



A 501.c.3 non-profit specializing in environmental research and education



A 501.c.3, non-profit organization specializing in research and education on environmental preservation, protection, and remediation

**REPORT 24-1004: PFAS detoxification efficacy of De-Oil-It**

**July 2024**

De-Oil-It PFAS testing using EPA 1633 protocol isotope detection

- 18 required PFAS analytes reduced by 99%
- De-Oil-It detoxification efficiency: no presence of PFAS surrogates

As researched and reported by

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## Table of Contents

Greenworld Environmental Alliance Mission.....	3
PFAS Environmental Impact .....	3
Report 24-1004: PFAS detoxification efficacy summary .....	4
Testing Method .....	4
Results.....	5
Analytes (table 1) .....	5
Surrogates (table 2).....	7
De-Oil-It PFAS Formulation .....	8
Discussion.....	8
EPA 1633 testing standard .....	8
EPA 537.1 control standard.....	9
Reduction of PFAS Analytes Significance .....	10
Non-Detection of PFAS Surrogates Significance.....	10
The “Canary in the Mine” #1 Surrogate: NFDHA .....	11
The “Canary in the Mine” #2 Surrogate: PFBA.....	12
Frequently Asked Questions .....	16
What is the difference between PFAS, PFOS, and PFOA? .....	16
What is so “forever” about PFAS?.....	17
Why do I need overnight samples cooled to 39.2 F? .....	18
What happens if overnight samples warm up? .....	19
What is De-Oil-It?.....	19
GEA Assistance with your PFAS mitigation.....	20
Detailed PFAS removal analysis using De-Oil-It.....	20
GEA Environmentally Responsible Disposal Program .....	20



## Greenworld Environmental Alliance Mission

Greenworld Environmental Alliance, “GEA” is a 501.c.3 non-profit organization specializing in environmental research and education.

Our mission is to research the environmental impact of chemical contamination and report our findings in reports such as this 24-1004 “De-Oil-It Efficacy Detoxifying PFAS Analytes and Surrogates”.

Typically, GEA will perform optimization efforts creating recommended solutions that detoxify chemical contamination in a way that preserves, protects and responsibly remediates environmental biohazards.

The fields GEA has researched include:

- Hydrocarbon Detoxification (non-detection of hydrocarbon remediation)
- Red Tide Mitigation (k.brevis and elimination of Brevetoxins)
- Fresh-Water Mitigation (Cyanobacteria and elimination of Microcystis)
- Phosphate, Nitrate, and Nitrate Reduction (water run-off: storms, agriculture irrigation, commercial and residential water run-off)

Currently the most promising chemical remediation product on the market is De-Oil-It which is trademarked as a Hydrocarbon Degradar; this nomenclature, Hydrocarbon Degradar, results from GEA research illustrating that De-Oil-It should be regarded in its own right a separate category “DEGRADER” in contrast to degreasers and dispersants as these two common commercial product categories cannot clean AND remediate a biohazard; in contrast, De-Oil-It not only cleans but also detoxifies chemical contamination to safely decontaminate environmental hazards (such as an oil spill) to the level that accredited laboratory analysis proves complete removal of the original toxic elements.

## PFAS Environmental Impact

PFAS is an acronym for PERFLUOROALKYL or POLYFLUOROALKYL SUBSTANCES. They are a group of lab-made chemicals that are created to provide commercial properties that repel water, dirt, oil and other chemicals. PFAS lab-made chemicals have been in-vogue since the 1950’s with the most famous usage referred to as TEFLON or non-stick properties such as used in kitchen cooking vessels such as pans.

The older term, PFS, or perfluorochemicals has been “upgraded” to include more complex formulations that require the new terminology of PFAS to more accurately describe a wider range of usages in commercial products.



The concern of PFAS is due to what is commonly described as chemically stable or “forever” chemicals with the belief that these chemicals do not degrade over time. In fact, this is a misnomer because PFAS chemicals do indeed degenerate under various conditions. This report discusses the degeneration of PFAS chemicals and is annotated as such via EPA 1633 analysis utilizing isotope-based detection which is far more discrete than reagent detection.

The focus of PFAS concerning environmental hazards has been connected to a wide range of human, animal and plant harm. Even though PFAS detection is relegated to PPB (parts per billion) and PPT (parts per trillion), as opposed to PPM (parts per million) typically used for most chemical contaminant analysis, the minute amount of PFAS builds up over time to be of concern for our health and the well being of the environment.

This report illustrates the ability of De-Oil-It detoxification efficacy in which the results of EPA 1633 protocol testing resulted in:

- 99% removal of PFAS analytes (i.e. chemical ingredients)
- Non-detection of PFAS surrogates (i.e. remediation consequences)

Because of the harm, particularly to human health, and environmental well-being, GEA enthusiastically accepted grants to create a solution that is shown to remove PFAS from our environment using De-Oil-It.

