End to End PFAS Treatment

Addressing Contaminants of Emerging Concern in the Water Cycle

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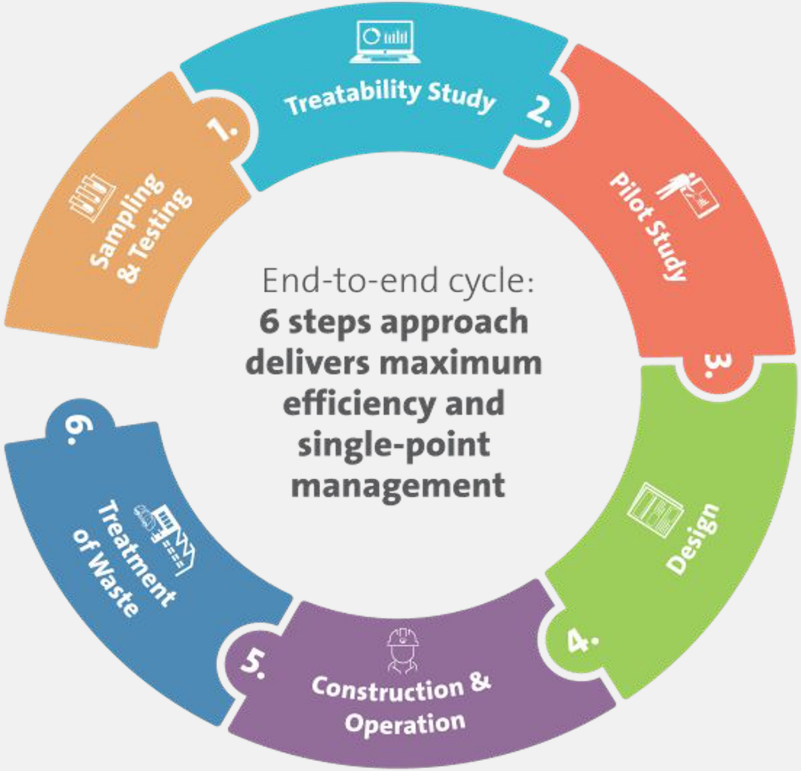
NOTICE: DISCLAIMER

The information contained in this statement is based on the Veolia group's understanding and know-how of the scientific and technical fields discussed herein as of the time of publication. Statements that may be interpreted as predictive of future outcomes or performance should not be considered guarantees of such, but rather reasoned assessments of the possible evolution of the technologies described.

As this document is based on the state of the Veolia group's scientific, technical, and regulatory knowledge at the time of its publication, the completeness and accuracy of the information contained herein cannot be guaranteed.

Descriptions contained herein apply exclusively to those examples and/or to the general situations specifically referenced, and in no event should be considered to apply to specific scenarios without prior review and validation.

SOLUTIONS & EXPERIENCE: PFAS – SIX STEPS OF THE END-TO-END TREATMENT SOLUTION



SOLUTIONS & EXPERIENCE:
DESIGN – BEST AVAILABLE TECHNOLOGIES

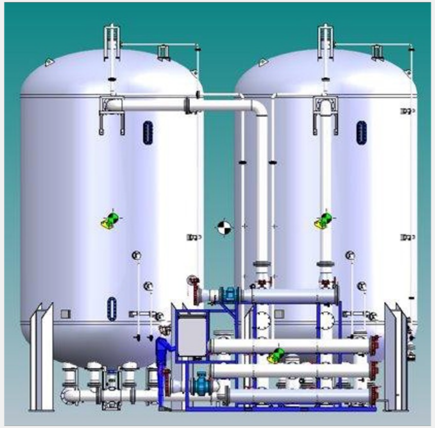
PFAS adsorption various medias:

- Activated Carbon
- Ion exchange resins

Considerations:

- Types of PFAS - long vs short chain, affinity for media
- Activity level - empty bed contact time (EBCT) - amount of media
- Overall capacity - volume treated before media replacement

LEAPfas™: proprietary designed vessels achieving Ultra-Low levels of PFAS in effluent on a consistent & reliable basis.

