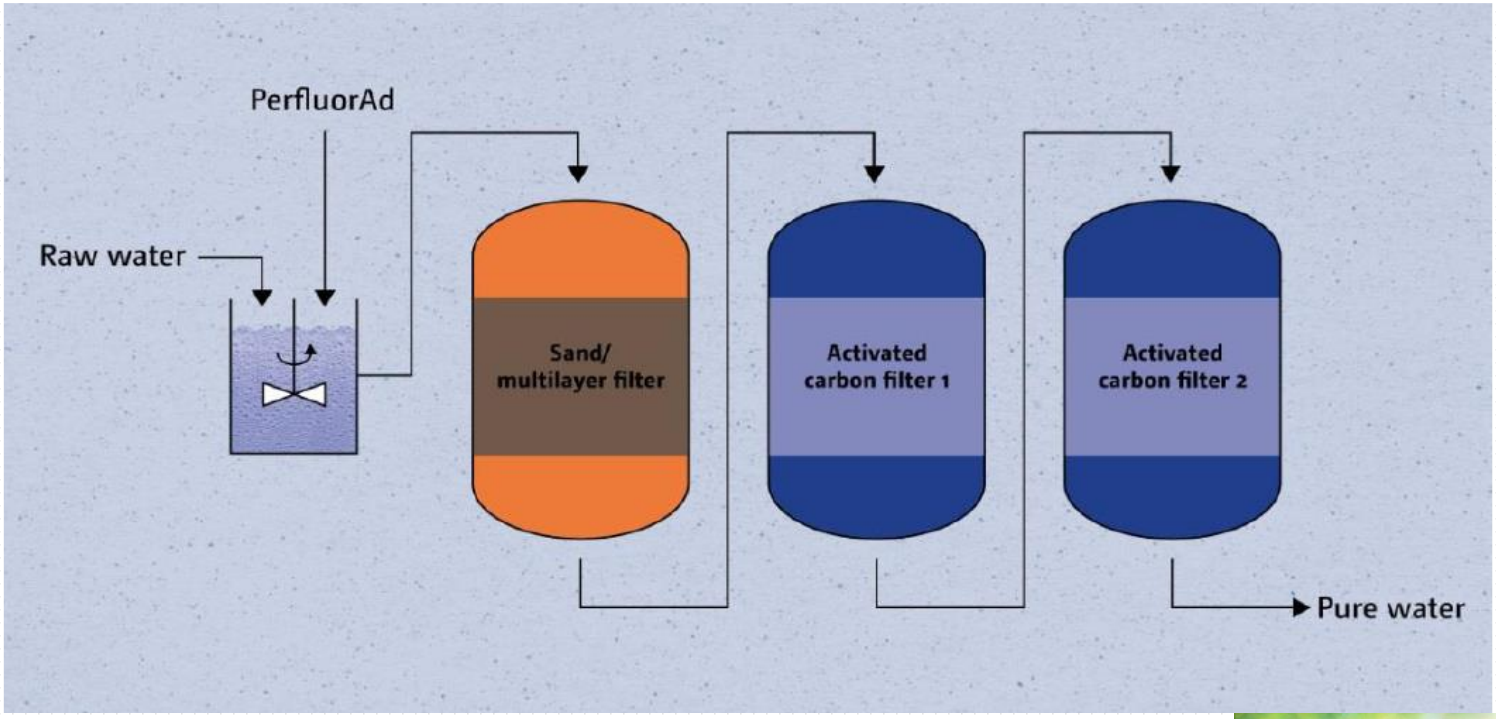
New Approach

- test in lab first
- simulating process of flocculation & filtration
- corresponding results



Innovative Approach

- filtration of particles
- removes majority of PFAS
- no interaction with DOC or BTEX



Site 1: Nuremberg

- challenge 2010: remediation of PFAS
- lab tests
- techniques pre-selected & tested
  - sorption
  - Nanofiltration
  - Reverse osmosis
  - Etc.