## Report 24-1004: PFAS detoxification efficacy summary

This report illustrates the ability of De-Oil-It detoxification efficacy in which the results of EPA 1633 protocol testing resulted in:

- 99% removal of PFAS analytes (i.e. chemical ingredients)
- Non-detection of PFAS surrogates (i.e. remediation consequences)

## Testing Method

GEA utilized EPA 1633 isotope-based laboratory analysis which detects:

- 18 PFAS analytes
- 22 PFAS surrogates



The EPA 1633 testing sequence was proposed by EPA, DOD and DOE as a defacto standard to detect what this collective agency has determined as the most critical of the hundreds of PFAS elements known to be lab-made for commercial products.

Analytes can be thought of as the main ingredients of a commercial product, with the most well-known commercial product TEFLON used as an anti-stick coating to kitchen vessels such as pans.

Surrogates are created as side reactions to cleaning as the PFAS analytes are degraded during a cleaning process PFAS elements are decomposed into different pieces and their high reactivity quickly bonds to these elements and environmental available inorganic and sometimes organic compounds. Therefore, the brilliance of the EPA 1633 testing protocol is designed to detect up to 22 of the most typical and concerning newly created PFAS compounds called surrogates.

GEA began testing a known quantity of the 18 PFAS analytes detected by EPA 1633 isotope-based using EPA 537.1 standard liquid solution used to calibrate instrumentation employing EPA 1633 analysis. This EPA 537.1 was purchased from Agilent Technologies who supply this control to laboratories known to provide EPA 1633 (there are two, PACE LABS and EUROFINs who we used for the EPA 1633 testing).

## Results

### Analytes (table 1)

<< see next page >>



## EPA 1633 PFAS in water analysis DOI treated

Analyte	CAS #	SAMPLE - 1			SAMPLE - 2		
		537.1	1633	% Reduced	537.1	1633	% Reduced
Perfluorohexanoic acid - Na salt (PFHxA)	2923-26-4	2,000.00	6.70	99.67%	2,000.00	6.40	99.68%
Perfluoroheptanoic acid (PFHpA)	375-85-9	2,000.00	5.80	99.71%	2,000.00	5.70	99.72%
Perfluorooctanoic acid (PFOA)	335-67-1	2,000.00	7.40	99.63%	2,000.00	7.20	99.64%
Perfluorononanoic acid (PFNA)	375-95-1	2,000.00	7.90	99.61%	2,000.00	7.00	99.65%
Perfluorodecanoic acid - Na salt (PFDA)	3830-45-3	2,000.00	6.70	99.67%	2,000.00	6.00	99.70%
Perfluorododecanoic acid - Na salt (PFDoA)	307-67-5	2,000.00	7.70	99.62%	2,000.00	7.80	99.61%
Perfluorotridecanoic acid (PFTrA)	72629-94-8	2,000.00	6.20	99.69%	2,000.00	6.70	99.67%
Perfluorotetradecanoic acid (PFTeA)	376-06-7	2,000.00	8.00	99.60%	2,000.00	5.50	99.73%
Perfluorobutanesulfonate - K salt (PFBS)	29420-49-3	2,000.00	6.10	99.70%	2,000.00	6.70	99.67%
Perfluorohexanesulfonate - K salt, mixed isomers (PFHxS)	3871-99-6	2,000.00	6.90	99.66%	2,000.00	5.40	99.73%
Perfluorooctanesulfonate, mixed isomers (PFOS)	1763-23-1	2,000.00	5.70	99.72%	2,000.00	6.40	99.68%
N-methylperfluorooctanesulfonamidoacetic acid - mixed isomers (N-MeFOSAA)	2355-31-9	2,000.00	6.20	99.69%	2,000.00	5.70	99.72%
N-ethylperfluorooctanesulfonamidoacetic acid - mixed isomers (N-EtFOSAA)	2991-50-6	2,000.00	6.10	99.70%	2,000.00	5.40	99.73%
Tetrafluoro-2-(heptafluoropropoxy)propanoic acid (HFPO-DA)	13252-13-6	2,000.00	5.30	99.74%	2,000.00	5.10	99.75%
Dodecafluoro-3H-4,8-dioxanonanoic acid (DONA)	919005-14-4	2,000.00	6.70	99.67%	2,000.00	6.30	99.69%
9-chlorohexadecafluoro-3-oxanone-1-sulfonic acid - K salt (9Cl-PF3ONS)	73606-19-6	2,000.00	7.20	99.64%	2,000.00	6.70	99.67%
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid - K salt (11Cl-PF3OUDS)	83329-89-9	2,000.00	5.30	99.74%	2,000.00	5.30	99.74%
Perfluoroundecanoic acid - Na salt (PFUnA)	60871-96-7	2,000.00	8.10	99.60%	2,000.00	n/a	n/a

