AECOM Imagine it. Delivered.

DE-FLUORO™ DEMONSTRATION PROGRAM RESULTS

AECOM and our partners have been developing a water treatment technology (DE-FLUORO™) that can destroy per- and poly- fluoroalkyl substances (PFAS) in solution, that will significantly reduce PFAS-related environmental liability for land owners, managers and communities.

Our ultimate focus has been to design a destructive PFAS treatment technology that is compact, highly efficient, economical and mobile. At present, the industry is limited in choice, having had to turn to conventional commercially available water treatment technologies that do not destroy the PFAS mass, or require offsite thermal treatment or disposal. In some instances, this may result in a transfer of liability associated with PFAS contamination from one location (site water) to another (disposed treatment media). Through our proprietary electrodes and the process of electrochemical oxidation, DE-FLUORO™ breaks the carbon and fluorine bonds that form PFAS and destroy these onsite - offering an alternative solution for onsite separation and offsite destruction options.

Purpose of DE-FLUORO™

Historically in Australia, PFAS have been widely used and released into the environment and due to the strong carbon-fluorine (C-F) covalent bond, have proven to not break down in the environment. The uniquely engineered properties of PFAS also mean that there is no one single effective treatment technology for this contaminant.

Mass transfer technologies are currently being employed by remediation contractors, such as granular activated carbon (GAC), ion exchange resin (IX-R) and reverse osmosis (RO). These technologies do not destroy PFAS and instead, simply concentrate PFAS onto another media that typically requires off-site incineration or regeneration, producing regenerant wastes that require further management and treatment. To avoid such a scenario, DE-FLUORO™ was designed to couple electrochemical destruction of PFAS in waste solutions that were generated by conventional filtration / separation technologies.

DE-FLUORO™ Demonstration Program - Destruction Trials

DE-FLUORO™ had proven to be successful in destroying the dissolved PFAS mass within laboratory bench scale trials and the next step in the evolution of the technology was to undertake the Demonstration Project which compromised the treatment of eight real world samples using electrochemistry.

The key objective of the Demonstrations Project included the evaluation of the effectiveness and suitability of DE-FLUORO™ in the following areas:

1. Treatment effectiveness on a diverse range of real world samples with varying solution chemistry
2. Suitability to operate as a stand-alone or coupling technology
3. Commercial viability and scalability of the technology, including evaluating AECOM's ability to design and manufacture a compact, highly efficient, cost-effective mobile treatment unit for onsite and/or offsite PFAS destruction treatment.

Client Supplied Samples

Eight (8) clients provided samples of PFAS-impacted solution from their real-world operating environments for AECOM's DE-FLUORO™ Demonstration Project (PFAS destruction trials). The Demonstration Project samples provided included:

- C8 based Aqueous Film Forming Foam (AFFF) product concentrate
- Spent AFFF (C6 based) solution
- Two PFAS impacted groundwater samples from two different fire training grounds (two samples)
- Groundwater from a comingled PFAS and chlorinated hydrocarbon plume
- Two PFAS-impacted waste solutions resulting from two different water remediation/treatments (IXR regeneration and ozone foam fractionation)
- PFAS-impacted waste solution resulting from soil remediation/treatment (soil washing).

The samples provided contained a broad range of PFAS concentrations, from extremely low (parts per billion [ppb]) to extremely high (parts per million [ppm]). The sum of PFAS concentrations in client supplied samples ranged from 27.3 ppb to 6,380,000 ppb (or 6,380 ppm). Concentrations of Regulated PFAS (Perfluorooctane sulfonic acid [PFOS], Perfluorooctanoic acid [PFOA] and Perfluorohexane sulfonic acid [PFHxS]) in the samples ranged from 13.4 ppb to 5,837,000 ppb (or 5,837 ppm).

Table 1 below provides further detail regarding the total and regulated PFAS concentrations in the samples provided by each of our clients for the DE-FLUORO™ Demonstration Project.

