DRAFT - Interim Report of the Independent PFAS Scientific Advisory Panel for Jersey – PFAS and Mains Water.

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PSAP
PFAS Scientific Advisory Panel

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1 Background

Per- and polyfluoroalkyl substances (PFAS) comprise a group of over 14,000 synthetic chemicals (this total number is evolving all the time and differs in various reports) used in a wide range of consumer product and industrial applications around the world including, from the 1960s, in fire-fighting foams, in non-stick cookware, water repellents, and food packaging(Glüge et al., 2020). Their chemical stability and resistance to degradation(Cousins et al., 2020), which has led to long-term environmental contamination and the toxicological profiles of certain PFAS (*Toxicological Profile for Perfluoroalkyls*, 2021) have driven concerns regarding possible human health effects(Buck et al., 2011).

The main source of concern in Jersey relates to the historical use of PFAS-containing aqueous film-forming foams (AFFF) used in firefighting. PFAS-containing AFFFs have been effective in extinguishing liquid fuel fires but have been identified as a significant source of environmental contamination(Prevedouros et al., 2006). These foams were in use at Jersey Airport and its on-site training facility in the parish of Saint Peter. Groundwater near the airport and, as a consequence, some water supplies became contaminated with PFAS. In 2006, mains water was extended to the area, and therefore the initial exposure from the airport is believed to have been markedly reduced for those households that switched to using mains water, although there will be some ongoing exposure from secondary sources and recirculation of PFAS. While AFFF use and consequent exposure started some years ago; before potential environmental and human health risks from PFAS had become known; the persistence of PFAS in the environment and in the human body mean that there are still concerns today.

In response to the concerns that had been raised, a company called Arcadis were commissioned in 2018 to survey private water supplies for the presence of certain PFAS, and an Officer Technical Group (drawing its membership from several directorates across Infrastructure and Environment, Public Health, Jersey Water and others) was established by the Government in 2019*PFAS in Jersey* (2023).

In 2022, a programme of blood testing was arranged for people who had regularly used borehole water supplies in the affected area as a source of drinking water and had symptoms consistent with conditions that have been associated with PFAS exposure.

In 2023, the Government of Jersey made provision, through the public health team, to commission an independent group of scientists to assess the current situation in Jersey, with regard to PFAS, and make recommendation for actions to be taken. The Independent PFAS Scientific Advisory Panel has three standing members and a standing observer from the public health team. They have regular, publicly livestreamed, meetings where they hear from subject matter experts from around the world, as well as from affected people in Jersey (experts by experience). The key issues brought to light by these contributors as well as those from the scientific literature are explored. The standing Panel members are:

- PFAS Scientific Advisory Panel Chair, Dr Steve Hajioff

  Steve Hajioff is an experienced leader with over 30 years as a practicing doctor and more than two decades in leadership roles in the health sector and public health practice: including being Director of Public Health in the London Borough of Hillingdon - an area with two international airports and other environmental challenges. He has worked for a variety of organisations including the WHO, World Bank, EU, international governments, UK government departments, the Greater London Authority (where he co-led the health impact assessment of the nine mayoral strategies), several NHS bodies, and has advised BMJ, Elsevier, British Standards Institute, Reuters, and many others. He is experienced at chairing scientific panels, having chaired two high-profile guideline development groups for NICE, and also at chairing groups with a high level of political and media engagement; he chaired the Representative Body of the British Medical Association for several years and several scientific fora, regional, national, and international. Steve has also served in Chief Medical Officer roles for a variety of biotechnology businesses and has been involved in many clinical trials.

- PFAS and health expert, Dr Tony Fletcher

  Tony Fletcher PhD is an environmental epidemiologist with over 40 years' work in occupational and environmental epidemiology and risk assessment, with experience of studies of exposure, biomonitoring, and health impacts such as cancer, respiratory disease, and metabolic disorders. He has been researching the health effects of PFAS – perfluorinated substances – since 2005, as a member of the C8 Science Panel which led a major investigation on potential health effects of PFOA polluted drinking water in West Virginia and Ohio. More recently he has been working in epidemiology programmes in PFAS-contaminated communities in Ronneby, Sweden and Veneto, Italy. He is currently Associate Professor at the London School of Hygiene and Tropical Medicine, where he has been since 1992, and has held jobs in the past at Public Health England, UKHSA, the International Agency for Research on Cancer (IARC) in Lyon, France, Birmingham University, the MRC Environmental Epidemiology Unit, Southampton and Aston University. He was Adjunct Research Professor in Environmental Health in the School of Public Health, Boston University, Massachusetts, and President of International Society for Environmental Epidemiology.

- PFAS and environment expert, Professor Ian Cousins

  Professor Ian Cousins is Professor of Environmental Organic Chemistry at the Department of Environmental Science at Stockholm University. Professor Cousins leads a research group focusing on understanding the sources, transport, fate, and exposure of organic contaminants and is particularly well known for his research on PFAS. Professor Cousins has extensive PFAS research experience, dating back over 20 years to 1999. Some notable career highlights include being a keynote speaker at international PFAS workshops on multiple occasions and receiving several best paper awards for his research. In recent years, Ian has coordinated a large European multidisciplinary project, PERFORCE3, which focused on PFAS. He was also chair of the recent international conference, FLUOROS 2023, where the world's leading experts on PFAS gathered. Ian's research currently focuses on better understanding uses of PFAS and investigating suitable alternatives, using analytical approaches to measure PFAS in consumer products and environmental samples, and investigating the transport and fate of PFAS in the environment.

- Standing observer and Group Director for Regulation, Kelly Whitehead:

  Kelly Whitehead is the Group Director of Regulation for the Government of Jersey. She has worked in Jersey's government for two decades and took on her current role in 2022. Kelly oversees regulatory areas including environmental protection and drinking water regulation. She is responsible for ensuring that regulatory frameworks protect public health and the environment and has been closely involved in the Government's coordinated response to PFAS contamination. Kelly is a standing observer so that she can contribute to the discussion, bringing regulatory insight and knowledge of how Jersey's systems can be used to support water quality and safety.

The panel will be producing five reports over the course of its work programme to provide best available evidence and evidence-based recommendations to the Government of Jersey, other key stakeholders like health services and Jersey Water and to wider society across Jersey and, potentially, beyond.

The five reports are:

1. An interim report on the appropriateness and feasibility of the use of therapeutic phlebotomy to lower PFAS body burden in affected individuals in Jersey.
2. A report on the current state of knowledge about the health effects of PFAS on people and an evaluation of which groups of people may be at increased risk.
3. A review of the range of interventions which may reduce PFAS body burden in those with elevated PFAS levels and the expected impacts, along with recommendations on the nature and extent of serum PFAS testing in both the affected community and the wider population of Jersey.
4. A systematic review of the technologies and methods that may be used to manage PFAS in the environment, along with key strategies for environmental monitoring.
5. An update report taking into account new and emerging evidence from the previous report areas, as well as progress made and any emergent results in the environment or population of Jersey.

All the reports will take due account of the balancing of risks and benefits and also of opportunity cost, including any potential consequences of impacts on services, and will pay particular attention to ensuring that people at greater risk are given additional consideration. The overall approach the panel will take is:

- Being led by evidence
- Working through consensus
- Involving input from experts by experience and subject matter experts
- Public involvement throughout the process
- Default to meetings being in public
- Ability to work in private where there is a need for confidentiality
- Regular engagement with key stakeholders in addition to Panel meetings
- No surprises

Each report will follow a similar process, with an initial draft scope being agreed within the panel and consulted on with stakeholders (including Islanders) before a final scope is developed. There will then be a series of systematic reviews of the available, relevant scientific literature and the consideration of evidence from subject matter experts and experts by experience. These draft reviews and meeting summaries will be shared in advance of the publicly accessible Panel meetings, where they will be discussed, and draft inferences and recommendations arrived at. A draft report will be prepared, integrating the various workstreams and will be shared with Government of Jersey through public health (the commissioners of the process) and with the public for consultation and comment. The consultation findings will be reviewed by the panel and, where appropriate, the report revised. The final report will be shared with the Government to consider the findings and launched through one or more public meetings. The panel meets normally once a month online and the public can observe and email in comments, the agenda and minutes of the meetings are publicly available on the Jersey Government website: PFAS in Jersey (gov.je)

In order to optimise the use of time, there may be some time overlap between consecutive reports, with reports processes starting before the previous report has been finalised.

2 Introduction and approach

2.1 Types of PFAS and their chemistry

This is a summary of a presentation given by Professor Cousins at the Panel meeting on 4/3/24. Further detail is available in the minutes of the meeting.

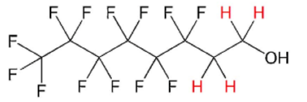
Per- and polyfluorinated alkyl substances (PFAS) represent a group of chemically related substances used across a wide array of applications due to their unique properties. This section clarifies the terminology, chemical structure, and regulatory aspects surrounding PFAS, with an emphasis on their environmental and health implications.

2.1.1 Definition and classification

PFAS are broadly categorized based on their chemical structure:

- **Perfluorinated**: These compounds have carbon chains fully saturated with fluorine atoms, replacing all hydrogen atoms.

- **Polyfluorinated**: In these substances, not all hydrogen atoms in the carbon chain are replaced by fluorine.



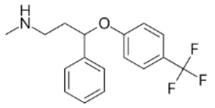
- **Alkyl Substances**: This term refers to compounds containing fully saturated chains of carbon atoms, and not rings of unsaturated carbon atoms.

There is no single globally approved definition of PFAS. The Organisation for Economic Co-operation and Development (OECD) defines PFAS as "fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom(OECD, 2021). This definition encompasses substances with at least one $-CF_2-$ or $-CF_3-$ group, including molecules that have a ring of unsaturated carbon atoms elsewhere, expanding the number of substances defined as PFAS compared to the previous narrower definition. This broad OECD definition includes both alkyl substances and those containing rings of unsaturated carbon atoms, which can be confusing because the name “PFAS” implies that only alkyl substances should be included in the definition. The UK regulators have their own less broad definition of PFAS than that proposed by the OECD (i.e. “fluorinated substances that contain at least one fully fluorinated methyl carbon atom (without any hydrogen, chlorine, bromine or iodine atom attached to it), or two or more contiguous perfluorinated methylene groups ($–CF_2–$).”)(*Regulatory management option analysis (RMOA)*, 2023).

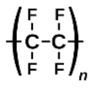
2.1.2 Types of PFAS and their properties

The extensive variety of PFAS includes compounds in various forms—solids, liquids, gases; and with diverse properties—reactive, inert, soluble, insoluble, volatile, non-volatile, mobile, immobile, and ranging from highly toxic to relatively non-toxic. Structurally, they can be long or short-chained, linear, or branched, anionic, cationic, or zwitterionic. Examples include:

- **Fluoxetine (Prozac)**: An antidepressant fitting the PFAS definition.

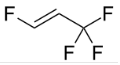


- **Polytetrafluoroethylene (PTFE, Teflon)**: A fluoropolymer used in non-stick cookware (where n in the structure below is >>1000, i.e. there are thousands of identical repeating units of tetrafluoroethylene connected together).



$$-\!\left(\overset{F}{\underset{F}{C}}-\overset{F}{\underset{F}{C}}\right)_{n}\!-$$

- **Hydrofluoroolefin**: Employed as a refrigerant and air conditioning agent.



This diversity demonstrates the ubiquity and functional versatility of PFAS in modern society.

Research is generally focused on specific subsets of PFAS, such as:

- **Perfluoroalkyl carboxylic acids (PFCAs)**: Ranging from C2 to over C20 in carbon chain length. Examples include (with 4 to 12 carbons):
    - perfluorobutanoic acid (PFBA)
    - perfluoropentanoic acid (PFPeA)
    - perfluorohexanoic acid (PFHxA)
    - perfluoroheptanoic acid (PFHpA)
    - perfluorooctanoic acid (PFOA
    - perfluorononanoic acid (PFNA)
    - perfluorodecanoic acid (PFDA)
    - perfluoroundecanoic acid (PFUnDA)
    - perfluorododecanoic acid (PFDoDA)
- **Perfluoroalkane sulfonic acids (PFSAs)**: Typically, C4, C6, C8, or C10, although other lengths are present:
    - perfluorbutanesulfonic acid (PFBS)
    - perfluorohexanesulfonic acid (PFHxS)
    - perfluorooctanesulfonic acid (PFOS)
    - perfluordecanesulfonic acid (PFDS)

These compounds form anions when their terminal carbons in the acidic functional groups lose hydrogen atoms. They are, or were, used widely due to their effective surfactant properties, as a result of having a hydrophobic “tail” and a hydrophilic “head”. PFCAs and PFSAs belong to the group of PFAS known as perfluoroalkyl acids (PFAAs). They have been used in the manufacture of fluoropolymers like PTFE and in firefighting foams, and were also present as impurities in textiles, carpets, and food packaging materials. Much of the research has focused on these PFAS because of their widespread presence in the environment, wildlife, and humans and because they have established toxicity data and there are analytical methods available to measure them.

2.1.3 Precursors

Precursors, such as perfluoroalkyl sulfonamides and fluorotelomer alcohols, are PFAS which degrade in the environment and in organisms to form other (more stable) PFAS (usually the abovementioned

PFAAs). This complicates environmental management and monitoring. For example, fluorotelomer alcohols degrade in the environment and within organisms to form PFCAs. While precursors can degrade to form PFAAs, PFAAs are highly stable and do not degrade into other PFAAs in the environment or in the human body (e.g. PFHxS cannot transform into PFOA)(Cousins et al., 2020; Prevedouros et al., 2006).

2.2 Chemistry of AFFF

Aqueous Film Forming Foams (AFFF) used for firefighting prominently incorporate PFAS because of the ability of these strong surfactants to spread an aqueous film over fuel fires and thus effectively extinguish the fire. Over the years, however, concerns over the bioaccumulation and environmental persistence (discussed below) of the PFAS in the AFFF have led to shifts in chemistries of AFFF.

2.2.1 PFAS Types in AFFF

Historically the PFAS-based foams containing PFSAs (especially PFOS and PFHxS) and PFCAs (notably PFOA) dominated the market. These legacy AFFF were made by the 3M Company using a process called electrochemical fluorination (ECF) and marketed under the trademark “Light Water”. Fluorotelomer-based AFFF, made by a process called telomerisation, were also supplied by several foam manufacturers since the 1970s but had a lower market share compared to 3M. When 3M discontinued the manufacture of the Light Water AFFF in 2002, there was a shift to using fluorotelomer-based AFFF, which remained on the market, and eventually towards fluorine-free alternatives in many countries and regions; Sweden, for example. The key characteristics of PFAS-containing foams are:

- **Legacy (ECF) foams**. Historical “Light Water” type formulations contained complex mixtures of fluorinated surfactants including long-chain perfluoroalkane sulfonates, dominantly PFOS with lesser PFHxS(Backe et al., 2013). Long-chain perfluoroalkyl carboxylates such as PFOA were also often present (Guelfo & Higgins, 2013) but in lower amounts.
- **Fluorotelomer foams**. These contain complex mixtures of so-called fluorotelomer surfactants which are partially fluorinated. One of the key fluorotelomer surfactants present in these types of AFFF, 6:2 fluorotelomer sulfonate (FTS), has a partially fluorinated six-carbon chain connected to a sulfonate head. Microbial and abiotic oxidation slowly convert 6:2 FTS to PFHpA, PFHxA, PFPeA and other PFAAs(NASF, 2019). Formulations may also contain cationic or zwitterionic fluorotelomer betaines introduced for film stability(Backe et al., 2013).
- **Complex mixtures**. Analyses of commercial foams reveal up to hundreds of distinct PFAS classes, including anionic, cationic, and zwitterionic species(Backe et al., 2013). Field contamination therefore reflects overlapping generations of usage, with long-chain sulfonates from ECF foams and short-chain acids from newer foams often co-located in soil and water(ITRC, 2021). The complex mixtures of substances in AFFF are unique to a particular product. Understanding the "chemical fingerprints" of these products in environmental samples, which include the presence of specific isomers or breakdown products, is crucial for tracking and mitigating environmental contamination.

The only AFFF products which have PFOS and PFHxS as markers are Light Water AFFF products. These were initially used in the US, from 1967, and were also used in Jersey and elsewhere. The presence of those specific PFAS in Jersey, suggest that it is these products, rather than something else, that are the primary source of PFOS and PFHxS contamination. Fluorotelomer-based AFFF were on the market since the 1970s so it is possible that they were used on Jersey in parallel to Light Water AFFF, but likely in lesser amounts. Most users transitioned away from Light Water to complete reliance on fluorotelomer-based products in the early 2000s when 3Mdiscontinued manufacture of Light Water AFFF in 2002. Some later transitioned to fluorine-free foams (3F). PFOA is a marker of both 3M Light Water AFFF products and fluorotelomer-based AFFF products. A unique marker of fluorotelomer-based foams is 6:2 FTS. It should also be noted that the precise formulation within each of these foams may have changed over time as manufacturers seek to optimise their products.

2.2.2 Bioaccumulation

The tendency of PFOS, PFHxS and PFOA to bioaccumulate in biological tissues raises concerns about their long-term health impacts. Regulatory bodies have identified long-chain PFAAs as particularly bioaccumulative (as they bioaccumulate in humans), emphasizing the need for stringent regulatory controls for PFAAs with eight carbons and greater (i.e. with 7 or more perfluorinated carbons) and PFSAs with six carbons and greater (i.e. with 6 or more perfluorinated carbons). So PFOA and PFCAs with longer perfluorinated carbon chains are bioaccumulative and PFHxS and PFSAs with longer perfluorinated chains are also bioaccumulative. PFSAs are relatively more bioacculative than PFCAs with equivalently long perfluorinated chains because of the special effect of the sulfonate functional group(Brunn et al., 2023; Buck et al., 2011).

2.2.3 Environmental Accumulation

The chemical stability of PFOS, PFOA, and PFHxS due to strength of the carbon-fluorine bonds leads to their persistence in the environment, posing significant challenges for remediation. Efforts to monitor and reduce environmental levels of these pollutants are ongoing, but their inert nature complicates effective degradation and removal strategies(Cousins et al., 2020; Prevedouros et al., 2006). This will be explored in more detail in Report 4.

2.2.4 Regulatory and environmental concerns

PFAS are notably persistent in the environment, which complicates their management and regulation. In response, Denmark, Germany, the Netherlands, Norway, and Sweden have proposed a REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) restriction for all PFAS meeting the OECD definition. It is recognized that PFAS have diverse properties (e.g. different toxicities), but they are all highly persistent in the environment. Additionally, there is an ongoing restriction proposal specifically targeting PFAS in firefighting foams, with a proposed 10-year phase-out, which is also currently under consideration at the European Commission.

PFAS encompass a broad and complex category of chemicals that pose significant challenges due to their persistence, bioaccumulation, and widespread use. Ongoing research and regulatory efforts aim to better understand and mitigate their health and environmental impacts. Looking forward, enhanced analytical methods and comprehensive toxicological data are increasingly important for guiding effective policy and industry practices.

2.3 PFAS in the natural environment and human infrastructure

2.3.1 Behaviour in Natural Environments

2.3.1.1 Soil and Vadose Zone

After use, PFAS in the spent firefighting foams infiltrate into the ground, which can consist of hard manmade surfaces (typically asphalt and concrete) or unsaturated soil. Sorption in unsaturated soil is driven by hydrophobic interactions of the fluorinated “tails” with soil organic matter and by accumulation at air-water interfaces(Guelfo & Higgins, 2013). Anionic PFAAs are electrostatically repelled by negatively charged clay minerals, yet multivalent cations, such as calcium ions, can bridge PFAS to mineral surfaces, increasing retention. Air-water interfacial sorption, especially for long-chain PFOS and PFHxS, can retard downward migration for years(Guelfo & Higgins, 2013). Sorption increases with chain length, so short-chain PFHxA and PFBS leach rapidly, whereas PFOS often remains concentrated in the top 0–50 cm, acting as a continuing source that slowly desorbs during rainfall events(Douglas et al., 2023). Several other factors, such as pH and the presence of co-contaminants are also important in controlling sorption and transport.

2.3.1.2 Groundwater

Once PFAS reach the saturated zone they behave as highly soluble, conservative solutes, forming plumes that may extend miles downgradient(Guelfo & Higgins, 2013). Differential mobility separates compounds by chain length (partly through differential sorption by chain length: PFBA and PFHxA form the leading edge, while PFOS and PFHxS lag nearer the source. Because natural degradation is negligible, and slow transport from unsaturated zones, plumes persist for decades; modelling suggests century-scale time frames for significant attenuation in the absence of intervention(ITRC, 2021).

Groundwater discharges to rivers and wetlands transfer PFAS to surface waters, broadening exposure pathways(Reinikainen et al., 2022).

2.3.1.3 Surface Water. Aquatic spray and Sediments

Stormwater runoff can carry foam residues from concrete pads, asphalt, and contaminated soil into drainage ditches and streams (Kali et al., 2025) (although a proportion can stick to the surface and slowly leach through). In open water, short chain acids remain dissolved. PFOS and PFHxS partition partly to suspended solids and, along with other longer chain PFAS, settle into sediments, creating long-term benthic reservoirs (ITRC, 2021). Aquatic foams formed during wave action can enrich PFAS by orders of magnitude, redistributing them to shorelines. Wave action can also lead to the ejection of small aerosols (or droplets known as “sea spray aerosols”) into the air which can be highly enriched with PFAS. The PFAS enriched on these aerosols can be transported long distances and potentially impact coastal areas. (Reinikainen et al., 2022; Sha et al., 2024).

2.3.1.4 Air

Many (but not all) AFFF-derived PFAS have negligible vapour pressure; however, spraying creates aerosols that transport PFAS locally. Additionally, volatile precursors such as fluorotelomer alcohols present in some formulations can evaporate, undergo atmospheric oxidation, and redeposit as PFAAs, contributing to regional background loads(Brunn et al., 2023).

2.3.1.5 Biota

Long-chain perfluoroalkane sulfonates and perfluoroalkyl carboxylates bind to blood proteins and bioaccumulate. PFOS and PFHxS display long half-lives in humans (3–8 years and 4–7 years, respectively), whereas PFHxA and PFBS are cleared within weeks to months(Li et al., 2022; Wee &

Aris, 2023). Half lives can vary greatly between and within species. In aquatic food webs near AFFF sites, PFOS concentrations in fish can exceed advisory thresholds, posing dietary risks(Reinikainen et al., 2022).

2.3.2 Interactions with Built Environments

2.3.2.1 Concrete and Asphalt

Porous concrete absorbs PFAS-laden foam. Core samples from fire-training pads routinely contain 10^2–10^5 µg kg^{-1} of PFOS and 6:2 FTS, with highest levels in the top centimetres(Douglas et al., 2023). Leaching experiments show that only a few percent of total mass is released per rainfall simulation, indicating decades-long secondary emissions. Asphalt runways also sorb PFAS; PFOS binds to the bitumen phase and can be mobilised by run-off, though initial leaching percentages are somewhat higher than for concrete(Li et al., 2024).

2.3.2.2 Stormwater Infrastructure

Drains, oil / water separators, and retention basins capture AFFF runoff and themselves accumulate PFAS in sediments and biofilms(Kali et al., 2025). Storm events resuspend these deposits, creating episodic pulses to downstream waters. Remediation therefore must consider physical infrastructure as an integral part of the PFAS mass balance(ITRC, 2021).

2.4 Key Transport and Redistribution Processes

- **Leaching:** Vertical migration of dissolved PFAS through soil into groundwater; rate controlled by chain length and interfacial sorption(Guelfo & Higgins, 2013).
- **Runoff:** Overland flow mobilises surface-deposited PFAS to bodies of water and into drains(Kali et al., 2025).
- **Sorption/Desorption:** Reversible binding to soils and concrete dictates long-term release; stronger for PFOS/PFHxS than for PFHxA/PFBS(Douglas et al., 2023).
- **Air–Water Interfacial Adsorption:** Major retention mechanism in unsaturated soils, particularly for long-chain PFAS(Guelfo & Higgins, 2013).
- **Precursor Transformation:** Partial fluorinated molecules such as 6:2 FTS biodegrade slowly to terminal PFAAs(NASF, 2019).
- **Aerosolisation:** Foam spray droplets generated during use of AFFF carry PFAS short distances downwind. Volatile precursors contribute to long-range deposition after atmospheric oxidation(Brunn et al., 2023).

2.5 Persistence

Fully fluorinated PFAAs (e.g., PFOS, PFHxS, PFOA) resist hydrolysis, photolysis, and microbial attack, giving environmental half-lives that exceed centuries in groundwater and sediments(Brunn et al., 2023). Precursors transform rather than mineralise, ultimately increasing the pool of persistent acids. Consequently, AFFF plumes function like conservative tracers, and contaminated infrastructure or soil continues to release PFAS indefinitely unless physically removed or isolated(ITRC, 2021).

2.6 Implications for Management

Because natural attenuation is negligible, mitigation must focus on source removal or immobilisation. Options include excavation of contaminated soil, in-situ stabilisation (e.g., soil blending with sorbents), pump-and-treat of groundwater, and removal or surface-sealing of PFAS-laden concrete and asphalt(Douglas et al., 2023). Stormwater capture and treatment; often with granular activated carbon or ion exchange resins; may be important for preventing offsite transport(Kali et al., 2025). Knowledge of differential mobility is useful: short-chain PFAS require hydraulic containment, whereas long-chain PFAS demand strategies targeting sorbed phases in soil or hardstanding.

2.7 Potential routes of human exposure

The presence of organic fluorine in human blood was first detected by the dental researcher Donald Taves in the 1960s(Taves, 1968). In 2024, it is now known that virtually all humans on the planet have certain PFAS in their bodies at low microgram per litre levels(Sunderland et al., 2019). Human blood concentrations of long-chain perfluoroalkyl acids (PFAAs) such as PFOS, PFHxS and PFOA, peaked in the late 1990s/early 2000s in the general population of most countries and have declined since the 3M industrial phase-out of long-chain PFAS chemistries (the phase-out was between the years 2000 and 2002).(Sunderland et al., 2019).

For humans, exposure to PFAS occurs by three routes, namely: ingestion, inhalation, and dermal absorption, as described below. Some special exposure routes for prenatal stages and infants are discussed further down this section.

1. Ingestion exposure of PFAS for humans occurs via consumption of contaminated food, water, and other beverages. Exposure by ingestion also occurs via the intentional or inadvertent non-dietary ingestion of soil, dust, or chemical residues on surfaces or objects that are contacted via hand-to-mouth or object-to-mouth activity (especially important for young children).
2. Inhalation exposure of PFAS for humans results from breathing air that is contaminated with fine particulate matter or gas-phase volatile PFAS. Individuals can be exposed via the inhalation route during a variety of activities, both outdoors and indoors. Individuals indoors could also be exposed to outdoor air contaminants that infiltrate the indoor environment.
3. Dermal exposure of PFAS by humans results from skin contact with PFAS-containing consumer products and contaminated environmental media, including water (e.g., during bathing, washing, swimming), bottom sediments in surface waters (e.g., while wading, fishing), outdoor soil or dust (e.g., during recreational and gardening activities), and indoor dust that has settled on carpets, floors, clothing, counter tops, or other surfaces.

The relative importance of the many different PFAS exposure pathways (e.g. dietary ingestion, versus dust ingestion, versus gaseous inhalation, etc.) has been estimated in multiple studies (e.g.(Gebbink et al., 2015a)) and these have been reviewed in the literature.(De Silva et al., 2021; Sunderland et al., 2019). There is general agreement that for PFOS, PFHxS and PFOA, and other long-chain PFAAs, dietary intake is the dominant exposure pathway for the general population compared to air inhalation or dermal contact(Sunderland et al., 2019). Furthermore, it is known that protein-rich foods such as eggs, meat and fish make the largest contribution to dietary exposure for the long-chain PFAAs(Vestergren et al., 2012).

In areas such as the plume area in Jersey where drinking water levels of PFAS have been substantially elevated due to contamination with AFFF, drinking water ingestion is the dominant exposure pathway for PFOS, PFHxS and PFOA(AECOM, 2016; Li et al., 2018; Yiyi Xu et al., 2021). In some areas (e.g. in Oakey, Australia) where contaminated water has been used for watering livestock or irrigating crops, substantial additional exposure can be derived from consumption of local produce.(AECOM, 2016).

A further complication to understanding exposure to PFAS is that humans can be exposed to the so-called precursors, which are substances that transform to PFAAs either in organisms (including in the human body) or in the environment(Vestergren et al., 2008b). Precursors are sometimes, but not always, measured when analysing exposure media for PFAS, which means that human exposure to certain PFAS is likely underestimated. Although these precursors certainly make an additional contribution to human exposure to PFAS, the extent of this contribution, and which precursors contribute, has been debated among scientists(Vestergren et al., 2008b).

Toxicokinetics is the study of the absorption, distribution, metabolism, and excretion of a chemical within an organism. Within the following sections we review the current knowledge of toxicokinetics of PFAS with particular focus on PFOS, PFHxS and PFOA. The chemical structure (e.g. chain length, functional groups, branching of the carbon chains) all impact the toxicokinetics. An exhaustive review of toxicokinetics for all PFAS is not possible here and we therefore aim to summarize the key points.

2.7.1 Absorption of PFAS into the body

The absorption behaviour of PFAS has been studied in laboratory animals (e.g., rodents and monkeys),(Gannon et al., 2011) but not typically in humans due to ethical considerations. Absorption of PFOS, PFHxS and PFOA via ingestion has been determined in animal experiments and it has been shown that 66–100% is absorbed into the body(OECD, 2002, OCA.0029.0001.0063) (Gannon et al., 2011; Kudo & Kawashima, 2003; Sundström et al., 2012). Animal studies also suggest that PFOA is easily absorbed via the lungs(Kennedy et al., 2004). Due to the high absorption of PFAS in animal studies, the absorption of PFOS, PFHxS and PFOA is typically set to 100% as a conservative assumption in human exposure modelling studies(Gebbink et al., 2015a; Trudel et al., 2008; Vestergren et al., 2008b). These reported absorption efficiencies for PFAS are higher than for other well studied hydrophobic organic contaminants (such as polychlorinated biphenyls)(Schlummer et al., 1998). Given this near consensus on very high levels of absorption, these are likely to be the primary routes in the bulk of cases.

Absorption through the skin, however, is more complex. Experimental studies on dermal absorption are scarce. *In vitro* exposure studies using rat and human skin replicates conducted by Fasano et al. in 2005 have shown that PFOA can penetrate the skin, albeit with a low absorption efficiency (1.44% and 0.048% of PFOA absorbed through the rat and human skin, respectively, after 48 h of exposure)(Fasano et al., 2005). A more recent study by Franko et al. in 2012(Franko et al., 2012) suggested that PFOA is readily absorbed by human and mouse skin, but on close examination this only occurred at unrealistically low pH (2.25) when PFOA was in its acidic neutral form. Franko et al., admitted in their study that PFOA will most likely be ionized on the skin surface. Interestingly, Franko et al. achieved similarly low absorption as in the 2005 Fasano study when PFOA was in its ionized form. These observations are consistent with the pH-partition hypothesis,(Shore et al., 1957) which suggests that the passive transport of charged chemical species across biological membranes is small, owing to their poor solubility in lipids.

Abraham and Monien (Abraham & Monien, 2022) investigated the dermal absorption of $^{13}C_4$-perfluorooctanoic acid ($^{13}C_4$-PFOA) mixed into a sunscreen that was applied on the skin of a volunteer. The blood concentrations of $^{13}C_4$-PFOA were monitoring over 115 days after application. After application, $^{13}C_4$-PFOA blood levels increased continuously with a maximum level measured 22 days after application. The fraction absorbed was estimated to be 1.6 % of the dose, which is still relatively low compared to ingestion and inhalation. The study of Abraham & Monien could be considered an extreme exposure scenario given that that the contaminated suncream is rubbed into the skin.

Ragnarsdóttir et al (Ragnarsdóttir et al., 2024) used 3D human skin equivalent models (multilayered laboratory grown tissues that mimic the properties of normal human skin) to study the dermal absorption of 17 PFAS including PFOS, PFHxS and PFOA. Of the 17 PFAS assessed, 15 substances were shown to absorb by at least 5% of the exposure dose, which is higher than observed in the previous abovementioned studies. It is unclear, however, if the artificial skin models represent the dermal absorption of PFAS compounds behaviour of real human skin, even if the authors claim that it does.

There are few dermal contact studies for PFAS but based on the existing studies it seems reasonable to assume that dermal absorption of PFAS is relatively low compared to ingestion and inhalation absorption. In exposure modelling studies,(Gebbink et al., 2015a) it is typically assumed that dermal absorption is less than 1% for PFOS, PFHxS and PFOA based on animal experiments for PFOA and typical exposure scenarios, and these exposure models provide good estimations of human serum levels of PFAS.

2.7.2 Distribution of PFAS in the human body

As discussed above, PFAS are readily absorbed into the human body via ingestion and inhalation routes, and to a much lesser extent via the dermal route. Once absorbed, PFAS are distributed throughout the body both in the blood and into extravascular tissues (i.e. in tissues other than the blood vessels)(De Silva et al., 2021). In the tissues, PFAS bind to both phospholipids and proteins (e.g. in the blood serum to a protein called human serum albumin (HSA)) and also to fatty acid binding-proteins (FABPs)(De Silva et al., 2021). It has long been considered that the blood, liver, and kidneys are the main tissues of distribution for PFAAs in humans(De Silva et al., 2021). A recent study measured the distribution of PFAAs between liver, kidneys, lungs, spleen, brain, and the whole blood of 19 deceased adult humans(Nielsen et al., 2024). The highest extravascular tissue PFAA concentrations were in the liver, lungs, and kidneys with concentrations in the brain and spleen being much lower. PFOS was particularly high in the liver compared to other organs. PFHxS was the only PFAA that showed higher concentrations in the kidney than in the liver, while PFOA was higher in the lungs than in the liver. Extravascular PFAA tissue concentrations were generally well-correlated with those in the blood and in reasonable agreement with the partitioning predicted by theoretical models. The differing accumulation of PFAAs in various tissues has been associated with their relative binding affinities to phospholipids and proteins (e.g. HSA and FABPs)(De Silva et al., 2021). Higher binding affinities to HSA and FABPs have been observed for long-chain PFAAs compared with short-chain PFAAs(Fischer et al., 2024).

2.7.3 Metabolism

PFAAs are not chemically modified or metabolised within the human body due to their chemical inertness(Zhanyun Wang et al., 2017). However, and as mentioned above, there are precursor substances which can metabolize to form PFAAs within the human body(Vestergren et al., 2008b).

2.7.4 Elimination

Some long-chain PFAAs are primarily eliminated slowly via urine(Cui et al., 2010) with others predominantly via the faeces(Ma et al., 2020). Women have some additional elimination pathways discussed below. Previous studies have shown relatively long human elimination half-lives (the time it takes for the amount of PFAS in the body to be reduced by 50 percent) of long-chain PFAAs. For example, average serum half-lives for PFOS, PFHxS and PFOA, of 2.9-8.5, and 2.9-7.3, 1.8-3.5 years, respectively, have been reported in different studies(Li et al., 2018; Olsen et al., 2007; Xu et al.). Shorter human serum half-lives have been observed for short-chain PFAAs (e.g. perfluorobutane sulfonate (PFBS) of 44 days, and perfluoropentane sulfonate (PFPeS) of 230 days).(Xu et al.) However, elimination half-lives are not only dependent on the length of the perfluoroalkyl chain. The head group (sulfonate versus carboxylate) and degree of branching in the perfluoroalkyl chain also impacts elimination rates of PFAAs.(Xu et al.)

Some of the differences in elimination half-lives for individual PFAAs between studies can be due to differing exposure histories. For example, the half-lives in retired fluorochemical workers (PFOS average elimination half-life of 8.5 years)(Olsen et al., 2007) are much higher compared to residents of contaminated communities who have received historical exposure via contaminated drinking water (PFOS half-life of 2.9 years).(Xu et al.) Additionally, elimination half-lives have also been reported to be highly variable between individuals and the reasons for this variability remain unknown.(Xu et al.)

Women between 12.5 and 50 years old have been shown to have lower blood serum levels of PFOS than men and this is thought to be primarily because women eliminate PFOS (and other long-chain PFAAs) more rapidly than men due to their additional elimination pathway of monthly menstrual blood loss(Upson et al., 2022). Women can also eliminate PFAS from their bodies by transfer to the child to some extent, during pregnancy, childbirth, and breast feeding(Wong et al., 2014).

The long elimination half-lives of long-chain PFAAs in humans is thought to be due to their ability to be reabsorbed by organic anion transporters (OATs) in the kidneys and due to their uptake from the gut via enterohepatic circulation(Niu et al., 2023). Therefore, renal elimination/reabsorption in the kidneys is a critical process in determining the elimination of PFAAs. However, the interactions between PFAAs and the renal transporters (i.e. OATs) are not fully understood(Niu et al., 2023). The active transport processes differ between different PFAAs and possibly also can explain differences in elimination between individuals. It is further possible that kidney disease can alter the expression of the renal transporters and further influence renal elimination of PFAS(Niu et al., 2023). However, little is currently known about how altered kidney function affects elimination rates of PFAS; this is an area of ongoing research.

2.7.5 Transmission

2.7.5.1 In-utero transfer

It has been shown that PFAS can pass the placental barrier from mother to child during pregnancy(Beesoon et al., 2011; Gützkow et al., 2012; S. Kim et al., 2011; Liu et al., 2011; Monroy et al., 2008; Pan et al., 2017). These studies have measured serum concentrations of PFAS in maternal and cord blood, or new-born blood samples directly after birth. The transplacental transfer efficiency (TTE) can be calculated for each individual mother-child pair as the ratio of foetal to maternal blood or serum concentrations, and these data have been reviewed and summarised(Winkens et al., 2017). TTEs vary significantly within and between the different studies. Strong positive correlations between maternal and foetal serum concentrations have generally been observed for PFOS, PFOA and other long-chain PFAAs. A comparison of TTEs for different PFAAs suggests a negative relationship with the perfluoroalkyl chain-length and a slightly lower transfer efficiency for sulfonates compared to carboxylates.