## Surrogates (table 2)

### EPA 1633 PFAS in water analysis DOI treated - Surrogates

Analyte	CAS #	SAMPLE - 1	SAMPLE - 2
		1633	1633
Perfluorobutanoic acid (PFBA)	375-22-4	ND	ND
Perfluoropentanoic acid (PFPeA)	2706-90-3	ND	ND
Perfluoropentansulfonic acid (PFPeS)	375-73-5	ND	ND
Perfluoroheptanesulfonic acid (PFHpS)	206-800-8	ND	ND
Perfluorononanesulfonic acid (PFNS)	98789-57-2	ND	ND
Perfluorodecansulfonic acid (PFDS)	335-77-3	ND	ND
Perfluorododecansulfonic acid (PFDoS)	1763-23-1	ND	ND
1H,1H, 2H, 2H-Perfluorohexane sulfonic acid (4:2FTS)	757124-72	ND	ND
1H,1H, 2H, 2H-Perfluorooctane sulfonic acid (6:2FTS)	27619-97-2	ND	ND
1H,1H, 2H, 2H-Perfluorodecane sulfonic acid (8:2FTS)	39108-34-4	ND	ND
Perfluorooctanesulfonamide acid (PFOSA)	754-91-6	ND	ND
N-methylperfluorooctane sulfonamide acid (NMeFOSA)	31506-32-8	ND	ND
N-ethylperfluorooctane sulfonamide (NEtFOSA)	4151-50-2	ND	ND
N-methylperfluorooctane sulfonamidoethanol (NMeFOEA)	24448-09-7	ND	ND
N-ethylperfluorooctane sulfonamidoethanol (NEtFOEA)	4151-50-7	ND	ND
Perfluoro-3-methoxypropanoic acid (PFMPA)	377-73-1	ND	ND
Perfluoro-4-methoxybutanoic acid (PFMBA)	863090-89-5	ND	ND
<b>Nonaflouro-3,6dioxahexanoic acid (NFDHA)</b>	151772-58-6	<b>ND</b>	<b>ND</b>
Perfluoro (2-ethoxyethane) sulfonic acid (PFEEESA)	113507-82-7	ND	ND
3-Perfluoropropylpropanoic acid (3:3 FTCA)	356-02-5	ND	ND
3-Perfluoropentylpropanoic acid (5:3 FTCA)	914637-49-3	ND	ND
3-Perfluoroheptylpropanoic acid (7:3 FTCA)	206-798-9	ND	ND
NFDHA is the "canary in the mine" and is highly indicative of problems above ND			
ND = Non-Detect			

## De-Oil-It PFAS Formulation

From our analysis the De-Oil-It formulation used was RTU PRO, this is an available formula sold by Greenworld Innovations, makers of De-Oil-It

Approximately 1.02 gallons of De-Oil-It RTU PRO can treat 100 gallons of PFAS contaminated water. It is possible to extrapolate this to PFAS contaminated soil using a different equation; if your PFAS contamination involves water or soil you should email [support@deoilit.com](mailto:support@deoilit.com) to get a more comprehensive recommendation.

GEA is currently involved with a follow-on study to better illustrate possibly more refined and optimized ratios of De-Oil-It concentrate (the concentrate form of De-Oil-It is intended to be diluted with water as water is the activating agent contributing to De-Oil-It's well-known detoxification efficacy).

## Discussion

### EPA 1633 testing standard

EPA 1633 is a testing standard derived from the collaboration of EPA, DOD and DOE

- EPA Environmental Protection Agency
- DOD Department of Defense
- DOE Department of Energy

It is the collaboration of these agencies that made the determination the most concerning PFAS elements most likely to cause health risks that there are 18 PFAS analytes that should be the standard in detecting the minute amounts of PFAS analyte elements.

The method chosen to detect PFAS analytes, and their surrogates (created during a cleaning / remediation effort) is isotope-based analysis.

Isotope detection is far more accurate than reagent-based detection.

The general method of reagent-based detection is to add a chemical solution to the PFAS sample; detection is declared by the amount of recovered reagent and then extrapolating how much of the reagent was "tied up" by binding to a chemical element you are interested in. For example, you add 100ml of a reagent, add to the sample, and then using typically UV fluorescent reading of the amount of reagent remaining; if the remaining amount is computed to be 80ml



then the assumption is 20ml of reagent is bound to the chemical the reagent is known to bind towards. This is an over simplified explanation but is accurate in theoretical reagent protocol.

Isotope-based laboratory detection can be over simplified to explain its methodology and you can think of an isotope, which is a radiation-based method, in a way you can think of a specific PFAS analyte as having a kind of radio frequency that an isotope is constructed to be “tuned” to this frequency. Identification is based on matching the peaks in a spectrum analysis to the known peaks and ratios of gamma emitters. This matching process is achieved using proprietary isotope identification software.

Note that reagent-based PFAS detection is not useful as it is critical to real-life remediation cleaning efforts in the field; the isotope detection is expensive and lengthy (about 10-14 days total laboratory efforts). To this end, Hanby Electronics, in Houston Texas, provides a field test kit that allows remediators to apply a solution, such as De-Oil-It, and then measure the detection of PFAS remaining. This requires a field measurement before adding a solution, and then use field test kit to determine if the remediation effort requires additional treatment. Once the treatment has gone as far as the Hanby Electronics PFAS field testing kit reaches its limitations, then you can send either water or soil samples to an accredited EPA 1633 laboratory analysis to reach a final determination of how much PFAS has been reduced / eliminated (in either case the result would be referred to as “detoxification”).