Table 1 Total PFAS Concentrations prior to DE-FLUORO™ treatment

Trial #	Client Sector	Sample Description	Initial 'total' PFAS concentration (µg/l)	Initial 'regulated' PFAS concentration (µg/l)
1	New Zealand Government	Source area groundwater	27	13
2	Chemical Manufacturer	Industrial wastewater	354	310
3	Australian Government	Source area groundwater	455	445.8
4	Remediation Contractor	IX R – soft wash recipe	1,570	54.9
5	Aviation	Remediation derived wastewater	1,590	1,088
6	Oil & Gas	Spent C6 AFFF solution	4,620	6
7	Remediation Contractor	Remediation derived wastewater	10,700	6,572
8	Oil & Gas	3M AFFF Concentrate / Product	6,380,000	5,837,000

The samples contained a broad range of PFAS concentrations and signatures, including short and long-chained PFAS. Treating such a variety of samples allowed the Demonstration Project to challenge the operational and performance boundaries of DE-FLUORO™ (Figure 1) and understand the versatility of this technology in different applications. Further details surrounding the results of the Demonstration Project are outlined in Table 2 and Figures 2 to 5 on the following page.

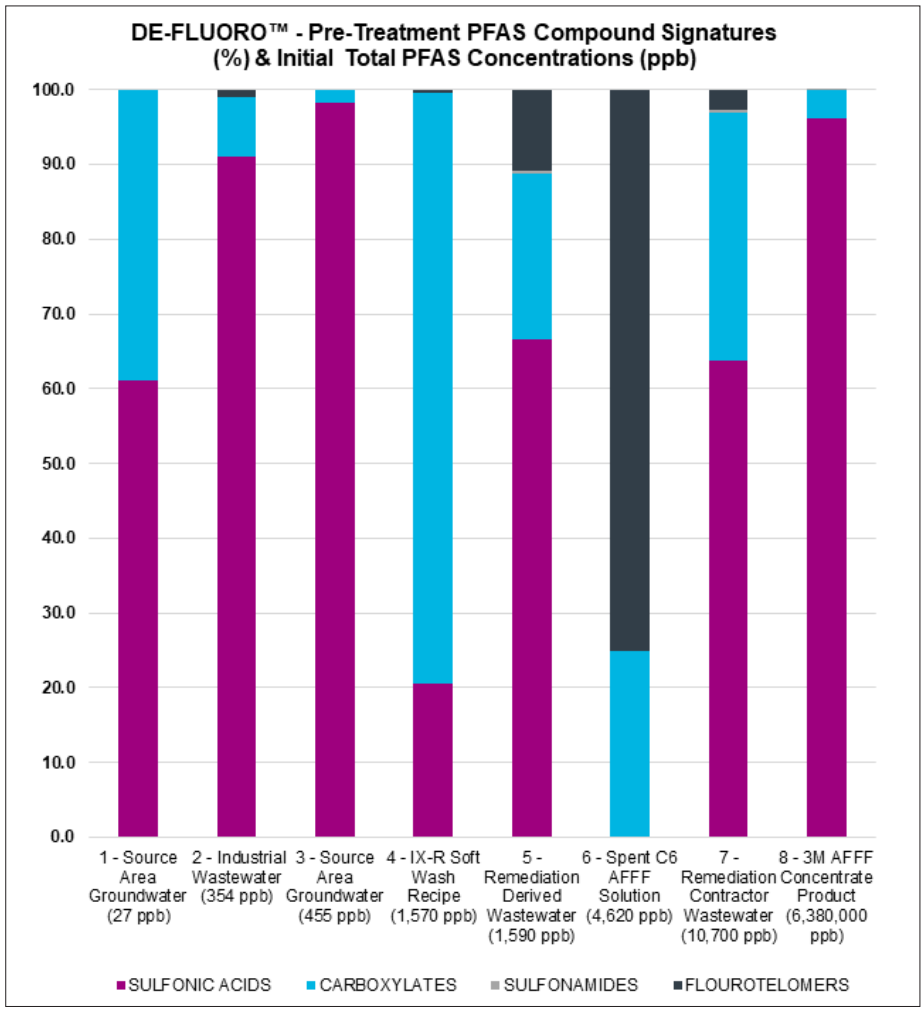


Figure 1 PFAS Compound Signatures prior to DE-FLUORO™ treatment

Table 2 Summary of DE-FLUORO™ treatment results

Trial / Sample #	Client Sector	Sample Description	Initial total PFAS concentration (µg/l)	% Mass Reduction (total PFAS) DE-FLUORO™	Initial 'regulated' PFAS concentration (µg/l)	% Mass Reduction (regulated PFAS) - DE-FLUORO™
1	New Zealand Government	Source area groundwater	27	84%	13	98%
2	Chemical Manufacturer	Industrial wastewater	354	100%	310	100%
3	Australian Government	Source area groundwater	455	99%	445	98%
4	Remediation Contractor	IX R – soft wash recipe	1,570	63.6%	54.9	100%
5	Aviation	Remediation derived wastewater	1,590	90%	1088	98%
6	Oil & Gas	Spent C6 AFFF solution	4,620	83%	6	71%
7	Remediation Contractor	Remediation derived wastewater	10,700	99%	6,572	100%
8	Oil & Gas	3M AFFF Concentrate / Product	6,380,000	58%	5,837,000	62%