2.7.5.2 Breastfeeding

PFAS have been measured in human breast milk and they are thus transmitted through lactation(Kärrman et al., 2007; S.-K. Kim et al., 2011; Liu et al., 2010; Llorca et al., 2010; So et al., 2006; Sundström et al., 2011; Tao, Kannan, et al., 2008; Tao, Ma, et al., 2008; Thomsen et al., 2010; Völkel et al., 2008). Breastfeeding is therefore an additional elimination pathway for breastfeeding mothers. Breastfeeding gradually reduces the mothers' concentration of PFOA and PFOS in serum and breast milk(Fei et al., 2010; Mondal et al., 2014; Thomsen et al., 2010). For PFOA and PFOS, a common 3% reduction has been observed per month of breastfeeding, whereas for PFNA and PFHxS a 2 and 1% reduction, respectively, per month of breastfeeding has been observed(Mondal et al., 2014). This is in accordance with the finding that primiparous women have the highest loads of PFOS and PFOA in their breast milk(Fei et al., 2010; Tao, Kannan, et al., 2008).

Breastfeeding is the dominant exposure pathway for PFAS for infants who are breastfed(Mogensen et al., 2015; Verner et al., 2016). Early-life longitudinal studies have shown a consistent increasing trend of both PFOS and PFOA during the first six months of life and this has been attributed to intake via breastfeeding(Fromme et al., 2010; Gyllenhammar et al., 2016; Koponen et al., 2018; Mogensen et al., 2015). The level of exposure to an infant depends on several circumstances, principally the level of PFAS in the mother, the amount of PFAS that transfers to her breast milk, and the duration of breastfeeding(Winkens et al., 2017).

2.8 Key findings from Report 2 on the human health effects of PFAS

Cardiovascular Health

The panel found a consistent association between exposure to certain PFAS and elevated cholesterol levels, particularly low-density lipoprotein (LDL), known as "bad cholesterol." Elevated LDL levels are typically associated with increased risk of cardiovascular diseases, such as ischaemic heart disease and strokes. However, despite the increased cholesterol levels, evidence of a corresponding increase in cardiovascular diseases among PFAS-exposed populations (particularly PFOA) was less clear. The panel hypothesized that factors such as increased high-density lipoprotein (HDL) levels (good cholesterol) and indications of lower inflammation in the body might mitigate some effect of LDL on cardiovascular risk. Nevertheless, the panel took a precautionary approach; they recommended that individuals with elevated cholesterol due to PFAS exposure should follow standard management practices, including diet, exercise, and possibly lipid-lowering medications.

Cancer Risks

There is evidence suggesting a probable increase in the incidence of kidney and testicular cancers among populations exposed to certain PFAS. The panel also noted some evidence indicating an increased risk of bladder cancer, though this was less clear. In contrast, common cancers such as breast, colon, and prostate cancers did not show a significant increase in incidence across the most relevant research studies, providing some reassurance. Nevertheless, a link not having been clearly found does not mean that a link is not there. The panel noted that there were also concerns expressed by Islanders about rarer cancers and concluded that, although there is not yet evidence to give a clear answer on rare cancers, there is also insufficient evidence to rule out any potential risk from PFAS exposure.

Immune System and Autoimmune Diseases

Exposure to certain PFAS has been associated with a reduced antibody response to childhood vaccinations, which could theoretically lower the effectiveness of immunisations. While the panel was of the view that it is very likely that there is an effect on antibodies after childhood vaccination, the studies to date do not show an increase in vaccine-preventable or other infectious diseases. There was not consistent evidence linking PFAS exposure to a higher incidence of autoimmune diseases, such as rheumatoid arthritis, ulcerative colitis, or lupus. The panel suggested that enhanced public health efforts to maintain high vaccination coverage should help protect vulnerable populations, including those potentially affected by PFAS.

Endocrine and Metabolic Disorders

The evidence linking PFAS exposure to endocrine disorders, including thyroid dysfunction and metabolic issues like obesity and type 2 diabetes, was found to be inconsistent. While some studies indicated potential associations, these were not uniformly supported across different populations and settings. The panel acknowledged the complexity of these potential health effects and were of the view that further research to clarify these associations and inform public health recommendations is needed.

Mental Health and Wellbeing

The psychological impact of environmental contamination, including stress, anxiety, and depression, was identified in the scientific literature. The panel recognized that these concerns may be impacting in Islanders' lives and recommended providing mental health support to those affected by PFAS exposure. This includes access to talking therapies and other mental health services as needed.

Reproductive Health

While the only concern raised by the community was fertility, subject matter experts brought up a broader range of issues. These included potential complications like intrauterine growth retardation, reduced birth weight, high blood pressure during pregnancy, and breastfeeding challenges. Studies on birth weight are inconsistent. Some research suggested a possible reduction in birth weight associated with maternal PFAS exposure, but others not. The panel noted that the studies showing a connection often relied on measurements taken later in pregnancy, potentially introducing bias. With regard to pregnancy-associated hypertension and polycystic ovarian syndrome (PCOS). While some studies, like the C8 study, reported an association between PFAS exposure and hypertension in pregnancy and there was a report of increased PCOS cases in a high-exposure area like Ronneby, the panel did not find sufficient evidence across other studies to establish a clear link. This was also no clear evidence of reduced fertility. Overall, the panel was not persuaded that PFAS exposure been demonstrated to have impacts on most reproductive health outcomes, except for some evidence pointing to challenges with breastfeeding. They strongly recommended that mothers, even those exposed to PFAS, should breastfeed, emphasising that the considerable benefits are likely outweigh any potential risks from PFAS transfer during breastfeeding.

Other Health Concerns

Additional health concerns explored included some gastrointestinal issues for which there was not good evidence, and changes in liver enzyme levels. The panel noted that while changes in liver enzymes were observed, they generally fell within normal ranges and were unlikely to be clinically significant or associated with poor health outcomes. The panel also looked at neurodevelopmental issues (such as speech and language delay), but the evidence in that area was also not yet clear. With regard to potential impacts on the musculoskeletal system, like osteoporosis and an increased risk of fractures the evidence was also not yet sufficiently clear. The panel was of the view that further research was needed in these areas in order to ascertain whether any risks can be corroborated across studies and what the magnitude of those risks might be.

2.9 Groups at increased risk

As discussed earlier, there are a very wide range of PFAS compounds, which seem to differ in their physiological effects, their persistence, and their route of elimination. It should be noted that patterns of exposure can be complex, and that elimination can vary from person to person.

Whilst there is not strong evidence in every area, there are indications of some groups who may potentially be more vulnerable. This may be through higher exposure risk, different patterns of elimination and different physiological effects.

2.9.1 Age

2.9.1.1 Children

Children, particularly neonates and infants, are potentially more susceptible to PFAS exposure due to their developmental stage. PFAS can cross the placental barrier, exposing the foetus during critical periods of development. Postnatally, infants can absorb PFAS through breast milk and contact with consumer products containing these chemicals(Fromme et al., 2009). Exposure during these formative years has been associated with vaccine resistance, developmental delays, and metabolic disorders(Fei et al., 2007; Grandjean et al., 2012).

2.9.1.2 Older people

While it is well-established that older people, on average, have reductions in kidney function (and the functions of some other organs and that they are more likely to have developed comorbidities, be taking medications and have accumulated risk factors), it is not clear if these have any impact on PFAS absorption, PFAS elimination or any physiological effects from PFAS exposure. Nevertheless, frailty may render certain conditions and symptoms more serious in an older person.

The elderly may experience more severe effects from PFAS exposure due to age-related decreases in renal function, which can slow the excretion of PFAS from the body. This slower clearance rate can lead to higher cumulative body burdens of PFAS. Moreover, the elderly often have multiple chronic conditions, which may be exacerbated by PFAS exposure, complicating their medical care, and adversely affecting their quality of life.

2.9.2 Additional exposure

2.9.2.1 Lived environment and diet

It is important to note that PFAS from all sources of exposure contribute to the body burden in an individual person. Consumption of water from contaminated supplies will increase levels, as will consumption of seafood from contaminated water. Fruit and vegetables irrigated with contaminated ground water or grown in contaminated soils may also be contributory factors(Sunderland et al., 2019). A diet rich in these sources in a contaminated area could be associated with increased risk of elevated body burden.

2.9.2.2 Occupational

Workers in industries where PFAS are produced, used, or disposed of including chemical manufacturing, firefighting, and environmental cleanup, face additional potential exposure. Firefighters, for example, are exposed to PFAS through firefighting foams and gear. These occupational groups often have elevated levels of PFAS in their blood, and are associated with higher rates of some health conditions(Lau et al., 2007).

2.10 Body burden and disease risk

By the term “body burden” of PFAS is meant the cumulative amount of these substances accumulated in an individual over time. Part of this is in the blood, mainly the serum or plasma rather than the cells, part of this is spread around other organs in the body. The proportion of the total body burden residing in other parts of the body is at least as much as in the blood, but we use the serum concentration as the measure of body burden. The rate of excretion (through bladder, gut and menstrual blood loss) is proportional to the serum concentration or body burden. Therefore, with steady intake (from diet and water) the body burden increases, until the rate of excretion equals intake and the serum concentration reaches a steady state.

Epidemiological studies seek to relate the risk of disease to PFAS exposure. The exposure can be in terms of comparing an exposed population with a non-exposed one, or comparing measured or estimated degree of body burden i.e. serum concentration, with the risk of disease. Disease can be directly characterised, such as having a diagnosed cancer or thyroid disease, or a clinical marker which if affected, may indicate a risk of development into clinical disease. Examples of these clinical markers include blood pressure, antibody reactions to vaccination, cholesterol levels or thyroid hormone levels measured in blood.

For understanding and preventing disease in populations exposed to potential toxins, both the nature of the relationship - the dose-response relationship - and the reversibility of these associations are important and we discuss them here.

2.10.1 Dose-Response Relationship

The dose-response relationship (or strictly speaking the exposure-response, as the exposure may be concentration or the accumulated dose) describes how the magnitude of exposure to a chemical relates to the severity or frequency of associated adverse health effects(Eaton & Klaassen, 2008). The shape can be a simple straight line where the effect proportionally increases with dose, though whether it is straight or a curve depends on how the data are analysed – in published papers the exposure or the outcome, or both may or may not be log-transformed. So the disease risk may be reported as rising with PFAS concentration or with the log of the concentration.

Such straight-line relationships are very helpful for assessing risk as one can extrapolate the risk from one study based on a particular exposure range, to estimate the risk at higher or lower exposure levels. Sometimes the dose response relationship may indicate a threshold response, when the low exposures are not associated with any risk relative to zero exposure, although in practice it can be hard to be sure that there is a threshold. At the other end of the exposure range, the effect may flatten off: further exposure does not incrementally increase the risk further. Rarer still are non-monotonic dose response curves, where the risk may go down and then up again as the exposure changes, or even suggest a beneficial effect at low doses but harmful at high doses(Vandenberg et al., 2012). In practice, we do not see clear evidence of non-monotonic (not straight line) dose-response for PFAS. Many studies show results by dividing the population into a number of groups by increasing exposure, and then investigate if there is trend of risk increasing with exposure across these groups. All these studies should also carefully adjust in these analyses, by other risk factors to avoid having a misleading or confounded dose-response pattern.

Studies have demonstrated an exposure-dependent relationship between PFAS exposure and immunotoxic effects. Higher serum concentrations of PFAS have been associated with reduced antibody responses to vaccines in children(Bline et al., 2024). Grandjean et al. found that a doubling of PFAS concentration corresponded to a significant decrease in antibody levels, indicating a dose-response relationship in this case between antibody levels and the logarithm of serum PFAS(Grandjean et al., 2012).

Several studies have demonstrated a positive dose-response relationship between serum PFAS levels and plasma cholesterol. Higher concentrations of the PFAS compounds perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are associated with increased total and LDL cholesterol levels. For instance, (Nelson et al., 2010)found that elevated serum PFAS concentrations correlated with higher cholesterol in a U.S. population sample. Several studies spanning large ranges of concentration show a pattern of steep increase in relation to PFAS at lower serum concentration ranges and a shallower or levelling of the dose response relationship at higher levels(Canova et al., 2020).

Several studies have demonstrated a positive dose-response relationship between serum levels of perfluorooctanoic acid (PFOA), and the risk of cancer. For example, Barry et al. found among individuals living near a chemical plant leading to PFOA exposure there was a dose response between groups of increasing estimated serum concentrations and increased incidence of kidney and testicular cancers(Barry et al., 2013). In this case the exposure measure was a cumulative dose reflecting both serum concentrations and length of exposure.

Overall, there are many studies indicating an increasing risk in relation to higher body burdens of PFAS, although the relationship may be curved, not a simple linear straight line.

2.10.2 Evidence for Risk Reduction Through Body Burden Decrease

Past PFAS exposure has been associated with adverse health effects such as cancers. Cross sectional studies show adverse effects on clinical markers, such as raised cholesterol.

Once exposure stops, we can observe the serum levels going down, although it takes some time for the body burden to go down, given the long half-life of these PFAS. One would like to know if the associated disease risks also fall. While reducing the body burden of PFAS may reasonably be considered to reduce disease risk, there is not yet much direct evidence on the reduction of risk following the reduction of PFAS exposure. Given the PFOA and PFOS serum levels have generally fallen over the last 20 years, we may expect some studies to come which will track PFAS-related health effects over time. One study which sought to address this in the Veneto region, could not demonstrate a decrease in exposure related risk after the PFAS exposure was identified and controlled, but the post clean-up follow up was still too short(Biggeri et al., 2024).

Considering infants, as the maternal body burden goes down this would directly benefit the unborn child and infants by preventing their exposure. However, for people with past exposure, whether these disease risks disappear if exposure falls to zero is not certain.

We do know from studies of other exposures that have reduced that the associated risks do fall. The increased cancer risk resulting from exposure to certain toxins can sometimes be reduced by eliminating or minimizing the exposure, but complete reversibility is not always possible. For example, smoking cessation significantly decreases the risk of lung cancer over time; former smokers experience a gradual risk reduction, approaching that of never-smokers after about 15 years(Peto et al., 2000). Similarly, reducing exposure to ultraviolet (UV) radiation can lower the risk of skin cancer, as DNA repair mechanisms may correct some of the damage caused by prior exposure(Armstrong & Kricker, 2001). However, for carcinogens like asbestos, the risk of mesothelioma remains elevated even after exposure stops due to irreversible changes in mesothelial cells and persistence of the fibres in the tissue (Stayner et al., 2013) . Therefore, while reducing exposure to certain toxins can decrease future cancer risk, the extent of reversibility depends on the type of toxin, the duration of exposure, and the timing of intervention. It is plausible this also applies to PFAS.

For immune effects, reversibility of immunotoxicity depends on factors such as the type of toxin, exposure duration, and individual health status. For instance, immunosuppression caused by heavy metals like lead and mercury can be partially reversible upon cessation of exposure and with appropriate medical intervention(Lawrence & McCabe, 2002). Similarly, exposure to certain pesticides has been linked to immune system impairments that may improve over time after the exposure ends(Corsini et al., 2013). However, the extent of recovery can vary, and in some cases, prolonged or high-level exposure may lead to lasting immune dysfunction. Overall, reducing exposure to immunotoxic substances can facilitate the partial or full restoration of immune function. It is plausible that this also applies to PFAS.

The only direct evidence of the impact of reducing PFAS exposure are some studies of the association of cholesterol in populations where exposure had fallen and serum levels were going down. In the C8 study of a US population exposed to PFOA a group of 700 people had repeated measurements of both PFAS and cholesterol four years apart(Fitz-Simon et al., 2013). Both PFOA and PFOS declined over the survey period, and they found that there was a tendency for people with greater declines in serum PFOA or PFOS to a drop in total cholesterol and LDL, relative to those whose PFAS decreased less. If serum PFOA fell by half, the predicted fall in LDL cholesterol was 3.6% (95% confidence interval = 1.5–5.7%). The association with a decline in PFOS was even stronger, with a 5% decrease in LDL (2.5–7.4%) per halving in PFOS. A larger study in Italy also included repeat measurements of both lipids and PFAS, averaging 4 years apart, with the same direction of association but smaller decreases in cholesterol(Batzella et al., 2024). Declines in PFAS concentrations were associated with decreases in all lipids. For a natural log-decrease in PFOA, HDL-C decreased by 1.99 % (95 % CI: 1.28, 2.70), TC by 1.49 % (95 % CI: 0.88, 2.10), and LDL-C by 1.40 % (95 % CI: 0.45, 2.37). A natural log decrease is a reduction by a little more than a half. Overall, there was not a decrease in cholesterol in the two populations, but the individual correlations of changes in PFAS to changes in lipids is reassuring that the association of cholesterol with PFAS is reversible.

Thus, in conclusion it is plausible, given research on other exposures, that reducing body burdens will result in reduction of any PFAS associated risks, but there is no direct evidence of this for PFAS and therefore it cannot be quantified. There is however direct evidence that reducing serum PFAS results in a reduction of the impact on serum cholesterol. It is therefore reasonable to conclude there are health benefits of a fall in the PFAS body burden. However, the benefit depends on whether future risks to the exposed person are more related to current body burden/serum concentration or the cumulative exposure. In a population with past exposure that has been stopped or reduced, there would have been higher serum levels in the past and the total cumulative exposure would not be reduced by much however rapidly one reduces the body from now. Conversely for future possible exposures to children during pregnancy and breastfeeding from maternal body burden, reducing serum levels would directly reduce that exposure to child.

3 Testing for PFAS

Testing (sampling and analysis) for per- and polyfluoroalkyl substances (PFAS) in the environment is challenging for four main reasons. Firstly, PFAS have an extraordinary chemical diversity. More than 14 000 PFAS moieties exist, but routine methods quantify only a few dozen; many others lack reference standards so they escape targeted detection(Z. Wang et al., 2017). Second, analytical methods need to be able to analyse parts-per-trillion (ppt) concentrations. Regulatory limits for drinking water are now moving towards the single-digit ng L^{-1} (i.e. ppt) range, demanding methods and instruments that can distinguish a handful of PFAS molecules from background contamination(Zahra et al., 2025). Third, strong matrix effects provide analytical challenges for PFAS identification and quantification.(ITRC, 2023). Matrix effects in PFAS analysis occur when components in complex environmental samples (soil, wastewater, or blood) interfere with the detection of PFAS by either suppressing or enhancing the analytical signal. This can lead to inaccurate quantification unless properly corrected using internal standards, matrix-matched calibration, or rigorous sample cleanup. Fourth, ubiquitous background contamination means that huge care must be taken to avoid contamination of samples. Fluoropolymer tubing, waterproof clothing, and even ambient laboratory air can introduce trace levels of PFAS into samples. Studies have shown that field blanks frequently contain detectable PFOS or PFOA, prompting laboratories to adopt PFAS-free materials and implement rigorous blank controls to ensure data integrity.(ITRC, 2023). Together, these factors mean that analysts must combine rigorous sampling protocols, isotope-dilution mass spectrometry, and multiple quality-control layers to produce reliable PFAS data.

3.1 How samples are taken

Because PFAS are ubiquitous outdoors and indoors, laboratories follow strict sampling rules to avoid adding contamination or losing the chemicals before they reach the instrument. Field teams avoid equipment and materials which are known to contain PFAS, and meticulously rinse all equipment (e.g., sampling tools and containers) with PFAS-free water between samples. They also collect field blanks (sealed bottles that are exposed in the field, which travel together and are analysed with the real samples) to prove the chain of custody is clean and also to determine quantification limits.

3.1.1 Surface water and drinking water

Scientists collect water samples in high-density polyethylene or polypropylene bottles (glass can adsorb PFAS). Samples are chilled, transported the lab and analysed as soon as possible. In the lab a solid-phase extraction (SPE) cartridge is typically used to concentrate PFAS from the water and to transfer the PFAS into a solvent. The solvent is concentrated down to a few hundred microliters of solvent and a tiny fraction is injected onto the instrument for analysis. Clean-up procedures may be applied to separate PFAS from the sample matrix which can interfere with the analysis.

3.1.2 Surface sea water and sea foam

Near some coasts wind and wave action can lead to the formation of foam on the sea surface. This foam is naturally produced from the many natural surfactants present in natural organic matter present in sea water. Research over the last few years shows that foam can concentrate PFAS many thousandfold above the surrounding water concentrations; single sea-foam samples from the US Atlantic coast recently contained almost one million nanograms per litre of PFOS(Enders J, 2025). To capture foam, scientists skim it gently with a pre-cleaned stainless steel ladle into PFAS-free bottles or plastic bags and treat it like a highly contaminated water sample (the foam rapidly collapses in sample bottles to brown-coloured water), diluting a measured portion with reagent water before applying SPE.

3.1.3 Soils and sediments

A stainless steel spade or core sampler takes at least 100 g of material to a specific depth (depending on the objectives of the study), which is stored chilled or even frozen before analysis. In the laboratory, a subsample is typically taken (e.g., 2 to 5 g are weighed), spiked with isotope-labelled standards, and then extracted with a solvent. The extract is concentration and cleaned to remove interring matric (e.g., humic and fulvic acids present in soil organic matter) prior to injection on an instrument for analysis.

3.1.4 Air sampling

High-volume air samplers (which are like powerful vacuum cleaners) draw hundreds of cubic metres of air through quartz fibre filters (to trap particles and particulate-bound PFAS) followed by polyurethane foam or XAD resin (to trap vapour-phase PFAS). The samples are extracted with solvent, concentrated and cleaned up prior to analysis on an instrument.

3.1.5 Wildlife tissues

Biological tissues (e.g., fish muscle, bird liver or invertebrate homogenates) are weighed, spiked with isotope labelled standards and then extracted with a solvent. The samples are extracted with solvent, concentrated and cleaned up prior to analysis on an instrument.

3.2 Core laboratory methods

Once in solvent, all sample types converge on similar analytical approaches: liquid chromatography coupled to tandem mass spectrometry (LC–MS/MS) for targeted analysis or liquid chromatography coupled to high resolution mass spectrometry for broader screening. The liquid chromatograph separates PFAS compounds based on their interactions with the column, while the mass spectrometer identifies and quantifies them. Triple-quadrupole instruments are the industry standard for targeted analysis, capable of detecting individual PFAS compounds in complex mixtures by monitoring specific ion transitions, even in the presence of thousands of other chemicals.

Each extract typically receives a set of stable isotopically labelled internal standards — PFAS compounds that are chemically similar to the targets but slightly heavier due to atoms like carbon-13 or deuterium. These internal standards mimic the behaviour of native PFAS during extraction and analysis, helping to correct for losses, matrix effects, and variability in the mass spectrometer. This approach enhances accuracy and quantification, though its effectiveness depends on how well the labelled compounds match their target analytes.

There are additional methods that are used to estimate total organic fluorine (TOF), but, given that there is not yet consensus on which the appropriate measure is, and that the methods produce very different results, they are not used widely by commercial labs.

3.3 How sensitive are laboratory tests?

- **Limit of detection (LOD)** is the smallest amount of a chemical that produces a signal distinguishable from background noise. Below the LOD the laboratory cannot reliably determine the presence of the chemical.
- **Limit of quantification (LOQ)** is higher than the LOD. It is the smallest amount the laboratory can measure with acceptable accuracy and precision (often defined as a relative standard deviation below 20 %). Between the LOD and LOQ a result is reported as “detected but not quantified.”

- **Reporting level** is the level at which an organisation views the margin of error to be sufficiently narrow for the results to be publicly reported without the risk of simple statistical variance potentially misleading the public.

Using today's instruments and one-litre water samples, typical LODs for PFOS, PFOA and PFHxS are 1 to 2 parts per trillion (ng/L) and LOQs are roughly 3-5 ng/L. High end systems concentrating five litres of water have pushed LOQs below 0.5 ng/L, while some research groups have demonstrated part-per-quadrillion capability for PFOS in ultrapure matrices(Ackerman Grunfeld et al., 2024). In soils and wildlife tissues, matrix interferences are stronger; so realistic LOQs are 0.5 to 2 parts per billion (ng/g): still sensitive enough to flag most contaminated hotspots.

3.4 Special challenges for PFOS, PFHxS and PFOA

All three target molecules ionise well in the mass spectrometer, which helps sensitivity, but they also stick to glass and Teflon surfaces, so sample bottles, pipette tips and tubing must be fluoropolymer-free. PFOS and PFHxS were historically manufactured as mixtures of linear and branched isomers. Modern analytical methods either sum the isomers or employ calibration standards that reflect the specific isomeric distribution in the sample.

PFHxS is shorter and more water-soluble than PFOS, making it more difficult to trap on traditional C18 cartridges used for extraction. However, weak anion exchange (WAX) sorbents introduced in 2019 have significantly improved recovery. PFOA, while phased out in many countries, continues to cause laboratory contamination problems due its ubiquitous presence (even in laboratory solvents). Therefore, quality control steps, such as reagent blanks, are vital to identify and correct for potential false positives during sample preparation.

4 Context in Jersey

In order to triangulate the panel's work to the context in Jersey, we heard expert evidence both from Jersey Water, and also from Arcadis; a specialist consultancy firm that has been contracted by government to assess the environment in Jersey and identify PFAS contamination and its pathways. The individuals who gave evidence to the panel were:

Jeanette Sheldon (Jersey Water): Jeanette Sheldon is the Head of Water Quality for Jersey Water. Jeanette's presentation provides a comprehensive overview of the water supply and treatment challenges faced by Jersey, particularly in relation to PFAS contamination.

Jake Hurst (Arcadis): Jake Hurst, the UK PFAS lead at Arcadis. He has a background in chemistry and remediation, with over 15 years of experience in PFAS and more than 20 years in the industry. For the past four years, he has provided technical leadership on a project for the Government of Jersey.

4.1 Presentation from Jeanette Sheldon (Jersey Water)

Jersey's public water system serves about 100,000 residents and relies almost entirely on rainwater that is captured in streams and stored in four reservoirs; existing storage equals roughly one hundred and twenty days of average demand. Two conventional treatment works—Augres and Handois—apply coagulation; clarification; dual-media filtration; chloramine disinfection; powdered activated carbon for pesticide control; and ultraviolet disinfection added during the past two decades. Seasonal demand ranges from sixteen to twenty-four megalitres per day; the La Rosiere desalination plant, originally built in 1970 and now upgraded to reverse osmosis, can provide up to ten megalitres per day and is viewed as a critical resilience measure, especially during drought.

PFAS contamination is linked mainly to historical releases at the airport, affecting the St Ouens boreholes and the Pont Marquet stream. Trace PFAS occur island-wide in surface sources. Routine monitoring covers forty-eight PFAS compounds in line with the Drinking Water Inspectorate list for England. Recent results for finished water show PFOS at 4 ng/L; PFOA at 6 ng/L; and an average combined PFAS concentration near 30 ng/L. Jersey Water's current strategy emphasises upstream source restriction but recognises that additional treatment will be required as standards tighten. A five-year water-resource plan therefore includes expanding the desalination plant and installing dedicated PFAS barriers.

A 2021 optioneering study investigated about thirty technologies; Surface Active Foam Fractionation (SAFF) was shortlisted after pilot trials demonstrated effective removal of long-chain PFAS. Performance for short-chain species proved insufficient, costs were high, and international regulatory limits continued to fall, prompting a reassessment. The current preferred option is granular activated carbon at both Augres and Handois with a design goal of keeping finished-water PFAS below 10 ng/L. Concept planning indicates a nominal bed life of twelve months, driven by relatively high total organic carbon that competes for adsorption sites. Implementation faces several hurdles: the Handois site occupies a narrow valley, necessitating land purchase and complex civil works; island roads restrict delivery of large vessels; and spent carbon would have to be regenerated or disposed of off island because no local kiln exists.

Ion-exchange resin remains under consideration as a potential alternative or polishing step; it could offer longer bed life for short-chain acids but is less mature operationally and sensitive to interfering ions. Any final treatment train may therefore combine source restriction; catchment management;

granular carbon for broad removal; ion exchange for difficult compounds; and periodic use of desalinated water to dilute PFAS in raw blends. Continuous operation of the desalination plant would require staffing and process changes, because the unit is currently configured for drought contingencies rather than full-time service.

Overall, Jersey Water plans a phased approach: improve understanding of PFAS sources; carry out detailed pilot trials for GAC and ion exchange; integrate new barriers into existing works despite space and logistics constraints; and expand desalination capacity to enhance resilience and provide a PFAS-free blending option. These steps aim to secure consistent compliance with present and emerging limits while managing financial and operational impacts in a small-island context.

4.2 Discussion with Jersey Water

Declining PFAS levels in Jersey's drinking water are attributed to management actions that removed the most contaminated raw sources; specifically, supply from the Pont Marquet stream and the St Ouens boreholes has been withdrawn. Although this measure lowered finished-water concentrations, it cannot be relied upon during severe droughts when all sources may be needed. A clear treatment objective is therefore required before specifying robust long-term technologies; premature adoption of immature processes was judged risky in retrospect.

Logistical constraints complicate plant upgrades: Jersey's narrow roads limit the delivery of large equipment; shipping heavy items directly to coastal sites may offer a practical alternative, given the island's established freight links with France and the United Kingdom. Capital expenditure has been roughly scoped at £20 million per treatment plant; this figure will guide future investment decisions.

Analytical monitoring already covers forty-eight PFAS compounds as listed by the Drinking Water Inspectorate for England; Jersey's data show a mixed PFAS profile with comparatively higher levels of slightly longer-chain species. Ultra-short acids are not yet part of the routine suite; specialised methods are required to quantify them and removal is technically challenging. Should future regulations include these compounds, treatment complexity and cost will increase; for now the panel remains focused on the airport-derived contamination that dominates current risk.

The treatment roadmap under consideration pairs short-term use of granular activated carbon with potential longer-term adoption of other technologies. This staged strategy must be coordinated with the renewal cycle of existing assets to avoid redundant civil works. Powdered activated carbon (PAC) is already dosed at low levels for pesticide control; higher dosing could help remove PFAS but would demand new infrastructure to capture and handle PAC sludge. Presently, sludge containing PAC is reused as soil improver; any intensification of PAC usage would require reassessment of this disposal route.

A hybrid option—PAC dosing followed by ultrafiltration—was proposed as a space-efficient retrofit for current plants and could act as an interim barrier until full-scale treatment works are commissioned. The panel regards this approach as promising because of its relatively low capital cost and compatibility with existing configurations; further information will be gathered to confirm feasibility.

Jersey Water is advancing a programme of desktop reviews and rapid column tests to evaluate granular activated carbon, ion-exchange resins and reverse osmosis under local water conditions. Concerns about global supply of GAC were raised; current market feedback indicates only distribution delays rather than a fundamental shortage of coal-based carbon, although supply-chain resilience will remain a planning consideration.

Overall priorities emerging from the discussion include: finalising a numeric treatment goal; verifying short-term performance and bed life of granular carbon through rapid testing; investigating shipping logistics for large equipment; examining PAC-plus-ultrafiltration as an interim retrofit; and monitoring potential regulatory inclusion of ultra-short PFAS that could necessitate membrane processes in the future.

4.3 Presentation from Arcadis

4.3.1 Project Overview & Objectives

Jake Hurst from Arcadis UK introduced the PFAS hydrogeological study, emphasising its significance in addressing long-standing environmental and public health concerns in Jersey. Commissioned by the Government of Jersey, the study aimed to understand the behaviour of PFAS (per- and polyfluoroalkyl substances) in the environment, particularly around Jersey Airport. The objectives included identifying how PFAS moves through groundwater and surface water systems, assessing potential risks to human health and the environment, and supporting the development of safe, long-term water supply strategies. A key goal was also to build public trust through transparent communication and to provide a scientific foundation for future remediation and policy decisions.

4.3.2 Phase 2 Scope of Works

Phase 2 built upon the foundational work of Phase 1, which had compiled and visualised historical data to identify gaps in understanding. In Phase 2, Arcadis conducted four quarterly monitoring campaigns between July 2023 and May 2024, collecting over 230 samples from approximately 30 boreholes and 27 surface water sites. The team used PFAS-specific sampling protocols to avoid contamination and ensure data reliability. Passive samplers were deployed to capture average contamination levels over time. The study focused on two key catchment areas; St. Ouen's Bay and Pont Marquet; and included the installation of three new boreholes to improve spatial data coverage. The work was conducted in collaboration with Jersey's Water and Air team, though Arcadis maintained independent oversight and data-led analysis.

4.3.3 Monitoring Results

The monitoring revealed persistent and significant PFAS contamination, particularly beneath the airport's former fire training ground, where concentrations were up to 1,000 times higher than EU drinking water standards. PFAS "fingerprints" indicated multiple sources, including both PFOS-based and mixed-foam types, suggesting varied historical usage across the airport. Surface water pathways, especially the Creepy Valley stream and the South SW outfall, were identified as key conduits for PFAS migration into drinking water catchments. Rainfall and airport de-icing activities were found to influence PFAS mobilisation, with passive samplers confirming variability and spikes in contamination following such events.

A distinct PFAS contamination pattern, referred to as the "pink PFAS fingerprint," was identified through analysis of varying concentrations and proportions of PFAS compounds, represented by different coloured bars. This fingerprint originates from a fire training ground and was observed to extend across St Ouens Bay, reaching as far as drinking water abstraction well 692. The consistency of this fingerprint across multiple locations indicates that the contamination is primarily from legacy PFOS-based firefighting foam. The presence of both linear and branched PFOS compounds suggests a mature plume, where PFAS has had sufficient time to equilibrate and distribute evenly throughout the affected area. However, not all locations showed the same pattern. A different PFAS fingerprint was detected at a borehole within the airport grounds, near a site used for foam spray testing. This alternate fingerprint, which includes a mix of PFOS and fluorotelomer-based foams, was also found in nearby off-site groundwater, suggesting that this secondary plume may have migrated beyond the airport boundary.

4.3.4 Hydrogeological Conceptual Model

Arcadis developed a detailed conceptual model of the subsurface environment to understand PFAS transport mechanisms. Beneath the fire training ground lies approximately 30 meters of unsaturated fractured shale bedrock, which acts as a long-term PFAS reservoir. Groundwater flows generally westward, with some influence from Simon's Sandpit, which may redirect flow toward the Jersey Water wellfield. The model showed that the sand and shale aquifers are hydraulically connected, and groundwater levels are typically higher than surface water levels in the north, allowing for potential discharge into streams. In contrast, in Pont Marquet, surface water tends to flow above the groundwater, limiting interaction. This model was critical in identifying how PFAS moves through the environment and where it may pose the greatest risk.

4.3.5 Risk Assessment

The risk assessment updated the conceptual site model and applied a tiered approach, comparing PFAS concentrations to UK and EU standards. Widespread exceedances were observed, particularly for PFOS, though many affected wells are not currently used for public supply. A detailed analysis estimated that PFAS could take 20–60 years to travel from the fire training ground to the wellfield and up to 100 years to reach the marine environment, depending on the compound. This long travel time underscores the persistence of PFAS and the need for long-term management. In contrast, surface water pathways like the Pont Marquet stream could respond more quickly to remediation. The assessment also considered historical site usage, including the construction of a containment cell beneath the fire training ground and the impact of rainfall and infrastructure on PFAS mobilisation.

4.3.6 Remediation Options Appraisal

Arcadis conducted a high-level appraisal of potential remediation strategies, guided by the principle of reducing PFAS mass flux in a cost-effective and sustainable manner. The appraisal prioritised interventions with the greatest potential benefit, such as targeted soil excavation and capping at the fire training ground, in situ flushing of bedrock, and enhanced groundwater pumping and treatment using technologies like activated carbon and ion exchange. For the broader plume, options like colloidal activated carbon injection and infilling Simon's Sandpit to redirect groundwater flow were considered. Drinking water treatment was emphasised as a high priority across all scenarios due to regulatory changes and the need for immediate action. For Pont Marquet, a phased approach was recommended, starting with source control measures such as pipe inspections and cleaning, followed by potential passive stormwater treatment technologies.

4.3.7 Summary of Recommendations

- **Support Government Decision-Making:** The findings from the study should directly inform the Government of Jersey's decision-making processes. A structured and transparent framework should be established to evaluate and select the most appropriate remediation options.
- **Establish a Coordinated Implementation Team:** A dedicated team and a clear schedule should be set up to manage the next phase of work. This team should include

representatives from key stakeholders such as the Government of Jersey, Ports of Jersey, and Jersey Water.

- **Targeted Assessment of Remediation Options:** The shortlisted remediation options should undergo further detailed assessment, including cost-benefit analysis and feasibility studies. This will help refine the strategy and ensure that selected interventions are both effective and practical.
- **Address Identified Data Gaps:** Several data gaps were identified during the study, particularly in relation to groundwater dynamics and PFAS sources. These gaps should be prioritised and addressed through additional investigations to strengthen the evidence base for decision-making.
- **Develop a Comprehensive Remediation Strategy:** A long-term, integrated remediation strategy should be developed. This strategy should balance environmental protection, public health, technical feasibility, and cost-effectiveness. It should also consider the evolving regulatory landscape and public expectations for timely action.
- **Continue Monitoring and Trend Analysis:** Ongoing environmental monitoring is essential to track PFAS trends, validate model predictions, and assess the effectiveness of implemented measures. This includes both groundwater and surface water monitoring.
- **Investigate Drinking Water Treatment Options:** Regardless of the remediation approach, drinking water treatment should be prioritised. This includes evaluating technologies for PFAS removal, blending strategies, and alternative supply options to ensure safe and secure water for the public.
- **Align Simon Sandpit Plans with Remediation Goals:** Any future plans for Simon Sandpit should be reviewed and potentially aligned with the broader remediation strategy, as the site may influence groundwater flow and PFAS transport.
- **Incorporate PFAS Waste and Soil Reuse Guidance:** The report includes a dedicated section on PFAS waste management, including waste acceptance criteria and soil reuse options. These should be considered in the development of any remediation or construction activities involving contaminated materials.

4.4 Discussion Jake Hurst (Arcadis)

Arcadis prioritised installing water-treatment barriers because they can be deployed quickly; directly lower human exposure; and make it possible to blend in water sources that are currently excluded. Sole reliance on remediation was judged uncertain for the complex fire-training-ground system, and future regulations are likely to mandate treatment in any case. Focused abstraction from the southern wellfield and immediate gains from the Pont Marquet catchment were noted as near-term opportunities.