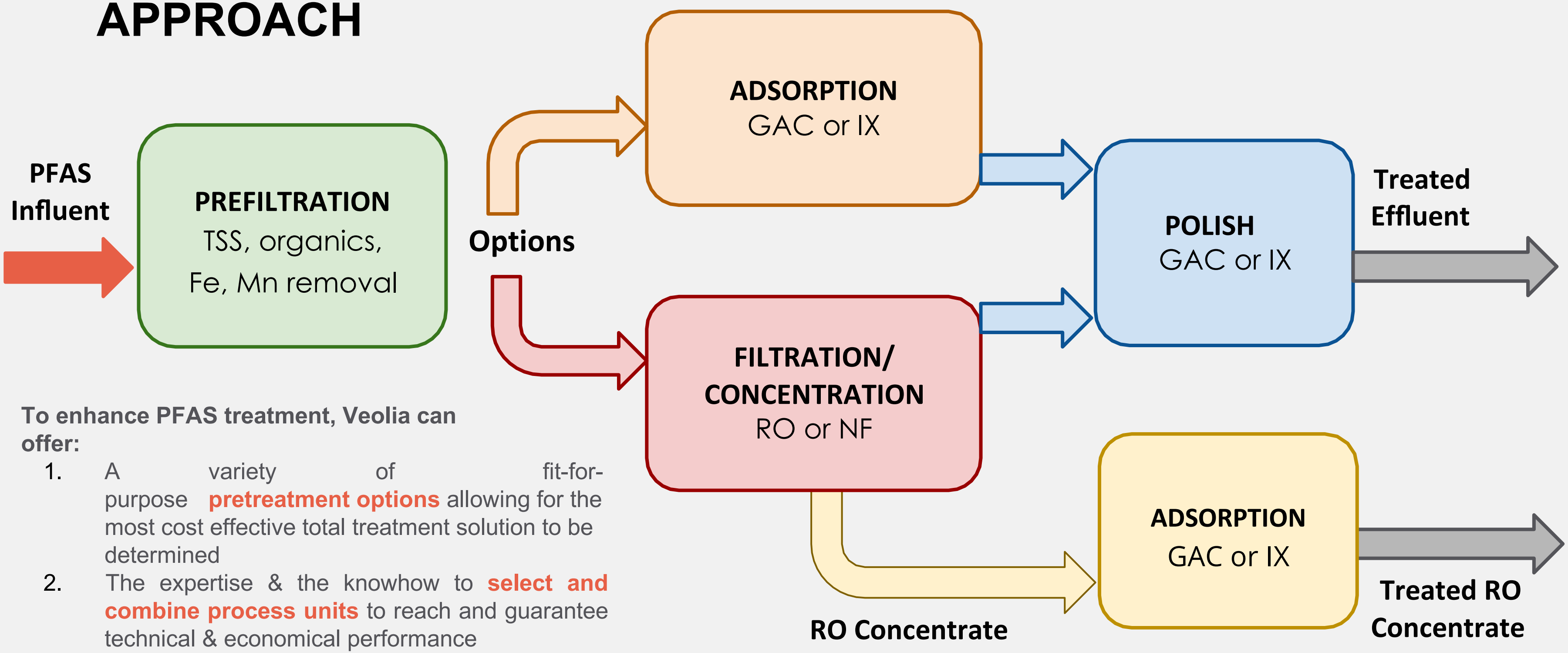


SOLUTIONS & EXPERIENCE:
DESIGN – BEST AVAILABLE TECHNOLOGIES

Our solutions for Membrane filtration

1. ZeeWeed UF hollow membrane
2. PROFlex NF and RO can be used for industrial, beverage, municipal and reuse applications
3. Sirion ®Reverse Osmosis standard product

SOLUTIONS & EXPERIENCE: WATER TREATMENT TECH FOR A MULTISTEP APPROACH



To enhance PFAS treatment, Veolia can offer:

1. A variety of fit-for-purpose **pretreatment options** allowing for the most cost effective total treatment solution to be determined
2. The expertise & the knowhow to **select and combine process units** to reach and guarantee technical & economical performance