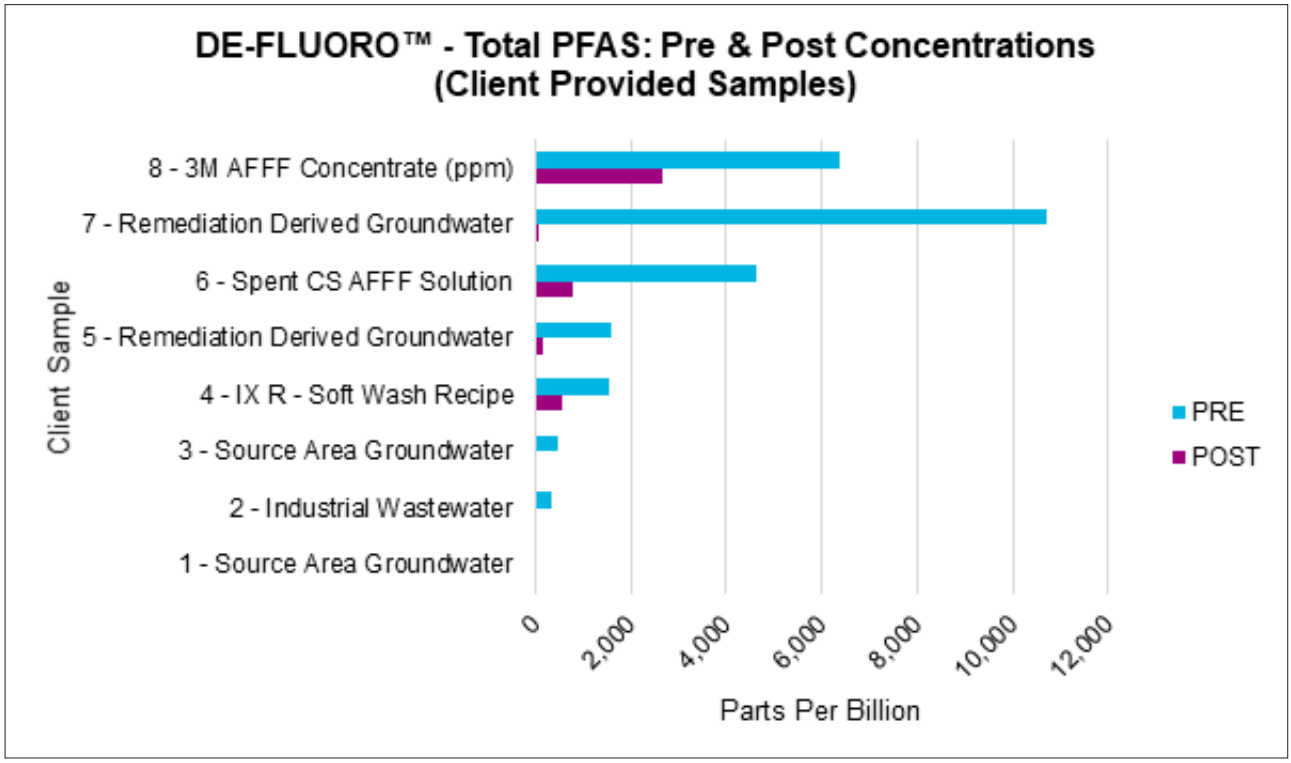


Figure 2 Total PFAS – Concentrations Pre and Post DE-FLUORO™ Treatment

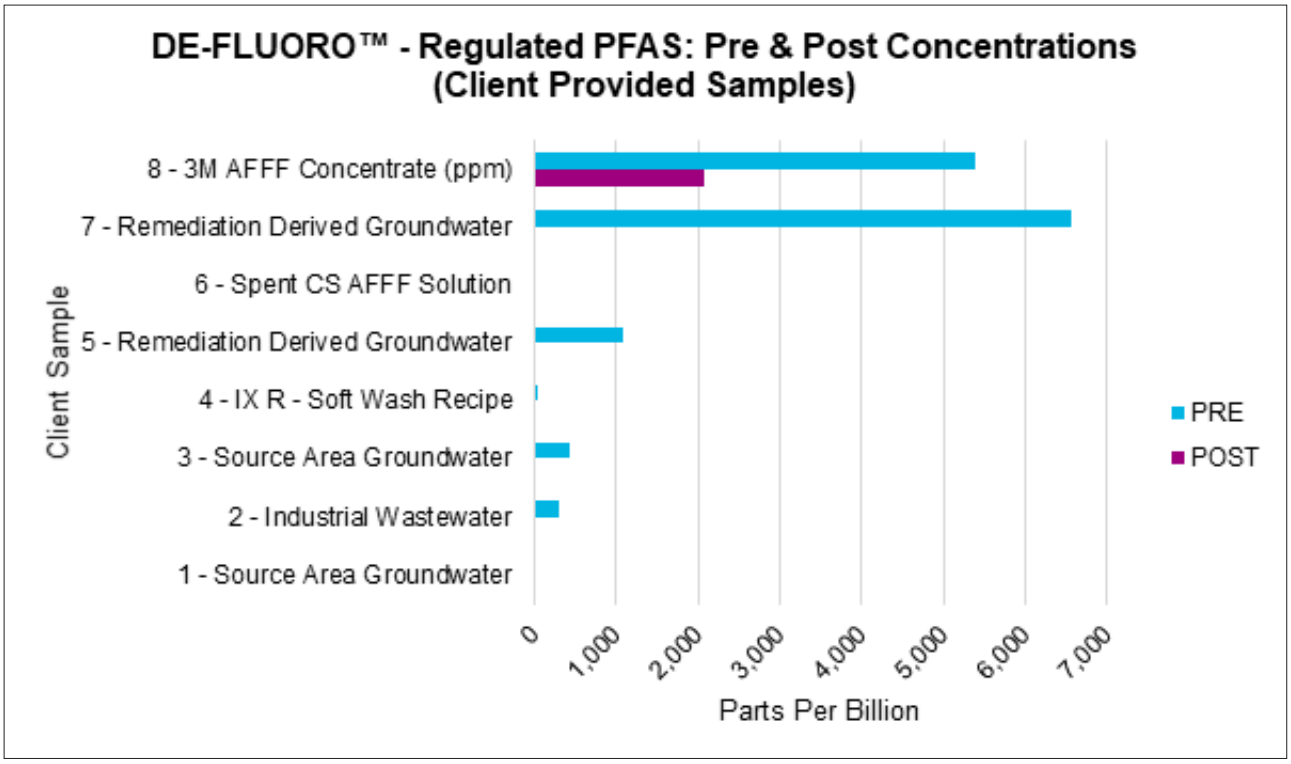


Figure 3 Regulated PFAS – Concentrations Pre and Post DE-FLUORO™ Treatment

Detailed Analysis of Results

Figure 4 shows that the PFAS signatures of pre-treatment samples were dominated by sulfonic acids and long chained carboxylates, whereas PFAS signatures post-treatment were all dominated by short chained carboxylates. Exceptions to this trend included the 3M AFFF Concentrate sample, where the PFAS signature did not significantly change and the Spent C6 AFFF Solution which was dominated by intermediate fluorotelomers, and to a lesser degree, carboxylates in the post treatment solution.