Sampling at the fire-training ground shows a dominant PFOS signature that reflects historic, uncontained foam use; fluorotelomer-based foams were also applied but appear only as minor precursors in current data. The aerobic subsurface and absence of hydrocarbon co-contaminants favour biotransformation, so long-term risks from remaining precursors are considered low. Potential migration delays for newer compounds remain under review.

A numerical model, built largely on literature partition coefficients because soil PFAS were not detectable, was calibrated with historical groundwater data and includes partitioning, dilution and migration processes. Although it may underestimate retention in the unsaturated zone caused by air-water interface sorption, incorporation of field measurements improved its accuracy. The model forecasts natural attenuation of sixty to one-hundred years; if source loads are reduced through interventions, revised simulations could show shorter timelines and lower equilibrium concentrations.

Possible PFAS reservoirs in airport infrastructure—drains, interceptor sludges, concrete or asphalt—were highlighted for future investigation; rainfall-response data hint at episodic leaching from some areas. The study encompassed both long- and short-chain PFAS and was designed to adapt to evolving standards, including expected moves toward sum-based concentration metrics. Ultra-short acids such as trifluoroacetic acid were judged of limited relevance because their likely atmospheric origins imply minimal local impact.

Historical records confirm that post-2004 containment practices sharply curtailed foam releases, whereas the dominant PFOS plume derives from earlier activities when containment was absent. Hydrogeological boundaries around the catchments restrict plume spread, a factor critical to evaluating population exposure and managing borehole operations. Sea-spray aerosol transport of PFAS was considered but appears negligible for the current plume; nevertheless, marine mass-flux estimates could be prepared in future assessments.

Overall outcomes: rapid treatment offers immediate protective benefits; PFOS remains the principal contaminant; calibrated modelling supports a long attenuation period yet can be updated as source terms change; additional assessments of infrastructure sources and unsaturated-zone retention are warranted; and the data set is comprehensive and digitised, facilitating future regulatory or technical updates.

4.5 Modelling background blood concentrations from environmental exposure in Jersey

This section discusses the potential contribution of drinking water intake to the average blood serum levels in addition to likely background levels from general exposure, mainly from food consumption.

We are all exposed to PFAS and some PFAS are so persistent and ubiquitous that it is nearly impossible to completely avoid them and there is some level of PFAS in almost everyone's blood. Thus population samples of people with no obvious direct exposure to PFAS always show low but clearly measurable levels of various PFAS, the top two nearly always being PFOS and PFOA.

As discussed in chapter 2.7, most of the intake of PFOS and PFOA in general population surveys is from non-water sources, principally food. For PFHxS and shorter chain PFAS, drinking water intake becomes relatively more important than food. In populations without a significant local contamination source, 10% to 20% of exposure of PFOS and PFOA is estimated to be from drinking water, but with heavily contaminated water the proportion from water can be high, rising well above 90%.

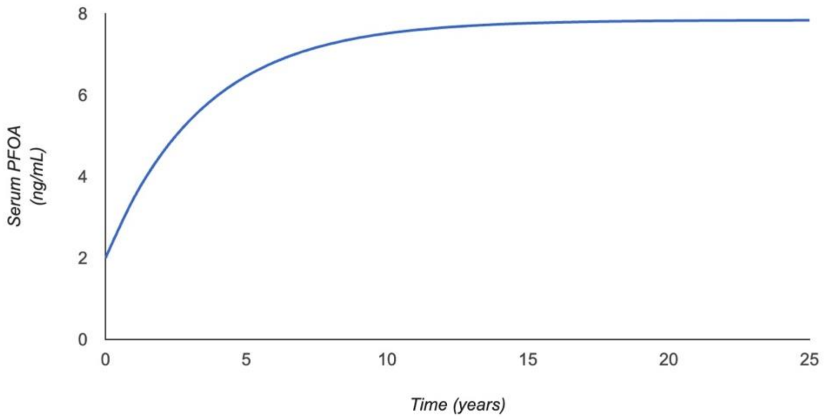
The likely concentrations of serum PFAS can be estimated if we know how much people are ingesting, from food and from drinking water. The average predicted concentrations will depend on how long people are exposed and the concentrations are hard to predict precisely as intakes from food and drinking water vary over time. However, we can get a reasonable approximate prediction based on average values.

For estimating the non-water intake, we can take the average serum levels across multiple recent general population studies, estimate the corresponding intake, and subtract the 10 or 20% attributable to drinking water.

For water intake the relationship between intake and serum levels is well understood in pharmacokinetic models and so it is straightforward to predict average intake and consequent impact on serum levels related to water intake in particular, given some assumptions.

There are online calculators developed in the US which do such a conversion. They use US values for several parameters including drinking water amounts and background exposures which don't apply in the UK, but they are helpful to illustrate some key aspects. One that shows the wide variability in predictions is at the end of this chapter, another which shows the time it takes to get to steady state is used here for the example of PFOA. In this example we assume a male with no prior water exposure but a background level of 2 ng/ml in serum starts drinking water with 50 ng/L of PFOA, and so his serum level builds up and as his body burden goes up his rate of excreting it also goes up, so the rate of increase of serum concentration levels off until steady state is reached after about 10 years, where the rates of excretion and intake are the same.(Bartell, 2017)

Figure 1 - Predicted serum PFOA from drinking 50 ng/L of PFOA in drinking water using serum predictor tool (Bartell, 2017)



To provide an indication of the relationship between water and serum levels in the Jersey population, predictions are presented below for 3 scenarios, each assuming constant exposure and after reaching steady state: likely background serum concentrations assuming a stricter limit is met and we have used the example of the Swedish limit of 4 ng/L for PFAS-4 ; likely average serum levels from recent measured water concentrations in Jersey water; possible average serum levels based on a higher exposure scenario using the highest water concentrations measured.

4.5.1 Background levels derived from general exposures

General population exposure comes from a variety of sources, both as the specific PFAS we can measure in blood samples, but also precursor chemicals that can be metabolised into these PFAS. This can be in food which contains PFAS accumulated through agricultural food chains or has absorbed it from food packaging (though PFAS in food packaging is now much less than earlier), from inhalation exposure to indoor and outdoor dust and from drinking water. Food as a source has been shown to account for 85% or more of general population intake for PFOS and PFOA, water as low as 10%(Gebbink et al., 2015b; Vestergren & Cousins, 2009; Vestergren et al., 2008a). Therefore we can assume that typical background serum levels are mainly an indicator of average PFOS and PFOA intake from sources other than drinking water. Such serum data have been available in the US for some years(Botelho et al., 2025), but not for the UK or Jersey. In the absence of local data, we can draw on the multiple studies of European general population serum levels assembled by the HBM4EU project(Govarts et al., 2023; HBM4EU). Both US and European data show that PFOS and PFOA serum levels have fallen since 2000, reflecting efforts to phase out their use. For PFAS, the HBM4EU database assembles a range of studies across Europe, and taking the more recent ones (data collected during 2017-2021), there are data from 9 studies summarised. For PFOS the median levels reported varied from 1.0 to 2.7 ng/mL, an average of 1.8 ng/mL. For PFOA the average was 1.1 (range 0.7 to 1.9). For PFHxS the average was 0.4 (range 0.2 to 0.6). For the others among the 8 PFAS of primary concern in Jersey (see ISAP Report 3), average background levels were 0.2 for PFNA, 0.1 for PFDA, and zero or below detection for PFPeS, PFHpS and MeFOSAA.

We will assume that these background intake and serum levels also apply to the Jersey population, and that the default 20% RSC (Relative Source Contribution, being the percentage of daily intake coming from drinking water) applies to the contributions from PFPS and PFOA . The sum of these values is 3.6 ng/mL (1.8+1.1+0.4+0.2+0.1) and we would therefore estimate the non-drinking water element is 20% less for PFOS and PFOA, that is 3.0 ng/mL (1.4+0.9+0.4+0.2+0.1) for PFOS, PFOA, PFHxS, PFNA, PFDA respectively.

4.5.2 PFAS concentrations in the Jersey water supply

In Jersey the average PFAS in drinking water has been summarised in the annual reports on drinking water. These data have been assembled with some older measurements and provided to the panel and the averages per year for each of the two water treatment works are as follows:

Figure 2 - PFAS concentrations in the Jersey Mains water supply

Year	PFOS (µg/l)		PFOA (µg/l)		PFHxS (µg/l)	
	Handois	Augres	Handois	Augres	Handois	Augres
2024	0.004	0.003	0.007	0.005	0.004	0.003
2023	0.006	0.005	0.007	0.005	0.004	0.003
2022	0.010	0.010	0.006	0.007	0.006	0.004
2021	0.012	0.008	0.005	0.004	0.007	0.004
2020	0.011	0.008	0.007	0.004	0.006	0.004
2019	0.022	0.015	0.005	0.004	0.008	0.006
2018	No data					
2017	<0.01	<0.01	<0.01	<0.03	<0.01	<0.01
2016	<0.01	<0.01	<0.03	<0.03	<0.01	<0.01
2015	<0.01	<0.01	<0.03	<0.03	0.021	<0.01
2014	<0.01	<0.01	<0.03	<0.03	0.014	<0.01
…						
2002	not detected				not detected	
1999	not detected					

Values marked as <0.01 are below the reporting level, either not detected or too low to be accurately reported. Both water treatment centres provide water so a reasonable estimate of the average concentration in water supplied to the population is the average of the two annual figures. We can assume that recent and current exposure is the average of the two last measurement years (2023-4). Predictions based on recent measurements would predict the serum levels in the future if current intake levels persisted. However, we know that past water concentrations were higher, so the current serum levels would reflect those higher water related exposures.

For the past high exposure scenario we take the highest annual average in either treatment works for each PFAS. Some of the reported measurements are lower than that so the expected average serum levels should lie between the predictions based on the high levels and the recent levels.

For the scenario of being below the 4 ng/L for the sum of these PFAS, we model based on 1.3 ng/L for each of the 3. That would be the expected serum levels after the water concentrations had fallen to these values and some years had passed so that steady states are reached.

Figure 3 - Water concentration scenarios

	Low water concentration Total less than 4 ng/L	Recent water concentration ng/L	High past water concentration ng/L
PFOS	1.3	4.4	22
PFHxS	1.3	3.5	21
PFOA	1.3	5.9	8

4.5.3 Estimating water concentration impact on serum levels

With some further assumptions we can estimate the impact of such concentrations on serum concentrations. If someone is exposed to a constant level of contamination from drinking water then serum levels start to build up and as these concentrations increase so does the rate of excretion, until they are same: at steady state the concentration is stable and reflects the daily intake, the excretion reflecting the serum concentration and the intake reflecting the drinking water exposure. These can be estimated from the following equations:

> the daily excretion in µg/day/kg = k x Cs x Vd , where k is a excretion rate constant which is related to half-life (k=$\log_e(2)$/half-life per year or =$\log_e(2)$/half-life/365 per day); Cs is the serum concentration in µg/L and Vd is the volume of distribution a measure of how much volume in our body the PFAS is spread through, expressed in terms of litres of plasma per kg body weight.
>
> the daily intake in µg /day /kg = (Cw x Vw)/BWt = where Cw is the water concentration in µg/L, Vw is the volume of water drunk and BWt is the average body weight.

At steady state the intake equals excretion. Rearranging the above equations we can estimate (at steady state) the conversion between drinking water concentration and the impact of that serum concentration on serum concentration:

$$Cs = \frac{Cw \times Vw}{Wt \times k \times Vd}$$

For PFOS we have used an average half life of 3 years, from which k is 0.231 per year and k per day for this equation is 0.000633(Li et al., 2022).

The volume of distribution for PFOS has a number of published estimates ranging from about 100 to about 400 (Chiu et al., 2022; Fletcher et al., 2023; Thompson et al., 2010) and a mid value of 200 ml/kg is used here;

The volume of water drunk varies between individuals but a reasonable average value for adults is 1.5 L/day(Guelinckx et al., 2015).

Body weight also varies and we have used an average value of 70kg.

So based on the assumed average values for volume of water drunk per day, body weight, half life and volume of distribution (3 years for PFOS, 4.5 years for PFHxS, 2.5 years for PFOA), we can estimate how much serum concentrations you would expect from drinking water contamination and adding that contribution to the average background levels.

The following table summarises the results for blood concentrations in terms of µg/L, which is equivalent to ng/ml, for the scenario of recent average concentrations

Figure 4 - Projected average PFAS concentrations based on recent water averages

PFAS	Serum Contribution from non-water sources µg/L	Water concentration ng /L	Serum Contribution from water µg/L	Sum in serum µg/L
PFOS	1.4	4.4	0.7	2.1
PFHxS	0.4	3.5	0.9	1.3
PFOA	0.9	5.9	0.8	1.7
Sum of 3	2.7		2.4	5.1
Other 5 PFAS	0.3	Assume zero		0.3
Sum of 8	3.0			5.4

The water table noted that some earlier measurements of PFHxS were higher so the following table shows the predicted serum levels in a worst case scenario:

Figure 5 - Estimated average concentrations based on historical PFHxS levels

PFAS	Serum Contribution from non-water sources µg/L	Water concentration ng /L	Serum Contribution from water µg/L	Sum in serum µg/L
PFOS	1.4	22	5.0	6.4
PFHxS	0.4	21	7.1	7.3
PFOA	0.9	8	1.5	2.4
Sum of 3	2.7		13.6	16.3
Other 5 PFAS	0.3	Assume zero		0.3
Sum of 8	3.0			16.6

The future scenario assuming that drinking water concentrations of each of the PFAS fell to 1.3 ng/L but the non drinking water element remained the same would lead to the following predictions:

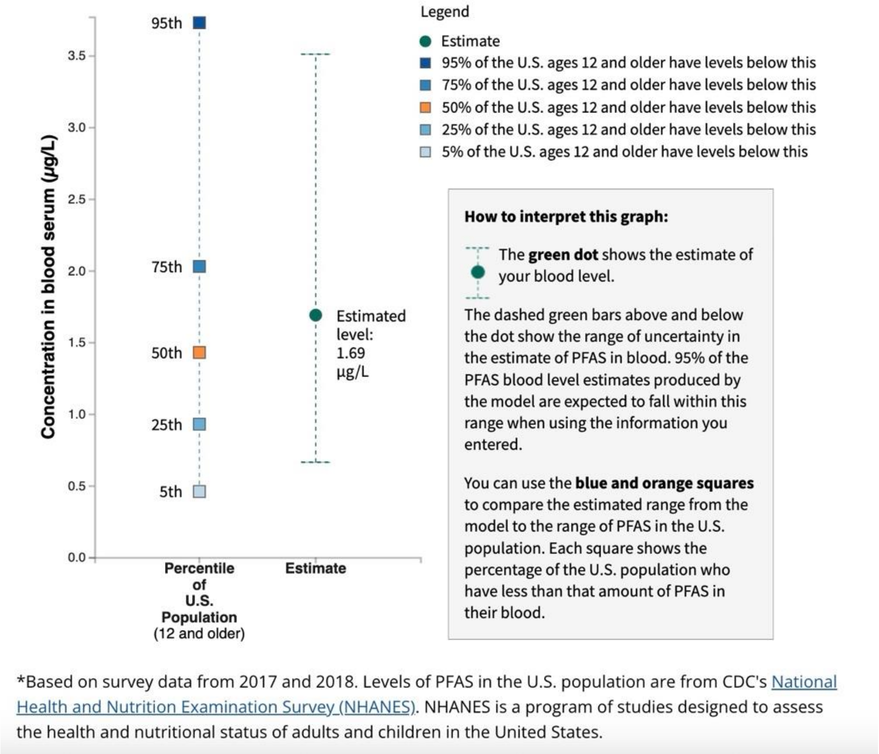
Figure 6- Potential future scenario with reduced PFAS in drinking water

PFAS	Serum Contribution from non-water sources µg/L	Water concentration ng /L	Serum Contribution from water µg/L	Sum in serum µg/L
PFOS	1.4	1.3	0.2	1.6
PFHxS	0.4	1.3	0.3	0.7
PFOA	0.9	1.3	0.2	1.1
Sum of 3	2.7		0.7	3.4
Other 5 PFAS	0.3	Assume zero		0.3
Sum of 8	3.0		0.7	3.7

It should be stressed that these predictions depend on several assumptions, thus if the body weight or daily water intake differs so would the predictions, and these are average predictions. Individuals can have much shorter or longer half lives than the average, so these predictions are for the population average, not for individuals. Also these average half life are for people without any interventions. If people adopt interventions such as taking bile acid sequestrant medicine as discussed in our third report, their serum levels should be much lower.

All the above estimates are based on models using assumed constant intake, steady state, average weight, average half life, average background levels, average water consumptions etc. Obviously these are simplifying assumptions and these parameters vary between individuals and water concentrations vary over time. To illustrate this uncertainty, these results are compared to those from an online tool available in the US which predicts serum concentrations from drinking water levels. https://www.atsdr.cdc.gov/pfas/blood-testing/estimation-tool.html. The methods are explained in detail in a recent publication(Lynch et al., 2023). Below is a screen shot of the prediction for PFOA, from a constant water concentration of 5.9 ng/L as our recent water concentration model, for a 60 year old adult. Their model predicts a serum level of 1.7 ng/ml in the blood, based on the US national average of 1.4, plus the additional PFOA in serum due to water intake of 0.3 ng/mL. Our model predicted 1.7 ng/mL but from 0.8 on top of a background average of 0.9 (as US PFAS levels have been generally higher than European levels). So the predicted increases due to water in the two models are a somewhat different. They take slightly different starting values for half life, daily intake etc, and don't take into account the water contribution in the US national average values, but the results are broadly similar. In addition to estimating the average expected value, they also model the uncertainty due to variability in all these starting values (for intake, half life and so on) and the bar in the chart illustrates that uncertainty: although the average expected serum is 1.7 for PFOA the possible values expected in an individual's blood test, range from 0.7 to 3.5 ng/mL.

Figure 7 - Person to person variation in PFAS levels in serum



How to interpret this graph:

The **green dot** shows the estimate of your blood level.

The dashed green bars above and below the dot show the range of uncertainty in the estimate of PFAS in blood. 95% of the PFAS blood level estimates produced by the model are expected to fall within this range when using the information you entered.

You can use the **blue and orange squares** to compare the estimated range from the model to the range of PFAS in the U.S. population. Each square shows the percentage of the U.S. population who have less than that amount of PFAS in their blood.

*Based on survey data from 2017 and 2018. Levels of PFAS in the U.S. population are from CDC's National Health and Nutrition Examination Survey (NHANES). NHANES is a program of studies designed to assess the health and nutritional status of adults and children in the United States.

In conclusion, we would expect based on the above modelling, that the average for sum of 8 PFAS in blood serum of Jersey adults outside the plume area, from the above scenarios would be currently between 5 and 16 ng/ml (µg/L), and that there would be variability for individuals around the average. Looking ahead we would expect the water concentrations to fall from current levels and so general average levels to fall to under 5 ng/ml. It has been recommended to measure a sample of the general population in Jersey to establish current background levels, and an assessment carried out on food sources of PFAS, which should allow improvements of this prediction model.

5 Global regulatory landscape

5.1 Drinking water

There are a number of guideline values for drinking water around the world. The picture is a little complex: Some are guidance values, some are enforceable standards which must be met. Some are for individual PFAS such as PFOA or PFOS, some for the sum of various numbers of PFAS with the concentrations added up. Some are based on toxicity estimated from animal tests, some from epidemiology and others based mainly on what is judged practicable to achieve. They vary between country and in larger countries such as the US, between states. Generally, however, they have been falling over time and we will summarise here key current or planned PFAS drinking water limits which have been recently established.

5.1.1 Limits reflecting the EFSA risk assessment

Several countries have drawn on the influential intake limits recommended by EFSA, the European Food Safety Agency(EFSA et al., 2020). They established a “tolerable weekly intake” (TWI) from all exposure sources of 4.4 ng/kg/week for people for the sum of 4 PFAS (PFOA, PFOS, PFHxS, PFNA, called PFAS-4 in this section). By dividing by 7 this can be expressed as the equivalent tolerable daily intake (TDI) of 0.63 ng/kg/day. The effect of interest that this limit seeks to avoid is reduction in vaccine effectiveness in young children, exposed via their mothers. But prevention of other effects of concern such as reduced birth weight or increased cholesterol also pointed to similar limits of exposure. This target value has been accepted by many authorities as a base for setting exposure limits.

Converting this TDI into a limit for drinking water requires two further assumptions: how much water is drunk per person by the population (in terms of litres per kg per day) and how important is water as a source of PFAS compares to other sources (mainly in food). In the case of water intake, sometimes the average water intake is used, whereas in other cases an upper percentile is used to be more protective. Consideration of other exposure sources relative to water intake is to avoid a situation where the daily intake from water meets the TDI, but added to the intake from other sources, tips the total intake over the limit. To address this, the Relative Source Contribution (RSC) is applied. The RSC represents the proportion of the TDI that can be attributed to drinking water, with the goal that the guideline concentration remains within safe limits when all sources are considered.

$$\text{water limit } (ng\ per\ L) = \frac{\text{target TDI } (ng\ per\ kg\ per\ day) \times \text{ RSC } (fraction)}{\text{daily water intake } \ (L\ per\ kg\ per\ day)}$$

The choice of the RSC is guided by surveys in the general population, away from local sources contaminating drinking water, which demonstrate that non-drinking water exposure sources account for most of the PFAS intake. For example, a number of studies in the general population provided estimates varying from 1% to 35% of PFOS intake coming from drinking water(IARC, 2025). A 2015 Swedish study in the general population estimated that 11% of PFOS intake on average came via the drinking water(Gebbink et al., 2015b).

In the past a wide range of RSC percentages have been applied in setting limits but since 2022 the WHO Guidance recommends assuming 20% for the RSC, and where water accounts for nearly all the intake, the RSC can be up to a maximum of 80%. “In the absence of adequate exposure data or where documented evidence is available regarding widespread presence in one or more of the other media (i.e. air, food, soil or consumer products), the normal allocation of the total daily intake to drinking-water is 20% (floor value), which reflects a reasonable level of exposure based on broad experience, while still being protective. This value reflects a change from the previous allocation of 10%, which was found to be “excessively conservative”(WHO, 2022). The default value of 20% is also used by the USEPA(Greene et al., 2025).

The proportion of PFAS coming from water varies and can be very high where the water is highly contaminated. So, for example, in Ronneby Sweden, those who had been drinking the AFFF contaminated drinking water averaged 262 ng/ml serum PFOS compared to a control area with clean water and average PFOS of 3 ng/mL(Y. Xu et al., 2021). These samples were taken a short time after the contaminated water had been replaced, but it is clearly evident that before, when they were drinking the contaminated water, the water source accounted for about 99% of their PFOS intake.

Sweden has applied this RSC value of 20% and derived a limit from the EFSA TDI of 4 ng/L for PFAS-4. This is a guidance value and will be a binding limit from 2026(KEMI, 2024; Livsmedelsverket, 2022).Also they have modified slightly the 100 ng/L limit for 20 EFSA by adding one more PFAS (6:2 fluorotelomer sulfonic acid) to the 20 specified in the EU directive and listed below. They have a standard of 100 ng/L for the sum of these 21.

Denmark also derived a limit based on the EFSA TDI, but noting that the TDI was in general exceeded in Denmark from food alone, decided (before the 2022 guideline on 20%) to set a stricter water guideline based on a 10% RSC, leading to a limit of 2 ng/L for PFAS-4(Vinggaard, 2021).

Germany, following a widespread survey of drinking water which revealed that many water supplies exceeded 2 or even 4 ng/L for PFAS-4, decided to set a more achievable limit of 20 ng/L with a delay till 2028 to allow implementation (Borchers, 2022).

The Netherlands has also established some guidance values for drinking water limit on the EFSA TDI, but with a key difference. EFSA assumed that the 4 PFAS had equal potency, but the Netherlands have introduced a weighting by degree of potency. They have set as a guidance value, a threshold for PFAS-4 of 4.4 ng/L expressed as PFOA equivalents(RIVM). The PFOA equivalents are derived by comparing the toxicity of each type of PFAS to that of PFOA. For example, PFOS is assigned a Relative Potency Factor of 2, meaning it is twice as potent as PFOA. For PFHxS the relative potency is 0.6 and for PFNA it is 10. Thus, the target concentration of the sum of PFAS depends on the balance of mixture, and would be lower for mainly PFOS and less strict for mainly PFHxS.

5.1.2 UK standards

Closer to home, the UK standards have been based on a tiering system with increasing obligations from concentrations of 10 ng/L to above 100 ng/L. These guidance values were reviewed last year and a report on that review also includes a helpful summary of drinking water limits in some other countries (DWI, 2024, 2025) .

Similar requirements used to apply to individual PFAS, PFOA and PFOS, but now they are applied to the sum of 48 specified PFAS. The table below summarises the detailed guidance required at each level of PFAS. These are not binding regulations, but the guidance seeks to ensure that no water supplied is above 100 ng/L (for the sum of PFAS), and progressive efforts are encouraged to reduce contamination down to below 10 ng/L. While these limits are for the sum, concentrations of individual PFAS should also be considered in the risk assessment. Water companies are also asked to report any other PFAS (outside of the 48) that are above tier guidance levels. Also it worth noting as many results are likely to be below detection, that these values (reported as not detected or ‘less than’ the reporting limit) are not counted in the sum of PFAS.

Figure 8 - Tiered guidance values for PFAS in UK

Item	Guidance values	Minimum action to be taken by water companies
Tier 1	10 ng/L (sum of PFAS or individual*)	· Conduct a regulation 27 risk assessment. · Monitoring frequency for PFAS should initially be quarterly to establish a baseline for risk assessment, accounting for temporal variation, then may be reduced to allow periodic validation of the risk assessment (minimum annual). · Consider further actions required where sites are likely to breach tier 2
Tier 2	<100 ng/L (sum of PFAS or individual*)	· Increase PFAS monitoring frequency, generally to between monthly and quarterly, sufficient to enable predictive modelling. Higher frequency monitoring may be appropriate where concentrations could breach tier 3. · Ensure regulation 27 risk assessments are up to date and under continuous review. · Review existing control measures, including the effectiveness, validation, and monitoring of that measure. Identify additional control measures required to reduce PFAS concentrations. · Water company will discuss the likelihood of a tier 3 breach with the DWI to determine whether the occurrence should be a reportable event. Consult/discuss with UKHSA and local health authorities. · Prepare emergency contingency measures to prevent the supply of water to consumers with ≥0.1 µg/L PFAS should existing control measures become inadequate. · Design a proactive and systematic risk reduction strategy which shall include a prioritised mitigation methodology to progressively reduce PFAS concentrations in drinking water. Appropriate mitigation may include catchment management, direct or indirect treatment, or process-controlled blending.
Tier 3	≥ 100 ng/L (sum of PFAS or individual*)	· Notify as an event any results ≥100 ng/L in water supplied to consumers, any raw water results that are likely to cause results ≥100 ng/L in water supplied to consumers, or any failure of PFAS treatment where raw water sources are in tier 3 (under the provisions of the current Water Industry (Suppliers' Information) Direction [the Information Direction]). · Notify UKHSA and local health authorities and determine what action (beyond monitoring) is appropriate to reduce exposure via drinking water supplies. Factors such as population demographics or consumer groups at particular risk should be considered. Action may, for example, include provision of alternative supplies to the affected area. · Sample investigation to include, as a minimum: resample point of contravention, individual raw water sources, blended or combined raw water points and final water from water treatment works. Consider sampling at treated water blending point (if applicable) and/or water quality zones. Samples should be fast-tracked. · Ongoing enhanced monitoring should be established at locations and frequencies to understand the impact for the specific supply situation. A minimum of one year of monthly samples at raw and final water points, timed to take account of any changes in hydrological conditions, such as precipitation, surface or groundwater flows and pumping regimes. · Review existing control measures, including the effectiveness, validation, and monitoring of that measure. Implement emergency contingency measures to prevent the supply of water with ≥100 ng/L PFAS to consumers. · Review the catchment risk assessment, including PFAS source information, within 3 working days of receiving the result. · Prioritise site within the company's PFAS risk reduction strategy for medium/long term mitigation. · This list of actions is not exhaustive; all necessary actions to investigate the source of the PFAS and reduce concentrations to below 100 ng/L in water supplied to consumers must be taken in the short term, with a longer-term strategy designed and implemented to progressively reduce PFAS concentrations in drinking water.

**Sum of PFAS refers to the sum of the concentrations of 48 compounds which water companies are required to test for.*

Scotland has adopted the EU limit for the sum of 20 PFAS of 100 ng/L, described below(Scottish_Government, 2022).

5.1.3 European Union standards

In the EU there is an overall limit to be complied with by January 2026 for the sum of 20 PFAS (listed in the table below), of 100 ng/L, and a further overall standard for total PFAS of 500 ng/L. Countries can implement more strict standards within that overall target (as Denmark, Sweden and Germany have done)(EU, 2020).

5.1.4 North American standards

In the US, the EPA established in 2024 health-based, non-enforceable Maximum Contaminant Level Goals (MCLGs) for six PFAS, being zero for PFOA and PFOS based on the conclusion that they are "likely to be carcinogenic to humans" and 10 ng/L for PFHxS, 10 ng/L for PFNA, and 10 ng/L for GenX. They also established enforceable Maximum Contaminant Levels in drinking water, based more on practicability of measurements and control, of 4 ng/L for PFOA, 4 ng/L for PFOS, while the enforceable Maximum Contaminant Levels for PFHxS, PFNA, and GenX were set at the health-based goals of 10 ng/L(EPA, 2024). Additionally, an MCL based on a Hazard Index which considers the relative toxicity of the individual PFAS was set for mixtures of PFHxS, PFNA, GenX, and PFBS. More recently the EPA confirmed that the MCLs for PFOA and PFOS at 4 ng/L will be retained, but that they intend to rescind and reconsider the MCLs for other four PFAS including PFHxS. The date by which these MCLs have to be met has now been extended from 2029 to 2031(EPA, 2025).

5.1.5 Summary of international limits

Figure 9 - International standards for PFAS, adapted from (DWI 2024)

Country / Region	Value (ng/L)	Comments
England and Wales	100	Sum of 48 named PFAS
Scotland	100	Sum of 20 named PFAS as EU
EU	100 500	Sum of 20 named PFAS Total PFAS
Germany	20	Sum of PFOS, PFOA, PFNA and PFHxS. In addition to the EU requirement
Denmark	2	Sum of PFOS, PFOA, PFNA and PFHxS. In addition to the EU requirement
Sweden	4	Sum of PFOS, PFOA, PFNA and PFHxS. In addition to the EU requirement
Netherlands	4.4	As PFOA equivalents across the sum PFOS, PFOA, PFNA and PFHxS, each weighted for potency relative to PFOA. In addition to the EU requirement
USA	4 4 10 10 10 10	PFOS PFOA PFNA PFHxS GenX PFBS
Australia	8 200 30	PFOS PFOA PFHxS
Canada	30	Sum of 25 named PFAS. (Government of Canada, 2024)

Australia recently updated their drinking water limits, setting health based limits on the toxicological not epidemiological data (Australia, 2025)

The Canadian value of 30 ng/L for a sum of 25 named PFAS (including most of the EU 20 PFAS, is based on animal toxicology and concentrations that they judge “can be reliably measured by available methods and achieved by drinking water treatment.” (Health_Canada, 2024)

The most comprehensive list of limits is provided by the ITRC website(ITRC, 2025). As well as national standards, many state-level regulations in the USA are summarised there, and it is frequently updated.

5.1.6 PFAS groupings

The table below lists the specific PFAS that are included in different regulations. The DWI requires water companies to sample for 48 PFAS and guidance values are for the sum of these 48 (Col 4). A number of countries such as Denmark focus on the sum of the 4 PFAS often present in human blood samples and used for the risk assessment by EFSA (Col 5). In the sampling carried out in Jersey of blood in 2022, 3 of these were detected in all samples (Col 6), and up to 8 PFAS were found in at least one of the samples, often at low levels. The sum of PFAS used for eligibility for potential interventions in report 3, is calculated for these same 8 PFAS (Col 7). The US National Academies of Science and Medicine (NASEM, 2022) recommended using a slightly different sum to identify levels of human exposure that are of potential concern (Col 8). The EU rules are based on the sum of 20 PFAS and this has also been used for regulations on drinking water in Scotland (Col 9). Abbreviations are provided for all of these 20 PFAS. In the most recent Arcadis Jersey water report, 8 PFAS were above detection limits in drinking water samples (Col 10).

The three PFAS of most concern for Jersey up to now for human health (PFOA, PFOS, PFHxS) are present in all of these lists of PFAS used for calculating sum of PFAS indices. In the sampling of PFAS in drinking water in Jersey 8 compounds were detected above detection limits, this list of 8 falls within the DWI 48 and the EU 20, so for these Jersey samples, the total under either of those ways of summing would be the same.

Figure 10 - Groupings of PFAS in measurements and some guidance values

PFAS name		CAS code	UK DWI PFAS-48	PFAS-4 (EFSA)	Jersey all blood samples	Jersey some blood samples	NASEM LIST	EU/ Scotland PFAS-20	Jersey water detections
Column 1	2	3	4	5	6	7	8	9	10
Perfluorooctane Acid	PFOA	335-67-1	y	y	Y	y	y	y	y
Perfluorooctane Sulfonate	PFOS	1763-23-1	y	y	Y	y	y	y	y
Perfluorohexane sulfonic acid	PFHxS	355-46-4	y	y	Y	y	y	y	y
Perfluorononanoic acid	PFNA	375-95-1	y	y		y	y	y	
Perfluorobutane sulfonic acid	PFBS	375-73-5	y					y	y
Perfluorobutanoic acid	PFBA	375-22-4	y					y	y
Perfluoroheptanoic acid	PFHpA	375-85-9	y					y	y
Perfluorohexanoic acid	PFHxA	307-24-4	y					y	y
Perfluoropentanoic acid	PFPeA	2706-90-3	y					y	y
2-(N-Methyl perfluorooctane	MeFOSAA	2355-31-9	y			y	y		

sulfonamido) acetic acid									
Perfluoropentane sulfonic acid	PFPeS	2706-91-4	y			y		y	
Perfluorodecanoic acid	PFDA	335-76-2	y			y	y	y	
Perfluoroheptane sulfonic acid	PFHpS	375-92-8	y			y		y	
Perfluoroundecanoic acid	PFUnDA	2058-94-8	y				y	**y**	
Perfluorodecane sulfonic acid	PFDS	335-77-3	y					y	
Perfluorododecane sulfonic acid	PFDS	79780-39-5	y					y	
Perfluorododecanoic acid	PFDA	307-55-1	y					y	
Perfluorononane sulfonic acid	PFNS	68259-12-1	y					y	
Perfluorotridecane sulfonic acid	PFTrDS	791563-89-8						y	
Perfluorotridecanoic acid	PFTrDA	72629-94-8	y					y	
Perfluoroundecane sulfonic acid	PFUnDS	749786-16-1	y					y	
Perfluoro-3-methoxypropanoic acid		377-73-1	y						
Perfluoro-4-ethyl cyclohexane sulfonic acid		646-83-3	y						
Perfluoro-4-methoxybutanoic acid		863090-89-5	y						
Perfluoro(2-ethoxyethane) sulphonic acid		113507-82-7	y						
Perfluorobutyl sulfonamide (perfluorobutane sulfonamide)		30334-69-1	y						
Perfluorohexadeconoic acid		67905-19-5	y						
Perfluorohexane sulfonamide		41997-13-1	y						
Perfluorooctadecanoic acid		16517-11-6	y						
Perfluorooctane sulfonamide		754-91-6	y						
Perfluorotetradeconoic acid		376-06-7	y						
11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid		763051-92-9	y						
2-(N-Ethyl perfluorooctane sulfonamido) acetic acid		2991-50-6	y						
2H,2H,3H,3H-Perfluorodecanoic acid		812-70-4	y						
2H,2H,3H,3H-Perfluorooctanoic acid		914637-49-3	y						
3-Perfluoropropyl propanoic acid		356-02-5	y						
4,8-Dioxa-3H-perfluorononanoic acid		919005-14-4	y						
4:2 Fluorotelomer sulfonic acid		757124-72-4	y						

6:2 Fluorotelomer sulfonamido propyl betaine		34455-29-3	y						
6:2 Fluorotelomer sulfonic acid		27619-97-2	y						
8:2 Fluorotelomer sulfonic acid		39108-34-4	y						
9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid		756426-58-1	y						
Hexafluoropropylene oxide dimer acid (Gen X)		13252-13-6	y						
Hexafluoropropylene oxide trimer acid		13252-14-7	y						
N-Ethyl perfluorooctane sulfonamide		4151-50-2	y						
N-Ethyl-N-(2-hydroxyethyl) perfluorooctane sulfonamide		1691-99-2	y						
N-methyl perfluorooctane sulfonamide		31506-32-8	y						
N-Methyl-N-(2-hydroxyethyl) perfluorooctane sulfonamide		24448-09-7	y						
Nonafluoro-3,6-dioxaheptanoic acid		151772-58-6	y						

6 Evidence from subject matter experts

The panel met with a wide range of subject matter experts across the whole scope of the report. For ease of understanding, they have been grouped by the particular area of expertise that they shared with the panel. Where an expert met with the panel on more than one area, their biography appears in each relevant section.

6.1 Experts on mains water regulation

Julia Hartmann is from the Dutch National Institute for Public Health and the Environment (RIVM). She has been involved in drinking water research and has contributed to various reports on PFAS and drinking water. Additionally, she has worked on deriving a drinking water guideline value for PFAS over the past few years.

Gloria Post is a recently retired toxicologist and human health risk assessor from the New Jersey Department of Environmental Protection, where she worked for almost 39 years. She developed numerous health-based drinking water guidelines and has been involved with PFAS since 2004. Gloria has also served on several advisory panels for the US, WHO, and IARC related to PFAS health effects.