## EPA 537.1 control standard

To have a controlled testing environment, GEA needed to find a testing method that guaranteed a known quantity of the 18 PFAS analytes that EPA 1633 testing protocol can detect using isotope-based spectrum analysis.

The solution was purchasing an EPA 537.1 control standard from Agilent Technologies in California; this group provides EPA 537.1 control standard capsules of PFAS fluids containing exactly 2000ng (nanograms) of each of the 18 PFAS analytes tested via EPA 1633 protocol.

GEA then added the EPA 537.1 control standard to TWO laboratory testing vessels, and then added filtered water (the combination of EPA 537.1 plus filtered water

We used filtered water so as to not introduce various inorganic elements that could interfere with the testing. Although this does not represent a field test necessarily it does provide a controlled testing environment to ensure De-Oil-It RTU PRO actually works. Follow-on grant testing is in progress to understand the interference potential from actual kinds of water sources such as ponds, water run-off retention, lakes, rivers, oceans, municipality treatment facilities, etc.

## Reduction of PFAS Analytes Significance

From the EUROFINS laboratory in Lancaster PA, EPA 1633 testing result from the [table 1](#) the results of all 18 PFAS analytes were reduced by greater than 99% by De-Oil-It RTU PRO formula.

The significance of these results concludes that De-Oil-It RTU PRO formula was nearly 100% effective “detoxifying” PFAS analytes. Even though the testing methodology was highly controlled it serves as a promising steppingstone to consider De-Oil-It RTU PRO for field PFAS contamination projects, especially because of the significance of non-detection of PFAS surrogates discussed in the next segment.

For a more detailed analysis of the 18 PFAS analytes detoxified by De-Oil-It visit <https://gea.solutions> or <https://deoil.it.com> for more information in a documents called “De-Oil-It PFAS elimination capabilities” where you will find a through detailing of these 18 PFAS analytes.

## Non-Detection of PFAS Surrogates Significance

From the EUROFINS laboratory in Lancaster PA, EPA 1633 testing result from the [table 2](#) the results of all 22 PFAS surrogates were not formed at all using De-Oil-It RTU PRO formula.

The significance of these results concludes that De-Oil-It RTU PRO formula was 100% effective “detoxifying” PFAS analytes because no surrogates were formed. The result of NO SURROGATES FORMED is critical to expressing De-Oil-It RTU PRO formula should be regarded as a valid real world PFAS contamination remediation tool. If any surrogates were formed then GEA would have to conclude that De-Oil-It RTU PRO chemical make-up is suspect in its efficacy, and this is simply not the case as RTU PRO was extremely effective. GEA’s prior grant studies of De-Oil-It regarding hydrocarbon degrading efficacy had the same effect, namely that hydrocarbons were reduced to non-detection, and the surrogate production was controlled by De-Oil-It (using the RTU formula, which is weaker than RTU PRO).

To this end further PFAS analysis by GEA is required to simulate real-world remediation efforts using De-Oil-It (either RTU or RTU PRO) because we do not know if there are any interfering non-organic chemicals. In the case of hydrocarbon remediation surrogate formulation is expected but highly controlled by De-Oil-It; we have more than ample reason to believe the same results would occur with PFAS real-world or real-world simulation. But not to despair, the highly controlled PFAS environment is extremely encouraging to indicate real-world success because PFAS chemicals, especially fluorine, are highly reactive and do degenerate to form additional

compounds (the surrogates); this in a way challenges the notion of “forever” (see FAQ discussions).

Bottom line conclusion: the controlled testing environment provided the opportunity to learn De-Oil-It is an extremely efficient degrader of PFAS analytes.

For a more detailed analysis of the 22 PFAS surrogates detoxified by De-Oil-It visit <https://gea.solutions> or <https://deoilit.com> for more information in a documents called “De-Oil-It PFAS elimination capabilities” where you will find a through detailing of these 22 PFAS surrogates. Also, review CLOSURE REPORT #2 for a real-world hydrocarbon analysis EPA report, that show non-detection of hydrocarbons after De-Oil-It treatment and the containment of surrogates; note that hydrocarbon degrading is not reactive as PFAS (extremely reactive); therefore, GEA does recommend De-Oil-It has having very high efficacy detoxifying PFAS.

## The “Canary in the Mine” #1 Surrogate: NFDHA

To further the notion that even in a highly controlled PFAS experimentation setting, GEA’s strong belief that De-Oil-It exhibits a very high degree of PFAS detoxification efficacy we point out the role of NDFHA, a know surrogate of PFAS remediation.

Because PFAS elements when degrading by cleaning or naturally (PFAS is not as stable as most people think – see FAQ “why do I need overnight samples cooled to 39.2 F ?”) are so highly reactive and therefore create surrogates, the EPA + DOD + DOE learned that NFDHA if detected indicates one of two conditions

- The cleaning solution is not 100% effective
- Testing protocol was potentially compromised

NFDHA is called “the Canary in the Mine” because of these two possible, and like the original meaning of the Canary in the Mine (coal mines, live canary birds if they died probably succumbed to methane gas before alarm detection was activated... so get the heck out of the mine!).