Short chained carboxylate compounds were the most recalcitrant to treat using electrochemical oxidation as was evident by the slower kinetics of degradation and the signature of % composition of PFAS compounds post-treatment. Figure 5 and Figure 6 summarise the degradation kinetics for the sum of measurable PFAS and regulated PFAS.

The DE-FLUORO™ treatment of the 3M AFFF concentrate product resulted in the greatest overall PFAS mass reduction (3,720,000 ppb) relative to the other trial samples, with pre and post treatment concentrations of 6,380,000 and 2,660,000 ppb respectively. Whilst it is noted that this represents a low percentage PFAS mass reduction relative to the other samples achieved during the trials, it is related to the extremely high pre-treatment PFAS concentrations, coupled with the limited retention times for this trial sample.

Note, additional data in relation to the degradation analytics associated with the Total and Regulated PFAS, as well as degradation rates in each of the individual PFAS compounds for each 'real world' sample can be provided on request.

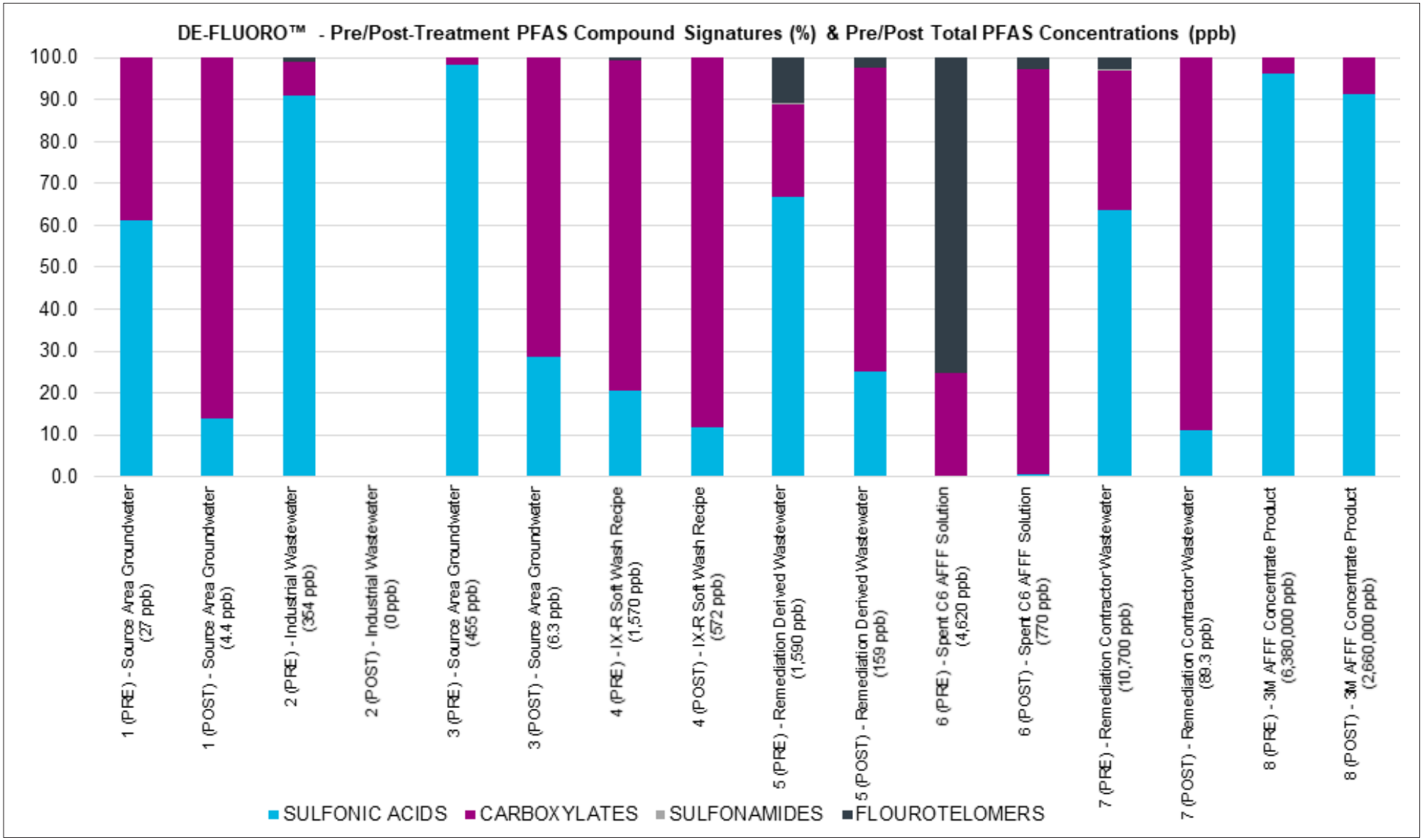


Figure 4 PFAS Compound Signatures Pre and Post DE-FLUORO™ Treatment

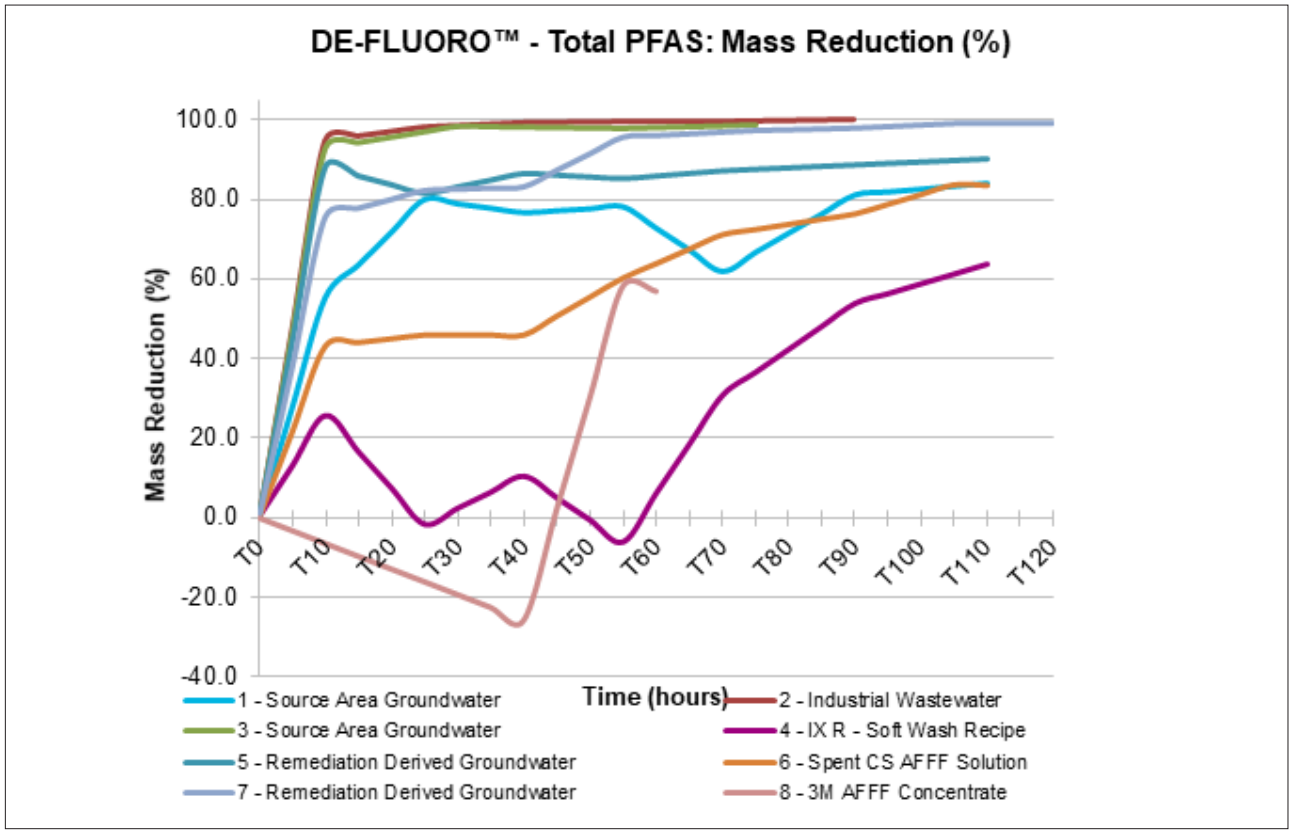


Figure 5 Total PFAS Mass Reduction (%)

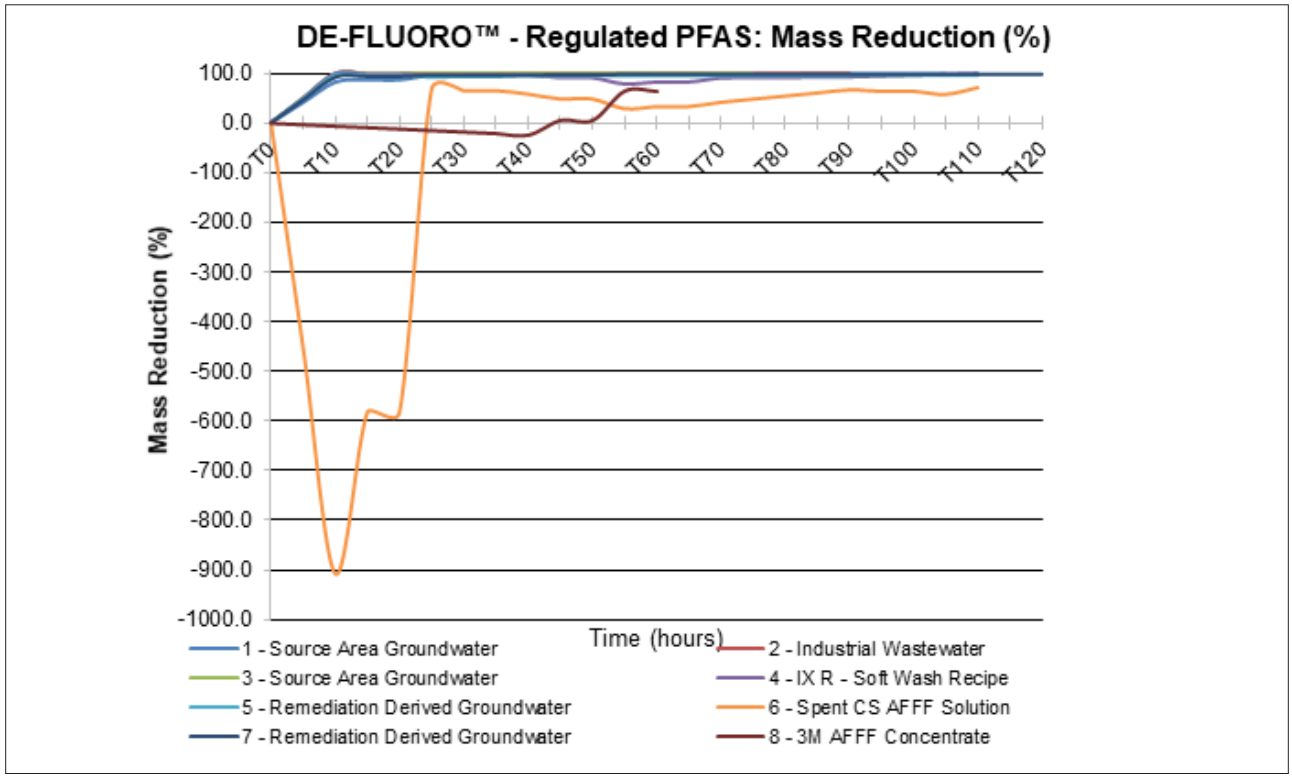
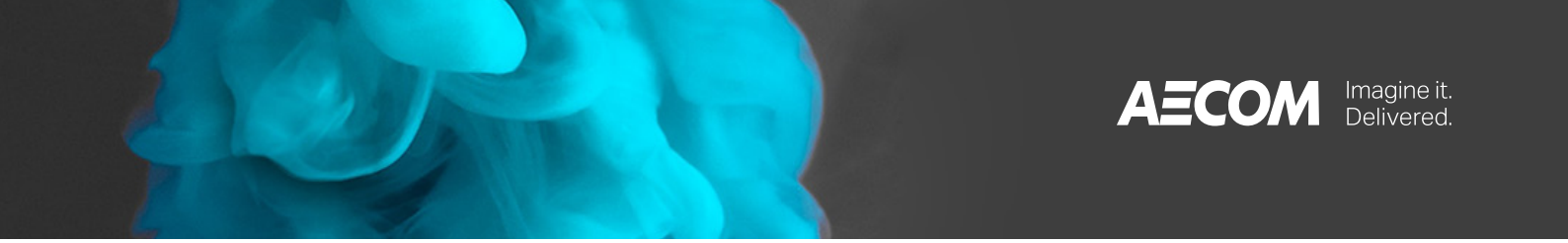