Toke Winther is from the National Food Institute at the Technical University of Denmark. He has close collaboration with the Danish Environmental Protection Agency (EPA) on PFAS and drinking water quality. Toke has been working with the Danish EPA for around 10 years, focusing on PFAS regulation.

Hans Peter Birk Hansen is as a geologist and team leader at the Danish Environmental Protection Agency (EPA). His area of work focuses on water supply and groundwater protection in Denmark. He leads a unit of around 15 people working on these topics.

6.2 Presentations from experts on mains water regulation

6.2.1 Presentation from Julia Hartmann

The Netherlands manages PFAS in drinking water through a dual structure: the National Institute for Public Health and the Environment (RIVM) derives health-based guideline values, while the Ministry of Infrastructure and Water Management sets legally binding limits after weighing technological and economic factors. Ten large public water companies and roughly 250 small supplies serve the country; about two-thirds of consumers receive groundwater, the remainder surface water—important because surface sources typically contain more PFAS.

Regulatory evolution.

Before 2020 the Netherlands maintained individual limits for PFOA and GenX chemicals, both relatively high. The European Food Safety Authority (EFSA) then published a far lower tolerable weekly intake (TWI) of 4.4 ng/kg bodyweight for four PFAS (the “EFSA-4”: PFOA, PFOS, PFHxS, PFNA), citing immunological endpoints as the critical effect. In response, the Ministry asked RIVM to propose a new drinking-water guideline. RIVM applied a mixture-risk approach that converts each PFAS to “PFOA equivalents” via relative potency factors (RPFs); drinking water was allocated 20 % of total acceptable exposure, consistent with WHO methodology. The resulting health-based limit is 4.4 n/L as PFOA equivalents across a broad PFAS set.

Population intake studies.

A 2021 assessment confirmed that diet contributes more PFAS than drinking water, supporting the 20 % allocation. An expanded 2023 study incorporated additional PFAS, 770 drinking-water samples, and newer analytical data. Although aggregate dietary plus water intake still exceeded the EFSA TWI, total exposure was about 40 % lower than earlier estimates. Within drinking water, trifluoroacetic acid (TFA), PFOA, and PFHxA were the largest contributors.

Current compliance status.

None of the analysed water samples exceeded 22 ng/L total, and all supplies, therefore, comply with the existing legal limit of 100 ng/L for the sum of 20 PFAS specified in the EU Drinking Water Directive. However, two-thirds of samples sourced from surface water surpassed the new 4.4 ng/L health-based value for the sum of 4, whereas groundwater supplies generally met it. The lower guideline is not yet regulated, but the Ministry intends to move towards it; a policy framework is under development, with an initial update expected in the summer and full implementation likely to span several years.

Technological and policy considerations.
Surface-water utilities may need additional treatment to reach 4.4 ng/L. Because RPFs weight PFAS by toxicity rather than simple concentration, compounds such as PFNA, assigned an RPF of 10, significantly influence total exposure even at low measured levels. While the Drinking Water Directive uses straightforward summation and does not require RPF application, an RPF-based method can produce a stricter outcome depending on sample composition.

Key clarifications from discussion.

The IARC evaluation of PFAS has not prompted changes to RIVM's health-based limits.

RPF methodology can yield lower allowable concentrations than simple summation, but historical data through early 2021 still demonstrate compliance with the Directive's 100 ng/L limit.

Implementation timing for the 4.4 ng/L guideline remains uncertain; multi-year planning is anticipated.

Analytical turnaround and data sufficiency are crucial; an inquiry into RPF fit to immunological data is ongoing and will be addressed by subject specialists.

Overall findings.
Dutch drinking water currently meets EU legal standards, yet the proposed 4.4 ng/L value identifies a particular vulnerability in surface-water supplies and underscores the need for tighter source control and potentially upgraded treatment. Adoption of mixture-risk assessment via RPFs offers the possibility to broaden regulatory coverage beyond the EFSA-4 and give emphasis to compounds whose toxicity weighting, rather than concentration alone, drives risk. The Ministry and water sector are preparing a phased policy response that balances public-health protection with technical feasibility and cost, aiming ultimately for a lower, health-based PFAS limit in all Dutch drinking water.

6.2.2 Presentation from Gloria Post

Drinking-water quality is governed by parallel federal and state Safe Drinking Water Acts. Both acts define the process for setting enforceable Maximum Contaminant Levels (MCLs) but do not list chemical-specific numbers; those are adopted later by the US EPA or individual states. Public water systems must meet MCLs through monitoring and treatment, while private wells remain largely unregulated. Some states, New Jersey is a noted example, routinely adopt stricter standards and can regulate chemicals not yet covered at federal level.

Historical evolution of national standards

Before 1986 only a handful of contaminants had federal limits. Amendments that year required the EPA to set standards for 25 chemicals every three years, prompting a large wave of regulations through the late 1980s and 1990s. The 1996 amendments slowed the pace, directing the EPA to consider at least five new contaminants every five years and imposing stringent criteria: evidence of health effects, occurrence at levels of concern, and clear opportunity for risk reduction. No new federal MCLs were added after the 1990s until the PFAS rule was finalised in April 2024.

Pathway for new MCLs

Candidate chemicals follow a multi-step process. They first appear on the Contaminant Candidate List (CCL), may be monitored under the Unregulated Contaminant Monitoring Rule (UCMR), and finally undergo a regulatory determination. Public-health criteria, analytical feasibility and economic impact all factor into the decision. The 2021 positive determination for PFOA and PFOS initiated the rule-making that produced the 2024 PFAS MCLs.

Why PFAS warranted regulation

PFAS occur widely, persist in the environment, bioaccumulate in humans and show multiple toxicity endpoints in animals. Drinking water can yield exposures far higher than other routes; infants are especially vulnerable because they ingest more fluid per body weight and receive additional PFAS through breast milk. EPA identified robust human epidemiology links at general-population exposure levels, including decreased vaccine response, lower birth weight and increased cholesterol, supporting a much lower tolerable intake than earlier guidance.

Federal PFAS standards

The new rule sets MCLs of 4 ng/L for PFOA and PFOS; the lowest concentration that commercial laboratories can measure with consistent precision. Maximum Contaminant Level Goals (health-based targets) were placed at zero because both chemicals are deemed likely human carcinogens. Four additional PFAS (PFHxS, PFNA, PFBS and GenX) were proposed to be regulated as a group via a Hazard Index to capture mixture toxicity. These are the first federal MCLs to rely on human epidemiology for risk assessment and to use a mixture-based approach for some compounds.

Cost–benefit analysis

EPA estimated annual compliance and monitoring expenses at USD 1.548 billion and projected health benefits at USD 1.549 billion, concluding benefits outweigh costs. Benefits include reduced health-care expenditure and productivity gains linked to avoided immune suppression, developmental impacts and chronic disease.

Implementation schedule

Public water systems must start quarterly monitoring within three years. Surface-water and large groundwater utilities will collect quarterly samples, smaller groundwater systems twice per year. Compliance is judged on a running annual average; if an MCL is exceeded, utilities have up to five additional years to install treatment. The final rule is currently subject to legal challenge, and the incoming administration has sought a temporary hold while it reviews the case, with an update due by mid-May.

Analytical and technical considerations

The practical quantitation level of 4 ng/L reflects the capability of most commercial laboratories. Federal MCLs are revisited every six years to incorporate advances in analytical sensitivity and new toxicological data. The rule assumes treatment technologies such as high-performance activated carbon, ion exchange, or membrane processes can reliably achieve the 4 ng/L level when properly designed.

State–federal interplay

Several states already enforce PFAS limits below the earlier EPA Health Advisory values; the new federal MCL pre-empts only the less stringent ones. States may still adopt tougher criteria or regulate additional PFAS. This tiered system ensures national minimum protection while permitting regional differences driven by local conditions or policy preferences.

Key findings

The United States is adopting its first new federal drinking-water standards in decades, focusing on PFAS because of their ubiquity, persistence and significant human-health evidence. MCLs of 4 ng/L for PFOA and PFOS represent the lowest reliable measurement threshold and place the public-health goal at zero. Implementation will require extensive monitoring, possible treatment upgrades and ongoing evaluation, but EPA's analysis indicates that the anticipated health gains balance the economic burden.

6.2.3 Presentation from Toke Winther

Denmark develops science-based drinking-water criteria for PFAS through collaboration between the National Food Institute at the Technical University of Denmark and the Danish Environmental Protection Agency; the country relies almost entirely on groundwater for supply, so protective benchmarks are crucial.

Regulated substance sets and timelines

- 2015: introduced a single limit of 100 ng/L for the sum of 12 PFAS; the list was built on a toxicological report by Larsen & Giovale that selected liver effects in rats for PFOS and PFOA as the critical endpoints; because data for PFOSA were insufficient, its toxicity was assumed equal to PFOS; the EPA then added nine additional PFAS detected near firefighting-foam sites, bringing the total to 12.
- 2021: adopted a far stricter limit of 2 ng/L for the sum of four PFAS—PFOS; PFOA; PFNA; PFHxS; this value was derived from the European Food Safety Authority tolerable weekly intake (TWI) of 4.4 ng/kg bodyweight/week that targets immune effects in breast-fed infants.
- 2023: implemented the recast EU Drinking Water Directive requirement of 100 ng/L for the sum of 20 named PFAS; Denmark expanded the list to 22 by including 6:2 FTS and PFOSA from its 2015 set; the concentration limit for this larger group remained 100 ng/L.

Derivation methodology

For health-based calculations Denmark converts the TWI to a tolerable daily intake by dividing by seven; applies an allocation factor of ten when drinking water is a minor exposure route; and uses a child-specific ingestion rate of 0.03 L/ kg/day; applying these parameters to the EFSA-4 produced the 2 ng/L drinking-water criterion.

Coexisting limits in practice

Current regulation enforces two parallel caps: 0.1 µg/L (100 ng/L) for the combined 22-PFAS set and 2 ng/L for the targeted sum of PFOS; PFOA; PFNA; PFHxS. Utilities must meet both numbers, ensuring broad control of legacy and emerging PFAS while providing additional protection for the four most toxic members.

Rationale and public-health protection

Criteria reflect the Danish policy of grounding limits in the most sensitive endpoints and adjusting for cumulative exposure; they also anticipate evolving European requirements by adding substances not yet covered in the directive; together, the twin limits safeguard groundwater-based supplies and maintain confidence in drinking-water safety.

6.2.4 Presentation from Hans Peter Birk Hansen

Denmark obtains ninety-nine percent of its drinking water from groundwater and follows a minimal-treatment principle: raw water is normally aerated and sand-filtered; only where pollution cannot be avoided are extra barriers added. National quality standards are laid down in the Water Supply Act and associated executive orders that transpose the EU Drinking Water Directive. Waterworks sample and monitor supplies; municipalities enforce compliance and upload results to the national Jupiter database; national health authorities provide technical guidance when exceedances occur.

The supply network is decentralised. Eighty-seven municipally owned utilities and about two-thousand-four-hundred consumer-owned works serve most citizens, alongside roughly fifty-thousand very small private supplies that each serve fewer than ten households. Local exceedances can therefore arise even when national compliance rates appear high.

Current PFAS limits

- A combined limit of 100 ng/L for the sum of twenty-two PFAS, mirroring the EU list and adding 6:2 FTS plus PFOSA retained from Denmark's earlier standard.
- A stricter limit of 2 ng/L for the sum of four PFAS (PFOS, PFOA, PFNA, PFHxS).

The four-compound value is derived from the European Food Safety Authority tolerable weekly intake of 4.4 ng/kg body weight/week. Denmark converts this to a tolerable daily intake by dividing by seven, applies an allocation factor of ten for drinking water, and uses a child ingestion rate of 0.03 L/kg/day; the calculation yields 2 ng/L.

Monitoring results (Jupiter database)

- Groundwater: PFAS appears in 700 of 15 600 samples, equal to 4.54 percent; most positives are from monitoring wells rather than drinking-water boreholes.
- Finished drinking water: no sample exceeds the 100 ng/L twenty-two-PFAS cap; 2.3 percent of samples exceed the 2 ng/L four-PFAS cap. Each exceedance was resolved through coordinated action by the local waterwork, municipality and health authority.

Fanø case study

Sea-spray aerosols from the North Sea deposited PFAS inland; infiltration raised groundwater concentrations up to several kilometres from the coast. Foam deposition was ruled out; airborne sea-spray particles were identified as the principal transport mechanism. Raw water entered the Fanø plant with 3–4 ng/L of the regulated four-PFAS group. A two-barrier treatment of granular activated carbon followed by ion-exchange resin reduced finished-water levels to 0–1.5 ng/L. Stage-by-stage sampling confirmed substantial PFAS removal after carbon and further removal by the resin.

Key points for Denmark

- Dual limits (100 ng/L for twenty-two PFAS and 2 ng/L for four PFAS) provide broad coverage and extra protection for the most toxic compounds.
- Decentralised governance combined with a national database enables early detection and rapid local mitigation.
- Minimal treatment remains viable if advanced barriers such as activated carbon or ion exchange are deployed when needed.
- Coastal regions must consider sea-spray aerosol as a potential PFAS source.

6.3 Discussion on mains water regulation

There was a wide-ranging discussion, (the full details of which are appended in the meeting minutes). This seeks to summarise the key matters and findings that emerged during the discussion among the subject matter experts and with panel members. It has been organised by theme to make it easier to follow.

6.3.1 Health basis for numerical limits

Most jurisdictions anchor PFAS thresholds in immunotoxicity endpoints; the United States is the main exception, basing federal values on carcinogenicity. Regardless of toxicological choice, allocation factors that assign a fraction of total allowable intake to drinking water largely set the final number. Using 20 percent, Sweden and the Netherlands arrive at 4 and 4.4 ng/L; using 10 percent, Denmark arrives at 2 ng/L. The convergence of values in the low-single-nanogram range shows that different national methods can lead to similar targert values once allocation and ingestion parameters are applied.

6.3.2 Regulatory architecture and laboratory feasibility

Two approaches exist: define a health-based threshold plus a separate detection or quantification requirement; or set a single enforceable level that laboratories must measure reliably. Regulators emphasise the quantification limit—calculated at roughly ten times the standard deviation of a blank sample—because it guarantees numerical accuracy; detection limits are lower but indicate only presence. Denmark vetted laboratory capacity before adopting its stringent limits; elsewhere, regulatory values are constrained by what commercial laboratories can quantify, typically 4 ng/L for either individual or the sum of 4 PFAS.

6.3.3 Exposure modelling assumptions

Danish calculations use a child-specific water ingestion rate of 0.03 L/kg/day; others may derive limits from maternal serum or adult consumption yet reach similar concentrations after applying allocation factors. Diet remains the primary PFAS exposure route in uncontaminated areas; drinking water dominates where supplies are polluted. Compound characteristics matter: short-chain acids tend to have water-dominated exposure; long-chain PFAS bioaccumulate and enter humans chiefly through food.

6.3.4 Occurrence patterns and exceedance rates

Danish monitoring shows no exceedance of the 100 ng/L limit for twenty-two PFAS and only 2.3 percent exceedance of the stricter 2 ng/L limit for the four most toxic PFAS. Many U.S. exceedances occur in inland regions where agricultural biosolids contribute PFAS to groundwater. Differences likely reflect Denmark's heavy reliance on relatively protected groundwater versus more varied source waters in other countries.

6.3.5 Mixture assessment using relative potency factors

The Dutch approach converts concentrations of four but potentially up to twenty-three PFAS into PFOA equivalents by applying relative potency factors; internal factors are based on immunotoxicity while external published factors derive from liver effects in male rats. Although imperfect, the method seeks to better represent potency differences than assuming equal toxicity for all PFAS and reduces the risk of underestimating health impact, especially when multiple PFAS co-occur.

6.3.6 Outstanding design questions

Regulators must balance health protection with enforceability, ensuring laboratories can meet lower quantification limits on schedule. Choice of age group, ingestion rate and allocation factor drives calculated thresholds and therefore influences treatment requirements. Mixture-based methods such as the relative potency approach expand compound coverage but introduce additional uncertainty that would need to be communicated clearly.

6.3.7 In summary

- Immunotoxic endpoints dominate international PFAS limit setting; allocation factors dictate resulting thresholds.
- Quantification limits—not detection limits—anchor enforceable standards; laboratory capability defines what is practical.
- Water contributes most PFAS exposure only in contaminated areas; otherwise diet prevails.
- Groundwater-based systems show fewer exceedances than mixed or surface-water supplies.
- Relative potency factors can improve mixture assessment though uncertainties remain.

Experts on mains (fresh) water treatment

Ian Ross, based in Monterey, California, originally from Yorkshire, works for CDM Smith, a company specialising in large-scale PFAS treatment. With a background in the fate, transport, and treatment of man-made chemicals, he has focused on PFAS since 2005. Ian is knowledgeable about global regulations, PFAS measurement, and removal techniques.

Christopher Bellona, an associate professor at the Colorado School of Mines in Golden, Colorado, specialises in PFAS treatment. With over 15 years of experience in PFAS treatment, he focuses on separation techniques like absorbance membrane treatment and has also worked on PFAS destruction projects. His work often involves field pilot scale evaluations of various technologies and comparing their treatment costs.

Kevin Berryhill, a consulting engineer with Provost and Pritchard Consulting Group in Clovis, California, specialises in designing treatment plants and selecting treatment processes for municipal and public drinking water supplies.

Lutz Ahrens is a professor in environmental chemistry at SLU in Uppsala, Sweden. He has been working on PFAS since 2005, focusing on their fate, transport, and treatment techniques.

Marcel Riegel is a chemical engineer with a PhD in drinking water treatment, specialising in the removal of uranium out of drinking water using ion exchanges. He has over 20 years of experience and works for TZW German Water Centre, focusing on research and consulting for water suppliers.

Philip McCleaf is stationed in Uppsala and works for Uppsala Water and Waste. He has 30 years of experience in drinking water treatment and 12 years specifically in PFAS removal. Uppsala has a similar PFAS contamination situation to Jersey.

Sebastian Castano introduced himself as a technology advisor at Oasen Drinkwater, a drinking water company in the Netherlands. He mentioned that he would share their experiences with PFAS presence in water sources and discuss their treatment options, particularly those involving membrane-based technologies.

6.4 Presentations from experts on mains water treatment

6.4.1 Presentation from Ian Ross

PFAS are a broad family of man-made fluorinated compounds that eventually transform in the environment into highly stable perfluoroalkyl acids, the chemicals most regulations target. Fire-fighting foams contain mainly polyfluoroalkyl “precursor” molecules that break down over time—much as a wooden arrow degrades in soil—leaving the more persistent acids behind; only a small fraction of the original foam ingredients are regulated at the point of release.

Chain length strongly influences environmental behaviour. Long-chain acids such as PFOS and PFHxS are less soluble and tend to stay near the source, whereas short-chain acids like PFHxA and PFBA travel readily in water. Ultra-short acids (for example trifluoroacetic acid) are even more mobile and difficult to capture with conventional adsorbents. Treatment technologies must therefore be matched to the specific chain-length profile and to competing ions or organic matter in the water.

Regulatory limits vary widely. European standards apply low combined limits across many PFAS, while the United States regulates only a few compounds but at increasingly strict levels. Laboratory analysis can focus on named PFAS using targeted standards, convert precursors to acids with total oxidisable precursor (TOP) assays, or measure overall organofluorine by the adsorbable organic fluorine (AOF) method.

Three commercial treatment classes dominate drinking-water practice:

- **Granular activated carbon (GAC)** removes long-chain PFAS well but saturates quickly with short chains or high natural organic carbon.
- **Ion-exchange (IX) resins** rely on charge attraction; they are efficient for short chains but lose capacity where sulfate or other ions are abundant.
- **Membranes (nanofiltration or reverse osmosis)** offer the broadest removal spectrum but have high operating cost, generate a concentrate stream, and need more space.

Large groundwater plants in California have shown that IX systems can meet strict limits at scale when water chemistry is favourable; where organic carbon is low, GAC remains cost-effective. In many cases a phased approach installs IX or GAC quickly to address immediate risk while more complex membrane systems are designed.

Membrane rejectate can be reduced in volume and treated by foam fractionation, which concentrates PFAS by exploiting their surface activity, making destructive steps such as super-critical water oxidation, sonolysis or plasma treatment more economical. Selecting an overall strategy requires accounting for site constraints, anticipated regulatory tightening and the rapid evolution of analytical science, ensuring that systems remain protective and practicable over their expected service life

6.4.2 Presentation from Christopher Bellona

Since 2010 the range of technologies used to control PFAS in water has expanded from a narrow focus on nanofiltration and granular activated carbon (GAC) to a broader set that now includes ion-exchange (IX) resins, high-recovery reverse osmosis, foam fractionation and several destructive processes. Despite hundreds of research papers published each year, adsorptive approaches—GAC and IX—remain the workhorses because they are simple to run at full scale and can be installed quickly.

Breakthrough curves, which plot effluent concentration against the number of bed volumes treated, show predictable patterns. Short-chain acids break through earliest, long-chain sulfonates latest, and carboxylates such as PFOA escape beds sooner than sulfonates of the same chain length such as PFOS. When cost rather than bed life is used as the metric, GAC and IX plants often come out similar: IX media achieve higher theoretical capacity but are priced far higher per kilogram. Operating costs rise sharply in waters rich in natural organic matter, which competes for adsorption sites. Utilities that already remove organics through coagulation, ozone or biologically active filtration typically achieve much longer PFAS run times and lower life-cycle costs.

New adsorbents aim to improve selectivity without the price premium of IX. Fluoro-sorb, a surface-modified bentonite, behaves like a weak-base resin at a fraction of the cost, while porous polymer networks are being engineered to create binding pockets sized for PFAS molecules. Both show promise but have yet to clear the hurdles of large-scale regeneration, hydraulic integrity and certification for drinking-water contact.

High-pressure membranes deliver the deepest PFAS cuts. Data from a firefighting-training-area pilot show nanofiltration rejecting more than 95 percent of measured PFAS at eighty-percent water recovery; reverse osmosis pushes rejection above 99 percent. The unavoidable downside is a concentrate stream containing milligram-per-liter PFAS that requires further treatment or disposal.

Destructive technologies now in late-pilot or early commercial stages include electrochemical oxidation, plasma reactors, super-critical water oxidation and the lower-temperature hydrothermal alkaline treatment under development by Aquagga. Each differs in energy need and effectiveness for short- versus long-chain PFAS, but all benefit from treating smaller volumes at higher concentration.

The emerging treatment train therefore concentrates PFAS first—using foam fractionation, nanofiltration or both—then applies a destructive step to the reduced volume. Department of Defense field demonstrations are testing foam fractionation followed by hydrothermal alkaline treatment to determine practical costs and reliability.

Practical issues remain: adsorbent systems in pressure vessels install faster than membrane plants but still need spent media disposal; tight nanofiltration and reverse osmosis demand remineralisation before distribution; regenerable IX resins and compact destruction units exist but have limited long-term field data. Final technology selection must weigh these trade-offs against site-specific contaminant profiles, water chemistry and regulatory deadlines.

6.4.3 Presentation from Kevin Berryhill

Until recently every state set its own drinking-water limits; values ranged from non-detect to more than 70 ng/L. New Jersey issued the first binding standard, while South Dakota barred any state limit stricter than the federal one. In 2024 the US EPA introduced a national maximum-contaminant-level rule covering six PFAS—PFOS, PFOA, PFHxS, PFNA, PFBS and GenX chemicals. The rule sets 4 ng/L as an annual-average limit for PFOS and PFOA and adds a “hazard index” that caps the combined risk of PFHxS, PFNA, PFBS and GenX. Utilities now need treatment that consistently meets single-compound limits in the low-ng/L range while also lowering the sum of short-chain acids.

Commercial treatment choices

Three adsorptive options dominate full-scale practice:

- **Granular activated carbon (GAC)** – a pair of pressure vessels in series gives operational security and uses the carbon bed more fully. About 20 minutes of empty-bed contact time is needed. Back-wash and first-flush water can contain milligram-per-litre PFAS and must be managed. Organic matter shortens carbon life; pH can spike during start-up; chlorine residual is removed, so secondary disinfection may be needed. Incidental benefits include removal of pesticides, taste and odour compounds, and many micropollutants.
- **Ion-exchange (IX) resin** – anion-exchange beads load PFAS rapidly so only about 5 minutes contact time and a much smaller footprint are required. Pretreatment with cartridge filtration is essential; oxidants must be absent. Resin life is reduced by competing anions such as sulfate, and changes in chloride-to-sulfate ratio can mobilise lead scales downstream. On-site regeneration is rare because it demands strong chemicals and generates a corrosive PFAS brine.
- **Fluoro-sorb** – a surface-modified bentonite clay now moving from pilot to early commercial use. It removes both long- and short-chain PFAS, is tolerant of organic matter and chlorine, and costs less than IX media. Utilities are cautious because long-term field data and supply chains are still limited.

Membrane processes—nanofiltration and reverse osmosis—remove virtually all PFAS but concentrate the contaminants into a brine that inland systems cannot discharge easily. Additional steps such as foam fractionation, electro-oxidation or super-critical water oxidation are required to destroy the concentrate, adding cost and complexity.

Selecting the best approach

Key factors are capital cost, operating cost, ability to remove short-chain acids, available space, waste-media disposal and compatibility with current infrastructure. IX generally has lower life-cycle cost for short chains, while GAC is favoured where utilities already manage carbon beds or value its co-benefits. Plants can be converted later: a GAC vessel can be refilled with IX resin or Fluoro-sorb if regulations tighten.

Regional practice in the United States

Water chemistry steers choices:

- Northeast systems often choose GAC because elevated iron and manganese foul IX resin.
- Florida utilities lean toward IX because high natural organics exhaust GAC quickly.
- Arizona anticipates tighter rules on 1,4-dioxane, so many plants install GAC for dual removal.
- Colorado Springs, with low sulfate and total dissolved solids, prefers IX.
- California mixes both technologies; selection depends on local blending options and legacy treatment trains.

Implementation hurdles

Space limits retrofit potential in older plants; media change-out logistics, transport of PFAS-laden carbon or resin, and the scarcity of high-temperature disposal facilities add cost. Inland utilities cannot pipe membrane brine to the sea, so destructive on-site options—including small-scale incineration or advanced oxidation—are under evaluation. Pretreatment to cut organic matter remains a cost-effective way to extend adsorbent life for both GAC and IX.

6.4.4 Presentation from Lutz Ahrens

PFAS are now detected almost everywhere in the environment and enter drinking-water supplies by multiple routes, from firefighting run-off to wastewater effluent and atmospheric deposition. How easily each substance moves and how tightly it binds to solids depend mainly on its perfluorinated chain length and head group. Long-chain sulfonates or carboxylates (for example PFOS, PFHxS and PFOA) attach strongly to soils and adsorbents, while short-chain acids such as PFHxA and PFBA remain highly mobile and difficult to capture.

Sweden addressed the problem early, after extensive contamination was discovered near Uppsala. The National Food Agency set a provisional drinking-water guideline in 2013 of 90 ng/L for a sum of seven PFAS, expanded in 2016 to eleven compounds at the same level. The 2020 EU Drinking Water Directive requires all member states to meet 100 ng/L for the combined total of twenty listed PFAS, or 500 ng/L for total PFAS measured as adsorbable organic fluorine. Sweden has opted for tighter limits: by January 2026 utilities must achieve 100 ng/L for twenty-one PFAS and, for the four most toxic (PFOA, PFNA, PFHxS and PFOS), no more than 4 ng/L each.

Meeting these numbers usually demands a treatment train that both concentrates and destroys PFAS. **Concentration processes** shrink large water volumes to smaller, more manageable waste streams. Reverse osmosis and other high-pressure membranes reject over 95 percent of both long-and short-chain PFAS, producing clean permeate and a brine that may be only one or two percent of the original flow. Foam fractionation injects air to collect PFAS at bubble surfaces and can reduce volumes by a factor of twenty, though it works best on long-chain molecules. **Adsorptive processes** such as granular activated carbon (GAC) and anion-exchange resin polish drinking water but eventually saturate; short-chain PFAS can even desorb, so beds must be replaced or regenerated on a planned schedule.

Because carbon–fluorine bonds are exceptionally strong, **destructive processes** are energy-intensive. Electrochemical oxidation breaks the bond directly at an electrode surface and steadily lowers PFAS levels, but short-chain acids may form in the early stages and must also be destroyed. Super-critical water oxidation, hydrothermal alkaline treatment and plasma have similar goals and are now moving from bench scale to full-scale pilots.

Swedish utilities, universities and consultancies are testing combinations of these methods through the SIDWater research programme. One pilot pairs nanofiltration with foam fractionation so that the membrane permeate meets drinking-water limits and the concentrate is reduced to a small, high-strength stream suitable for destructive treatment. Another project compares GAC, ion-exchange columns and membrane-plus-destruction trains under identical raw-water conditions, measuring cost, robustness and waste management needs.

Results so far underline that no single technology delivers a complete answer. Effective schemes separate waste streams early, concentrate PFAS as much as practical, and then apply destruction to the smallest possible volume while polishing the main water flow with GAC, ion-exchange or membranes. Tailoring those building blocks to local water chemistry, infrastructure and regulatory targets is essential for reliable long-term compliance.

6.4.5 Presentation from Marcel Riegel

PFAS is not a single chemical but a family whose adsorption behaviour changes markedly with chain length and head group. This diversity drives both regulatory targets and treatment performance. The European Drinking Water Directive sets a composite limit of 100 ng/L for the sum of 20 specified PFAS. Germany applies stricter goals: 100 ng/L for 21 PFAS and just 4 ng/L each for the four most toxic members—PFOA, PFNA, PFHxS and PFOS—by January 2026. Operators must therefore understand exactly which PFAS are present, at what levels, and which legal limit applies.

Only two technologies presently appear on Germany's "positive list" for potable use:

- **Granular activated carbon (GAC)**, installed as pressure vessels or gravity filters.
- **Dense membranes** such as nanofiltration and reverse osmosis, which reject almost all PFAS but create a brine that needs further handling.

Ion-exchange resins and modified clay adsorbents such as Fluoro-sorb show promise yet remain unapproved for municipal drinking water.

Adsorption fundamentals

Isotherm studies reveal that adsorption strength rises with chain length and with sulfonate versus carboxylate head groups. Short-chain carboxylates (C-4, C-5) show weak partitioning and thus exit GAC beds early, whereas long-chain sulfonates (PFOS, PFHxS) adsorb strongly and break through late. Performance is tracked by "bed volumes" (BV), the number of filter-bed void volumes treated before effluent exceeds the chosen limit.

Natural organic matter competes for sites on carbon. Where dissolved organic carbon (DOC) is high, BV to breakthrough can fall by more than half, raising both media and disposal costs. Pre-oxidation, biologically active filtration or conventional coagulation can strip DOC and extend GAC life, but add complexity.

Lessons from six German pilot studies

1. **Paper-sludge plume, high PFBA and PFOA.** PFBA (C-4 acid) breaches 100 ng/L after only 8 000 BV, forcing frequent carbon change-out; PFOA and longer chains follow later.
2. **Same plume, lower inlet concentrations further downgradient.** Breakthrough order stays the same—PFBA then PFPeA, PFHxA—but limits are crossed at 18 000 BV, demonstrating how dilution lengthens bed life.
3. **Airport foam plume, moderate PFAS.** PFBS (C-4 sulfonate) emerges first, then PFOA, PFHxS and PFOS. The 4 ng/L "sum of four" limit is exceeded by PFHxS well before the 100 ng/L 20-compound limit, highlighting how a tighter metric can effectively halve run time.
4. **Airport plume with high DOC.** Although PFAS levels are moderate, DOC above 4 mg/L cuts BV to breakthrough for PFHxS to about 8 000 BV, mirroring the worst paper-sludge case.
5. **River Rhine bank-filtrate, low PFAS overall.** Even at single-digit nanogram inputs, steady equilibrium loading pushes short-chain acids through once the carbon surface nears saturation; low concentration is no guarantee of long life.
6. **Reverse-osmosis concentrate, high PFAS and DOC.** Treating the brine stream raises media stress: PFBA exceeds limits after 3 000 BV, PFOA after 7 000 BV. This confirms that small-volume, high-strength streams still need robust adsorbent management.

Implications for design

- **Short-chain acids** quickly dictate replacement schedules; without extra treatment they can make carbon impractical.
- **DOC control** can double or triple carbon life and should be considered where organics exceed 2 mg/L.
- **Regulatory metric** matters: operating to the strict 4 ng/L per-compound goal demands earlier change-out than the 100 ng/L composite goal.
- **Membranes** or future ion-exchange/modified clays may be needed as polishing steps when extremely low targets apply or when DOC loads are high.

Activated carbon remains a proven first line for long-chain PFAS, but its runtime and cost hinge on the specific PFAS mix, inlet concentration, DOC content and the regulatory endpoint. Utilities must size beds, schedule media change and evaluate complementary technologies accordingly.

6.4.6 Presentation from Philip McCleaf

Uppsala, Sweden has almost two decades of direct operating experience with granular activated carbon (GAC) for PFAS removal. The Backlösa treatment plant first installed GAC in 2005 to control pesticides; discovery of PFAS in 2012 forced a rapid redesign of both operating targets and filter hydraulics. The city's raw-water scheme is unusual: water from the River Fyris is infiltrated into a glacial-esker aquifer beneath the city, diluting natural groundwater but also carrying in PFAS released from a military airbase 10 km upstream. Concentrations start at roughly 21 000 ng/L at the base boundary, fall to about 200 ng/L at the first wellfield, and reach 35 ng/L at the second. The mixture is dominated by long-chain sulfonates and PFOS, compounds that adsorb readily onto carbon.

Filter configuration and operating strategy

Uppsala converted its existing pesticide filters to PFAS duty by reducing flow so that empty-bed contact time increased; six of the eight concrete gravity filters run in parallel while two stand by. Filters are brought offline after 17 000–20 000 bed volumes (BV) when PFHxS, the lead indicator, approaches the former 90 ng/L Swedish limit (sum of 11 PFAS). Low dissolved-organic-carbon levels—2 to 3.5 mg/L—help extend BV to breakthrough. Reactivation occurs at specialised kilns in Germany or Belgium: spent carbon is heated to 900 °C with steam, off-gas is incinerated, and about 90 percent of the volume is returned. Shorter contact time during the loading phase and a second polishing stage will be used from 2026 onward to comply with Sweden's new requirement of 4 ng/L for the sum of four PFAS (PFOS, PFHxS, PFOA, PFNA). Annual carbon reactivation frequency is rising from one to up to three cycles, pushing operating costs from roughly EUR 350 000 to about EUR 540 000, driven by kiln fees and natural-gas price increases.

Performance data

Plant records for 2021–2022 show raw-water PFAS between 120 ng/L and 230 ng/L, but finished water consistently below 13 ng/L—well under the old national guideline. Pilot work indicates that tightening the target to 4 ng/L will require either more frequent reactivation or a two-stage carbon bed. With two stages, the lead filter operates to partial breakthrough, allowing a higher utilisation of carbon mass, while the lag filter guarantees compliance; modelling suggests 30 percent savings in media costs.

Future upgrades

By 2026 the concrete gravity beds will be replaced with stainless-steel pressure filters to simplify media change-out and allow tighter hydraulic control. A long-term plan calls for a new plant by 2033 that combines nanofiltration with GAC polishing and on-site concentrate destruction, further lowering PFAS to future standards while reducing reliance on foreign reactivation.

Lessons learned

- Long-chain PFAS are readily removed by GAC, but short-chain acids require longer contact times or multi-stage beds.
- Bed life is best predicted in BV; Uppsala reaches first breakthrough at around 8 000 BV when short-chain PFBA dominates, but can exceed 18 000 BV when long-chain sulfonates prevail.
- Reactivation logistics and energy prices now dominate cost (about 0.8 EUR per cubic metre of treated water).
- Integrating upstream DOC removal and combining concentration with destruction technologies will be essential for meeting future, even stricter, PFAS standards.

6.4.7 Presentation from Sebastian Castano

Oasen supplies drinking water to more than 700 000 consumers in the western Netherlands, producing about 47 million m³ per year at seven plants. Most raw water is riverbank filtrate drawn from the Rhine system, which arrives more stable and with fewer bacteria than open surface water but still contains anthropogenic chemicals, notably PFAS released by the Chemours works upstream. Monitoring shows that wells closest to the river carry the highest PFAS load; concentrations are tracked as "PFAS equivalents," multiplying individual levels by relative-potency factors to represent overall risk.

Treatment strategy

Oasen relies on two main barriers: granular activated carbon (GAC) and reverse osmosis (RO). GAC removes long-chain sulfonates and carboxylates well but performs poorly for the ultra-short acid TFA (trifluoroacetic acid) and other highly mobile compounds. RO, in contrast, rejects virtually the full PFAS spectrum. Two plants (Nieuw Lekkerland and Bodegraven) operate full-stream RO, while two others route only a portion of flow through RO and blend the permeate with conventionally filtered water.

Reverse-osmosis performance and costs

RO forces water through a dense membrane at high pressure, generating a clean permeate and a smaller, contaminated concentrate. Oasen runs its trains at 80 percent water recovery: eight parts of every ten become drinking water, two parts become concentrate. Permeate tests below detection for all monitored PFAS, whereas concentrate is roughly five times the raw-water level. Total production cost is estimated at 0.23 euro per cubic metre; electricity for high-pressure pumps is the largest single cost.

Residue management

Handling the concentrate remains the key challenge. The preferred option is discharge to municipal wastewater treatment plants, subject to regulatory permits and periodic surface-water impact studies. Because the concentrate volume is modest, modelling shows no exceedance of downstream quality standards once it is diluted in the sewer network and treated effluent. Nonetheless, Oasen is researching supplementary options—foam fractionation, ion-exchange polishing, advanced oxidation; to minimise the PFAS load leaving the company's boundary.

Results and operational lessons

Full-stream RO at Nieuw Lekkerland consistently delivers non-detect PFAS in finished water. At split-stream sites, mixing RO permeate with conventionally treated water reduces most PFAS below 10 ng/L, but TFA remains because it slips through GAC and is only partly removed in the blended configuration. Oasen is therefore evaluating whether to expand RO capacity or adopt an additional polishing step to meet future standards.