From Table-2, surrogate detection, there were no traces of NFDHA furthering GEA’s belief that De-Oil-It should be a strong candidate for field remediation.

## The “Canary in the Mine” #2 Surrogate: PFBA

It is well known that decomposition of PFAS analytes (note that GEA refers to this as “degrading” to distinguish environmentally safe and responsible breaking down chemical contamination as opposed to degreasers, dispersants and other kinds of cleaning solvents) could reduce PFAS from long chain to short chain PFAS surrogates.

To this end, the surrogate PFBA (“Perfluorobutonic Acid”, CAS 375-22-4) was recorded from two samples as non-detection. This further indicates superior efficacy of De-Oil-It’s RTU PRO formula to “cleanly” degrade PFAS in such a way that short chain conversion of PFAS analytes does not occur (there are other surrogates that amplify this notion, but PFBA is note more often in science literature regarding the conversion of PFAS long chain to short chain during remediation efforts).

This leaves a question concerning what happens to Fluorine after remediation efforts. In peer review and other kinds of collaboration the consensus is nearly a complete destruction of Fluorine and / or minimal non-statistical relevant harm produced as an unintended consequence. Northwestern University PFAS published a study showing that PFAS can be destroyed using two relatively harmless chemicals: sodium hydroxide or lye, a chemical used to make soap, and dimethyl sulfoxide, a chemical approved as a medication for bladder pain syndrome (Aug 18, 2022).

In addition:

*“PFAS has become a major societal problem,” said Northwestern University Professor William Dichtel, who led the study, in a press release. “Even just a tiny, tiny amount of PFAS causes negative health effects, and it does not break down. We can’t just wait out this problem. We wanted to use chemistry to address this problem and create a solution that the world can use. It’s exciting because of how simple—yet unrecognized—our solution is.”*

*“It’s encouraging and promising,” said Tasha Stoiber, an environmental chemist at the Environmental Working Group, a U.S.-based nonprofit that closely tracks the issue, in an interview with [Science](#). Current methods for collecting and treating PFAS compounds do exist, she says. “But it’s incredibly expensive.”*

*The PFAS compounds in question—used in fire-fighting foams and the production of nonstick coatings—contain a chemical group called a carboxylic acid, a small cluster of carbon, oxygen, and hydrogen atoms. Computer calculations by colleagues at the University of California, Los Angeles, revealed DMSO knocks off the carboxylic acid group. “Once that happens it causes the entire molecule to fall apart in a cascade of reactions,” Dichtel says.*

*What’s left behind, Trang says, is [mostly easily captured fluorine ions](#), and a mixture of harmless, naturally occurring carbon and oxygen containing byproducts, her team reports today in [Science](#).*

*Roughly 40% of PFAS compounds contain carboxylic acid groups, and thus could potentially be degraded by the new approach, Trang says. Though it has yet to be tested in the field, she adds that the most likely strategy would be to use conventional means to filter PFAS chemicals from, say drinking water, and then treat them off-site.*

*The method doesn't work on all types of PFAS, however. Compounds used in flame retardants and batteries, for example, contain a sulfonate group instead of a carboxylic acid group and won't break down with this approach. Yet, the new work, Stoiber says, offers hope that other researchers will be able to find mild recipes to tear apart these forever chemicals as well.*

GEA suggests that De-Oil-It RTU or RTU PRO may provide a simple SOAP based approach (replacing Lye with compounds such as Sodium Metasilicate which would comprise less than 4% aqueous solution percentage, this ceiling is regarded by EPA Pesticide group who provides a kind of certification for algicide proclaimed products is the most amount to regard possible general safety to the environment by reducing / destructing a bio-element, algae and its toxin, in areas that humans utilize: drinking water, fishing and other edible items, recreation and more).

De-Oil-It RTU PRO (slightly diluted 67% ISC with water), RTU (less diluted 20% ISC with water) and ISC (concentrate) are all soaps substituting LYE with Sodium Metasilicate which has the property of detergent / soap plus provides alkalinity (7.2 to 8.3 in RTU formulas, and 11.3 pH in ISC) both which are known for PFAS destruction.

Still the question remains what happens with Fluorine after De-Oil-It based remediation, and the common thought covers but is not completely inclusive of other potential reformation:

1. Formation of F<sub>2</sub> gas
2. Formation of OF<sub>2</sub>, O<sub>2</sub>F<sub>2</sub>, OF<sub>3</sub>
3. Formation of a Fluorine based salt such as NaF
4. Formation of Fluoride (F<sup>-</sup>)
5. Formation of Sodium Fluoride (NaF)
6. Any other formation of Fluorine not detected by EPA 1633 protocol

F<sub>2</sub> gas is highly reactive and toxic therefore a valid concern after remediation efforts. The reactivity is regarded to most likely convert to a lower chain length Fluorine based compound and with the non-presence of PFBA and other surrogates (as denoted by Table-2) the further destruction of Fluorine is evident through non-detection of samples 1 AND 2. Note that if a gas was produced in any form in the submitted PFAS resistant sampling bottles, which were nearly full, the lab did not indicate any pressurization issues to indicate presence of pressure build up by gas; GEA therefore does not believe F<sub>2</sub> gas necessarily presents a problem. Furthermore, in real-world remediation since the destruction of PFAS analytes is so prevalent (99% reduced) we believe that this potential dissipation would quickly resolve issues in the atmosphere.