Figure 6 Regulated PFAS (PFOS, PFOA and PFHxS) mass reduction



Project Findings

The Demonstration Project data concluded that:

- DE-FLUORO™ destroyed between 90% to 100% of the total PFAS mass in the majority of the samples treated. The trials were limited to a set duration and a longer residency time would likely have resulted in all samples achieving 100% destruction
- DE-FLUORO™ destroyed between 98% to 100% of Regulated PFAS Mass, in all but two samples. The trials were limited to a set duration and a longer residency time would likely have resulted in all samples achieving 100% destruction
- DE-FLUORO™ treats both measurable and unmeasurable PFAS compounds with a range of compound signatures
- DE-FLUORO™ is not limited by PFAS concentration nor the presence of other contaminants (organic or inorganic)
- DE-FLUORO™ is a feasible PFAS destructive technology for 'real world' samples.

In addition, AECOM modelling indicates that greater reduction rates can be achieved by:

- Increasing the residency time / treatment duration (with the same sized reactor)
- Undertaking a sequential run of electrochemical reduction and electrochemical oxidation (i.e. reverse the polarity of the electrodes)
- Increasing mass transfer and the current density, the current density planned for future pilot systems will be scaled up by a factor of 40.

In response to this, our team are currently conducting efficiency trials to evaluate the potential for DE-FLUORO™ to reduce the required treatment duration.

DE-FLUORO™ Next Steps

The results of the Demonstration Project ('Real World PFAS Destruction Trials') using DE-FLUORO™ were highly encouraging and for that reason AECOM plans to invest in the build of a field scale mobile DE-FLUORO™ plant with multiple reactors in a stack and rack configuration. We are seeking opportunities to partner with clients / contractors to pilot DE-FLUORO™ in an onsite PFAS Destruction Pilot Program which would include:

- Mobilising a DE-FLUORO™ Pilot Scale System to site
- Undertaking a two to four month onsite PFAS destruction program to confirm DE-FLUORO™ as a cost effective, onsite PFAS destruction solution
- Data analysis and interpretation of the findings, followed by design of a full scale DE-FLUORO™ PFAS destruction solution. Scaling up would only be recommended based on results the pilot program including a cost benefit analysis against other existing destruction technologies.

We would welcome the opportunity to discuss the results of this program and the next steps in the evolution of DE-FLUORO™. We would also welcome the opportunity to provide a proposal to undertake a DE-FLUORO™ Pilot Program on your site.

To discuss the invitation in more detail, please contact:

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DE-FLUORO™
PFAS Destruction Technology