Source-control and advocacy

Alongside treatment, Oasen works with national and European water associations to push for zero PFAS discharge from industrial sources such as Chemours. The utility shares monitoring data, lobbies regulators, and participates in joint research aimed at stricter emission permits and better analytical methods.

Outlook

Oasen's experience shows that combining robust membrane technology with targeted use of GAC can secure very low PFAS concentrations in finished water. Long-term success, however, will depend equally on upstream emission control, economically and environmentally sound concentrate disposal, and continued collaboration across the water sector to tighten standards and share best practice.

6.5 Discussion on freshwater treatment

There was a wide-ranging discussion over several meetings, (the full details of which are appended in the meeting minutes). This seeks to summarise the key matters and findings that emerged during the discussions among the subject matter experts and with panel members. It has been organised by theme to make it easier to follow.

6.5.1 Logistical Challenges and Background Contaminants

- **Nitrate legacy:** Historical fertiliser runoff keeps nitrate close to 30 mg/L in parts of Jersey's supply. Nitrate at this level is considered problematic and must not rise further during treatment. Fresh granular activated-carbon (GAC) beds can leach nitrate when water is warm, but the island's generally cool temperatures should limit this release.
- **Organic-matter baseline:** After coagulation and filtration, the water's dissolved-organic-carbon (DOC) concentration is described as "relatively low." Low DOC favours longer adsorbent life because less organic matter competes with PFAS for sorption sites.
- **Water security:** Water security is potentially an issue in Jersey, especially in the summer months. Interventions that have high levels of water loss may lead to insufficiency of supply.
- **Site access and site dimensions:** Existing water treatment plants are constrained for space and additional plant may require increasing site footprint through the acquisition of additional land. In addition, vehicular access is generally through narrow, tortuous roads. This may constrain the dimensions of any components that may need to be delivered to site for incorporation into additional treatment capacity.

6.5.2 Primary Treatment Options Discussed

6.5.2.1 Granular activated carbon (GAC)

Strengths: Proven full-scale use; effective for long-chain sulfonates and carboxylates; compatible with existing pressure-vessel layouts.

Run time*:* Field data show 17 000–20 000 bed volumes (BV) before breakthrough when DOC is low and PFAS are dominated by long-chain compounds; only 8 000 BV when PFBA is dominant or DOC is high.

Weaknesses: Short-chain PFAS break through early; reactivation costs reach roughly €0.5 million per year for comparable plants; 10 % of carbon is lost each kiln cycle; weekly PFAS analyses across multiple filters add notable expense.

6.5.2.2 Ion-exchange (IX) resins

Strengths*:* Shorter empty-bed contact times; superior removal of short-chain PFAS; smaller footprint than GAC.

Weaknesses*:* Higher media cost; capacity reduced by competing DOC and anions such as sulphate, bicarbonate or nitrate; spent resin requires disposal or regeneration; not yet listed on all national "positive" lists for drinking water.

6.5.2.3 Fluoro-sorb (modified clay)

An emerging adsorbent that performs comparably to IX for PFAS but at GAC-like media cost. It is not yet fully approved for potable use; therefore, it represents a potential future upgrade rather than an immediate option.

6.5.2.4 *Reverse osmosis (RO)*

Performance*:* Removes 99.9 % of monitored PFAS, including ultra-short acids.
Water loss: Produces a concentrate that equals roughly 20 % of feed flow; mitigating this loss would require 20 % more raw-water capacity or pressure.

Footprint: Compact modules (six per 12 m vessel) make physical space acceptable even on narrow sites.

Waste stream*:* Concentrate disposal demands permits and evaluation of river dilution; high recovery stages are technically feasible but raise energy, chemical and carbon-footprint costs.

6.5.2.5 Nanofiltration (NF)

Performance*:* Water loss falls to about 5 %, yet short-chain PFAS removal is only 80–90 %, lower than RO's 99.9 %.

Role*:* Suited to partial-stream treatment or as a step when multiple contaminants (softening, uranium, bicarbonate) need simultaneous control, as illustrated by overseas practice.

6.5.3 Staged Implementation and Future Upgrades

Stepwise approach

- Start with GAC or IX sized for current PFAS limits.
- Plan vessel internals so the lead filter can later be filled with Fluoro-sorb or IX, leaving the lag filter as a polishing bed.
- Keep pipework and foundations compatible with potential membrane skids if regulations demand tighter PFAS removal or simultaneous control of other contaminants.

Why future-proof?

Regulatory trajectory indicates stricter limits, especially on short-chain PFAS. A system that allows insertion of higher-performance media or membrane units postpones major civil re-builds and stretches initial capital further.

6.5.4 Pilot-Testing Rationale and Design

- **Rapid small-scale column tests:** Provide a quick comparison among GAC, IX and emerging media under controlled conditions. Results correlate with pilot performance but are not sufficient for design decisions.
- **On-site pilot skids:** Recommended pilot is a pallet-sized unit housing small columns. Running for several months exposes media to seasonally varying water, covering nitrate fluctuations and any temperature-driven effects on sorption or leaching. Pilot duration "of a few months" is expected to yield meaningful results while remaining manageable.
- **Pilot timetable:** Skids are straightforward to deploy; setup can start soon after media selection and plumbing arrangements. Overall timeline is compatible with near-term decision points.

6.5.5 Cost Drivers and Opportunities for Optimisation

- **Reactivation and media replacement:** For GAC, annual reactivation around €0.5 million already covers the 10 % top-up of lost carbon. Any probe that identifies filter exhaustion in real time could lower laboratory costs and avoid premature change-outs.

- **Laboratory analysis:** Weekly PFAS turnaround for multiple filters is a non-trivial cost element. Development of inline probes could reduce frequency and expense.
- **Energy and consumables:** RO running costs are dominated by energy for high-pressure pumps. NF has lower energy demand but may need secondary polishing if short-chain PFAS limits tighten, adding indirect costs.
- **Capital flexibility:** Two-stage GAC layouts allow different media in each stage, spreading costs over time and enabling incremental performance upgrades without full plant replacement.

6.5.6 Special Operating Considerations

- **Nitrate interaction:** Nitrate levels near 30 mg/L must not increase through treatment. While warmer waters can promote nitrate release from new carbon, Jersey's cool climate may limit this. Nonetheless, filters should be monitored for nitrate leaching, especially during start-up.
- **Water-loss impacts:** RO's 20 % reject stream reduces overall water availability; a concern for an island with limited supply. NF's 5 % loss is less severe but carries lower PFAS removal for difficult compounds.
- **Concentrate disposal:** Concentrate can be discharged to wastewater treatment only with regulatory approval and impact analysis. Dilution capacity in recipient waters governs feasibility.

6.5.7 Enhancing Adsorbent Longevity and Supply Assurance

- **Process adjustments:** Optimising coagulation to further reduce residual organic matter could extend adsorbent life. Lower DOC translates to slower pore blocking and later PFAS breakthrough.
- **Supply chain:** New GAC manufacturing capacity coming online should ease media availability concerns, although freight and global energy costs will still influence price and timing.

6.5.8 Economic and Multi-Contaminant Considerations

- **Two-stage filtration benefits:** A two-stage GAC system accommodates different absorbents in lead and lag positions, enabling phased adoption of new media aimed at short-chain PFAS. The configuration also spreads the PFAS load, lengthening change-out intervals and lowering average treatment cost.
- **Multiple contaminants:** Where raw water also needs softening, uranium removal, or bicarbonate adjustment, nanofiltration can address several issues simultaneously, potentially offsetting its higher capital with savings in separate unit processes.

6.5.9 Suggested Action Points for Jersey

- Conduct rapid column screening on GAC, IX and Fluoro-sorb.
- Install a multi-month pilot skid to capture seasonal variability and nitrate interactions.
- Select a base system of GAC or IX capable of meeting current 4 ng/L and 100 ng/L PFAS limits.
- Design vessels and pipework that can accept future media substitutions or membrane skids.
- Monitor ions (sulfate, bicarbonate, nitrate, etc.), DOC and PFAS regularly, adjusting coagulation to protect adsorbent life.
- Evaluate concentrate-handling pathways and permitting hurdles before committing to any membrane expansion.

6.5.10 Summary of Technology Strengths and Weaknesses

Figure 11, below, summarises the discussions with the water treatment experts and the panel on the potential and relative benefits and disbenefits of different mains water treatment technologies for PFAS management in Jersey.

Figure 11 - Summary of Panel and Expert discussion on treatment technologies

Technology	**Main Advantages**	**Main Drawbacks**	**Jersey-specific Factors**
GAC	Proven removal of long-chain PFAS; straightforward change-out; modest footprint	Short-chain breakthrough; reactivation cost (~€0.5 M yr^{-1}); nitrate leaching possible at high temperature	Low DOC extends bed life; cool climate lessens nitrate release risk
Ion-exchange resin	Strong removal of short-chain PFAS; small contact time and footprint	High media cost; spent resin disposal; capacity lost to binding of DOC, sulfate, bicarbonate, nitrate and other ions present in water	Needs pilot to confirm capacity under varying water quality
Fluoro-sorb	Resin-like efficacy at GAC-like cost; easy handling	Not yet approved for potable use; limited long-term data	Candidate for future upgrade, pending pilot performance
Nanofiltration	95 % water recovery; lower energy than RO; tackles multiple contaminants	80–90 % removal of the toughest short-chain PFAS; concentrate still generated	Lower water loss suits island supply; may still need polishing
Reverse osmosis	99.9 % PFAS removal, including ultra-short acids; resilient to multiple pollutants	20 % water loss; concentrate disposal; high energy cost	Water-resource penalty significant; logistics manageable but energy and permits critical

6.5.11 In summary

Within the constraints discussed, adsorptive solutions; either GAC or ion-exchange; offer the most immediate and practical path for Jersey, with pilot testing essential to confirm media performance against local water quality and PFAS profiles. Futureproofing through vessel design and staged media upgrades will allow adaptation to evolving regulations, supply-chain developments and emerging technologies such as advanced clays or membranes.

7 Treatment technologies for removing PFAS from fresh water intended for human consumption

This section focuses on mature technologies that have been implemented for the removal of PFAS from water at municipal drinking water treatment plants. Emerging or developing technologies are not included, as they are not yet sufficiently advanced for implementation by Jersey Water in the near future. For the purposes of this review, mature technologies are defined as those that have been successfully applied in the field by multiple organizations across various sites, with well-documented results either in practice or in peer-reviewed literature.

In the context of treatment of water for human consumption, mature PFAS removal technologies fall into two primary categories: sorption and high-pressure membranes. The main types of sorption technologies are granular activated carbon (GAC) and ion exchange resins(McCleaf et al., 2017; Ross et al., 2018), though some novel sorbents (e.g. graphene-based materials, biochar, magnetic nanoparticles, layered double hydroxides, polymeric sorbents, activated carbon derivatives, metal-organic frameworks, electrospun nanofibers, modified clays, zeolites, cellulose-based materials, dendritic polymers, carbon nanotubes, composite materials, and metal sulfides/nanoparticles) have also been explored(Burkhardt et al., 2025). The abovementioned Fluoro-sorb is just one of many potential novel sorbents emerging on the market. The high-pressure membrane category includes nanofiltration (NF) and reverse osmosis (RO)(Li et al., 2020; McCleaf et al., 2023; Sadia et al., 2024; Safulko et al., 2023).

Additionally, foam fractionation may be used to concentrate and remove a portion of PFAS from water intended for human consumption(McCleaf et al., 2023). However, this method is typically employed as a pretreatment step, followed by further purification using sorption technologies.

7.1 Granular activated carbon (GAC)

Sorption is a physical process where PFAS molecules bind to a sorbent media. GAC is a widely used sorbent that effectively removes many organic contaminants, including long-chain PFAS such as PFOA, PFHxS and PFOS, reducing their concentrations to low ng/L levels until breakthrough occurs (i.e., the media becomes saturated and cannot continue to sorb PFAS). Because GAC is non-selective, it also adsorbs co-contaminants and even natural organic matter (NOM), which can accelerate the saturation of the GAC and increase replacement frequency(McCleaf et al., 2017; Ross et al., 2018).

GAC removal capacity and breakthrough time vary by PFAS type. Longer chain PFAS (e.g., PFOS) are more effectively removed than shorter chain PFAS (e.g., PFHxA), which tend to break through more quickly and require more frequent changes of the GAC. Adsorption efficiency is also influenced by PFAS functional groups; sulfonates generally have higher affinity than carboxylates of the same chain length. PFAS precursors can also compete for adsorption sites and degrade to other PFAS (e.g., PFAS) over time(McCleaf et al., 2017; Ross et al., 2018).

Most full-scale GAC systems focus on treating water for human consumption and have demonstrated reliable removal of PFOA and PFOS(McCleaf et al., 2017). However, data on other PFAS, especially short-chain compounds, are more limited. Research continues towards improving GAC performance for shorter chain PFAS and integrating complementary technologies such as ion exchange. Hybrid treatment systems, where GAC precedes ion exchange, are also adopted. In such setups, GAC removes longer chain PFAS and non-PFAS organics, while ion exchange also targets the shorter chain PFAS(McCleaf et al., 2017).

GAC system design should be based on lab treatability tests (e.g., rapid small-scale column tests) as well as pilot-scale testing to refine system parameters under site-specific conditions. Conditions that should be tested include bed depth (vertical height of the GAC in the treatment vessel), empty bed contact times (how long the water stays in contact with the GAC), how often the GAC needs to be replaced, and treatment cost. Testing with actual site water is critical, as water chemistry greatly influences performance.

GAC is produced from materials such as bituminous coal, lignite, and coconut shells. Bituminous coal-based GAC is most commonly used for PFAS treatment due to its good performance in testing(Westreich et al., 2018). Media selection should consider PFAS type, co-contaminants, material performance, availability, and cost. GAC systems use relatively long empty bed contact times(McCleaf et al., 2017), which means that they require larger vessels compared to alternatives like ion exchange.

Spent GAC can be thermally reactivated and reused(Baghirzade et al., 2021), reducing life cycle costs, though this option depends on access to reactivation facilities. Currently, Jersey lacks such facilities, and regulatory limitations may restrict off-island transport of PFAS-laden GAC, potentially classifying it as hazardous waste.

Some challenges associated with GAC systems include: energy-intensive production and transport, large vessel requirements due to longer empty bed contact times, increased space and infrastructure needs and transportation and disposal or reactivation of spent media. These factors must be accounted for during system planning and lifecycle analysis to ensure cost-effectiveness, environmental compliance, and operational resilience.

7.2 Ion-exchange resins (IX)

Ion exchange involves replacing charged ions in the water with non-toxic ions (e.g., chloride), targeting the ionized functional groups in PFAS molecules (e.g., the sulfonate group in PFOS). PFAS are removed by ionic bonding between the negatively charged sulfonate or carboxylate heads and the positively charged resin, along with hydrophobic interactions between the PFAS tail and the resin matrix. Similar to GAC, PFSAs are more easily removed compared to PFCAs of the same chain length, with longer-chain PFAS more strongly retained(McCleaf et al., 2017; Ross et al., 2018).

Ion exchange resins have long been used in treatment of water for human consumption for the removal of contaminants such as nitrate, perchlorate, and arsenic. For PFAS removal, both single-use and regenerable ion exchange resins are available(Ellis et al., 2023). Single-use resins are operated until breakthrough at a target concentration, then disposed of; typically via incineration or landfilling. They are commonly used for drinking water applications due to ease of use and high removal capacity, often achieving low ng/L levels. Regenerable resins, on the other hand, are cleaned in place using brine or solvent-brine regenerant solutions, restoring some of their PFAS removal capacity. These systems are more suitable for sites with high influent PFAS concentrations where the cost of resin replacement would be high.

Ion exchange resin systems are typically designed using “lead-lag” vessels(Rodowa et al., 2020). The lead vessel treats the incoming water and the lag vessel, placed directly after the lead, sorbs PFAS that break through the lead vessel. A third polisher vessel (“lead-lag-polisher” design) may also be added to extend operational capacity and reduce change-out frequency. Empty bed contact times are much shorter than for GAC, allowing for smaller treatment systems which require less space on site. Selective ion exchange resins can treat large bed volumes, depending on PFAS type and influent water quality.

Co-contaminants such as natural organic matter, sulfate, bicarbonate and nitrate can reduce PFAS removal capacity by competing for resin sites or causing fouling. Pretreatment may be necessary, especially for surface waters with high organic matter or groundwater with iron and manganese. Influent characterization is critical to assess pretreatment needs and resin performance. Lab-scale and pilot testing are required to predict resin performance, including breakthrough curves and loading capacities.

Challenges for the operational implementation of ion exchange resin technologies are the energy and materials required for continual replacement and disposal of the resins (in the case of single-use resins) and for regeneration, transportation and disposal of spent resins and regenerant waste (in the case of regenerative resins). Finally, although ion exchange resins have high selectivity for PFAS, their lifetimes are ultimately determined by competition from more abundant anions present in the water such as chloride, sulfate, and bicarbonate.

Regenerable systems may offer long-term cost benefits for high-load sites, especially when centralized regeneration facilities are available. Regenerant waste can be concentrated and managed as solid waste (incinerated or landfilled), or possibly treated via emerging destruction technologies. However, Jersey is not a high-load site and regeneration facilities are not currently available for ion exchange resins on island. In a recent study, reactivated GAC was shown the have lower lifecycle impacts compared to both single-use GAC and regenerable ion exchange resins(Ellis et al., 2023).

7.3 Nanofiltration (NF)

Nanofiltration is a pressure-driven membrane technology that offers high water flux at low operating pressures and typically rejects polyvalent ions and larger molecules (including PFAS), while allowing smaller molecules and monovalent ions, such as sodium and chloride, to pass through. Data on PFAS removal with NF comes from laboratory-scale tests, with limited application at full-scale drinking water treatment plants. Membranes tested include NF-270, NF-200, NF-90, DK and DL membranes(Appleman et al., 2013; McCleaf et al., 2023; Steinle-Darling & Reinhard, 2008). These membranes generally show over 95% rejection of PFAS. Full-scale removal of PFAS to low ng/L levels has been confirmed(McCleaf et al., 2023). Recent research has focused on modifying membrane surfaces to further enhance PFAS selectivity (Johnson et al., 2019). NF technologies are usually part of a treatment train (e.g.,(McCleaf et al., 2023)) given the potential for membrane fouling, and pre-treatment prior to applying NF is recommended.

The disposal or treatment of the membrane concentrate stream is an important consideration, particularly when applying high-pressure membranes in inland communities (coastal communities often emit the reject water into the sea). At the Jersey treatment plants there is currently no provision for disposal of excess water.

The use of fluoropolymers in membrane manufacturing raises concerns given that fluoropolymers are a type of PFAS. It is well known that low molecular weight PFAS are emitted during fluoropolymer lifecycles (during manufacturing and potentially during disposal),(Lohmann et al., 2020) but it was not expected that PFAS could be released during use of the membranes. It was thought that fluoropolymer membranes contained negligible leachable impurities of low molecular weight PFAS. Recent research has shown, however, that low molecular PFAS can potentially leach out of membranes used in membrane technologies such as RF and RO(Sadia et al., 2024).

7.4 Reverse osmosis (RO)

Reverse osmosis is an effective technology for removing multiple types of contaminants, including PFAS, from water by applying pressure to push water through a semipermeable membrane(Sadia et al., 2024; Safulko et al., 2023). RO works mainly through size exclusion, with contaminants being rejected based on their size. For PFAS removal, RO membranes effectively reject a wide range of compounds, achieving >98.3% removal for a wide range of perfluoroalkyl chain lengths(Safulko et al., 2023). Similar to NF, RO systems produce a PFAS-concentrated reject water. RO is often part of a treatment train, with pretreatment necessary for optimal performance.

RO removes not only contaminants but also beneficial minerals like calcium and magnesium. This can result in less palatable and less healthy drinking water for long-term consumption. Remineralization may be required to restore taste and essential minerals(Vingerhoeds et al., 2016).

It is important to distinguish between RO used for freshwater treatment with RO used for desalination of sea water. On Jersey, there is already a sea water RO desalination plant, which is brought into service periodically as an integral part of our drought management strategy. On Jersey, the purified seawater permeate from RO is discharged into the Val de la Mare raw water reservoir, and the reject water is discharged into the sea. As mentioned, it is only operated periodically. For example, in 2022, the sea water RO plant was operated for four months and the sustained addition of permeate into the system resulted in a noteworthy reduction in reservoir PFAS concentration.

Recent advances have improved efficiency of RO, notably by reducing pressure requirements and lowering costs. However, compared to GAC and ion exchange, RO has much higher capital and operating costs(Tow et al., 2021).

Challenges for implementation of RO include energy consumption for the high-pressure pumps, the disposal of PFAS-enriched reject water, the need for remineralization and the high water loss (15-30%). This high water loss is a particular drawback on Jersey where there is water scarcity in times of drought. Effective treatment of the reject water from RO is also needed and is an area of ongoing research.

NF usually has slightly higher water recovery than RO under similar conditions. Moreover, NF membranes operate at lower pressure than RO, reducing energy needs and potentially increasing sustainability. Finally, NF does not require remineralization of the drinking water. NF is therefore the most promising among the membrane techniques for treatment of water for human consumption on Jersey.

Jersey Water have estimated that using the sea water RO plant would not be sustainable over a full calendar year due to high power demands and associated costs, which is consistent with our own findings from the literature as well as the testimonies provided by subject matter experts. Therefore, we do not recommend desalination of sea water using RO as a viable long-term primary option for supply of water for human consumption on Jersey. The costs would be enormous and ultimately passed on to the consumer.

7.5 Surface Active Foam Fractionation (SAFF)

SAFF is a physical separation method which uses rising gas bubbles in a water column to remove amphiphilic substances like PFAS, which adsorb to the bubble surface and concentrate in the foam formed on the surface(Buckley et al., 2022). This foamate, which is concentrated with PFAS, is then collected for further treatment or disposal. Removal efficiency varies with PFAS type, water chemistry, and other operational parameters(Buckley et al., 2022).

SAFF has progressed from bench to full-scale application for PFAS removal. It has achieved removal of PFAS down to low ng/L levels of PFOS and PFOA. Full-scale systems are in operation in Europe as well as in other regions. Removal of shorter chain PFAS remains a challenge, with ongoing research to improve performance. Cationic surfactant additives can enhance short-chain PFAS removal, but effectiveness varies depending on water properties(Buckley et al., 2023). SAFF performs consistently across diverse water types and concentrations (ng/L to mg/L) and is less affected by background contaminants than the abovementioned treatment technologies and thus has been used as a pre-treatment option(McCleaf et al., 2023). Similar to the other treatment techniques, site-specific testing is recommended to optimize performance. Key factors influencing performance include: water characteristics affecting natural foaming, hydraulic retention time, bubble size, bubble formation, foamate removal method, column height, and which chemical additives to enhance foaming or removal of short-chain PFAS.(Buckley et al., 2022)

Research has shown elevated airborne PFAS concentrations near foam fractionators, with aerosolized PFAS matching foamate composition. Emission controls and enclosures are recommended to minimize exposure risks of workers at water treatment facilities(Smith, Lewis, et al., 2023).

Collected foamate can be further treated using adsorptive media or destruction technologies (e.g., electrochemical oxidation)(Smith, Lauria, et al., 2023). Energy use is moderate in comparison to, for example, RO(Molzahn et al., 2024). The volume of foamate is lower compared to RO concentrate. Disposal or treatment of the foamate produced from SAFF would be a key consideration for Jersey.

7.6 Conclusions

For Jersey, where water scarcity during periods of drought and options for waste disposal/treatment are constraints, selecting the right PFAS treatment technology requires balancing effectiveness, sustainability, and operational feasibility. GAC and ion exchange resins are both proven for removing long-chain PFAS, including PFOS, PFHxS and PFOA. GAC systems require more space and face disposal challenges. Ion exchange resins are more compact and effective for short-chain PFAS, though performance can be affected by co-contaminants and natural organic matter. Ion exchange could potentially be used in a treatment train following GAC. GAC cannot be reactivated on Jersey, which means that spent GAC would have to be disposed of on island (e.g., by incineration or landfill), if it is not possible to ship the waste GAC off island for reactivation. Modern regenerable ion exchange resins could potentially be regenerated on Jersey, but this would require investment in specialized regeneration systems. Otherwise, spent ion exchange resins would also need to be disposed of on Jersey by incineration or landfill.

It is also acknowledged that it may be possible to change media in vessels as sorption technology improves (e.g. use the promising sorbent Fluoro-sorb or one of the other emerging sorbents on the market). However, such changes are not trivial for process engineers. For example, even changing from GAC media to ion exchange media would require considerable process considerations such as different pre-treatment or backwashing requirements.

Among membrane technologies, nanofiltration (NF) is the most suitable for Jersey. It offers high PFAS removal, lower energy use, higher water recovery, and no need for remineralization, making it more sustainable than reverse osmosis (RO), which suffers from high water loss (15–30%), energy demand, and mineral removal. There are some questions raised regarding leaching of PFAS from the fluoropolymer membranes. There are also questions regarding how the reject water can be treatment or disposed.

SAFF is a useful pre-treatment step to reduce PFAS load, but requires careful management of concentrated waste and emissions, and there are considerations regarding worker safety.

A hybrid approach, such as GAC followed by NF or ion exchange, may prove to be suitable. Final decisions cannot be made through a review of the literature alone and must be guided primarily by lab-scale testing followed by pilot-scale testing using site-specific water. Testing is the only way to assess how water quality factors affect treatment (e.g., the impact of dissolved organic matter, sulfate, bicarbonate, nitrate, etc. on sorption) and how treatment, in turn, affects water quality (e.g., whether nitrate levels rise above 30 mg/L). Jersey Water have already commenced the necessary testing of multiple state-of-the art treatment combinations. They have so far completed small-scale column tests of treatment technologies and hope to publish the results. Pilot-scale testing will also be needed before treatment technologies can be implemented.

There are also some special limitations to implementation of treatment technologies which are specific to small islands such as Jersey such as lack of space, small roads and additional power requirements. For example, Jersey Water have informed the Panel that the access constraints of narrow roads means that standard pressure vessel sizes are not feasible on Jersey. To ensure manufacturing integrity, vessel fabrication cannot take place on site therefore bespoke vessels would be required with one of the engineering options explored proposing 30 plus, 2 m diameter x 6 m height vessels on each of the water treatment works.

Finally, as there is continuous high demand for drinking water and only two drinking water plants on Jersey, there is a high risk to the drinking water supply during the implementation of new drinking water technologies. Changes would need to be made quickly as the plants cannot be turned off without risking the Island's drinking water supply.

8 Discussion

8.1 Summary of expert discussions and literature review on permissible PFAS levels in drinking water

8.1.1 Need for new guidance or regulations on PFAS in drinking-water

Monitoring data from several jurisdictions show that supplies can comply with the EU "sum-of-20 PFAS" ceiling of 100 ng/L yet still exceed far lower health-based values now under discussion. In the Netherlands, two-thirds of surface-water samples fall above a 4.4 ng/L health guideline even though all meet the legal 100 ng/L limit; Denmark reports a 2.3 % exceedance of its 2 ng/L four-PFAS standard despite full compliance with 100 ng/L; and the United States has introduced new federal Maximum Contaminant Levels (MCLs) of 4 ng/L for PFOA and PFOS after concluding that immunological and developmental effects occur well below past advisory levels. These convergent moves indicate that the current EU cap alone is no longer viewed as adequately protective wherever fresh toxicological and epidemiological evidence has been reviewed.

8.1.2 Separate health-based value and legally enforceable level versus a single-level approach

Some jurisdictions now operate, or are considering, a two-tier structure that distinguishes between (a) a legally enforceable level judged achievable with today's laboratory sensitivity and treatment technology, and (b) an aspirational health benchmark that signals the ultimate aim of "as low as reasonably possible," even if that level is currently unattainable system-wide.

The United States (EPA example): For six PFAS the EPA sets non-enforceable Maximum Contaminant Level Goals (MCLGs) at concentrations that pose "no known or anticipated health risk": 0 ng/L for PFOA and PFOS and 10 ng/L for PFHxS, PFNA and GenX. Alongside these it fixes enforceable Maximum Contaminant Levels (MCLs) based on what laboratories can quantify and utilities can reliably meet, 4 ng/L for PFOA and PFOS and 10 ng/L for the other three PFAS, plus a Hazard-Index requirement for mixtures. The health goals therefore mark the direction of travel, while the practicable targets trigger legal compliance and investment planning. Most other jurisdictions do not have such an arrangement.

8.1.2.1 Implications for policy design

- Publishing a health goal (even at 0 ng/L) communicates that *no* exposure is fully risk-free and helps justify future tightening; it also guides remediation priorities when levels fall below the legal standard but above the goal.
- A practicable target gives utilities a clear, time-bound obligation that reflects current analytical quantitation limits and treatment costs, enabling credible compliance timetables.
- Operating both levels in parallel supports progressive risk reduction without imposing immediate costs that smaller systems could not absorb, but there is a significant risk of public confusion.

8.1.3 Guidance versus regulation

Where values remain advisory; e.g., the UK's tiered guidance with triggers at 10 and 100 ng/L; water suppliers must conduct risk assessments and progressive mitigation, but enforcement is indirect. In Denmark and the United States, exceedance of an enforceable limit triggers statutory action, mandatory public notification and deadlines for treatment. Guidance can be issued quickly and updated frequently, whereas regulation is harder to enact, but offers legal certainty for consumers, investors. It must rest on demonstrated independent analytical capability and a full cost-benefit case.

8.1.4 Level at which a standard should be set

Five numerical clusters emerge:

- Low-single-nanogram levels (2-4.4 ng/L): Denmark (2 ng/L sum of PFOS, PFOA, PFNA, PFHxS); Netherlands (4.4 ng/L PFOA-equivalents); Sweden (4 ng/L for the same four PFAS); US (4 ng/L for each of PFOA and PFOS). Apart from the US, these limits draw on the European Food Safety Authority's tolerable weekly intake of 4.4 ng/kg bodyweight per week for immunological endpoints; or comparable epidemiology.
- Intermediate mixture limits: The US proposed but for now not established rule for PFHxS, PFNA, GenX and PFBS ties compliance to relative toxicity within the mixture at roughly 10 ng/L per most of these components. Germany have set a a pragmatic intermediate value of 20 ng/L.
- Broad-group caps at 100 ng/L: EU sum-of-20 PFAS, UK sum of 48
- Total-PFAS caps at 500 ng/L: EU "total PFAS" safeguard concentration.

Because diet usually contributes 80 % or more of PFAS exposure in uncontaminated areas, while water dominates under polluted conditions, regulators basing standards on the EFSA intake have typically allocated 20 % (Netherlands, Sweden) or 10 % (Denmark) of total exposure to drinking-water and derived a 2–4 ng/L range. The US selected 4 ng/L both for regulation because it matches the lowest concentration that most commercial laboratories can measure with consistent precision.

8.1.5 Should the level be based on Relative Potency Factors (RPFs)?

Two calculation methods are highlighted:

- **Simple summation**: Concentrations of selected PFAS are added without weighting. This underlies the EU 100 ng/L rule, Denmark's 2 ng/L for four PFAS and Sweden's 4 ng/L value. Simplicity aids communication and enforcement but assumes equal toxicity.
- **RPF weighting**: The Netherlands converts each PFAS to PFOA equivalents (e.g., PFNA potency × 10; PFHxS × 0.6) before summing. The US Hazard Index proposal would do something similar for four PFAS by dividing each measured concentration by its health-reference value, then summing the ratios to assess compliance.

RPF-based values may be stricter or more lenient than simple sums, depending on mixture composition, and the specific type of toxicity upon which the RPFs are based. Regulators must communicate the added uncertainty clearly if this approach is chosen.

8.1.6 Lead time needed for implementation

Timelines vary and are closely linked to treatment upgrades and laboratory capacity:

- **Netherlands**: The policy framework is still in development; a full move toward 4.4 ng/L is expected to span "several years," with surface-water utilities facing the largest workload.
- **United States**: Utilities must begin quarterly monitoring within three years of rule publication and have up to five additional years for remediation; many systems must comply by 2031.

- **Denmark**: The 2 ng/L limit is already in force; exceedances are typically resolved within months using activated-carbon or ion-exchange treatment.
- **Sweden**: A 4 ng/L limit will come into force in January 2026. It will be legally binding.

8.2 Summary of expert discussions and literature review on freshwater treatment approaches:

8.2.1 Granular activated carbon (GAC)/ powdered activated carbon (PAC)

GAC is the most used PFAS barrier; equivalent-scale plants elsewhere achieve 17 000-20 000 bed volumes before breakthrough when dissolved organic carbon is low and long-chain sulfonates dominate but only about 8 000 bed volumes when short-chain acids or high organic matter prevail. The technology removes PFOS, PFHxS, PFOA and most precursors; it also strips pesticides and taste compounds, aligning with Jersey's existing powdered carbon practice. Capital demands are moderate; vessels can be installed outdoors and connected to current pipework. GAC beds must provide approximately 15-20 minutes empty-bed contact time; that translates to large steel vessels that are difficult to move on narrow roads unless delivered by barge. Short-chain carboxylates such as PFBA or PFHxA break through early; higher nitrate can further reduce capacity and young carbon can leach nitrate until equilibrium is reached. Two-stage lead/lag operation extends run time by about thirty percent because the lag bed guarantees compliance while the lead bed is driven toward partial breakthrough.

Jersey already doses powdered activated carbon seasonally for pesticides; raising the dose could be part of potential solutions. While this is relatively low cost, particularly as a short-term bridge to a more comprehensive solution, there remains an issue around the disposal of the exhausted PAC.

8.2.2 Ion-exchange resin (IX)

Strong-base anion resins exchange chloride for the anionic heads of PFAS; equilibrium is rapid so contact times of five minutes or less are feasible and footprints are much smaller than those for GAC. Resins capture short-chain acids more strongly than carbon; in pilot work resin beds last two to three times longer than GAC when PFHxA dominates. Resin expense is high; disposal or off-site regeneration costs add complexity because strong brines produced by regeneration require destruction or secure disposal. Capacity drops when DOC, sulphate, bicarbonate or nitrate compete for sorptive sites on IX; chloride/sulphate fluctuations can also loosen pipe-scale metals downstream. IX therefore suits low-sulfate waters or polishing duty behind carbon.

8.2.3 Reverse osmosis (RO)

RO offers the deepest barrier, rejecting more than 99.9 percent of PFAS including ultra-short acids. Energy demand is high; the process discards about 20 percent of feed water; remineralisation must restore calcium and bicarbonate; and waste disposal can be energy intensive. The level of loss has significant implications for water security.

8.2.4 Nanofiltration (NF)

NF rejects more than 95 percent of long- and most short-chain PFAS; water recovery is close to 95 percent so only five percent of feed water becomes concentrate; pressure and specific energy are lower than for RO; remineralisation is unnecessary. There is emerging evidence that fluoropolymer membranes can release trace PFAS.

8.2.5 Surface Active Foam Fractionation (SAFF)

SAFF bubbles air through water; PFAS concentrated at the air-water interface rise in foam and are skimmed. Full-scale trials removed long-chain PFAS efficiently; performance on short-chain acids was limited; energy demand is moderate and equipment is compact. SAFF cuts the volume of brine or resin regenerant by a factor of ten to twenty, which sharply lowers the cost of downstream destruction.

8.2.6 Fluoro-sorb modified clay

Fluoro-sorb is a bentonite mineral treated with quaternary amines that create a high density of cationic exchange sites; lab tests show more than 95 percent removal of PFOS and PFHxS and more than 80 percent removal of PFHxA at contact times comparable to ion exchange; removal is tolerant of dissolved organic carbon and chlorine; media cost is similar to GAC. Field life beyond one to two years remains unproven and the product is not yet on formal potable-water approval lists, so its near-term role is as an upgrade path: the same steel vessels used for GAC or IX can later be refilled with Fluoro-sorb when approvals are secured; staged adoption allows water suppliers to hedge against future short-chain limits without committing capital twice.

8.2.7 In summary

- GAC; mature, broad-spectrum and already part of the island skill set; limited by bed size, high reactivation cost and fast breakthrough of short chains.
- Ion exchange; strong for short-chain acids and compact; limited by high media cost, sulphate competition and disposal hurdles.
- RO; maximal removal; highest energy and reject loss; needs remineralisation and disposal.
- NF; balanced recovery and removal; misses ultra-short acids and still leaves a small brine.
- Fluoro-sorb (or other emerging sorbents); promising low-cost variant with resin-like uptake; presently lacks long-term approvals. PAC-UF; lowest capital as an interim retrofit; uncertain sludge disposal and membrane fouling.
- SAFF; cheap concentrator that pares down brine volume; needs polishing.

These technologies can be combined into a “treatment train”

8.3 Panel discussions in the light of all the evidence

In order to structure the discussion, the panel considered the evidence and its conclusions, segmented into several questions. These discussions are summarised below.

8.3.1 Is there a need for new guidance/regulations on drinking water levels?

The panel explored whether Jersey's existing approach to per- and polyfluoroalkyl substances (PFAS) in public water supplies offers adequate health protection. It quickly became clear that no statutory PFAS limits exist: the Water (Jersey) Law does not currently include these chemicals, and the island therefore has no formal enforcement powers. In practice, Jersey Water follows guidance from the United Kingdom Drinking Water Inspectorate, including using an aspirational level of 10 ng/L for the sum of 48 specific PFAS. That figure is neither written into Jersey law nor consistently achieved in routine monitoring, it functions solely as a reference.

This arrangement was considered problematic. Health protection rests on a foreign benchmark whose scientific rationale and future revisions lie outside the island's control, and authorities have no leverage to compel remedial investment or to reassure residents who may distrust voluntary measures. Although PFAS concentrations are monitored, any exceedance breaches no rule and attracts no sanction. Available data show that readings above 10 ng/L (sum of PFAS) are common; even though the threshold is pragmatic rather than toxicologically derived, repeated breaches indicate that the present voluntary approach has not achieved sub threshold exposure. Dependence on UK guidance levels was also seen as risky, because Jersey's geography and water supply arrangements are different from those of the UK and external standards can change without warning, leaving the country reactive rather than proactive.