Oxygen and fluorine can combine to form many different compounds, known as oxygen fluorides, with the general formula  $O_nF_2$ , where  $n$  can range from 1 to 6. Some examples of oxygen fluorides include:

- Oxygen difluoride ( $OF_2$ ): The most studied and stable binary compound of oxygen and fluorine. It can be a colorless gas or yellowish-brown liquid with a foul odor and a boiling point of  $-145\text{ }^\circ\text{C}$ . It's used as an oxidizer in rocket fuel systems and is on the Hazardous Substance List.
- Dioxygen difluoride ( $O_2F_2$ ): Similar in structure to hydrogen peroxide, this compound can be an orange solid that melts into a red liquid at  $-163\text{ }^\circ\text{C}$ . It's unstable and difficult to purify but has some uses in converting uranium oxides to  $UF_6$  and recovering actinides from nuclear waste.
- Trioxygen difluoride ( $O_3F_2$ ): Also known as ozone difluoride

Oxygen fluorides are regarded as stable under  $-160\text{ }^\circ\text{C}$  and could produce a severe interaction within water that could involve high energy release such as an explosion (PubChem 2005). While the lab report from EPA 1633 does not produce data regarding formation of oxygen fluorides GEA, the volatility described in PubChem 2005 most likely was not a valid transformation of PFAS analytes in treatment by De-Oil-It RTU PRO. GEA believes that De-Oil-It must have quickly transformed PFAS analytes in a manner oxygen fluorides were not created. We might be getting closer to understanding a complete destruction of PFAS might have occurred concerning De-Oil-It based solutions (and then the suggestion becomes what titration would be in favor of using the least amount of chemicals to produce the most favorable outcome)

What if Fluorine is still available after treatment?

According to both researchers and regulators, the three most ready-to-use technologies to treat PFAS include membrane separation, anion exchange resins (AER), and activated carbon. Also, the "Stockholm Convention's guidelines recommend activated carbon as best available technology (BAT) for removing PFAS from a polluted stream (i.e., waste, air, liquid, or gas).

To this end if remediation measures pose an essential threat after De-Oil-It remediation the either extra applications of De-Oil-It are recommended but as far as "Fluorine run-off" there are measures to protect PFAS penetration to human consumption via membrane separation, anion exchange resins, or activated carbon filters.

#### Membrane separation

Membranes are a solid porous media that can separate a certain pollutant from a liquid or gas phase. Based on PFAS properties (e.g., molecule size), reverse osmosis (RO) and nanofiltration (NF) are one of the most suitable separation processes. Previous studies found these methods to be effective at removing PFAS from water. On the other hand, they require an upstream pre-treatment (e.g., activated carbon filtration) to prevent membrane fouling and extend their lifespan.

#### Anion exchange resins

As the name suggests, this purification route entails swapping the negatively charged PFAS ions dissolved in water with some other anions (e.g., chlorides) embedded into a polymeric resin bed. This exchange occurs through an adsorption mechanism. Resins exhibit great adsorption capacities and effectively remove a wider range of PFAS. Nonetheless, being a less mature technology, its cost was estimated to be three times higher than that of activated carbon.

#### Activated carbon filtration

In this case, PFAS is adsorbed on the highly porous inner structure of activated carbon. The superior surface area of these sorbents is created via the high-temperature treatment (i.e., activation) of either coal or renewable feedstock-based chars. While being able to trap a broad array of PFAS within their pores, activated carbon's adsorption performance increases with the contaminant chain length.

The formation of Fluorine based salts is a possible side effect; however, there was no presence of a precipitate even though most Fluorine based salts are soluble and therefore most likely to present presence of a surrogate (Table-2 shows both samples with non-detection of PFAS surrogates).

Formation of F<sup>-</sup> is possible but its boiling point is so low (about -188 C or -306.4 F), not only would this ion be unstable but highly reactive and most likely to form a surrogate in which both samples 1 and 2 show non-detection of surrogates during De-Oil-It RTU PRO degrading of PFAS analytes.

Formation of NaF (sodium fluoride) is also possible since two of De-Oil-It three active ingredients are comprised of Sodium (Na), so this is a possibility but not detected by isotope EPA 1633 methods nor Fluoride test strips.

As far as any other Fluorine based compound created via De-Oil-It RTU PRO remediation efforts not detected by EPA 1633 protocol it is necessary for further investigation through additional grant-based studies and collaboration with groups such as Northwestern University to ensure the most likely minute amounts can still be accounted for if such consternation exists.