Municipal Mobile Bridge to Permanent – Resin

Borough of Bellwawr, NJ

Operational Conditions/Challenges

- 900 GPM average
- Well water - Iron & Manganese removed
- Alkalinity = 131 ppm
- Chloride = 28 ppm
- Sulfate = 24 ppm
- Nitrate < 1.0 ppm as Nitrate NO3
- Iron < 0.1 ppm
- TSS < 1ppm
- TOC < 2.4
- **PFNA = 36 ppt**
- **PFOA/PFOS <10 ppt**

Solution

- Mobile container using Purolite PFA694E PFAS selective Ion Exchange media to quickly get the plant back online
- Performance model = 487,000 bed volumes
- **Treatment Target <2 ppt or Non detectable**
- **Lower life cycle costs vs GAC**

suez

Water Technologies & Solutions
Case Study

Borough of Bellmawr mitigates PFAS ahead of State's mandated schedule

SUEZ's temporary treatment solution bridges to long-term solution for PFAS removal

Challenge

The Borough of Bellmawr in New Jersey, United States found that they had PFAS contamination in their wells in the low parts per trillion, for PFOS, PFOA, PFNA, among other variants. The source well was immediately closed in the interest of the public's health, safety and welfare. The Borough quickly engaged state and local health and regulatory agencies, holding a public forum to allay any fears from the residents.

Local leaders decided in addition to the long-term solution to meet New Jersey's emerging Maximum Contaminant Levels (MCLs) due in 1-2 years, they would also investigate what could be done right away. As the water authority addressed the long-term treatment plan to remove the PFAS from the source water, they also contacted SUEZ – Water Technologies & Solutions to discuss the interim period. They concluded that a build-out of the permanent installation would take a year or more to implement, so SUEZ presented options for a faster interim implementation.

About the SUEZ Process

SUEZ tested the water, performed mass balance calculations, evaluated the discharge conditions, studied the regulatory framework, measured the economics of alternative approaches, considered local and national "headline" possibilities, and then provided options for the best overall, tailored solution.

When addressing PFAS, SUEZ remains technology agnostic: We select from a range of technologies which may include Ion Exchange, Carbon Adsorption, Reverse Osmosis, pretreatment including Clarification, Ultrafiltration, or Media Filtration; as well as water conditioning processes, along with Laboratory and on-site Water Analysis, among many other services. In all these decisions SUEZ seeks the Best Available Technology to do the job.

Figure 1: SUEZ specialty ion Exchange container used to remove PFAS in the drinking water supply

With our deep understanding of the special needs of Municipal, Industrial, Firefighting & other sites; for applications including drinking water, remediation, process treatment, discharge, compliance, solids management, & PFAS destruction; SUEZ delivers the right solution.

As an owner or operator of dozens of municipal and private drinking water systems, municipal drinking and wastewater systems, and solid waste handling/treatment facilities, SUEZ knows the Municipal challenge from the perspective of the owner / operator -

Find a contact near you by visiting www.suezwatertechnologies.com and clicking on "Contact Us."

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R&D – PFAS membrane testing

Source – well water containing PFAS (no spike)
Test – in lab on 2540 spiral elements (2.5-inch dia x 40-inch long)
3 Membrane types – brackish water, low energy and nanofiltration
Single element, single pass
Composite permeate @ 90% recovery (10x concentration)

$$\% \text{ Removal PFAS} = (1 - (\text{Concentration}_{\text{Permeate}} \div \text{Concentration}_{\text{Feed}})) * 100\%$$