➡ most promising:
PerfluorAd

Site 1: Site Data

Compound	unit	max	min	average
pH		6,1	5,1	5,6
iron	mg/l	33,0	13,0	26,0
VOC	µg/l	49,0	15,0	27,0
BTEX	µg/l	15,0	0,0	4,0
DOC	mg/l	15,0	7,0	9,0
PFC	µg/l	777,0	144,0	357,0

- Aquifer about 2 m thick
- low flow rate per well
- sandy soil
- sandstone (bedrock) below

Site 1: Implementation

- first field test on site in 2014 (Sep-Nov)
- selected technique for up-scale
- full-scale Sep 2015 for 9 gpm
- effluent 0.3 ppb (230 ppt PFOS)
- now again up-scale to 22 gpm
- effluent < 20 ppt PFOS

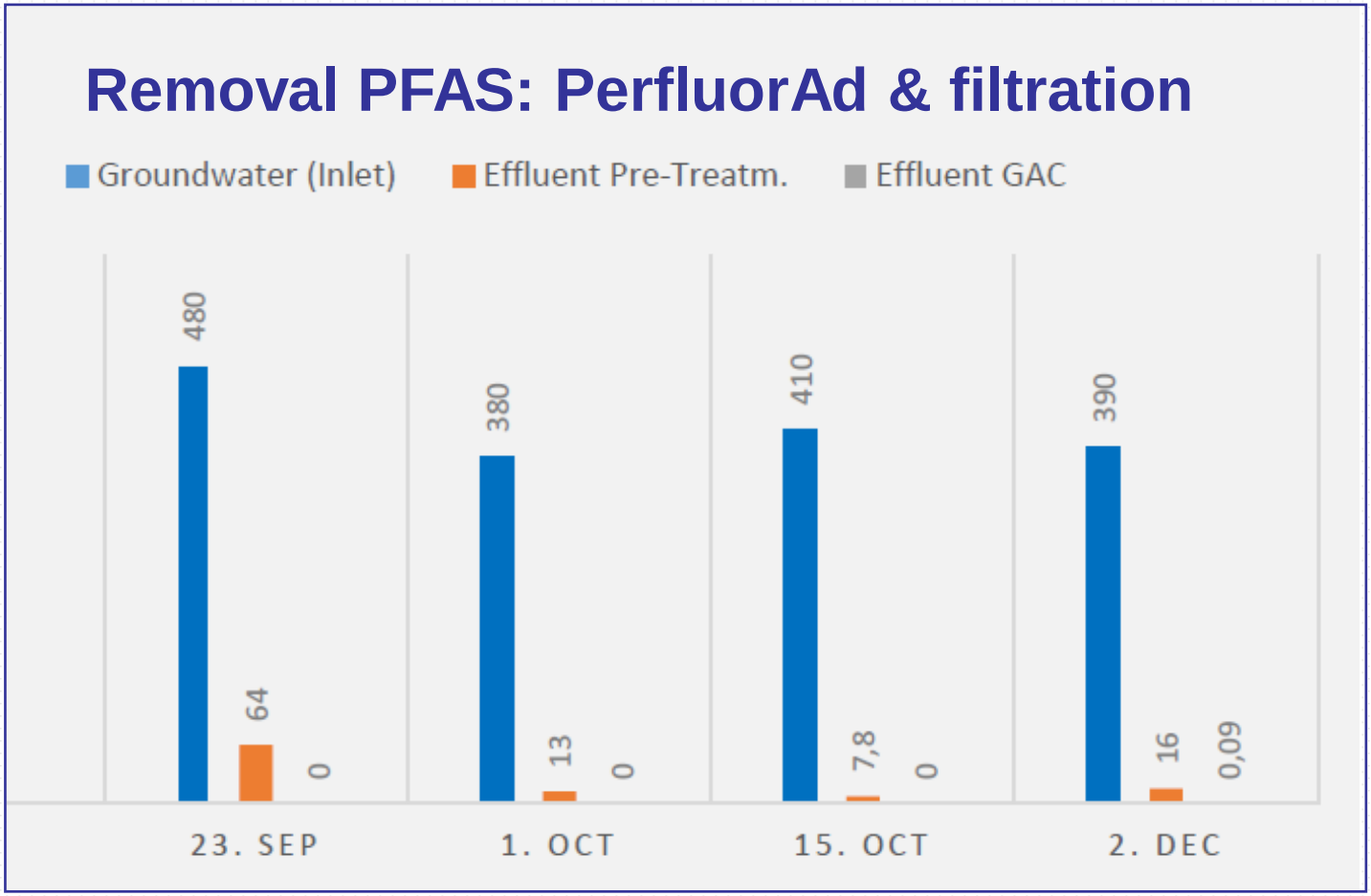
Site 1: Performance

PFAS Parameter	Acronym	Units	Pre-Treatment		Removal
			Before	After	%
Perfluorbutansäure PFBA	PFBA	µg/l	3,3	2,1	36,4
Perfluorpentansäure PFPeA	PFPeA	µg/l	6,7	1,9	71,6
Perfluorhexansäure PFHxA	PFHxA	µg/l	17,0	1,5	91,2
Perfluorheptansäure PFHpA	PFHpA	µg/l	3,7	0,18	95,1
Perfluoroktansäure PFOA	PFOA	µg/l	6,7	0,15	97,8
Perfluorbutansulfonsäure PFBS	PFBS	µg/l	11,0	0,89	91,9
Perfluorhexansulfonsäure PFHxS	PFHxS	µg/l	120,0	<1	100,0
Perfluoroktansulfonsäure PFOS	PFOS	µg/l	240,0	1,1	99,5
Sum PFAS		µg/l	408,40	7,82	98,09