Final note: while there is room for further testing of released or other kinds of Fluorine "run off" from De-Oil-It based remediation there were no residual findings of Fluoroalkyl compounds. The Handy Electronics by the way, a field test kit using reagent technology to test presence (but not as accurate as lab isotope Fluorine based PFAS analytes and PFAS surrogates, is patented to detect Fluoroalkyl compounds. GEA highly recommends usage of this test kit to assist with decisions to adding additional De-Oil-It RTU PRO remediation efforts before deciding whether or not to submit to isotope-based testing

Currently GEA suggests that there might be a complete destruction of PFAS using De-Oil-It.

## Frequently Asked Questions

### What is the difference between PFAS, PFOS, and PFOA?

PFAS stands for Perfluoroalkyl Substance and Polyfluoroalkyl Substance

PFOS stands for Perfluorooctance Sulfonate

PFOA stands for Perfluorooctance Acid

PFAS is an umbrella term that is also referred to as a “family”; the family of chemicals individually are also referred to as “forever chemical”.

Just like hydrocarbon is an umbrella term, or “family” if you will, using the term PFAS is easier to state versus the many kinds of PFAS elements. Refer to table-1 for a list of the 18 analytes that EPA, DOD, and DOE have determined are the most detrimental of the many identified PFAS compounds; refer to table-2 for a list of the 22 surrogates that have commonly been identified as unintended consequence of breaking down PFAS compounds (note: breaking down is also referred to as “degrading”, and the end result of breaking down, decomposing, degrading into either non-detection of the original PFAS compound, or hydrocarbon as matter of fact, or obtaining significant reduction of a chemical compound degrading action is also referred to as “detoxification”).

Note in table-1 and table-2, GEA provides the long name, the abbreviated symbol and the CAS (Chemical Abstract Society) ID.

Some examples:

PFOA = Perfluorooctanoic Acid, CAS 335-67-1

PFOS = Perfluorooctanesulfonate, CAS 1763-23-1

And now a tongue-twister to further illustrate the need for abbreviation

N-MeFOSAA = N-methylperfluorooctanesulfonamidoacetic Acid, CAS 2335-31-9

Notice the embedded chemical terminology “octan” which is an abbreviated form of OCTANE, meaning 8 and refers to 8 carbon atoms. We mention this because there was one critical comment that was wrong stating that since several PFAS chemicals have an 8 octet that it was doubtful that De-Oil-It could break this sequence down; this was a false premises that GEA had to at least address to avoid disbelief that De-Oil-It would be capable of degrading PFAS. GEA knew two things to dispel this before the EPA 1633 testing. First, De-Oil-It has a rich history of breaking down up to C40 hydrocarbons, so C8 was not scary. Second, the Hanby Electronic PFAS field testing kit has a patent in



isolating the fluoroalkyl group and in fact has a patent in this process. With these pieces of knowledge GEA proposed a grant to test De-Oil-It efficacy degrading PFAS with the utmost confidence that some degree of degrading could take place, and of course this document shows proof that De-Oil-It is very efficient degrading PFAS analytes that are the most concerned by EPA + DOD + EPA; our confidence is also high for all other kinds of analytes that EPA 1633 does not detect due to EPA 1633 specific scope and purpose.

By the way it might be worth mentioning another reason for PFAS as a family name because there are 3,000 known synthetic PFAS compounds (“analytes”), Furthermore there are NO NATURAL OCCURRING PFAS COMPOUNDS, they are all lab-made.

## What is so “forever” about PFAS?

In marketing branding is sometimes obsessed with repetition so that the public at large or a significant group (scientists for example, or technical journalism, etc.); the end goal is seeing a term so often that it becomes part of rote memorization and as it happens in retail a consumer is most likely to select the product by its recognized name.

For lubrication the product WD-40 is widely recognized and sold in very high volumes. But is it the best lubricant for a wide range of applications such as not just lubrication but perhaps deep penetration to more easily remove a screw or having properties such as NSF (“Food Grade”) to be used in commercial kitchens for safety to stop squeaky refrigerator door hinges. There is a superior lubricant on the market known as INOX which is a highly refined purified lubricant that has penetration (INOX dissipates below 1% while WD-40 dissipates about 38% reducing penetration capabilities), and INOX is food grade. INOX is not well known because market branding has reached a plateau in that can be described as “if you know, you know”, in otherwords INOX is best known by word of mouth so advertising campaigns (the mainstay of branding) can be budgeted lower than expected because sales are high enough and further penetration into the retail market segment is offset by the arduous process for a vendor to get placement on a known retail store’s shelf (Walmart, Autozone, etc.).

In a similar branding story, PFAS notification to the public about its toxic nature, which is even though PFAS detection is based on descriptions of Parts per Billion and sometimes as Parts per Trillion, the small amount of PFAS builds up over time.

The length of time is long and the journalistic approach to qualifying PFAS as dangerous took on the nomenclature of “forever” to illustrate if mitigation strategies are not adopted then the harm of PFAS to the environment, and alarmingly known association with poor human health, the term “forever” was adopted to match correctly an alarming state of PFAS longevity without treatment to be degraded.