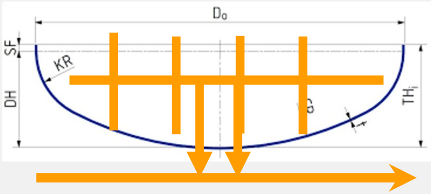
PFAS membrane performance – well water

			Feed	Permeate			Concentrate			% Removal		
PFAS	g/mol	# C's		BW	LE	NF	BW	LE	NF	BW	LE	NF
PFBA	214	4	7.1	<1.0	<1.0	4.8	80	70	58	100%	100%	32.4%
PFPeA	264	5	28.3	<1.0	<1.0	4.1	290	250	220	100%	100%	85.5%
PFHxA	314	6	25.6	<1.0	<1.0	3.4	250	210	190	100%	100%	86.7%
PFHpA	364	7	13.2	<1.0	<1.0	1.6	140	120	98	100%	100%	87.9%
PFOA	414	8	18.6	<1.0	<1.0	1.8	160	150	120	100%	100%	90.3%
PFNA	464	9	9.5	<1.0	<1.0	<1.0	70	65	49	100%	100%	100%
PFDA	514	10	1.2	<1.0	<1.0	<1.0	7.1	5.3	4.2	100%	100%	100%
PFUnA	564	11	3.0	<1.0	<1.0	<1.0	16	12	7.9	100%	100%	100%
PFBS	300	4	3.8	<1.0	<1.0	1.4	38	33	25	100%	100%	62.8%
PFPeS	350	5	5.2	<1.0	<1.0	1.7	53	49	42	100%	100%	67.0%
PFHxS	400	6	73.0	<1.0	1.8	13	740	670	530	100%	97.5%	82.2%
PFHpS	450	7	3.4	<1.0	<1.0	<1.0	29	29	22	100%	100%	100%
PFOS	500	8	200.0	<1.0	2	13	1300	1200	780	100%	99.0%	93.5%
6:2 FTSA	428	8	14.0	<1.0	<1.0	1.5	120	100	87	100%	100%	89.3%
8:2 FTSA	528	10	4.3	<1.0	<1.0	<1.0	21	24	16	100%	100%	100%
TOTAL			410.1	<1.0	3.8	46.3	3,314.1	2,987.3	2,249.1	100%	99.1%	88.7%

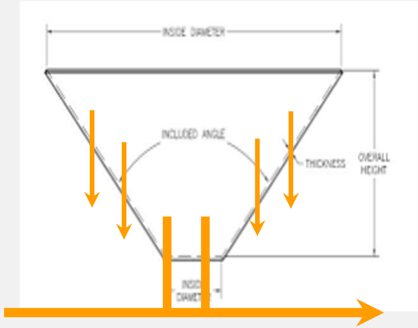
*All values are in ppt

Permeate results BDL (below detection)

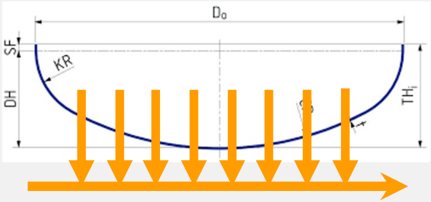
Various Underdrain Collection Systems



Traditional Laterals
With Hub



Inverted Cone/
False Bottom



External Collection Ring

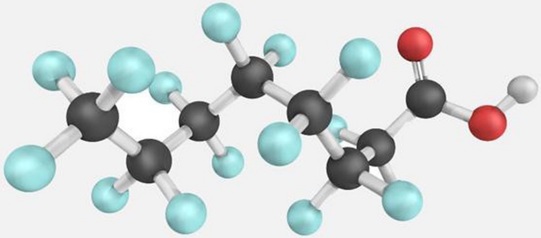
Operational Challenges

- Problems removing "stuck-on residue" on interior surfaces
  - Purity targets at "ultrapure" level (ppt, ng/L)…cleanliness not well addressed
  - Contaminants stick to surface and re-contaminate water
- Challenges to Operational safety
  - Confined space entry: maintenance, repair, cleaning, inspection risk/OSHA/recordable
  - Removing entire collection manifolds is clumsy, difficult
- Operational Pressure Ratings too Low
  - Default 100-125 psi often inadequate
  - Vulnerability to pressure events
  - Loss of operational flexibility civil rework, new pumps, pipes & valves
- Underutilized media is costly
  - High purity, long lived, single use, specialty now often required
  - PFAS / Microcontaminant cost of media = 80-90% of total Lifecycle cost
  - Maximum media longevity + achieving high purity not addressed with existing designs

SOLUTIONS & EXPERIENCE:
VEOLIA'S INCINERATION FACILITY IN PORT ARTHUR, TX

PFAS contaminants, which have been isolated and removed, can ultimately be handled through disposal at specialized waste management facilities.

These solutions are just beginning to be available at various locations in the U.S., and technology is rapidly



Thank you

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