Data from 15 Oct 2015

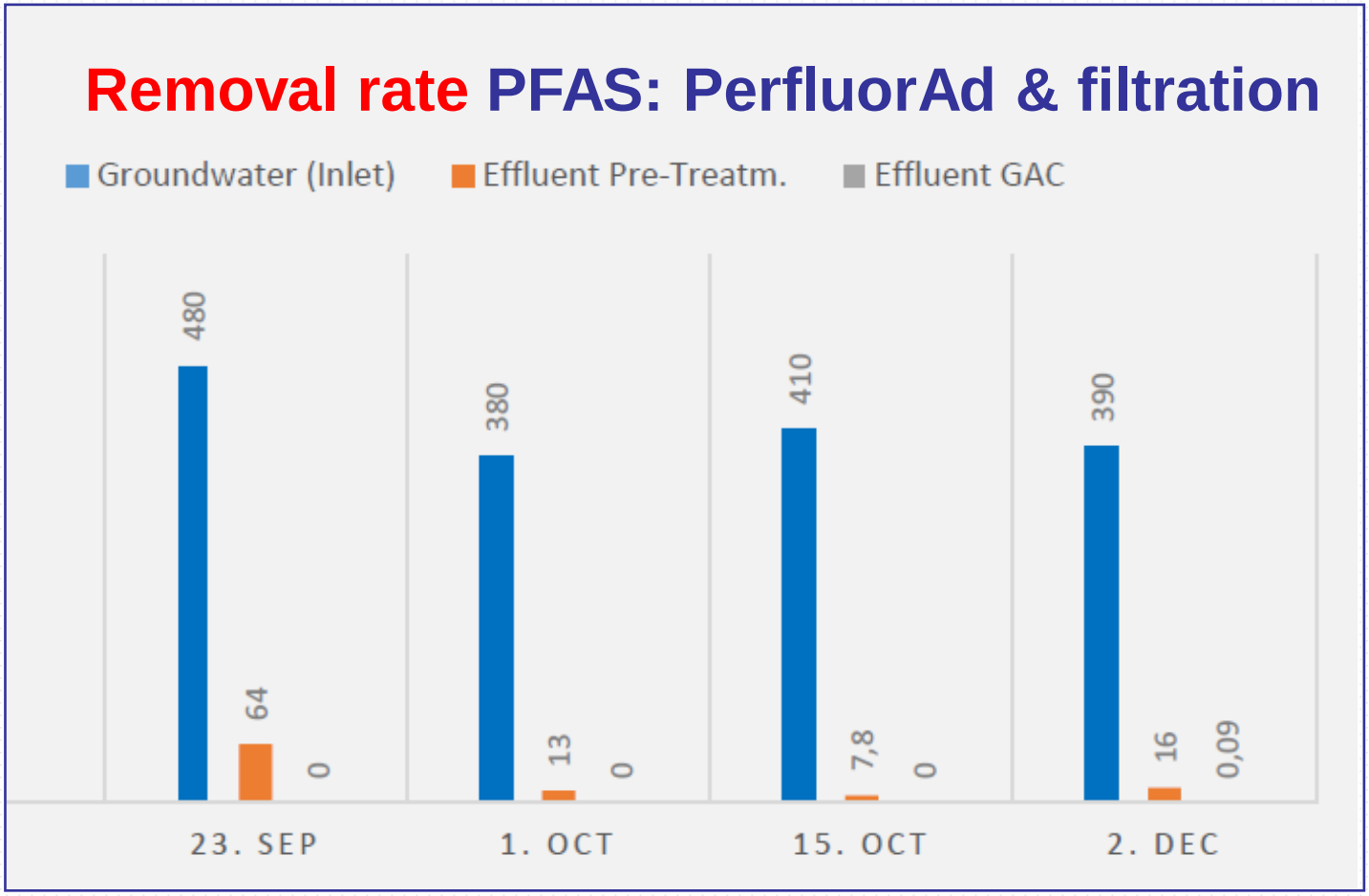
Dosing rate PerfluorAd at about 25 mg/L

Site 1: Performance



Key:
14 PFC
in ppb

Site 1: Removal Rate



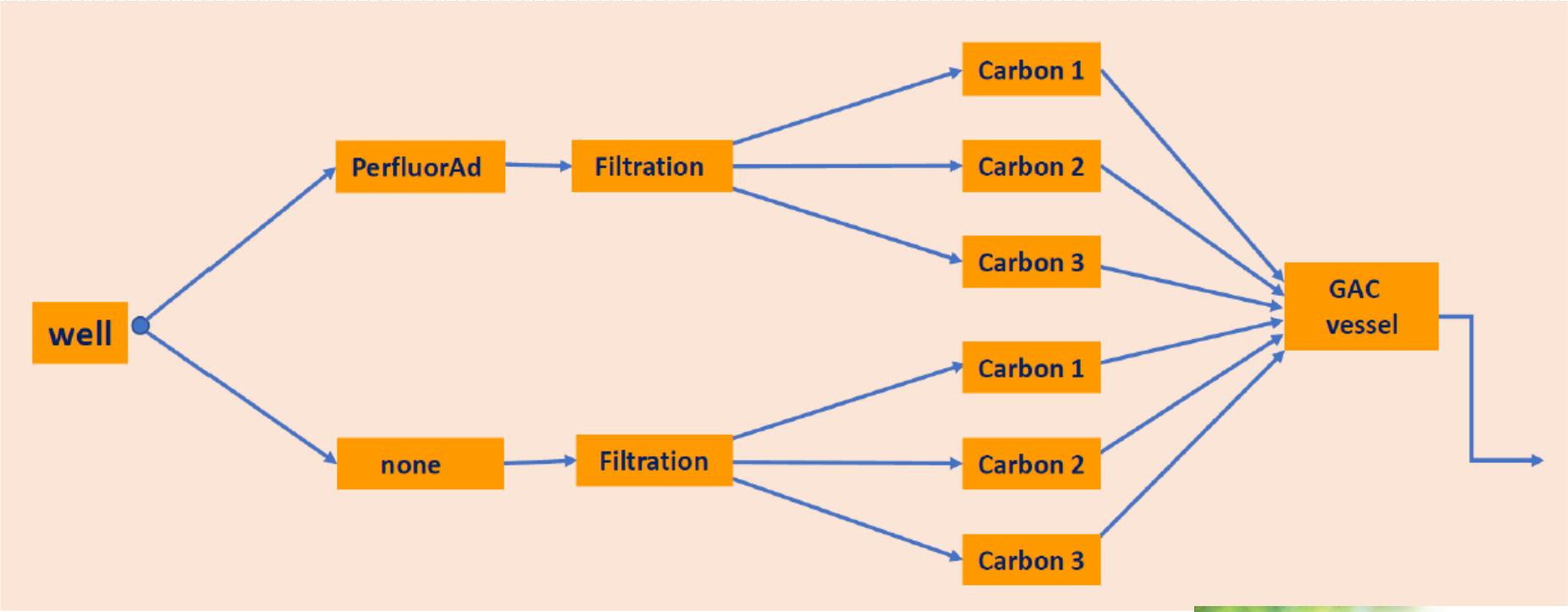
- 86.7%	- 96.4%	- 98.1%	- 95.9%