Voluntary management of PFAS levels by Jersey Water, while welcome, cannot substitute for an endorsed public standard. Without a clear rule, long-term infrastructure planning is particularly difficult. Throughout the discussion the panel separated the immediate question of whether the regulatory arrangements were sufficient from the later task of setting numerical limits, and concluded that the current arrangement does not deliver a transparent, enforceable or future-proof mechanism for controlling PFAS in Jersey's drinking water. Clearer and tighter measures are necessary.

8.3.2 Should there be separate health regulations or a single level approach?

A two-level scheme, which pairs an aspirational health goal with a more achievable legal ceiling, offers the symbolic reassurance that the ultimate aim is "no avoidable harmful exposure" while preserving short-term practicality. Its supporters note that it mirrors arrangements already used in the US and gives policymakers a clearly sign-posted trajectory for tightening standards in the future. Yet the drawbacks are substantial. Two different numbers may confuse consumers, blur accountability for operators, and oblige regulators to explain why a concentration deemed medically undesirable can still be lawful. Duplicate thresholds would also complicate monitoring and reporting systems and risk diverting investment towards meeting the softer target rather than working steadily toward the stricter one.

By contrast, a single binding standard delivers one unambiguous compliance trigger. Communication becomes simpler, administrative overhead lighter, and the relationship between regulators, laboratories and water suppliers clearer. Because the chosen value must be feasible from the outset, disputes over what counts as "as low as is reasonably practicable" are largely avoided. The principal weakness is that a standalone figure can date rapidly if scientific understanding or treatment technology advances. Without a scheduled review clause, credibility could erode. The panel therefore explored how the “as low as is reasonably practicable” principle could be woven into recommendations: choose a level that current analytical detection and treatment can reach, but lean on the conservative side so that public-health protection is materially improved, allowing scope for future improvement. Scientific uncertainty makes this balance delicate. Existing toxicological benchmarks, such as the European Food Safety Authority’s tolerable weekly intake, are informative yet stop short of drawing a clear line between “safe” and “unsafe” exposure, while certain PFAS; especially those recently judged carcinogenic; might justify an assumption that no exposure is entirely without risk. These uncertainties reinforce the need for a precautionary but realistic starting point and a formal procedure for updating the limit when compelling new evidence emerges.

After weighing the alternatives, the panel coalesced around a clear preference: Jersey should determine a single numerical limit for PFAS in drinking water. The chosen concentration has to be attainable with present-day monitoring methods and treatment technology, yet low enough to be consistent with one or more of the range of health-based limits set in other countries. The limit should also be periodically reviewed so that the standard can be tightened in line with advances in science, technology and international norms.

8.3.3 Should it be guidance or regulation?

The panel examined whether future limits on PFAS in Jersey’s drinking water should take the form of non-binding guidance or be given legal force. Jersey’s Water Law already obliges the supplier to deliver “sufficient and wholesome water,” but the statutory schedule of chemical parameters established some years ago, does not include PFAS. Adding them would require an amendment to primary legislation, a process that involves ministerial approval, public consultation, debate in the States Assembly, Royal Assent and registration in the Royal Court. Once enacted, non-compliance would constitute a criminal offence, enforceable only after evidence gathering and a decision by the Attorney General that prosecution is in the public interest.

Guidance could be issued far more quickly as ministerial policy, yet it would carry no sanction if breached. The panel noted that a purely advisory figure might suffice in a small jurisdiction with one water supplier and close governmental oversight, but such an approach risks providing insufficient reassurance to the public and leaving authorities powerless should voluntary compliance falter. By contrast, criminal enforcement offers clear sanctions but introduces a high burden of proof (beyond reasonable doubt, rather than balance of probabilities) and limited agility if standards need prompt adjustment. There are also practical issues with having a delayed implementation of a standard when it is added to the schedule of the water law. The current legislative framework, however, already treats other contaminants, such as mercury, as enforceable parameters, suggesting that the addition of PFAS is administratively feasible.

To avoid framing the issue as a rigid choice between guidance and regulation (with potential criminal sanction), the panel explored the broader concept of enforceability. Standards could, for example, be incorporated into civil or contractual obligations: an approach that would impose clear duties and sanctions without the evidential threshold of criminal law: making it easier to prosecute violations. The discussion concluded that the decisive factor is not the precise legal vehicle but whether the chosen PFAS limit carries a binding effect. Enforceability was seen as essential for credibility, accountability and long-term compliance, whereas the route selected; statutory amendment, contractual condition or another mechanism; should be left to policymakers once the technical standard is agreed.

8.3.4 Is the level based on RPFs?

Relative Potency Factors (RPFs) were examined as a possible way to weight individual PFAS when setting a drinking-water standard. RPFs assign each compound a toxicity multiplier so that more harmful chemicals contribute proportionally more to the final number. The panel recognised their conceptual appeal but identified serious practical obstacles. RPF values originate mainly from laboratory studies in which rats showed liver-weight or immune-system changes; translating those effects to human risks; especially for outcomes such as cancer; remains uncertain. Potency ranks vary by the health endpoint chosen, the age at exposure and whether the data are expressed as intake or as serum concentration, meaning a single compound can be awarded different multipliers under different assumptions.

Implementation questions compounded these scientific doubts. RPFs have been used formally only in the Netherlands, and even there they remain advisory rather than enforceable. Applying them in regulation would require laboratories to report every PFAS individually at low detection limits, and enforcement agencies would then recalculate an “equivalent” sum each time the mixture shifted. That administrative load would be heavy, vulnerable to error and difficult to explain to the public. The approach also depends on having reliable RPF values for every PFAS included in the regulatory list; yet many of the forty-plus compounds now detected in the environment have no agreed potency factor. Where data are missing, regulators must either assign a default value; introducing further uncertainty; or exclude the chemical, risking under-protection if its concentration is high.

Local monitoring data suggest that Jersey’s main issues involve PFOS and PFHxS, whose reported RPFs effectively offset one another. Weighting would therefore add complexity without much change to the overall exposure figure. A simple unweighted sum of concentrations for a clearly specified group of PFAS was judged more transparent, easier to police and less prone to legal challenge. It also aligns with current laboratory practice, most countries’ regulations and in which composite results for a small core list of long-chain PFAS are already reported. Because the protective margin built into the numerical limit can account for potency differences, the panel concluded that RPFs offer little added value for deriving a fixed standard. Unanimous agreement was reached to recommend an unweighted summation approach for Jersey’s drinking-water rule.

8.3.5 At what level do we believe it is appropriate to be set?

While there are many different drinking water guidelines around the world, the Panel’s discussions, having looked at the US and other international jurisdictions, focussed on three main candidate frameworks for setting a PFAS concentration limit in drinking water: a sum of four long-chain compounds (used in Sweden, Demark and the Netherlands), a sum of twenty compounds (the EU standard) and a broad sum of forty-eight (used in the UK). Drawing on syntheses such as the EFSA tolerable weekly intake, the panel first tested which framework best matched Jersey’s exposure profile and analytical capacity. Calculations derived from the EFSA intake converge on relatively low limits: 2 (Denmark), 4.4 (Netherlands, but modified by RPFs) or 4 (Sweden) ng/L: when applied to the four PFAS most often detected in European water. The most common assumption used in calculating relative exposure from food and water is that 80% of PFAS intake is from food and 20% from water. Denmark is an outlier, assuming that 90% of PFAS load comes from food, which is why their regulatory limit is slightly lower than Sweden and the Netherlands.

The panel noted that the four-compound approach captures the substances most relevant to Jersey; particularly PFOS and PFHxS; while avoiding inclusion of less potent chemicals. A 4 ng/L threshold, mirroring the Swedish standard, was judged both protective and practically achievable; it also aligns with values that are already enforceable in comparable jurisdictions, and aligns with the majority view on the proportion of PFAS that comes from food; making it easier to defend scientifically.

Attention then shifted to the broader sums. Relying solely on a 10 ng/L limit for forty-eight PFAS was considered potentially misleading because a single high concentration of a hazardous compound could still fall within the combined cap, masking real risk. Nevertheless, the panel recognised the value of providing a backstop that embraced a wider set of PFAS: particularly shorter-chain variants that may grow in importance as industry substitutes away from legacy chemicals. Treating the broader sum as a secondary, non-enforceable metric would therefore strengthen surveillance without diluting the clarity of the primary standard.

Current practice already sees Jersey Water publishing annual data on individual PFAS and their sums, so referencing an additional 10 ng/L guidance value with existing monitoring was viewed as both feasible and transparent. Because the roster of measurable PFAS is expanding, the panel stressed that the current UK list of forty-eight compounds will need to remain flexible, with periodic updates to reflect new science and regulation.

8.3.6 What treatment technologies are appropriate and what would be the necessary lead time to implementation?

The panel considered treatment and timing together, mapping actions across three horizons—immediate, medium-term and long-term. Immediate options centred on powdered activated carbon (PAC) being used in existing infrastructure. Laboratory evidence suggests PAC can suppress PFAS concentrations quickly, but performance at full scale remains uncertain, and disposal of the contaminated PAC sludge would require careful management. The panel therefore viewed PAC as something to investigate, not to prioritise, preferring to reserve primary efforts for permanent solutions.

Attention then turned to technologies capable of providing a durable reduction in PFAS across the public-water network. Granular activated carbon (GAC) and ion-exchange resins (IX) emerged as the leading candidates. Both are in widespread use at scale, deliver reliable removal of long-chain PFAS and can be integrated into conventional treatment trains. Reverse osmosis was considered for freshwater treatment, but discounted because of the high levels of water loss (around 20%) and energy requirements, while nanofiltration was deemed promising but not yet mature enough for immediate deployment. In the local context, the theoretical advantages of GAC; such as regeneration; may be offset by the absence of regeneration facilities and the difficulties of international transport of waste material. IX offers a smaller footprint and lower waste mass. It still requires pilot testing to optimise resin choice and regeneration cycles. The panel agreed that a rigorous, Jersey-specific appraisal comparing GAC and IX is needed, incorporating life-cycle cost, infrastructure constraints, waste logistics, land availability and future regulatory pressures.

For future upgrades, complementary techniques such as foam fractionation or novel sorbents could form part of a treatment train, especially if standards later expand to cover shorter-chain compounds. Horizon scanning should therefore remain an ongoing task, but immediate design should rest on the proven performance of GAC or IX.

Estimating lead time proved challenging. International experience shows that a well-resourced programme can commission full-scale treatment in about three years, yet Jersey’s limited space (necessitating bespoke vessels) and the potential need for the compulsory purchase of land could stretch this to five years or more. The panel resolved that PFAS treatment to the recommended standard should be operational “as soon as is reasonably practicable, ideally within five years.”

9 Recommendations

The panel recommends that:

1. **There needs to be a new standard for PFAS in water specifically for Jersey. This should involve a single regulatory level and the principle that PFAS in water should be "as low as is reasonably practicable"**
2. **The new standard for PFAS should be enforceable through either legal or contractual means**
3. **The enforceable primary standard for PFAS in drinking water should be 4 ng/L for the simple sum of four PFAS (PFOS, PFOA, PFHxS, PFNA). If any of those moieties is below the limit of quantification, it should be assumed to be at the limit of quantification.**
4. **Monitoring and reporting should include a 10 ng/L guidance value for the average sum of forty-eight measurable PFAS. This should be used to trigger further investigation and is not an enforceable limit.**
5. **Consider the use of powdered activated carbon (PAC) in existing infrastructure as an interim measure to reduce PFAS before longer term treatments come on stream.**
6. **Granular activated carbon (GAC) or ion-exchange resins (IX) appear to be the optimal primary water treatment technologies currently available for removing the health-relevant PFAS on Jersey. The panel recommends a whole lifecycle cost-effectiveness analysis (including costs borne elsewhere in the economy) and local piloting be conducted to guide the choice between the best treatment technology or treatment train.**
7. **Mains water should be treated to achieve a level of 4ng/L of the four PFAS as soon as is practicable and within five years.**

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Glossary

AFFF	aqueous film-forming foams; used in firefighting, particularly where liquid fuel may be involved. Can contain PFAS.
ALT (Alanine Aminotransferase)	An enzyme found in the liver and blood, often measured to assess liver health
anaemia	a condition where there is a lower-than-normal number of healthy blood cells. This can reduce oxygen availability and lead to shortness of breath and fatigue.
anionic	Refers to PFAS molecules that carry a negative charge in aqueous solutions. Anionic PFAS compounds are commonly found in industrial applications and consumer products, often as surfactants due to their ability to lower surface tension
apheresis	A process separating specific components from blood (like plasma or cells), then returning the remainder to the donor or patient.
aplastic Anaemia	A serious condition where the body stops producing enough new blood cells, leading to fatigue, infections, and bleeding risks.
ATSDR (Agency for Toxic Substances and Disease Registry)	A federal public health agency within the United States Department of Health and Human Services. The ATSDR is responsible for assessing the health effects of exposure to hazardous substances and providing guidance on preventing or reducing harmful exposures. It conducts public health assessments, health consultations, and studies to evaluate the impact of environmental contaminants on human health, offering recommendations and support to communities, health professionals, and policymakers
attributable risk	The difference in the rate of a condition between an exposed population and an unexposed population, attributable to a specific risk factor
autoimmune diseases	Conditions where the immune system mistakenly attacks the body's own cells
beneficence	Acting in the best interest of others, especially in healthcare, by promoting well-being, preventing harm, and ensuring positive outcomes for patients or communities.
bile acid sequestrants	Medications that bind bile acids in the gut, promoting excretion of certain substances (including lipids or pollutants, like PFAS) to lower blood levels.
bioaccumulative, bioaccumulation	The accumulation of substances, such as pesticides or chemicals, in an organism over time
biological plausibility	The logical relationship between a cause and an effect based on existing biological or medical knowledge
BMJ	British Medical Journal.
body burden	describes the amount of chemicals in the human body.
bwt	Bodyweight.
C8	the name given to the surfactant PFOA in some commercial contexts, the name deriving from it having an 8-carbon length structure. Fluorosurfactants known as C8. It is also the name given to a research study and remediation programme of a contamination incident in the Unite States of America
cationic	Refers to PFAS molecules that carry a positive charge. These cationic PFAS compounds are less common than anionic ones but can be used in specific industrial applications, such as coatings and textile treatments, where they help bind the PFAS to surfaces
causality (Causal relationship)	The relationship between cause and effect, where one event (the cause) directly influences another event (the effect)

causation	The action of causing something; a relationship where one event causes another
CDC	Centers for Disease Control, a national public health body in the US.
cerebrovascular disease	Disorders affecting the blood vessels in the brain, which can lead to strokes
chance association	A relationship between two variables that occurs randomly rather than through a causal link
Cholestyramine	A bile acid sequestrant that binds bile acids in the intestines, used to lower cholesterol or remove certain contaminants.
Colesevelam	A newer bile acid sequestrant that helps lower cholesterol levels and can remove specific toxins or pollutants in the digestive tract.
Colestipol	Another bile acid sequestrant medication, reducing cholesterol or unwanted substances in the gut by binding bile acids.
community advisory boards	Groups of local stakeholders who offer guidance, feedback, and support to ensure research or interventions align with community interests.
confounding (confounding bias)	A distortion in the perceived relationship between an exposure and an outcome caused by a third variable that is associated with both the exposure and the outcome
cost effectiveness	A measure of whether an intervention's benefits justify its financial cost, helping compare different strategies for achieving the best outcomes with limited resources.
c-reactive protein (CRP)	A substance produced by the liver in response to inflammation, used as a marker in blood tests
data triangulation	The use of multiple data sources or methods to validate research findings and ensure accuracy
decile groups	Statistical divisions that split a population into ten equal parts, often used in data analysis to compare different groups
degradation	The breakdown or decay of substances
dose-response	Describes how varying levels of exposure to a substance relate to changes in magnitude or frequency of an observed effect.
dyslipidaemia	An abnormal level of lipids (fats), like cholesterol or triglycerides, in the blood, potentially increasing cardiovascular disease risk.
Ecological fallacy	The error of making inferences about individuals based on aggregate data for a group
EFSA (European Food Safety Authority)	An agency of the European Union that provides independent scientific advice on food-related risks
EMA	The European Medicines Agency, which evaluates and supervises medicines within the European Union to ensure their quality and safety.
endometriosis	A condition where tissue similar to the lining inside the uterus grows outside of it, causing pain and potential fertility issues
endometrium	The mucous membrane lining the uterus, which thickens during the menstrual cycle
enterohepatic circulation	The circulation of substances from the liver to the bile, absorbed by the intestine, and returned to the liver
EPA	Environmental Protection Agency, the federal agency in the US responsible for protecting the environment.
EQ5D-5L	European 5 dimension, 5 level, quality of life assessment. A commonly used tool to assess health related quality of life.
EU	European Union

experts by experience	Individuals who provide expertise based on personal experiences rather than formal qualifications
exposure media	The different environments (e.g., air, water, soil) through which individuals can be exposed to substances
FDA	Food and Drug Administration, the regulator of medicines in the US.
FDA	The Food and Drug Administration, a U.S. agency regulating food, drugs, medical devices, and related public health measures.
gastrooesophageal reflux	A condition where stomach acid frequently flows back into the tube connecting the mouth and stomach, causing heartburn
Gen X	Refers to a specific type of PFAS developed as a replacement for older, longer-chain PFAS chemicals. The term "Gen X" in this context is used both to describe the chemical process and the resulting products, which are marketed as having a shorter environmental persistence and potentially lower toxicity compared to traditional PFAS like PFOA and PFOS. However, concerns remain about the environmental and health impacts of these substances.
GMP	Good Manufacturing Practice, guidelines ensuring products are consistently produced and controlled to quality standards.
gut microbiome	The community of microorganisms living in the digestive tracts of humans and other animals
haematoma	localised collection of blood outside blood vessels.
haemodialysis	A procedure using a machine to filter wastes, salts, and excess fluid from the blood when kidneys cannot perform adequately
haemolytic Anaemia	Occurs when red blood cells are destroyed faster than they can be made, leading to fatigue, jaundice, and other health issues.
half-life	the time it takes for the concentration of a substance in the body or in the environment to reduce to half its initial value
HBM	Human Biomonitoring Committee of the German Environmental Agency.
herd immunity	The resistance to the spread of a contagious disease within a population, achieved when a high proportion of individuals are immune
high-density lipoprotein (HDL)	Known as "good" cholesterol, it helps remove other forms of cholesterol from the bloodstream
hypotension	Low blood pressure, where the force of the blood pumping through the arteries is below normal, possibly causing dizziness or fainting.
IARC (International Agency for Research on Cancer)	An agency of the World Health Organization that conducts and coordinates research on the causes of cancer
immunosuppression	The reduction of the activation or efficacy of the immune system, which can occur naturally or be induced by medication or disease
immunotoxic	Refers to a substance that harms the immune system, potentially reducing the body's ability to fight infections or maintain normal immune function.
information bias	Bias arising from measurement errors or misclassification in the data collection process
intrauterine growth retardation	A condition where a foetus is smaller than expected for the number of weeks of pregnancy, due to various factors
ischaemic heart disease	A condition characterized by reduced blood supply to the heart, often due to clogged arteries
Kg	Kilograms.
leiomyoma	A benign smooth muscle tumour, often found in the uterus (uterine fibroids)

log	Short for "logarithm," a mathematical function indicating how many times a base number must be multiplied by itself to reach a specific value.
log-transformed	A mathematical operation converting data by applying the logarithm function, often used to handle skewed distributions or stabilize variance in statistical analysis.
low density lipoprotein (LDL)	A type of cholesterol known as "bad" cholesterol because high levels can lead to plaque buildup in arteries
mean	a statistical average where all values are added up and divided by the number of readings.
median	a statistical measure where the middle value of a list of findings is used.
MeFOSAA	N-Methylperfluorooctanesulfonamidoacetic acid.
mesothelioma	A rare and aggressive cancer of the lining of the lungs or abdomen, often linked to asbestos exposure.
MHRA	The Medicines and Healthcare products Regulatory Agency, responsible for overseeing the safety and efficacy of medical products in the UK.
millilitre (ml)	one thousandth of a litre.
ml/y	millilitre per year.
monotonic dose response	A relationship in which increases in exposure consistently lead to either increasing or decreasing effects, without reversing direction. A straight-line relationship.
moral injury	Psychological distress resulting from actions that violate one's moral or ethical code
nanogram (ng)	one billionth of a gram.
natural log-decrease	A reduction measured using the natural logarithm (base e), often applied in studies to describe exponential declines or half-life processes.
nephrotic Syndrome	A kidney disorder causing the body to lose excess protein in the urine, leading to swelling, low protein levels, and other complications.
neurodevelopment	The process of brain development, often focusing on growth and maturation from birth through adolescence
ng/ml	nanogram per millilitre.
NHANES	The National Health and Nutrition Examination Survey in the United States, which collects data on health and nutrition from a representative population sample.
NHS	National Health Service.
NICE	The National Institute of Health and Care Excellence, the national clinical guidelines organisation in England.
non-maleficence	The duty to "do no harm," requiring healthcare providers and researchers to avoid causing injury or suffering
non-monotonic dose response	A relationship in which increases in exposure do not consistently lead to either increasing or decreasing effects, without reversing direction. The dose response is a curve or may have multiple phases.
OECD	The Organisation for Economic Cooperation and Development, an international organisation comprising the countries with advanced economies.
osteoporosis	A condition characterized by weakened bones, increasing the risk of fractures
PCOS (Polycystic Ovary Syndrome)	A hormonal disorder causing enlarged ovaries with small cysts on the outer edges
PFAS	per- and polyfluoroalkyl substances.
PFCAs	perfluoroalkyl carboxylic acids or perfluoroalkyl carboxylate.
PFDA	perfluorodecanoic acid.
PFHpS	perfluoroheptane sulfonic acid.

PFHxS	perfluorohexane sulfonic acid.
PFNA	perfluorononanoic acid.
PFOA	perfluorooctanoic acid.
PFOS	perfluorooctane sulfonic acid.
PFPeS	perfluoropentane sulfonic acid.
PFSAs	perfluoroalkane sulfonic acids or perfluoroalkane sulfonates.
PFUnDA	perfluoroundecanoic acid.
plasma	the liquid portion of the blood.
plasmapheresis	A procedure that filters out plasma (where certain substances reside) from a patient's blood, returning blood cells to the body.
plume	the geographical area over which a contaminant spreads. In the context of this report, it is interpreted broadly, to mean the area where contamination is likely, and not just to relate to the known dispersion of the contaminant
primiparous	Referring to a woman who has given birth for the first time
Probenecid	A medication increasing urinary excretion of certain compounds, historically used to manage gout and sometimes investigated for pollutant removal.
Psyllium husk	A natural soluble fibre often used to improve digestion and lower cholesterol, possibly aiding in excreting certain substances.
PTFE (Polytetrafluoroethylene)	A synthetic fluoropolymer, commonly known by the brand name Teflon™, used in non-stick cookware and other products
REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals)	A European Union regulation governing the use of chemicals to protect human health and the environment
reliability	The consistency and stability of a measurement or test over time
renal calculi	Also known as kidney stones, these are hard deposits of minerals and salts forming in the kidneys, potentially causing pain.
reverse causality	A situation where the direction of cause and effect is opposite to what is presumed
rheumatoid disease	Refers to autoimmune conditions like rheumatoid arthritis, where chronic inflammation affects joints and other parts of the body
risk factors	Characteristics or variables associated with an increased risk of a disease or condition
saturated	Refers to organic compounds where all the carbon atoms are fully bonded with hydrogen and fluorine atoms, with no double or triple bonds present. Their saturated nature contributes to their stability and low reactivity under normal conditions.
saturation Point	The level above which a further increase in the level of PFAS does not lead to any additional increase in risk of a particular health condition. This may apply in some instances but is not yet proven.
Scotchgard	a waterproofing and stain proofing treatment developed by 3M.
selection bias	A type of bias caused by the non-random selection of participants, leading to unrepresentative samples
serum	the liquid that is left when blood has clotted, often used for doing medical tests.
somatisation	The manifestation of psychological distress through physical symptoms
specificity	The extent to which a particular exposure leads to a specific outcome, used to help establish causal relationships

systemic lupus erythematosus (SLE)	A chronic autoimmune disease affecting multiple organ systems, including the skin, joints, and kidneys
Teflon	A brand name for PTFE, known for its non-stick properties
temporality	The timing of exposure relative to the occurrence of an outcome, important in establishing causality
therapeutic phlebotomy	withdrawal of blood to prevent or cure disease.
threshold response	A dose-response pattern where no effect is observed until a certain exposure level (the threshold) is reached, after which effects appear.
total risk	The overall risk of an outcome occurring in a population or study group, encompassing all possible contributing factors
toxicokinetics	The study of how a substance enters, moves through, and exits the body
toxicologist	A scientist who studies the effects of chemicals on living organisms
UK	United Kingdom.
validity	The extent to which a measurement or test accurately represents the concept it is intended to measure
venesection	taking blood
Volume of Distribution (Vd)	the theoretical volume into which an amount chemical or drug would be dispersed to result in the observed concentration in serum or plasma. Usually expressed in volume per body weight ml/kg.
WHO	World Health Organization, the United Nations agency devoted to health and health protection.
zwitterionic	Molecules with both positive and negative charges but are overall electrically neutral

Appendix 1 – Minutes of Panel meetings

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 10:00am on 27 February 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair
	Dr Tony Fletcher – PFAS and Health member
	Professor Ian Cousins – PFAS and Environment member
In attendance:	Julia Head – Senior Public Health Officer
	Grace Norman – Deputy Director of Public Health
	Standing Observer - Kelly Whitehead – Group Director of Regulation, Infrastructure and Environment Department
	Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declarations of Interest

No additional declarations.

Minutes of last meeting and matters arising

Matters of accuracy

Dr Hajioff noted the following accuracy corrections:

- Page 5: Rewording needed regarding stockpiles of PFAS-containing foams after their sale had stopped.
- Page 9: Remove incorrect wording "start and stop levels for those in the plume area."

Professor Cousins also noted the following correction:

- Page 6: Correct the phase-out date of PFAS-containing AFFF foams, which was inaccurately stated with wording still to be agreed upon.

Mr Fletcher also noted the following that needed amending:

- Page 7: Update half-life information for PFOS and PFOA to reflect average values.

Matters arising

Dr Hajioff stated that an Islander had inquired about what was appropriate testing. Dr Hajioff noted that a recommendation was not made in the previous meeting regarding what constitutes testing in humans and that for environmental samples you need a chain of custody with accredited laboratories, and this should also apply for blood samples taken from humans. After a discussion it was agreed that when the term “elevated PFAS” is used it refers to samples that have gone through this chain of custody. Grace Norman noted that it was important to specify that any consumables involved in the taking of blood be PFAS free and Dr Hajioff agreed that this should be the case and only accredited laboratories would be used.

Following an enquiry from an Islander there as a discussion relating to the potential stockpiling of the 3M firefighting foams known as Light Water. It was noted that other foams (not containing PFOS/Flurotelomа) were available from the 1970s and that it was common for organisations to switch over to these. 3M stopped producing Lightwater in 2002, however it was noted that typically organisations would use the old stock up before switching over to the new foams. It was also noted that all equipment that had been contaminated by the PFOS containing foams would not be able to be cleaned to eradicate the chemical and would need to be replaced with new equipment. It was further noted that PFOS foams have a shorter half life in humans. Dr Hajioff suggested that the heads of both Fire Services in Jersey be asked 1) what was the date that Lightwater products were last used, and 2) are products containing Fluoreteloma still in use and if not then when were they last used? This action was agreed by the Panel.

Additional findings since the last meeting

Dr Hajioff noted that he had been invited by Bailiwick Express to do a podcast last week regarding PFAS in general and that this is now available.

Recent public meeting

The outline of scope for Report 4 was discussed in the public meeting which was held approximately 10 days ago. There was a discussion regarding this scope and it was noted that the focus will be on mains water and mains water treatment, then more broadly at other elements of the environment and home water treatments. At the public meeting it was pointed out that Ulva sea lettuce is used as fertiliser in Jersey and the Panel was asked whether that was a PFAS risk so this has been added to the framework to be looked at and tested. Treatments are also covered in the framework and it was noted that the framework will change as the Panel discusses the various issues with experts and evidence is discovered. An Islander also brought up a question at the public meeting about what had happened in the past and what the legal arrangements were and it was noted that the Panel's remit is prospective and not retrospective and is about how to make things better going forward and that they are not qualified to give legal opinions. There as a discussion regarding what legal arrangements had been made in other areas of the world, such as Sweden and Australia, and it was agreed that this aspect is not in the Panel's remit. There was also a suggestion at the public meeting that the Panel should recommend that there be an independent environmental regulator put in place. There was a discussion regarding this and it was noted that the Panel were best placed to make scientific recommendations and not to consider potential regulatory structures.

Agenda item 6 and 7 – Cost effectiveness analysis – Dr Hajioff

It was noted that items 6, 7 and 8 will be focused on in the next 3 to 4 months regarding mains water and it is what the requisites are that the Panel needs answers to before they can make interim recommendations. Item 6 relates to conducting a review and asking subject matter experts what the statutory levels are for PFAS in drinking water around the world. Prof Cousins noted that he has identified experts from several countries that can give advice on drinking water guidelines and Dr Hajioff suggested it would be useful to invite Gloria Post to discuss the approach to this in New Jersey.

Kelly Whitehead noted that it would be helpful to understand in terms of international regulatory approaches what the limits are and what the structure of their regulations is, whether these are in statute or whether they're in guidance. Also, what the enforcement powers are in each of the relevant jurisdictions as well so when limits are set there will be an understanding of how to enforce those limits.

Dr Hajioff agreed this would be helpful and that the Panel should ensure the experts approached encompass all those points.

Water Treatment Technologies

Dr Hajioff noted that water treatment technologies have already been discussed such as granular activated carbon as well as other options. It was suggested that the Panel needs to speak to international experts around these particular areas and that Prof Cousins had already identified a list of people. Prof Cousins felt that Philip Mclee (Uppsala Water) would be useful to contact as he had experience of this. He has also identified a mixture of consultants and academics from around the world that have a broad range of experience in these matters. He also felt that Jersey Water should be approached as one of the experts. Dr Hajioff noted that Jersey Water were experts but would also be a recipient of the Panel's recommendations so they would need to be worked with slightly differently. He suggested that a long list of experts be collated and then reduced to a shortlist of the most appropriate experts noting that the following key points be covered in their advice:

- Effectiveness: How well each regulatory approach controls PFAS levels.
- Cost: Financial implications of implementing regulations.
- Clean-Up: Processes and costs associated with clean-up.
- Deployment Time: Time required to implement regulations.
- Energy Requirements: Energy consumption associated with regulatory measures.
- Scale: Physical space required for implementing regulations.
- Enforcement: Structure and enforcement powers of regulations.

Prof Cousins noted that the focus should be on techniques that are operational, manageable and have been proven in the real world which the Panel agreed with.

Agenda Item 8 – Association between PFAS in the environment

Dr Hajioff noted that Dr Fletcher had been working on translating what levels in water locally are likely to mean and there was a discussion relating to the association between PFAS in water and serum levels and the modelling to estimate those levels based on water contamination and food intake. Considerations to consider include the following:

- Relative Contribution: Contribution from different sources to PFAS body burden.
- Control Measures: Importance of controlling drinking water.
- Scenario Modelling: Potential scenarios based on food contamination data.

Any other business

No other business was raised by the panel.

Date of next meeting

Friday 28th March 2025. It will be held 10am -1pm online.

There will be a public meeting with the Panel in Jersey on 3rd April 2025 at 6pm to launch the draft of Report 3.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 14:00 on 26 March 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department Standing Observer (Public Health) - Grace Norman – Deputy Director of Public Health Various European Water Treatment Experts Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declaration of Interests

- No new interests declared.

- Dr. Hajioff updated his previous declaration, noting he stepped down from his role at Celadon Pharmaceuticals PLC.

Minutes and Matters Arising

- February meeting minutes were not yet available.
- No matters arising.

Additional Findings Since the Last Meeting

Dr. Hajioff addressed a public query regarding cumulative exposure and clarified the panel's stance on exposure recommendations. The query felt that the panel were deprioritising people within the plume area, Dr. Hajioff clarified that because of the different cumulative exposure, there cannot be a logical rationale for excluding people outside the plume area for any recommendations that we made. Emphasising that any recommendations for lowering PFAS levels should be geographically independent. Dr Tony Fletcher added that eligibility for reducing your levels will be based on the levels now not the past.

Modelling Background Serum Levels in Jersey and the Implication for Treatments

Dr Tony Fletcher presented a detailed analysis of PFAS serum levels, decay rates, and the impact of various interventions. Dr Fletcher discussed the modelling of PFAS serum levels in Jersey and the implications for treatment recommendations.

Key Findings

1. **Background Levels of PFAS**:
    - **Estimation**: Background levels of PFAS in Jersey were estimated based on general environmental exposure and local water supply. These estimates were derived from studies in other countries and local measurements of PFAS in Jersey's water supply.
    - **Sources**: The primary sources of PFAS exposure include food, food wrappings, general environmental contamination, and local water supply.
2. **Decay Rates and Half-Lives**:
    - **Natural Decay**: PFAS levels in the human body decrease over time due to natural excretion processes. The rate of decline depends on the half-life of the specific PFAS compound.
    - **Half-Lives**: Different PFAS compounds have varying half-lives. For example, PFOS has a half-life of approximately 3 years, while PFOA has a slightly shorter half-life.
3. **Impact of Interventions**:
    - **Dietary Changes**: Increasing dietary fibre can help enhance the excretion of PFAS, leading to a steeper decline in serum levels.
    - **Phlebotomy and Plasma Exchange**: These interventions can reduce PFAS levels by removing contaminated blood or plasma. The effectiveness varies based on the specific PFAS compound.

- **Bile Acid Sequestrants**: Drugs like cholestyramine and colesevelam can significantly reduce PFAS levels by binding to bile acids and promoting excretion.

4. **Modelling Background Serum Levels**:
    - **Graphical Representation**: Tony Fletcher presented graphs showing the decline in PFAS serum levels over time for different interventions. The graphs illustrated the natural decay, the impact of dietary changes, and the effectiveness of phlebotomy, plasma exchange, and bile acid sequestrants. It was estimated that the background serum levels were approximately 7g/mL.
    - **Comparison of Interventions**: The graphs compared the anticipated reduction in PFAS levels for each intervention, highlighting the steep decline achieved by bile acid sequestrants.
5. **Implications for Treatment Recommendations**:
    - **Threshold Levels**: The discussion focused on the appropriate threshold levels for intervention, particularly for women of childbearing potential. The current threshold of 10 nanograms per millilitre was debated, with considerations for adjusting it based on modelled background levels. The panel decided to stick with the original recommendation.
6. **Additional Findings**:
    - **Cumulative Exposure**: The importance of cumulative exposure was highlighted, with discussions on how past exposure impacts current serum levels and future recommendations.
    - **Validation**: The need for validating the estimated background levels through random population data was emphasised to ensure accurate modelling and recommendations.

Presentation from Water Treatment Expert Lutz Ahrens

Lutz Ahrens is a professor in environmental chemistry at SLU in Uppsala, Sweden. He has been working on PFAS since 2005, focusing on their fate, transport, and treatment techniques.

Lutz provides an in-depth overview of PFAS treatment techniques for drinking water. He begins by explaining the widespread presence of PFAS in the environment and the various pathways through which these substances accumulate and expose humans. The focus of the presentation is on the characteristics of different PFAS, such as chain lengths and functional groups, which are crucial for understanding their behaviour and treatment. Longer carbon chain lengths have a strong sorption potential, while shorter chain lengths exhibit higher mobility, making them particularly challenging to remove.

Lutz then discusses the Swedish context, highlighting the early establishment of guideline values for PFAS in drinking water due to contamination issues in Uppsala. The Swedish National Food Agency set initial guideline values in 2013 of 90 nanograms per litre for 7 PFAS. These guidelines were updated in 2016 to 90 nanograms per litre for 11 different PFAS. The EU established guideline values in 2020 that member states must implement of

100 nanograms per litre for the sum of 20 PFAS compounds, and 500 nanograms per litre for total PFAS.

Sweden chose to adopt stricter regulations of 21 PFAS compounds at 100 nanograms per litre, and 4 specific PFAS (PFOA, PFNA, PFHxS, PFOS) at 4 nanograms per litre. This is to be achieved by January 2026.

Lutz covers various treatment strategies, emphasising the need for a combination of techniques. Concentration strategies involve reducing large volumes of contaminated water to smaller volumes for more efficient treatment or destruction. Adsorption techniques, such as activated carbon and ion exchange, are commonly used, but they can lead to desorption of short-chain PFAS over time, necessitating periodic replacement of the adsorbent material. Destructive techniques aim to break down PFAS to prevent their release into the environment, with electrochemical oxidation being one example that requires high energy to break the strong carbon-fluorine bonds.

Lutz explains concentration techniques like membrane filtration, including reverse osmosis, which use pressure to filter water and produce PFAS-free permeate and concentrated reject water. Handling the reject water is crucial. Foam fractionation is another method discussed, which uses air injection to accumulate PFAS in foam. This technique is effective for long-chain PFAS but less so for short-chain variants. Adsorption techniques, such as activated carbon and ion exchange, are also covered, with column tests showing varying removal efficiencies over time. Short-chain PFAS can desorb, requiring continuing replacement of the adsorbent material.

Destructive techniques, such as electrochemical oxidation, are highlighted for their ability to decrease PFAS concentrations over time. However, short-chain PFAS may initially increase before decreasing, making it important to address transformation products. Lutz maps these treatment options based on their maturity and practicality, noting that while some methods like activated carbon and membranes are already in full-scale use, others, particularly destructive techniques, are still in the experimental stage.

Lutz includes examples from ongoing projects, such as a large initiative on sustainable, innovative drinking water treatment solutions (SIDWater, funded by Formas) involving multiple water producers and universities. These projects combine membrane techniques, foam fractionation, and adsorption methods to achieve the best results. One example involves nanofiltration followed by foam fractionation to concentrate PFAS for destruction. Another example compares column tests using activated carbon and anion exchange with a combination of membrane filtration and subsequent treatment of reject water.