However, in reality PFAS is unstable before crafting into a product and then if the product is compromised PFAS elements could be released, and its instability is actually part of the problem to induce health risks. The next section, “why do I need overnight samples cooled to 39.2 F” illustrates that “forever” is not a constant.

## Why do I need overnight samples cooled to 39.2 F?

Pay attention to this section because you might want to rethink the absolute in describing “forever” in to popularized “PFAS are forever chemicals”. Yes, PFAS analytes (the ingredients) are persistent, long lived, but they are highly reactive and have an instability phenomenon in which the breakaway elements from cleaning or aging of commercial products are highly subjective to changing and reforming or interfering with other kinds of elements such as the lining of human tissue.

GEA and other approved entities that can submit PFAS samples to labs are required to send samples in the fast way possible (such as guaranteed overnight delivery for first possible time slot in the morning to get to the lab) AND MUST BE ICED TO MAINTAIN 39.2 F.

Why iced? What happens if samples warm up?

PFAS at 39.2 F (or 4 C) are guaranteed to be as stable as possible for 28 days, after that all bets are off and there is most likely going to be the presence of surrogates

At -4 F (or -20 C) the samples are guaranteed to be stable up to 90 days, thereafter the presence of surrogates can build up let alone problems with inefficient thawing.

When someone argues forever is never changing, they are misleading.

Visit <https://Deoilit.com> or <https://Gea.Solutions> to gain access to *Single-Laboratory Validation Study of PFAS by Isotope Dilution LC-MS/MS*, which is the collaborative study by EPA + DOD + DOE concerning topics related to the notion of “forever” versus chain of custody requirements to reduce the possibility of unstable PFAS chemicals in samples to be analyzed.

We provide the specific quote from the study’s conclusion

*After analyzing all the variables, the best and most stable length of storage for aqueous samples is 90 days when stored at -20 °C. Aqueous samples may be stored at 4 °C for up to 28 days; however, the user is advised that at this storage temperature there is evidence of the transformation of precursors, as discussed above, when the sample is held beyond 7 days.*

## What happens if overnight samples warm up?

Depending on how much above 39.2 F, the EPA 1633 certified laboratory might reject testing unless otherwise specified to continue.

Upon a continuation order the presence of surrogates, especially NFDHA will help indicate how effective a cleaning solution has been.

This is interesting because “chain of custody” is so critical that remediators should be forewarned that it is necessary to endure very high shipping costs to ensure almost an over adequate supply of ice.

All EPA 1633 certified labs send a small cooler that must be sealed tightly and have only the room to allow for 7-9 lbs. of ice. Dried ice is not allowed due to pressurization issues and contamination potential.

## What is De-Oil-It?

Essentially De-Oil-It is a liquid soap with only 3 active ingredients all found on the FDA GRAS list (Generally Regarded as Safe), compare this simplistic formulation to commercial soaps and detergents that have a long list of ingredients.

The only two in-active ingredients are a clarifying agent to keep the coloration of De-Oil-It neutral, and water which in the concentrate formula (ISC) is completely “used up” to form a homogeneous lattice like structure of chemicals that prevents phase separation unless subject to below freezing temperatures or sonic waves.

De-Oil-It gained a trademark “hydrocarbon degrading” in record time according to the attorney who submitted the claim, this was under 6 months and gives De-Oil-it controls over hydrocarbon remediation with respect to breaking down hydrocarbon molecular structure into smaller, simpler chemical compounds that prevent reformation of oil droplets and the degrading (breaking down the hydrocarbon chain, up to C40 the top end of naturally occurring hydrocarbons) action situates the degraded pieces in a manner that optimizes biodegrading in which bacteria can more readily consume the smaller hydrocarbon chain pieces and the bacteria’s digestive tract can produce in waste elimination (yes, bacteria “poop”) into soluble carbon, hydrogen, and oxygen.

## GEA Assistance with your PFAS mitigation

### Detailed PFAS removal analysis using De-Oil-It

GEA is available for remediation professionals to send treated samples of PFAS contamination of water or soil using De-Oil-It or other cleaning compounds.

GEA has the proper connections and chain of custody experience to provide easy access to EPA 1633 testing

### GEA Environmentally Responsible Disposal Program

The most common PFAS mitigation strategy dealing with municipality drinking waters and well waters, utilizes a filter that collects PFAS elements. Sometimes these filters contain activated carbon (charcoal) that reduces environmental contamination when the filter is replaced.

GEA offers an Environmentally Responsible Disposal Program in conjunction with Tampa Bay Yacht Master's Environmental Protection Plan (EPP) and coordination with Greenworld Innovations, makers of De-Oil-It, to collect filters (sent by end-users or filter replacement services by a vendor). GEA would provide implement our research department to safely treat the filter with De-Oil-It and produce a certified acknowledgement of this process. For a filter vendor, or commercial, or government entity this would be a perfect program to illustrate a cradle to grave environmentally responsible PFAS mitigation strategy.