Key:
14 PFC in ppb

PerfluorAd

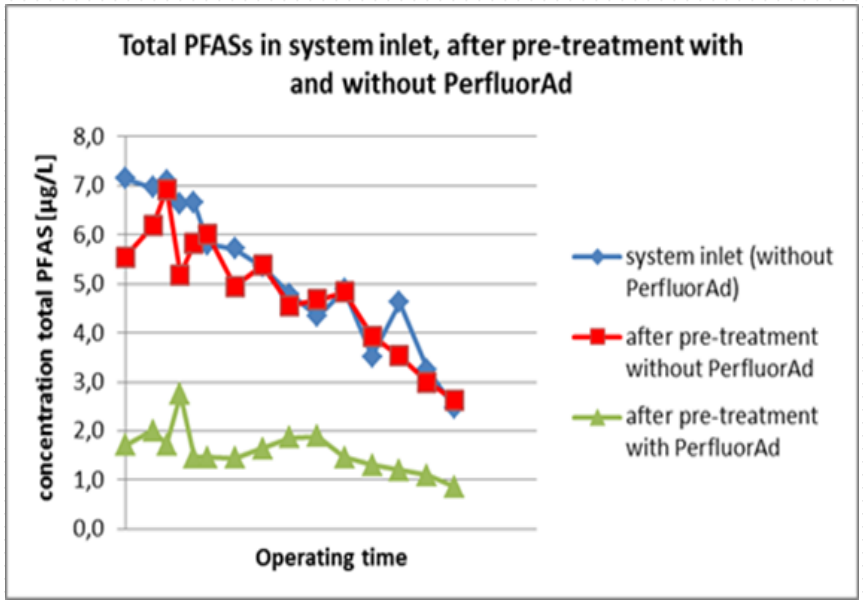
Site 2: Comparison

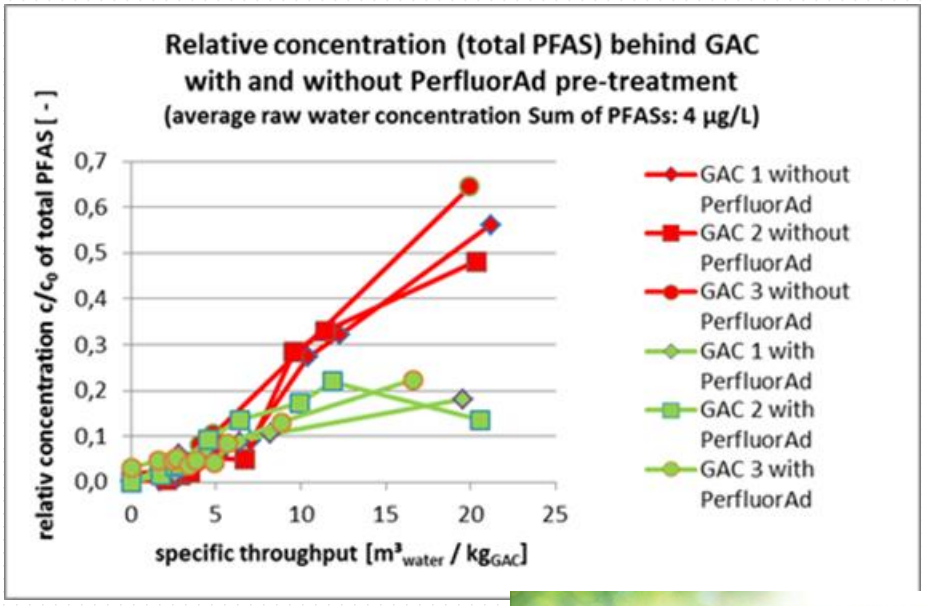
- fire-fighting in 2008: PFOS & 6:2 FTS
- PerfluorAd plus carbon vs carbon only