Lutz concludes by emphasising that no single solution exists for PFAS treatment. Instead, a combination of techniques tailored to specific conditions is necessary. He stresses the importance of separating waste streams and concentrating PFAS for efficient destruction, ensuring that treated water can be reused or safely released back into the environment.

Presentation from Water Treatment Expert Marcel Riegel

Marcel Riegel is a chemical engineer with a PhD in drinking water treatment, specialising in the removal of uranium out of drinking water using ion exchanges. He has over 20 years of experience and works for TZW German Water Centre, focusing on research and consulting for water suppliers.

Marcel begins his presentation by emphasising that PFAS is not a single substance but a group of substances, each with different characteristics. This distinction is crucial for understanding the effectiveness of removal techniques, such as activated carbon filtration. He highlights the importance of knowing the specific PFAS substances present in contaminated water and the existing drinking water limits, which serve as the minimum treatment goals. Marcel mentions the European Union's drinking water limit for the sum of 20 PFAS compounds, set at 100 nanograms per litre, and notes that some European countries have implemented stricter limits for the sum of four specific PFAS compounds.

Marcel explains that the sum of 20 PFAS includes 10 carboxylic acids and 10 sulfonic acids with varying chain lengths, ranging from 4 to 13 carbon atoms. The sum of four PFAS, which includes two carboxylic acids and two sulfonic acids, is particularly relevant for drinking water treatment. He notes that in Germany, the primary technologies available for PFAS removal are adsorption with activated carbon and the use of dense membranes like reverse osmosis or nanofiltration. Although ion exchange and modified clay materials are known to work, they are not yet listed on the positive list for drinking water treatment in Germany, limiting their use.

Marcel then delves into the effectiveness of activated carbon filtration, starting with the concept of drinking water limits based on the sum of concentrations of different PFAS substances. He explains that the efficiency of activated carbon depends strongly on the specific PFAS substances present. Using isotherms, he illustrates how short-chain carboxylate PFAS are poorly absorbable, while long-chain PFAS and sulfonic acids are better absorbed by activated carbon.

He provides several examples of groundwater contamination in German waterworks, using data from pilot plants. The first example involves PFAS contamination from paper sludge, with high concentrations of PFBA and PFOA. Marcel shows breakthrough curves for activated carbon filters, indicating that short-chain PFBA breaks through first, followed by longer-chain PFPeA and PFHxA. The sum of 20 PFAS exceeds the limit after 8,000 bed volumes, highlighting the need for frequent replacement of activated carbon in cases of high PFBA concentrations.

The second example features lower concentrations of PFAS due to the well being further from the contamination source. The breakthrough curves show a similar pattern, with PFBA breaking through first, followed by PFPeA and PFHxA. The sum of 20 PFAS exceeds the limit after 18,000 bed volumes, with PFPeA being the relevant substance for limit exceeding.

Marcel's third example involves contamination from firefighting foam near an airport, with lower concentrations of PFAS. The breakthrough curves show PFBS breaking through first, followed by PFOA, PFHxS, and PFOS. The sum of four PFAS exceeds the limit due to PFHxS, and Marcel discusses how different drinking water limits affect the operational time of activated carbon filters.

The fourth example highlights the impact of high dissolved organic carbon (DOC) on activated carbon efficiency. Contamination from firefighting foam with high DOC results in early breakthrough of PFHxS, reducing the operational time of activated carbon filters to 8,000 bed volumes.

Marcel also discusses riverbank filtrate from the River Rhine, showing that even low concentrations of PFAS can lead to early breakthrough due to equilibrium loading. He emphasises that low concentrations do not necessarily result in long operational times for activated carbon filters.

The final example involves treating concentrate from a reverse osmosis plant, with high PFAS and DOC concentrations. Marcel shows that PFBA breaks through after 3,000 bed volumes, and the specific limit for PFOA is reached after 7,000 bed volumes. He explains the significance of bed volumes in determining operational time, noting that frequent replacement of activated carbon can be a significant operational issue.

Marcel concludes by summarising the key points: the efficiency of PFAS removal using activated carbon depends on the PFAS spectrum and concentrations in the contaminated water, the treatment goals, and the presence of DOC. He emphasises that short-chain carboxylic acids and high DOC can drastically reduce the runtime of activated carbon filters, and achieving very low filtrate concentrations is challenging even with long-chain PFAS.

Presentation from Water Treatment Expert Philip McCleaf

Philip McCleaf is stationed in Uppsala and works for Uppsala Water and Waste. He has 30 years of experience in drinking water treatment and 12 years specifically in PFAS removal. Uppsala has a similar PFAS contamination situation to Jersey.

Philip's presentation provides a comprehensive overview of Uppsala's experience with activated carbon for PFAS removal in drinking water. He begins by explaining that Uppsala has been using activated carbon since 2005, initially for pesticide removal. However, they discovered PFAS contamination in 2012, which led to a steep learning curve and subsequent modifications to their coal filters. Today, Uppsala effectively removes PFAS from their water, and Philip shares their journey and strategies.

Uppsala Water employs 350 people and operates 14 water treatment plants, including the Backlosa plant, which is affected by PFAS. They also manage wastewater treatment plants, a lab, recycling centres, biogas, and solid waste facilities, giving them extensive experience in water and waste management. Uppsala's drinking water treatment process is unique due to artificial infiltration, where river water is infiltrated into a large esker groundwater aquifer beneath the city. This process helps dilute PFAS concentrations in the natural groundwater.

Philip describes the PFAS contamination in Uppsala, which originates from a military airbase to the north. The groundwater flow carries PFAS southward, affecting two wellfields. Near the airbase, PFAS concentrations are about 21,000 nanograms per litre, decreasing to 203 nanograms per litre at the first wellfield and 35 nanograms per litre at the second. The primary PFAS contaminants are long-chain compounds like hexane sulfonates and PFOS, which are more effectively removed by absorbent materials.

In 2012, Uppsala converted their existing carbon filters, initially used for pesticide removal, to focus on PFAS removal. They optimised the filters by slowing down contact times to improve PFAS removal efficiency. Typically, six filters operate simultaneously, with others in reserve. Filters are cycled annually, and reactivation occurs after 17,000 to 20,000 bed volumes, similar to Marcel's findings. Uppsala benefits from relatively low dissolved organic carbon (DOC) levels of 2 to 3.5 milligrams per litre, which aids in PFAS removal.

Philip explains their strategy of reducing flow rates to extend filter life before reactivation. This approach helps optimise the use of granular activated carbon (GAC) and reduce costs. Uppsala plans to rebuild their plant in 2026 to meet new Swedish PFAS standards of 4 nanograms per litre. The current filters are concrete, but future designs will likely use pressure filters made of stainless or regular steel for easier operation and cost efficiency.

The reactivation process involves removing GAC using an ejector, storing it temporarily, and then sending it to reactivation sites in Germany or Belgium. Reactivation heats the carbon to 900°C with added humidity to remove pollutants. The off-gas is incinerated to prevent environmental contamination. Reactivated carbon retains about 90% of its original volume and performs as well as or better than new carbon. Uppsala aims to establish a reactivation site in Sweden to reduce costs.

Philip presents data showing PFAS concentrations in raw and treated water. In 2021-2022, Uppsala aimed for 13 nanograms per litre of PFAS in treated water, well below the required 90 nanograms per litre. However, new regulations require reducing PFAS to 4 nanograms per litre by 2026. Uppsala has adjusted their strategy, increasing reactivations and shortening bed times to achieve this goal. Costs have risen from €350,000-€400,000 per year to €450,000-€540,000 due to increased reactivation frequency and natural gas prices.

Philip calculates the cost of PFAS treatment at 0.8 euros per cubic meter of water, noting that costs are driven by reactivation expenses. Future plans include retrofitting the existing plant with two-stage GAC filtration to achieve 30% cost savings. This method allows for continuous high loading of GAC, improving efficiency. Uppsala also plans to build a new plant by 2033, incorporating nanofiltration and concentrate treatment to achieve drinking water standards.

In summary, Philip highlights Uppsala's success in using GAC to remove PFAS from groundwater, achieving levels below 4 nanograms per litre. The efficiency of PFAS removal depends on the type of PFAS and contact time with GAC. Costs are primarily driven by reactivation and treatment goals. Future plans focus on optimising costs and incorporating advanced filtration techniques to meet stringent PFAS standards.

Discussion with Experts

Participants: Panel members and water treatment experts.

The discussion begins with Steve Hajioff posing a question about the costs associated with PFAS treatment. He notes that the annual cost for reactivation is roughly half a million euros and inquires if the additional cost for replacing the 10% of granular activated carbon (GAC) lost during reactivation is significant. Philip McCleaf clarifies that this cost is included in the overall reactivation expense. However, he mentions that analysis costs for PFAS samples, which need to be turned around within a week, are not included and can be substantial, especially when multiple filters are in operation. Philip highlights an ongoing project aimed at developing a probe to monitor the condition of GAC, potentially reducing the need for frequent lab analyses.

Ian Cousins praises the presentations, particularly Philip's practical insights relevant to Jersey's treatment plants. Ian questions whether the move towards nanofiltration is driven primarily by cost considerations or the ability to achieve lower PFAS levels, given that Uppsala is already meeting the four nanogram target. Philip explains that the decision is influenced by the need to build a new plant. He notes that Uppsala's existing plant, which includes processes for softening, calcium and bicarbonate removal, and uranium removal, makes nanofiltration a cost-effective choice for a new facility. Nanofiltration can address multiple contaminants simultaneously, eliminating the need for separate processes. Philip mentions that Uppsala already operates two full-scale nanofiltration plants and is confident in their efficacy, with the main challenge being the treatment of concentrate.

Tony Fletcher joins the discussion, recalling his visit to the Little Hawking water treatment plant, which employed a two-stage process similar to what Philip described. He notes that DuPont faced significant costs for GAC replacement and questions whether the two-stage process is becoming standard practice. Philip responds that while two-stage filtration is not common in large-scale facilities, it offers strategic advantages. It allows for different absorbents in each stage, potentially improving PFAS removal efficiency and accommodating future advancements in absorbent materials. Philip emphasises that the two-stage approach is not only cost-effective but also adaptable to future needs, such as better removal of short-chain PFAS.

The discussion concludes with Philip outlining Uppsala's future plans, including retrofitting the existing plant with two-stage GAC filtration and constructing a new plant by 2033. The new plant will use nanofiltration and concentrate treatment to achieve drinking water standards. Philip summarises Uppsala's success in using GAC to remove PFAS, achieving levels below four nanograms per litre, and highlights the importance of contact time and reactivation costs in determining treatment efficiency. He reiterates that future strategies will focus on optimising costs and incorporating advanced filtration techniques to meet stringent PFAS standards.

Presentation from Jeanette Sheldon (Jersey Water)

Jeanette Sheldon is the Head of Water Quality for Jersey Water. Jeanette's presentation provides a comprehensive overview of the water supply and treatment challenges faced by Jersey, particularly in relation to PFAS contamination.

Jeanette begins by describing the island's water supply network, which serves approximately 100,000 people. The water primarily comes from rainwater collected via streams, with 120 days of storage capacity. Jersey has four major reservoirs, and two treatment works at Augres and Handois, which use traditional treatment methods such as coagulation, clarification, dual media filtration, and chloramine disinfection. These facilities have been upgraded over the past 20 years to include powdered activated carbon for pesticide removal and UV disinfection.

Jeanette emphasises the importance of water resilience for the island, highlighting the role of the La Rosiere desalination plant, built in 1970 and upgraded to a reverse osmosis system. This plant can supply up to 10 megalitres per day, approximately half of the island's demand, which varies seasonally between 16 and 24 megalitres. The desalination plant is crucial for maintaining water supply during droughts.

The primary PFAS contamination in Jersey is associated with the airport, affecting the St. Ouens boreholes and the Pont Marquet stream source. Trace concentrations of PFAS are found in all streams, necessitating treatment to meet varying standards. Jeanette notes that Jersey is currently undergoing a water resource management plan to evaluate future water needs, with plans to expand the desalination plant within the next five years.

Jeanette explains that Jersey has been aware of PFAS contamination for some time, relying on source restriction to minimise PFAS in drinking water. The island samples for 48 PFAS compounds as specified by the Drinking Water Inspectorate (DWI) in England, although Jersey is not regulated by the DWI. Recent annual reports show treated water PFAS concentrations of 4 nanograms per litre for PFOS and 6 nanograms per litre for PFOA, with average sum of PFAS concentrations approximately 30 nanograms per litre.

In 2021, Jersey conducted a comprehensive treatment optioneering study, exploring 30 different options and narrowing it down to SAFF (Surface Active Foam Fractionation). Initial trials with SAFF showed some success, particularly with longer-chain PFAS, but the high cost and evolving standards led to further exploration. More recently, Jersey Water commissioned a study to cost and plan the installation of GAC (Granular Activated Carbon) at both treatment works to achieve PFAS levels below 10 nanograms per litre.

Jeanette discusses the challenges of integrating new treatment processes into Jersey's existing infrastructure. The Handois treatment works, located in a small valley, would require land purchase and complex retrofitting to accommodate GAC or ion exchange systems. Transport and road infrastructure restrictions further complicate the installation of large equipment. Additionally, Jersey lacks local regeneration facilities for GAC, necessitating off-island regeneration or disposal.

The treatment options explored include catchment management, SAFF, GAC, and ion exchange. Catchment management focuses on understanding PFAS at the source and source restriction, while SAFF trials showed limited success with shorter-chain PFAS. GAC is considered a mature and established technology, but its implementation would require significant infrastructure changes and ongoing operational challenges. Initial estimates suggest a bed life of 12 months for GAC, with frequent regeneration needed due to higher TOC levels in the water.

Jeanette also mentions the potential of ion exchange, which is less mature but might offer long-term cost benefits. However, the effectiveness of ion exchange depends on the specific PFAS compounds and other interfering factors in the water. Any treatment solution may involve a combination of methods to ensure comprehensive PFAS removal.

Finally, Jeanette highlights the role of the desalination plant, which produces PFAS-free water and might provide short-term solutions to reduce PFAS concentrations in raw water. However, the plant is designed for drought contingency and would require operational changes to run continuously.

In summary, Jeanette emphasises Jersey Water's commitment to addressing PFAS challenges through a combination of treatment options, ongoing research, and infrastructure improvements. The goal is to ensure compliant water supply while adapting to evolving standards and technological advancements.

Discussion with Jersey Water and Experts

Participants: Panel members, water treatment experts, and representatives from Jersey Water

The discussion begins with Jeanette Sheldon addressing Ian's question about the declining PFAS levels in Jersey's drinking water. She explains that active management, including the removal of the most contaminated sources like the Pont Marquet stream and St. Ouens boreholes, has contributed to the reduction. However, she notes that this approach is not sustainable in the long term, especially during severe droughts. Jeanette emphasises the need for a clear treatment goal to specify robust treatment methods. She reflects on the hindsight that implementing certain technologies prematurely could have been ineffective due to their immaturity at the time.

Tony Fletcher raises the logistical challenges of transporting large equipment on Jersey's narrow roads and suggests exploring the possibility of using shipping for more efficient transport. Jeanette acknowledges the suggestion and mentions the island's good links with France and the UK, indicating that it would be worth investigating.

Kelly Whitehead brings up a public scrutiny meeting where the minister mentioned a rough capital expenditure estimate of £20 million per treatment plant. Jeanette confirms this high-level cost estimate. Philip then asks if Jersey has analysed ultra-short PFAS, noting that Uppsala has found significant levels of these compounds. Jeanette responds that Jersey analyses 48 PFAS compounds as required by the Drinking Water Inspectorate (DWI) in England, finding a mixture of PFAS, with higher levels of slightly longer chains.

Ian adds that ultra-short PFAS require special analytical methods and are widespread in drinking water across Europe. He emphasises the difficulty of removing these compounds and the potential challenges if they are included in regulatory limits. Steve Hajioff agrees, noting that the panel's primary focus is on addressing contamination from the airport, with the possibility of expanding their remit in the future.

Philip concludes by discussing the strategy of using GAC for the short term and considering membranes for the long term. He highlights the importance of understanding the renewal cycle of existing water treatment infrastructure to make informed recommendations. Jeanette mentions the use of powdered activated carbon (PAC) at low doses for pesticide removal and the potential for higher doses to remove PFAS, though this would require further research and infrastructure changes.

Philip inquiries about the disposal of sludge containing PAC, and Jeanette explains that it is currently used as a soil improver. Steve Hajioff outlines the panel's process, focusing on mains drinking water initially and expanding to broader environmental issues in the future. Philip suggests a process that doses PAC and removes it with ultrafiltration, which could be a space-effective retrofit for existing plants. He offers to provide more information on this process, which could be a cost-effective interim solution until new treatment plants are built.

The discussion concludes with Steve Hajioff expressing interest in the potential of this approach and its relatively low capital cost, making it a viable option for Jersey's immediate needs.

Any other business

No other business was raised by the panel.

Reminder of the upcoming event to launch the Islander input into the draft of Report 3 on April 3rd. The start time will be 6pm, taking place at St. Brelade's Parish Hall.

Date of next meeting

Wednesday 23rd April 2025. It will be held 4pm - 6pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 16:00 on 23 April 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department Various US Water Treatment Experts Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Minutes, matters arising and additional findings

Steve addressed that these will not be discussed as this is an additional meeting to accommodate time difference in US in order to hear from our US water treatment experts. These agenda items will be brought up in the main meeting on 30th April.

Declaration of interests

- Nothing to declare

Experts Introductions

Ian Ross, based in Monterey, California, originally from Yorkshire, works for CDM Smith, a company specialising in large-scale PFAS treatment. With a background in the fate, transport, and treatment of man-made chemicals, he has focused on PFAS since 2005. Ian is knowledgeable about global regulations, PFAS measurement, and removal techniques.

Christopher Bellona, an associate professor at the Colorado School of Mines in Golden, Colorado, specialises in PFAS treatment. With over 15 years of experience in PFAS treatment, he focuses on separation techniques like absorbance membrane treatment and has also worked on PFAS destruction projects. His work often involves field pilot scale evaluations of various technologies and comparing their treatment costs.

Kevin Berryhill, a consulting engineer with Provost and Pritchard Consulting Group in Clovis, California, specialises in designing treatment plants and selecting treatment processes for municipal and public drinking water supplies.

Presentation from Water Treatment Expert Ian Ross

Ian Ross began the presentation by explaining the definition and scope of PFAS (Per- and Polyfluoroalkyl Substances). PFAS are a large class of man-made synthetic molecules, primarily polyfluoroalkyl substances, which have a fluorinated carbon backbone and additional chemistry on the side. These substances transform in the environment over time through biological and abiotic reactions, forming perfluoroalkyl acids, which are the focus of most regulations. Ian emphasised the complexity and diversity of PFAS molecules, noting that there are many different types, each with unique properties and behaviours in the environment.

Ian discussed the presence of PFAS in firefighting foam, noting that these are precursors to the more commonly regulated PFAS. He used an analogy to explain the degradation process of these molecules, comparing it to the degradation of a wooden arrow in soil. The wooden part of the arrow represents the polyfluoroalkyl substance, which degrades over time due to microbial attack, eventually forming perfluoroalkyl acids. This analogy helped illustrate the transformation of PFAS precursors into regulated PFAS. Ian highlighted that the majority of PFAS in firefighting foams are polyfluoroalkyl precursors, which eventually form perfluoroalkyl acids through environmental processes.

The presentation covered the chemical properties of PFAS, including their solubility and mobility in water. Ian explained that longer chain PFAS are less soluble and travel shorter distances in water, while shorter chains are more soluble and mobile, posing challenges for treatment. He also mentioned the emergence of ultra-short chains, which are extremely mobile and difficult to remove with traditional methods like activated carbon. Understanding these properties is crucial for designing effective treatment systems and predicting the environmental fate of PFAS.

Ian provided an overview of global regulations and analytical methods for detecting PFAS. He highlighted the disparity in regulations across different regions, with varying levels of PFAS allowed in drinking water. For example, Europe has stringent regulations for PFAS concentrations, while the US focuses on a smaller number of PFAS molecules. Ian discussed targeted analysis methods, which involve using analytical standards to quantify specific PFAS molecules. He also mentioned total oxidisable precursor assays, which convert precursors to perfluoroalkyl acids for measurement, and the more comprehensive adsorbable organic fluorine method used in California to assess the total mass of fluorine in water.

The presentation detailed three main commercial-scale treatment options for removing PFAS from drinking water: granular activated carbon (GAC), ion exchange resins, and membrane filtration (nano filtration and reverse osmosis). Ian explained the advantages and limitations of each method. Granular activated carbon is effective for longer chain PFAS but less so for shorter chains. Ion exchange resins work based on charge and are more effective for shorter chains but can be impacted by other ions in the water. Reverse osmosis provides comprehensive removal but is more expensive and requires a larger footprint. Ian emphasised the importance of selecting the appropriate treatment method based on the specific PFAS present and the water quality parameters.

Ian shared examples of large-scale PFAS treatment projects, including the largest system in California using ion exchange resins to treat groundwater. He discussed the design considerations for these systems, such as the impact of other water components on treatment efficiency and the need for pragmatic solutions based on site constraints and regulatory requirements. For instance, high organic carbon in water can reduce the effectiveness of activated carbon, while high nitrate or sulfate levels can interfere with ion exchange resins. Ian highlighted the importance of considering these factors when designing treatment systems.

The presentation described methods to treat rejectate liquids (containing elevated PFASs concentrations) from application of membrane filtration, such as foam fractionation and supercritical water oxidation, which aim to concentrate and destroy PFAS more economically. Ian explained that these methods help reduce the volume of PFAS waste, making it more feasible to apply destructive treatments such as supercritical water oxidation, sonolysis etc. He emphasised the importance of considering future regulations and the evolving scientific understanding of PFAS when designing treatment systems. Ian noted that the regulatory landscape for PFAS is constantly changing, with new standards and guidelines emerging as more scientific data becomes available.

The panel members engaged in a discussion following the presentation. Ian Cousins raised a technical question about the treatment of reverse osmosis rejectate with foam fractionation, to which Ian Ross explained the economic benefits of concentrating PFAS for more effective destruction. Steve Hajioff inquired about the speed of deployment and phased approaches for treatment systems, highlighting the need for quick solutions within existing infrastructure. Ian Ross acknowledged that ion exchange resin systems and activated carbon systems can be designed and installed more quickly than reverse osmosis systems, making them suitable for immediate needs while larger projects are being planned.

Presentation from Water Treatment Expert Christopher Bellona

Christopher provided an overview of the evolution of PFAS treatment technologies since he began working on PFAS projects around 2010. Initially, the focus was on membrane technologies like nanofiltration and granular activated carbon (GAC). Over time, ion exchange resins and reverse osmosis have also been explored. Despite numerous research papers published annually, adsorptive treatments remain the most implemented, with ongoing efforts to develop more selective adsorbents and newer technologies like foam fractionation.

Christopher discussed the comparative effectiveness of activated carbon and ion exchange resins for PFAS removal. He explained the concept of breakthrough curves, where the normalised effluent concentration is plotted against bed volumes processed. Shorter chain PFAS tend to break through quicker than longer chains, and carboxylates like PFOA break through faster than sulfonates like PFOS. He emphasised the importance of cost analysis over breakthrough curves for evaluating treatment technologies. Despite the higher media usage rates for shorter chain PFAS, the costs of GAC and ion exchange systems are often comparable due to the higher expense of ion exchange resins.

Christopher highlighted the challenges posed by organic matter in water, which can interfere with PFAS adsorption. Higher organic matter content reduces the bed volumes to breakthrough, increasing operational costs. He discussed pre-treatment processes like ozone and biologically active filtration to remove organic matter, thereby extending the lifespan of adsorbents. This approach is particularly beneficial in conventional drinking water treatment plants that already remove organic matter through coagulation and filtration.

Christopher introduced novel adsorbents like Fluora-zorb, a surface-modified bentonite clay, which behaves similarly to ion exchange resins but at a lower cost. He also mentioned the development of porous polymer networks designed to improve selectivity and capacity for PFAS removal. Although promising, these novel adsorbents are still in the developmental stage and require further research to be viable for full-scale treatment systems.

Christopher discussed the use of high-pressure membranes, such as nanofiltration and reverse osmosis, for PFAS removal. He presented data showing high rejection rates for PFAS, even at high recovery rates. Fieldwork at a firefighting training area demonstrated the effectiveness of these membranes in separating PFAS from contaminated groundwater. However, the production of a waste stream (concentrate) remains a challenge, necessitating further treatment or disposal.

Christopher reviewed various destructive technologies, including electrochemical oxidation, plasma, supercritical water oxidation, and hydrothermal alkaline treatment. These technologies vary in energy requirements and effectiveness, with some being more suitable for short-chain PFAS. He highlighted the commercial development of hydrothermal alkaline treatment by a company called Aquagga, which has shown promising results in destroying a wide variety of PFAS.

Christopher discussed the strategy of using membrane processes to concentrate PFAS, followed by destructive technologies to treat the concentrate. He mentioned ongoing projects funded by the DoD, including field demonstrations of foam fractionation combined with hydrothermal alkaline treatment. This approach aims to make PFAS destruction more economically viable by reducing the volume of waste.

The presentation concluded with a Q&A session. Steve Hajioff inquired about the deployability of adsorbents and the need for remineralisation after membrane treatment. Christopher explained that while other adsorbents can be used in gravity filters, they are typically employed in pressure vessels. He also confirmed the necessity of remineralisation for water treated with tight nanofiltration and reverse osmosis due to the removal of ions. Ian Cousins raised practical considerations for Jersey Water, including the disposal of spent ion exchange resins and the feasibility of on-site destruction technologies. Christopher noted that while regenerable ion exchange resins exist, they are less common due to lower capacity and the need for harsh regeneration chemicals. He also mentioned that commercial units for electrochemical oxidation and plasma are available, but their long-term viability for treating PFAS concentrate is still under evaluation.

Presentation from Water Treatment Expert Kevin Berryhill

Kevin Berryhill began his presentation by providing an overview of the regulatory framework for PFAS in the United States. He explained that prior to the EPA's involvement, each of the 50 states had its own regulations, leading to a wide range of standards. New Jersey was the first state to enact a PFAS drinking water standard, while states like South Dakota had laws preventing the enforcement of standards stricter than federal regulations. In the previous year, the EPA established a maximum contaminant level (MCL) for six PFAS compounds, including PFOA and PFOS, set at four parts per trillion on a running annual average. Kevin also highlighted the introduction of the hazard index, which accounts for the combined effects of multiple PFAS compounds.

Kevin discussed proven treatment technologies for PFAS, focusing on granular activated carbon (GAC), ion exchange resins, and emerging technologies like fluorosorb. He noted that while reverse osmosis and nanofiltration are effective, they are less practical for inland utilities due to the lack of access to the ocean for waste disposal. He emphasised the importance of process selection for utilities, considering factors like water quality, operational costs, and space constraints.

Kevin detailed the operational considerations for GAC systems, which typically involve pairs of vessels in series to increase reliability and optimise carbon usage. He explained the need for 20 minutes of empty bed contact time and the challenges of backwashing and flushing the carbon, which can generate significant waste. He also discussed the potential for pH spikes, the removal of disinfectants, and the impact of naturally occurring organics on carbon life. Kevin highlighted issues like metal release, nitrate sloughing, bacterial growth, and short circuiting, as well as the incidental benefits of GAC, such as the removal of pesticides and taste and odour compounds.

Kevin compared ion exchange resins to GAC, noting that ion exchange requires only five minutes of contact time and has a smaller footprint. He discussed the complexities of on-site regeneration, which is rare due to the challenges involved. Ion exchange systems require pretreatment with cartridge filters and cannot tolerate oxidants in the water. He highlighted the potential for interference from other anions, the risk of lead release due to changes in the chloride to sulfate mass ratio, and the lack of incidental benefits compared to GAC.

Kevin introduced fluorosorb as an emerging technology that performed well in pilot studies, particularly in the Orange County Water District. He noted its resistance to organics and chlorine, and its potential to become a proven technology. However, he acknowledged the reluctance of utilities to be the first to adopt new technologies.

Kevin outlined the key parameters for selecting a treatment process, including capital and operating costs, effectiveness for short-chain PFAS, footprint, and waste disposal. He explained that ion exchange is generally less expensive and more effective for short-chain PFAS, but GAC offers incidental benefits and is more familiar to many utilities. He also noted the potential for converting GAC systems to ion exchange or fluorosorb systems if needed.

Kevin provided a survey of treatment practices across the United States. In the Northeast, utilities favour GAC due to the presence of iron and manganese in the water, which can damage ion exchange resins. In Florida, high organic content in the water makes ion exchange more practical. Arizona utilities are preparing for future regulations on 1,4-dioxane by using GAC. Colorado Springs favours ion exchange due to low TDS and sulfate levels. In California, the choice between GAC and ion exchange varies based on local water quality and existing treatment practices.

Kevin concluded his presentation by emphasising the importance of considering local water quality and regulatory requirements when selecting a PFAS treatment technology. He noted that while reverse osmosis and nanofiltration are effective, they are less practical for inland utilities. The discussion that followed included questions about the implications of discharging PFAS-rich effluent into the sea, the practical considerations for Jersey Water, and the potential for pretreatment to reduce the impact of organic matter on GAC and ion exchange systems. Kevin and the panel members discussed the challenges of space constraints, the logistics of media disposal, and the potential for on-site incineration of spent media.

Discussion with Experts

General Discussion: The meeting opened with a general discussion among the experts. Tony Fletcher raised a concern about nitrate contamination in Jersey, noting historical issues with high nitrate levels from fertiliser runoff. Kevin Berryhill responded that nitrate levels around 30 milligrams per litre are problematic, especially since nitrate is an acute contaminant. He explained that warmer temperatures can exacerbate nitrate release from carbon, but Jersey's cooler climate might mitigate this issue.

Summary of Presentations: Ian Cousins summarised the key points from the three presentations, noting that reverse osmosis and nanofiltration are not currently viable options due to high costs and waste disposal challenges. He highlighted that ion exchange resins, and granular activated carbon (GAC) are the leading contenders for PFAS treatment, with each having its own advantages and disadvantages.

Future Considerations: Steve Hajioff suggested considering a staged implementation approach, starting with GAC or ion exchange and potentially upgrading to fluorosorb or membrane technologies in the future as regulations evolve. He emphasised the importance of understanding the relative performance of these technologies, especially in light of potential future regulations targeting short-chain PFAS compounds.

Water Quality and Treatment Pathways: Christopher Bellona reviewed Jersey's water quality, noting that post-coagulation and filtration, the organic matter levels are relatively low. He recommended starting with rapid small-scale column tests to screen different adsorbents and then conducting a pilot study. Christopher emphasised that membranes might be overkill given the current PFAS levels, but nitrate levels remain a concern.

Pilot Studies: Kevin Berryhill explained the importance of pilot studies, noting that rapid small-scale column tests are a good starting point but should not be solely relied upon for decision-making. He recommended a pilot study to expose treatment options to the variable water quality in Jersey, which would take a few months to yield meaningful results.

Practical Implementation: Ian Cousins inquired about the timeline and complexity of pilot studies. Kevin Berryhill clarified that pilot studies are relatively straightforward, involving small skids about the size of a pallet. Ian Ross added that recent research supports the comparability of rapid small-scale column tests to pilot trials, but a pilot study is still essential for accurate assessment.

Future Proofing: The discussion also touched on future-proofing treatment systems. Hajioff suggested that specifying systems to allow for future upgrades could be beneficial. Christopher and Kevin noted that while future-proofing is important, it is speculative to predict the exact requirements of future media and technologies.

Jersey Water's Current Efforts: Jeanette Sheldon from Jersey Water provided an update on their efforts, including desktop studies and plans for rapid column testing. She mentioned that they are considering a range of technologies, including GAC, ion exchange, and reverse osmosis, to address various potential standards. Sheldon also raised concerns about the supply chain for GAC, to which Kevin Berryhill responded that while there are distribution delays, there is no long-term shortage of coal-based carbon.

Additional Comments: Christopher Bellona mentioned that optimising coagulation processes could improve the removal of organic matter, benefiting adsorbent longevity. He also noted that new GAC manufacturing facilities are coming online in the US, which could help address supply chain concerns.

The meeting concluded with a consensus on the need for pilot studies to determine the most effective PFAS treatment technology for Jersey. The experts agreed that while GAC and ion exchange are the current leading options, future-proofing and considering emerging technologies like fluorosorb are important for long-term planning.

Any other business

No other business was raised by the panel.

Date of next meeting

Wednesday 30th April 2025. It will be held 2pm - 5pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 14:00 on 30 April 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department Various Regulatory Experts Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declaration of Interests

- No new interests declared.

Minutes and Matters Arising

- Minutes from 27th February meeting approved as a true and accurate record by the panel
- Minutes from 26th March meeting approved as a true and accurate record by the panel
- No matters arising.

Additional Findings Since the Last Meeting

1. **Responses to Report 3:** The latest PFAS and health report received the largest volume of responses, about five times more than any previous report. Some responses are more relevant to Report 4 but will still be addressed in Report 3 and shared with Kelly's team for future consideration.
2. **Additional Meeting:** An extra meeting was held last week to consult with water treatment experts about technologies like ion exchange resins. The minutes from this meeting will be shared after verification.
3. **Meeting with Former Policy Maker:** The panel met with a former deputy and policy maker to discuss various issues, which will help shape Report 4 and future reports.
4. **UKMPS Inquiry:** Ian mentioned that the UKMPS has launched an inquiry into the risks of PFAS, calling for expert evidence by May 26th. There is a suggestion to forward Report 3 to them, even if it is not finalised.

Experts Introductions

Julia Hartmann introduced herself as a representative from the Dutch National Institute for Public Health and the Environment (RIVM). She has been involved in drinking water research and has contributed to various reports on PFAS and drinking water. Additionally, she has worked on deriving a drinking water guideline value for PFAS over the past few years.

Gloria Post introduced herself as a recently retired toxicologist and human health risk assessor from the New Jersey Department of Environmental Protection, where she worked for almost 39 years. She developed numerous health-based drinking water guidelines and has been involved with PFAS since 2004. Gloria has also served on several advisory panels for the US, WHO, and IARC related to PFAS health effects.

Toke Winther introduced himself as a representative from the National Food Institute at the Technical University of Denmark. He mentioned his close collaboration with the Danish Environmental Protection Agency (EPA) on PFAS and drinking water quality. Toke has been working with the Danish EPA for around 10 years, focusing on PFAS regulation.

Hans Peter Birk Hansen introduced himself as a geologist and team leader at the Danish Environmental Protection Agency (EPA). His area of work focuses on water supply and groundwater protection in Denmark. He leads a unit of around 15 people working on these topics.

Sebastian Castano introduced himself as a technology advisor at Oasen Drinkwater, a drinking water company in the Netherlands. He mentioned that he would share their experiences with PFAS presence in water sources and discuss their treatment options, particularly those involving membrane-based technologies.

Presentation from Regulatory Expert Julia Hartmann

Julia Hartmann began her presentation by providing an overview of the PFAS situation in the Netherlands, with a specific focus on drinking water. She introduced the Dutch National Institute for Public Health and the Environment (RIVM), explaining its role within the regulatory landscape. The RIVM, owned by the Ministry of Health, Welfare, and Sports, is an independent knowledge organisation that provides scientific advice to the government. Julia emphasised that while the RIVM derives health-based drinking water guideline values, the responsibility for setting legal drinking water limits lies with the Ministry of Infrastructure and Water Management, which considers additional factors such as technological feasibility and economic impact.

Julia provided an overview of the drinking water supply in the Netherlands, highlighting that there are ten large public drinking water companies serving the general population and industry, as well as about 250 small water supplies for campsites and recreational parks. She noted that approximately two-thirds of the population receives drinking water from groundwater, while the remaining third receives it from surface water. This distinction is important because surface water in the Netherlands contains higher amounts of PFAS compared to groundwater.

Julia discussed the historical and current regulatory landscape for PFAS in the Netherlands. Before 2020, the Netherlands had two drinking water limits for PFAS: one for PFOA and one for GenX substances. These limits were based on higher threshold values, and at the time, PFAS concentrations in drinking water were below these limits. However, the publication of the European Food Safety Authority (EFSA) scientific opinion in 2020 introduced a much lower tolerable weekly intake (TWI) of 4.4 nanograms per kilogram body weight for four PFAS compounds, known as the EFSA-4. This new limit value is protective against the most critical human health effect, the decreased response of the human immune system, as well as other health effects.

Following the EFSA opinion, the Ministry of Infrastructure and Water Management requested the RIVM to derive a new drinking water guideline value for PFAS. Julia explained that the RIVM uses a mixture risk assessment method, incorporating relative potency factors (RPFs) to account for the varying toxicity of different PFAS compounds. This approach allows the EFSA TWI to be applied to a broader set of PFAS.

Julia discussed an intake study conducted in 2021 to assess the intake of the EFSA-4 PFAS compounds by the Dutch population through food and drinking water. The study concluded that food contributes more to PFAS intake than drinking water. Following the WHO guidelines for drinking water quality, this validates the use of a 20% allocation percentage for drinking water in deriving the guideline value. The resulting drinking water limit value is 4.4 nanograms per litre in PFOA equivalents.

Julia presented the results of an updated intake study published in 2023, which included more PFAS compounds and more recent data. The study analysed 770 drinking water samples from all Dutch drinking water companies, distinguishing between surface water and groundwater sources. The study found that TFA, PFOA, and PFHxA were significant contributors to PFAS exposure from drinking water. Although the total PFAS intake was above the EFSA TWI, the ingested quantity via food and drinking water was 40% lower than previously calculated.

Julia noted that the derived drinking water guideline value of 4.4 nanograms per litre is not yet implemented in Dutch regulation. Currently, the Netherlands follows the Drinking Water Directive's sum of PFAS limit of 100 nanograms per litre for 20 PFAS compounds. However, the Ministry of Infrastructure and Water Management aims to implement the lower limit value in the future, working with the drinking water sector to develop a policy framework.