- 3 different carbon qualities



Site 2: Results

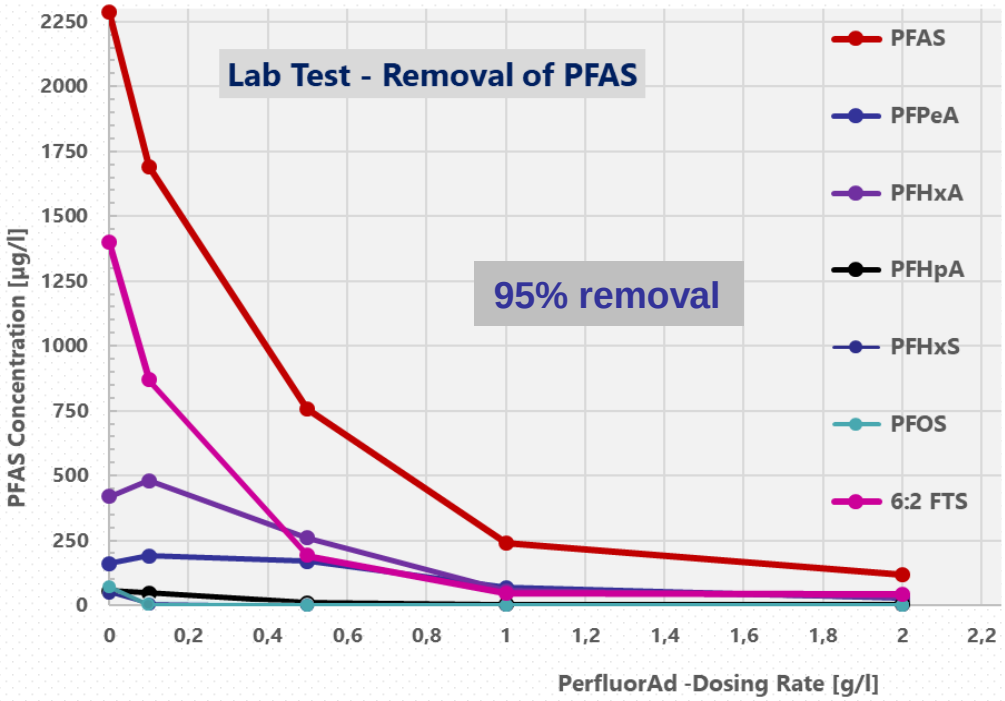
- PFAS from 7 to 2 ppb during test
- Filtration removes 65 / 75% PFAS
- difference in effluent of carbon
- Pre-treatment line - 15% cheaper





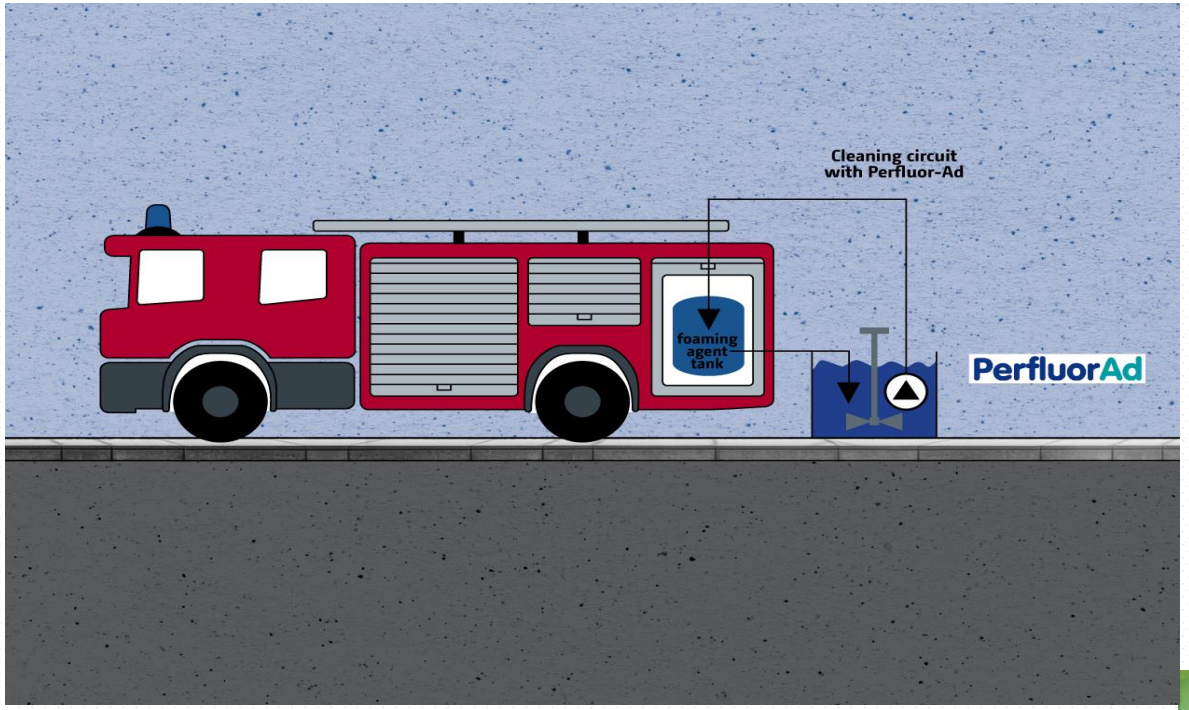
Conclusions: New Approach

- pre-treatment with precipitation/filtration
- dosing & reactor (small extra & adjustable)
- removes up to 99% of PFAS
- simplifies use of GAC/IX for polishing (lifetime)



Conclusions & Prospects

- PFAS collected in sludge
- waste reduced (GAC with PFAS)
- more economical



More Information (#208)

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