Julia concluded that, based on the analysis, Dutch drinking water is safe with respect to PFAS, as none of the analysed samples exceeded 22 nanograms per litre. However, action is needed as two-thirds of the drinking water samples from surface water exceeded the 4.4 nanograms per litre guideline value. The presentation ended with a Q&A session, where Julia addressed questions about the potential impact of the IARC report on PFAS health effects and the use of RPFs in regulatory calculations.

Summary of Q&A:

1. **Health Tolerable Levels and IARC Report:** Julia confirmed that no changes have been made to the health tolerable levels for PFAS in light of the IARC report.
2. **Relative Potency Factors (RPFs):** Tony Fletcher inquired about the use of RPFs and their impact on the goodness of fit to immunological data. Julia noted that this question would need to be forwarded to a colleague for a detailed response. Additionally, it was clarified that the Drinking Water Directive does not mandate the use of RPFs; instead, it requires the simple summation of PFAS concentrations.
3. **Comparison of RPF-Based and Simple Summation Methods:** Steve Hajioff sought clarification on whether using RPFs would result in significantly different values compared to simple summation. Julia explained that while the RPF-based method can be, depending on the composition of the sample, more stringent. Based on data between 2015 to early 2021, RIVM concluded that the Dutch drinking water complies with the 100 nanograms per litre limit set by the Drinking Water Directive.
4. **Timeline for Regulatory Implementation:** Ian Cousins asked about the timeline for making the health-based guidelines regulatory. Julia indicated that it is still uncertain, with the first update on the policy framework expected in the summer, suggesting a multi-year plan.
5. **PFNA Contribution to PFAS Exposure:** Ian also inquired about the significant contribution of PFNA to PFAS exposure from drinking water. Julia explained that PFNA's high relative potency factor (RPF) of 10 means that even low concentrations contribute significantly to total exposure.

Presentation from Regulatory Expert Gloria Post

Gloria Post began her presentation by explaining the regulatory framework for drinking water contaminants in the United States. She highlighted the existence of both federal and state Safe Drinking Water Acts, which provide general requirements and processes for developing drinking water standards. These acts do not typically include chemical-specific standards but direct environmental agencies on how to establish such standards. The regulatory standards, known as Maximum Contaminant Levels (MCLs), can be set by the federal government or individual states and are enforceable regulations requiring monitoring of public water systems. Private wells, however, are not regulated in most states, leaving it up to homeowners to test and treat their wells if necessary.

Gloria discussed the differences between state and federal standards, noting that some states, like New Jersey due to its industrial background, have a long history of developing their own drinking water standards. States can have stricter standards than federal ones and can regulate contaminants not covered by federal standards. She provided examples of states with their own standards for PFAS and other contaminants, emphasising the increased attention to PFAS regulation in recent years.

Gloria provided a historical overview of regulation of drinking water contaminants, noting that before 1986, there were very few national standards for drinking water contaminants. The 1986 amendments to the Safe Drinking Water Act required the EPA to adopt standards for 25 contaminants every three years, leading to the adoption of many new standards in the 1980s and 1990s. The 1996 amendments changed the process, requiring the EPA to decide whether to regulate at least five contaminants every five years, with a high bar for positive determinations. The PFAS MCLs are the first new federal MCLs for contaminants since the 1990s.

Gloria explained the complex process for developing new MCLs, including the Contaminant Candidate List (CCL), Unregulated Contaminant Monitoring Rule (UCMR), and regulatory determinations. The criteria for regulating a new contaminant include potential adverse health effects, occurrence in public water systems at levels of public health concern, and the opportunity for meaningful health risk reduction.

Gloria highlighted the reasons for concern about PFAS, including their widespread occurrence in drinking water, persistence in the environment, bioaccumulation in humans, and multiple types of animal toxicity. She emphasised the compelling evidence for human health effects even at general population exposure levels and the higher exposure from contaminated drinking water compared to other sources. Infants are particularly susceptible due to higher fluid intake and exposure through breast milk.

Gloria reviewed the history of EPA Health Advisories for PFOA and PFOS, noting the dramatic decrease in guideline values over time. She provided a graph showing the trend of decreasing state and EPA guidelines for PFAS since the early 2000s, culminating in the current federal MCLs of 4 nanograms per litre for PFOA and PFOS.

Gloria described the process leading to the development of federal PFAS standards, including the EPA's positive determination to regulate PFOA and PFOS in 2021, the review by the EPA Science Advisory Board, and the finalisation of the rule in April 2024. The MCLs for PFOA and PFOS were set at 4 nanograms per litre, based on the lowest feasible level for reliable measurement by laboratories. The EPA concluded that both PFOA and PFOS are likely human carcinogens, setting the Maximum Contaminant Level Goals (MCLGs) at zero.

Gloria explained the health effects basis for the PFAS MCLs, noting the use of human epidemiology data for the first time in EPA PFAS risk assessment. The EPA considered decreased vaccine response, decreased birth weight, and increased serum cholesterol as key health effects, resulting in Reference Doses far below previous values. The MCLs for mixtures of four other PFAS were based on non-cancer effects in laboratory animals, using the Hazard Index approach.

Gloria briefly discussed the cost-benefit analysis conducted by the EPA, which estimated the costs and health benefits of the PFAS rule. The analysis concluded that the health benefits justified the costs, with monitoring and treatment costs estimated at $1.548 billion per year and health benefits at approximately $1.549 billion per year.

Gloria outlined the implementation schedule for the PFAS rule, noting that monitoring must begin within three years of the final rule, with quarterly sampling for surface water systems and large groundwater systems. MCL violations are based on the running annual average of sampling results, and systems have five years to comply if there is an MCL violation. She also mentioned the legal challenge to the rule and the current hold requested by the new administration, with information on how the new administration plans to proceed regarding the legal challenge expected on May 12th.

The presentation concluded with a Q&A session, where Gloria addressed questions about the analytical limits for PFAS, the review process for drinking water standards, and the establishment of target concentrations for non-cancer effects. She clarified that the practical quantitation level of 4 nanograms per litre is based on what most commercial labs can achieve, and the six-year review process for federal MCLs considers new health effects information and analytical capabilities.

Presentation from Regulatory Expert Toke Winther

Toke Winther began his presentation by introducing his role at the National Food Institute at the Technical University of Denmark. He explained that the institute has a contract with the Danish Environmental Protection Agency (EPA) and the Danish food authorities to provide science-based advice on various issues, including setting drinking water quality criteria. Toke's presentation focused on the process of setting quality criteria for PFAS in Denmark, providing a historical overview and discussing the implementation of these criteria in Danish regulation.

Toke provided an overview of the PFAS substances for which Denmark has established groundwater and drinking water quality criteria. He highlighted that Denmark primarily uses groundwater for drinking water. The criteria cover 22 PFAS substances, with different sources and overlaps among them. He detailed the timeline for the introduction of these criteria, starting with the sum of 12 PFAS in 2015, the sum of 4 PFAS in 2021 based on the EFSA tolerable weekly intake, and the sum of 22 PFAS in 2023 based on the EU Drinking Water Directive.

Toke explained that the 2015 quality criteria for the sum of 12 PFAS were based on a background report by Larsen and Giovale, which focused on the effects of PFOS and PFOA on the liver in rats. Due to insufficient data for PFOSA, its toxicity was assumed to be equal to PFOS based on structural similarity. The Danish EPA administratively added nine additional PFAS identified in groundwater near firefighting foam usage areas, resulting in a combined quality criterion of 100 nanograms per litre for 12 PFAS.

Toke discussed the 2023 quality criteria for the sum of 22 PFAS, which were based on the recast of the EU Drinking Water Directive adopted in December 2020. Denmark chose to implement the sum of 20 specific PFAS from the directive, adding two more substances (6:2

FTS and PFOSA) that were part of the 2015 criteria but not included in the directive. This resulted in a total of 22 PFAS being regulated in Danish drinking water.

Toke detailed the 2021 quality criteria for the sum of 4 PFAS (PFOS, PFOA, PFNA, and PFHxS) based on the EFSA tolerable weekly intake (TWI). The EFSA set a TWI of 4.4 nanograms per kilogram body weight per week for these four PFAS, protecting against immune effects in children exposed via breastfeeding. Denmark used this TWI to establish a drinking water quality criterion of 2 nanograms per litre for the sum of these four PFAS.

Toke explained the methodology for calculating drinking water quality criteria in Denmark. The tolerable daily intake (TDI) is derived from the TWI by dividing by seven. Denmark uses an allocation factor of 10 for substances where drinking water is not the primary exposure source, and an ingestion rate for children of 0.03 litre per kilogram body weight per day. This approach resulted in the low quality criterion of 2 nanograms per litre for the sum of 4 PFAS.

Toke concluded by summarising the coexistence of the quality criteria for 22 PFAS (0.1 micrograms per litre) and the sum of 4 PFAS (2 nanograms per litre) in Danish regulation. He emphasised the importance of these criteria in ensuring safe drinking water and protecting public health in Denmark.

Presentation from Regulatory Expert Hans Peter Birk Hansen

Hans Peter Birk Hansen began his presentation by explaining the regulatory framework for PFAS in Danish drinking water. He highlighted that 99% of Denmark's drinking water comes from groundwater, with no use of surface water for drinking purposes. The principle of minimal treatment is applied, where groundwater is usually only oxygenated and filtered. Additional treatments are implemented only when pollution cannot be avoided. Water quality is regulated by Danish laws and executive orders, which implement the EU Drinking Water Directive.

Hans Peter described Denmark's decentralised abstraction and distribution system. The country has major public and private waterworks, with 87 public utilities owned by municipalities and around 2,400 consumer-owned utilities. Additionally, there are about 50,000 private utilities serving fewer than ten households each. This decentralised system ensures widespread access to drinking water across Denmark.

The Drinking Water Directive is implemented in Denmark through the Water Supply Act and its derived orders, particularly the drinking water order. This order sets quality standards for specific chemical compounds, primarily to protect human health. Some standards, especially for pesticides, are established due to political considerations. The responsibility for water quality is shared among waterworks, municipalities, and national health authorities. Waterworks are responsible for supplying and monitoring water quality, municipalities ensure compliance and report data to the national database (Jupiter), and health authorities provide guidance in case of pollution.

Hans Peter presented data from the Jupiter database, showing the presence of PFAS in groundwater and drinking water. Out of 15,600 groundwater samples, 700 showed PFAS presence, representing 4.54%. However, these samples were mostly from monitoring wells, not drinking water boreholes. In drinking water, Denmark has two quality standards: 100 nanograms per litre for the sum of 22 PFAS and 2 nanograms per litre for the sum of 4 PFAS. No exceedances were found for the 22 PFAS standard, but 2.3% of drinking water samples exceeded the 4 PFAS standard. All exceedances were mitigated through cooperation between waterworks, municipalities, and health authorities.

Hans Peter shared a case study from Fanø, where the source of PFAS in groundwater was sea spray from the North Sea. PFAS accumulated on surfaces and were transported inland by wind, leading to elevated PFAS levels several kilometres from the coast. The Fanø waterworks initially had PFAS levels of 3-4 nanograms per litre in drinking water. They implemented a combination of activated carbon filtration and ion exchange resins, reducing PFAS levels to 0-1.5 nanograms per litre. Hansen presented data showing the effectiveness of this treatment process, with significant reductions in PFAS concentrations after each treatment stage.

Hans Peter concluded by summarising the regulatory and treatment approaches for PFAS in Danish drinking water. He emphasised the importance of cooperation between different authorities to ensure safe drinking water. The presentation ended with a Q&A session, where Hansen addressed technical questions about sea spray transport and the impact of aerosols on PFAS levels in groundwater. He clarified that sea spray aerosols, rather than foam, are the primary transport mechanism for PFAS from the sea to inland areas.

Preliminary Discussion with Experts

An initial observation was raised regarding how, with the exception of the U.S., most health-based threshold levels for PFAS appear to be based on immunotoxicity rather than carcinogenicity, which, it was noted, may not significantly alter risk assessments unless differing assumptions are made about acceptable carcinogen exposure. Ian Cousins agreed, noting that despite different national approaches, similar threshold values are often reached, although the underlying assumptions—such as allocation factors—can notably shift the resulting limit. For example, Sweden and the Netherlands use similar percentages leading to a value of 4 ng/L, while Denmark’s use of 10% results in a lower threshold of 2 ng/L.

Steve Hajioff introduced the regulatory dilemma of whether to define a health-based threshold with a separate detection-based regulation or set a single regulatory value. Hans Peter Birk Hansen elaborated that Denmark had ensured laboratories were prepared for stringent limits before introducing new quality standards, underlining the importance of providing laboratories adequate time to adapt. This prompted a broader discussion on detection versus quantification limits. Gloria Post highlighted the distinction, noting that in the U.S., enforceable standards rely on the quantification limit, which must ensure precise measurement. Ian Cousins clarified that quantification limits are typically ten times the standard deviation of a blank sample, as opposed to detection limits, which are lower and offer only a basic indication of presence. All agreed that clarity in terminology is crucial in regulation.

Julia Hartmann inquired about the ingestion values used in calculations. Toke Winther explained that Denmark’s guidelines, although 20 years old, are based on exposure estimates for children, using the median. Steve Hajioff clarified for observers that dietary intake is the primary exposure route in uncontaminated areas, while drinking water becomes the dominant source in contaminated zones. Ian Cousins further noted that the specific PFAS compound also matters—short-chain PFAS often lead to water-dominated exposure, whereas long-chain PFAS typically bioaccumulate through food.

Tony Fletcher queried the rationale behind using children's water intake values rather than converting maternal serum values, as done by the UK FSA. Toke Winther responded that although default values used children as a reference group, recalculations for adults yield similar results. Tony also expressed surprise at the low number of exceedances in Danish water supplies, especially when compared to higher figures from the U.S., attributing potential differences to Denmark's heavy reliance on groundwater. Ian Cousins and Gloria Post confirmed that many U.S. exceedances are found in inland areas affected by agricultural biosolids, while Danish sources are more variable and less understood.

On the issue of treatment technologies, Tony Fletcher observed that PFAS appeared to saturate granular activated carbon filters rapidly, with ion exchange also showing slower signs of saturation. Hansen confirmed this observation and noted varying success between facilities using different technologies. Sebastian Castano added that PFAS breakthrough occurs much more quickly in activated carbon filters compared to other contaminants, emphasising the complexity of treatment.

As the conversation neared its conclusion, Steve Hajioff acknowledged the value of the two-stage treatment system observed in Denmark and flagged it for further exploration, particularly whether the first stage pre-filters organic matter that could affect ion exchange resin performance.

Before ending, Gloria Post raised a question about the Dutch RIVM's application of Relative Potency Factors (RPFs) in deriving water guidelines. She questioned whether it was appropriate to apply RPFs derived from liver effects in male rats to human infant immune responses. Julia Hartmann and Ian Cousins clarified that the most recent internal RPFs are in fact based on immunotoxic effects, not liver toxicity. The external RPFs used for the assessment of drinking water, are derived from liver effects. By applying these RPFs, it is assumed that the differences in harmfulness also apply to other effects which can be caused by PFASs, including immune effects. The RPF method also takes account of the possibility that individual PFAS in mixtures can cause different effects. The method proposed by RIVM is not perfect but probably approximates the mutual potency differences in terms of immune effects by PFASs more effectively than the assumption that the various PFASs are equally harmful.

Presentation from Water Treatment Expert Sebastian Castano

Sebastian Castano began his presentation by providing an overview of Oasen, a drinking water company in the Netherlands. Oasen is not the largest but also not the smallest water company in the country, serving over 700,000 clients through more than 300,000 connections. The company produces approximately 47 million cubic metres of water per year across seven locations. Sebastian highlighted that most of Oasen's water comes from riverbank filtrate, which offers advantages such as natural pre-treatment and more stable water quality compared to surface water.

Sebastian discussed the sources of PFAS contamination in Oasen's water supply, noting the influence of the chemical company Chemours, which is located upstream of some of their wells. This has led to higher concentrations of PFAS in certain wells. He presented data showing PFAS concentrations in two wells and the Rhine River, using PFAS equivalents to account for relative potency factors (RPFs). Oasen actively participates in lobbying efforts to achieve zero PFAS discharge from Chemours and other sources, working with national and international water associations.

Sebastian detailed the treatment technologies used by Oasen to remove PFAS from drinking water. The company employs both activated carbon and membrane technologies, including reverse osmosis (RO). He explained that Oasen has two locations fully equipped with RO systems and two more with partial RO processes. RO is favoured for its robustness and high removal efficiency across a wide range of PFAS. However, the production of concentrate, which contains high levels of contaminants, poses a challenge.

Sebastian provided a technical overview of the RO process, explaining that it involves using pressure to push water through a membrane, resulting in two streams: permeate (clean water) and concentrate (contaminated water). Oasen's RO systems achieve a water recovery rate of 80%, meaning 80% of the input water becomes permeate, while 20% becomes concentrate. The concentrate has a concentration factor of about five, making its disposal challenging. The cost of producing drinking water with RO is approximately $0.23 per cubic meter, with energy being the largest cost component.

Sebastian presented data from Oasen's Nieuw Lekkerland plant, showing that the RO process effectively removes PFAS, resulting in non-detectable levels in the drinking water. He also discussed the shared RO process used at other locations, where only part of the water undergoes RO treatment before being mixed with conventionally treated water. This results in some PFAS remaining in the drinking water, particularly compounds like TFA, which are difficult to remove with activated carbon.

Sebastian addressed the management of RO concentrate, noting that the best available technology for Oasen is discharging the concentrate to wastewater treatment plants. This process requires emission approvals and periodic impact analyses to assess the effects on surface water and wastewater treatment. Oasen is also exploring further research and technologies to improve concentrate treatment and reduce environmental impact.

Sebastian concluded by emphasising Oasen's commitment to addressing PFAS contamination through a combination of treatment technologies, source control, and active participation in regulatory and lobbying efforts. He highlighted the importance of collaboration with other water companies and stakeholders to achieve long-term solutions for PFAS management.

Final Discussion with Experts

Steve Hajioff opened the discussion by expressing concern about the 20% water loss associated with reverse osmosis (RO) and its implications for water security, especially in areas with limited water supply. Sebastian Castano confirmed that RO systems indeed result in a 20% water loss, requiring 20% more capacity to produce the same amount of water. He noted that this loss can be mitigated by increasing pressure or recovering water from other process streams, but it remains a significant consideration for water management.

Steve Hajioff inquired about the size and logistics of RO systems, particularly for areas with narrow roads like Jersey. Sebastian Castano explained that RO systems have a relatively small footprint compared to conventional treatment processes. The size of the vessels depends on the number of modules they contain, with each module being about 1.5 metres long and 15 centimetres in diameter. Typically, Oasen uses six modules per vessel, resulting in a total length of about 12 metres. Despite the compact size, multiple vessels are often configured in a train to achieve the desired treatment capacity.

Ian Cousins asked about the water loss associated with nanofiltration compared to RO. Sebastian Castano responded that nanofiltration generally has lower water losses, around 5%, making it more efficient in terms of water recovery. However, nanofiltration is less effective at removing short-chain PFAS like TFA and PFBS, achieving about 80-90% removal compared to the 99.9% removal efficiency of RO.

Ian Cousins also inquired about the motivation for implementing RO at Oasen as early as 2017. Sebastian Castano explained that the initial motivation was to ensure long-term water quality stability, anticipating future pollution. RO is a robust technology that removes a wide range of contaminants, including pharmaceuticals and micro-pollutants, making it a forward-thinking choice for water treatment.

Tony Fletcher asked about the cost-effectiveness of using a second RO stage to further concentrate the 20% waste stream. Sebastian Castano noted that while it is technically feasible to achieve up to 89% water recovery, the additional costs in terms of chemicals, energy, and CO2 footprint make it less attractive. Instead, Oasen focuses on implementing other water reuse technologies to reduce water losses more sustainably.

Tony Fletcher also raised the issue of discharging the concentrate back into the river, questioning whether it would increase pollution. Sebastian Castano explained that the feasibility of discharging concentrate depends on the background concentration of contaminants in the river and the flow rate at the discharge point. In the Rhine, high dilution factors make it less challenging, but it requires careful evaluation and emission permits.

Hans Peter Birk Hansen highlighted the challenges Denmark faces with membrane technology due to the disposal of concentrate. The Water Framework Directive poses significant hurdles for disposing of wastewater, making it a major challenge for Denmark and potentially other European countries.

The discussion concluded with a consensus on the need for careful evaluation of treatment technologies and their environmental impacts. The panel acknowledged the complexities of managing PFAS contamination and the importance of considering both technical feasibility and regulatory requirements in decision-making.

Any other business

No other business was raised by the panel.

Date of next meeting

Wednesday 29th May 2025. It will be held 10am - 1pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on

RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 10:00 on 29 May 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department Jake Hurst - Arcadis Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declaration of Interests

- No new interests declared.

Minutes and Matters Arising

- Minutes from 23 April 2025 meeting approved as a true and accurate record by the panel
- It was noted that the minutes from 30 April 2025 meeting are delayed because one of the experts consulted hasn't yet confirmed the accuracy of their statements. These will be available in June.
- No matters arising.

Additional Findings Since the Last Meeting

No additional findings to report.

Jake Hurst Introduction

Jake Hurst, the UK PFAS lead at Arcadis. He has a background in chemistry and remediation, with over 15 years of experience in PFAS and more than 20 years in the industry. For the past four years, he has provided technical leadership on a project for the Government of Jersey.

Presentation from Arcadis Representative Jake Hurst

Project Overview & Objectives

Jake Hurst from Arcadis UK introduced the PFAS hydrogeological study, emphasising its significance in addressing long-standing environmental and public health concerns in Jersey. Commissioned by the Government of Jersey, the study aimed to understand the behaviour of PFAS (per- and polyfluoroalkyl substances) in the environment, particularly around Jersey Airport. The objectives included identifying how PFAS moves through groundwater and surface water systems, assessing potential risks to human health and the environment, and supporting the development of safe, long-term water supply strategies. A key goal was also to build public trust through transparent communication and to provide a scientific foundation for future remediation and policy decisions.

Phase 2 Scope of Works

Phase 2 built upon the foundational work of Phase 1, which had compiled and visualised historical data to identify gaps in understanding. In Phase 2, Arcadis conducted four quarterly monitoring campaigns between July 2023 and May 2024, collecting over 230 samples from approximately 30 boreholes and 27 surface water sites. The team used PFAS-specific sampling protocols to avoid contamination and ensure data reliability. Passive samplers were deployed to capture average contamination levels over time. The study focused on two key catchment areas—St. Ouen's Bay and Pont Marquet—and included the installation of three new boreholes to improve spatial data coverage. The work was conducted in collaboration with Jersey's Water and Air team, though Arcadis maintained independent oversight and data-led analysis.

Monitoring Results

The monitoring revealed persistent and significant PFAS contamination, particularly beneath the airport's former fire training ground, where concentrations were up to 1,000 times higher than EU drinking water standards. PFAS "fingerprints" indicated multiple sources, including both PFOS-based and mixed-foam types, suggesting varied historical usage across the airport. Surface water pathways, especially the Creepy Valley stream and the South SW outfall, were identified as key conduits for PFAS migration into drinking water catchments. Rainfall and potentially airport de-icing activities were found to influence PFAS mobilisation, with passive samplers confirming variability and spikes in contamination following such events.

A distinct PFAS 'fingerprint' (determined by analysis of the varying concentration and proportion of PFAS compounds), was identified in groundwater beneath fire training ground. This fingerprint was observed to extend across St Ouens Bay, reaching as far as drinking water abstraction well 692 (A1) and was indicative of predominantly a legacy PFOS-based firefighting foam. The consistency of this fingerprint across multiple suggests a mature plume, where PFAS has had sufficient time to equilibrate and distribute evenly throughout the affected area. However, not all locations showed the same pattern. A different PFAS fingerprint was detected at a borehole within the airport grounds, near a site used for foam spray testing. This alternate fingerprint, which includes a mix of PFOS and fluorotelomer-based foams, was also found in nearby off-site groundwater, suggesting that this secondary plume may have migrated beyond the airport boundary.

Hydrogeological Conceptual Model

Arcadis developed a detailed conceptual model of the subsurface environment to understand PFAS groundwater and PFAS transport mechanisms. Beneath the fire training ground lies approximately 30 meters of unsaturated fractured shale bedrock, which is likely acting as a long-term PFAS source to underlying groundwater. Groundwater flows generally westward, with some influence from Simon's Sandpit as well as historical pumping by Jersey Water, which may draw some of the flow more south-westerly, toward the Jersey Water wellfield. The model showed that the sand and shale aquifers are hydraulically connected, and groundwater levels are typically higher than surface water levels around La Plat Doue, allowing for potential discharge into streams. In contrast, in Pont Marquet, surface water tends to flow above the groundwater, limiting interaction. This model was critical in identifying how PFAS moves through the environment and where it may pose the greatest risk.

Risk Assessment

The risk assessment updated the conceptual site model and applied a tiered approach with an initial, generic screening stage comparing PFAS concentrations to UK and EU drinking water and environmental standards. Widespread drinking water exceedances were observed, including at Jersey Water abstractions although these abstractions are not currently in use and many affected wells are also not currently used for public supply. Detailed assessment and modelling estimated that PFAS could take 20–60 years to travel and reach stable concentrations ('steady state') from the fire training ground to the wellfield and up to 100 years to with respect to the marine environment, depending on the compound. This long travel time underscores the persistence of PFAS and the need for long-term management. In contrast, surface water pathways like the Pont Marquet stream could respond more quickly to remediation. The assessment also considered historical PFAS usage at the fire training ground, including the presence of a containment cell beneath the fire training ground and the impact of rainfall and historical drainage on PFAS mobilisation. Finally, an assessment of PFAS ‘mass flux’ was undertaken which looks at both concentrations and flow to understand which pathways transport the most PFAS mass and are the priority for targeting remediation.

Remediation Options Appraisal

Arcadis conducted a high-level appraisal of potential remediation strategies, aiming to reduce-PFAS mass flux and associated risks in a cost-effective and sustainable manner which is acceptable to stakeholders. The appraisal prioritised interventions with the greatest potential benefit, targeting certain high mas flux pathways and areas with the most contamination in a relatively small volume. Shortlisted options included-targeted soil excavation and capping at the fire training ground, in situ flushing of bedrock, and enhanced groundwater pumping and treatment using technologies like activated carbon, ion exchange and foam fractionation. For the broader plume, the (partial) restoration of Simon’s Sandpit to redirect groundwater flow were considered. Drinking water treatment was emphasised as a high priority across all scenarios due to the timescales and inherent uncertainties associated with remediation in such as complex system as well as potential future regulatory changes. For Pont Marquet, a phased approach was recommended, starting with measures to reduce PFAS entering drainage such as pipe inspections and cleaning, followed by potential passive stormwater treatment technologies.

Summary of Recommendations

1. **Support Government Decision-Making**

The findings from the study should directly inform the Government of Jersey’s decision-making processes. A structured and transparent framework should be established to evaluate and select the most appropriate remediation options.

2. **Establish a Coordinated Implementation Team**

A dedicated team and a clear schedule should be set up to manage the next phase of work. This team should include representatives from key stakeholders such as the Government of Jersey, Ports of Jersey, and Jersey Water.

3. **Targeted Assessment of Remediation Options**

The shortlisted remediation options should undergo further detailed assessment, including cost-benefit analysis and feasibility studies. This will help refine the strategy and ensure that selected interventions are both effective and practical.

4. **Address Identified Data Gaps**

Several data gaps were identified during the study, particularly in relation to groundwater quality beneath the airport and PFAS migration across the plume in certain areas which couldn’t be accesses previously. These gaps should be prioritised and addressed through additional investigations to strengthen the evidence base for decision-making.

5. **Develop a Comprehensive Remediation Strategy**

A long-term, integrated remediation strategy should be developed. This strategy should balance environmental protection, public health, technical feasibility, and cost-effectiveness. It should also consider the evolving regulatory landscape and public expectations for timely action.

6. Continue Monitoring and Trend Analysis

Ongoing environmental monitoring is essential to track PFAS trends, validate model predictions, and assess the effectiveness of implemented measures. This includes both groundwater and surface water monitoring.

7. Investigate Drinking Water Treatment Options

Regardless of the remediation approach, drinking water treatment should be prioritised. This includes evaluating technologies for PFAS removal, blending strategies, and alternative supply options to ensure safe and secure water for the public.

8. Align Simon Sandpit Plans with Remediation Goals

Any future plans for Simon Sandpit should be reviewed and potentially aligned with the broader remediation strategy, as the site may influence groundwater flow and PFAS transport.

9. Incorporate PFAS Waste and Soil Reuse Guidance

The report includes a dedicated section on PFAS waste management, including waste acceptance criteria and soil reuse options. These should be considered in the development of any remediation or construction activities involving contaminated materials.

Discussion with Panel and Jake Hurst

The discussion began with Jake emphasising the prioritisation of water treatment due to its rapid deployment potential, direct impact on human exposure, and ability to enhance water security. Hurst explained that remediation may take many years and the outcomes are uncertain, especially in large, complex systems like the St Ouen's Bay, and that evolving regulations may necessitate treatment regardless. He highlighted the potential for focused abstraction from the southern wellfield and potentially more rapid benefits from action in the Pont Marquet catchment.

The discussion then turned to the chemical signatures found at the fire training ground, where a dominant PFOS signature was identified, though a mixture of foams, including fluorotelomer-based products, had been used historically. Ian Cousins and Tony Fletcher raised technical questions about PFAS distribution, precursor presence, and the potential for delayed migration of newer compounds. Hurst noted that while some precursors were detected, the system's aerobic nature and lack of hydrocarbon co-contaminants likely facilitated biotransformation, reducing long-term precursor risks. Precursors were observed to diminish with distance from source areas.

The panel explored the modelling approach used, which relied on literature values due to the absence of detectable PFAS in soil samples. The model, calibrated using historic data, accounted for partitioning, dilution, and migration, though Hurst acknowledged its limitations and the need for ongoing monitoring. The discussion also addressed the potential for PFAS retention in the unsaturated zone due to air-water interface interactions, a mechanism flagged in the report. Hurst confirmed that while the model may not fully capture this, empirical data helped calibrate it effectively. The panel discussed the estimated 60–100 year natural attenuation timeframe and the possibility of revising this with intervention. Hurst affirmed that revised modelling could reflect reduced source terms and new equilibrium concentrations.

Further questions addressed potential PFAS contamination in airport infrastructure, with Hurst noting that while not extensively studied, it was flagged for future assessment. Rainfall response patterns suggested possible adsorbed and leachable sources in certain areas. The conversation shifted to regulatory changes, with Hurst confirming that the study considered both long- and short-chain PFAS and was designed to be adaptable to evolving standards, including the DWI's shift to sum-based PFAS metrics. The data collected was comprehensive and digitised for future use. The panel also discussed the limited relevance of ultra-short PFAS like TFA in this context, given their likely sources and low expected impact.

Finally, the panel examined the historical use of firefighting foams, noting that post-2004 containment practices significantly reduced environmental releases. The dominant PFOS signature in the environment reflects earlier, uncontained usage. Hurst clarified that while different foam types were used, their environmental signatures are mixed and not easily separated by location. The hydrogeological boundaries of the catchment areas were confirmed as limiting factors for plume spread, important for assessing population exposure and advising on borehole use. The potential for sea spray aerosol transport of PFAS was discussed, but Hurst indicated that the data did not suggest significant marine influence on the plume. However, he noted that mass flux into the marine environment could be estimated for future assessments.

Any other business

No other business was raised by the panel.

Date of next meeting

Wednesday 26th June 2025. It will be held 10am - 1pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 10:00 on 26 June 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair
	Dr Tony Fletcher – PFAS and Health member
	Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department
	Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declaration of Interests

- No new interests declared.

Minutes

- Minutes from 30 April 2025 meeting approved as a true and accurate record by the panel following these changes:
- Page 7
    - **First line**: The Netherlands is said to use different percentages, but they actually use **similar percentages**.
    - **Fourth paragraph**: A phrase says, "I question the rationale," but it should be "**query the rationale**."
    - **Fifth paragraph**:
        - "Ion exchange shows signs of saturation" should be "**slower signs of saturation**" to contrast with GAQ.
        - "Immunotoxin effects" should be "**immunotoxic effects**."
        - A sentence about RPF and PFAS mixtures is unclear: "The RPF takes account of the possibilities of the numerous PFAS can cause an effect." It should clarify **that individual PFAS in mixtures can have different effects**.
- Top of page 8
    - A sentence claims the RPF method accounts for a maximum of 23 PFAS, but this is uncertain. It was suggested to **remove the sentence** due to lack of clarity or necessity.
- It was noted that the minutes from 29 May 2025 meeting are delayed because we are waiting for the expert consulted to confirm the accuracy of their statements. These will be available in July.

Matters Arising

- For those observing the meeting, all subject matter expert content will be shortened and reviewed by the experts for accuracy. The full summaries will be included in both the interim report (to be published in a few months) and the final draft report (to be released for Islander input later in the year).

Additional Findings Since the Last Meeting

Engagement with Islanders

- Held side meetings with Islanders and others who had:
    - Concerns about their well-being.
    - Questions about how to engage with the panel or interpret its work.
- Provided clarifications and offered follow-up contact opportunities.

- Responded to emails from Islanders seeking to understand:
    - The panel’s processes.
    - Its terms of reference.
    - Its ways of working.
- Offered meetings with himself or the panel to those interested.

Household Water Treatment & PFAS

- A letter was received asking about household-level water treatment for PFAS.
- Clarifications provided:
    - The panel is currently focused on mains water.
    - In-home and borehole treatment will be addressed after July/August.
    - Previous responses included publicly available information on PFAS water treatment, but the panel:
    - Has not formally reviewed this information.
    - Cannot vouch for its scientific rigor.
    - Is willing to share it with a caveat.
- A review by the Environmental Working Group (US) was mentioned:
    - Focused on American market products.
    - May not fully reflect UK availability.
- A subject matter expert has offered to contribute insights on this topic.
    - Will be invited to the August panel meeting.
    - The panel is beginning to identify experts to invite.

International Developments

- Australia released new drinking water guidelines:
    - These are higher than many other international standards.
    - Will be discussed further under agenda item 9.
- The UK Parliamentary Office for Science and Technology:
    - Issued a report on PFAS on 2 June.
    - Contains a useful summary and literature references.
    - However, the international standards table is outdated (e.g., old Danish standards).

  - The report will be linked in the meeting minutes.

Firefighting Foam Contamination (Bentham Angus Fire Plant, Yorkshire)

- Renewed public interest in PFAS contamination from firefighting foam.
- A public meeting and TV news coverage occurred.
- ITV is planning a documentary on the issue.
- Key points:
  - High contamination in the ground.
  - Water supply is clean (sourced from a reservoir).
  - Exposure scenario differs from airport-related foam use.
  - Foam is produced and tested at the site, leading to runoff.

Public Engagement by Ministers

- Ministers held a quarterly public Q&A session last Wednesday.
  - Part of a commitment to regular public engagement.
  - Islanders could ask questions directly.
- Minutes of the session are being prepared:
  - Will be approved at an upcoming board meeting.
  - Will be published on the government website.

Discussion Papers for Approval

1. Environmental Behaviour of PFAS from Firefighting Foams

Steve Hajioff introduces the context, explaining that this section—along with others—is designed to help readers better understand the findings of the report by providing essential background. Although the content extends beyond the immediate focus on mains water quality, it is being developed now to avoid duplication and to build toward the final report. The team will later decide which parts are relevant enough to include in the interim report.

Steve notes that the section aims to provide a broad overview of how PFAS behave in various environmental media—soil, surface and groundwater, air, plants, animals, and the built environment. He emphasises that PFAS persistence is not only due to their behaviour in water but also due to their slow release from materials like concrete and asphalt, which can prolong contamination. The section also touches on adsorption and desorption processes, and the persistence and mobility of PFAS compounds, particularly those found at elevated levels in Jersey.

Steve acknowledges his limited background in environmental chemistry and credits Ian Cousins for correcting technical inaccuracies in the draft. Ian responds positively, noting that while the topic could easily span hundreds of pages, the plain-language approach taken by Steve is appropriate for the intended audience. Ian confirms that he has ensured the technical accuracy of the content and supports the decision to keep the section concise to avoid overshadowing the panel's deliberations and expert testimony.

Tony Fletcher contributes a specific correction regarding the half-life values of PFOS and PFHxS cited in the draft. He points out that the ranges used (4–8 years and 5–7 years, respectively) are inconsistent with what he considers the most reliable data from a Swedish study (Lee et al., 2020), which suggests 3–8 years for PFOS and 4–7 years for PFHxS. Steve agrees to update the figures and requests the reference for accuracy.

The group then discusses whether this section should also be included in the interim report on water quality. Kelly Whitehead supports its inclusion, and Tony suggests adding a brief introductory note to clarify that the section is broader in scope and anticipates content from both the interim and final reports. Steve agrees and commits to incorporating the changes and formatting the section accordingly.

2. Chemistry of AFFF

The panel convened to review and refine the section of the report concerning the chemistry of AFFF, particularly in relation to PFAS contamination in Jersey. Steve Hajioff introduced the item, noting that most of the content was previously published in Report 2, based on a presentation by Ian Cousins. However, recent insights—especially from Arcadis—revealed that the contamination profile in Jersey is more complex than initially understood, prompting the addition of three new bullet points to the section.

These additions clarify the presence of multiple types of AFFF used in Jersey:

1. Legacy AFFF, notably 3M Lightwater, which was linked to the primary contamination plume.
2. A more modern formulation, associated with contamination in a different area near Pont Marquet.
3. A general note that all AFFF products are complex mixtures of PFAS compounds, each with a unique chemical "fingerprint" that can help trace contamination sources through environmental analysis.

Ian Cousins supported the inclusion of these distinctions and emphasised two key points:

- Telomer-based AFFF was available and used in parallel with 3M products as early as the 1970s, despite 3M's market dominance.

- Formulations of AFFF have evolved over time, with subtle or significant chemical changes introduced regularly. Multiple manufacturers produce telomer-based AFFF, each with distinct formulations. Ian suggested that Jersey authorities have been documenting these formulations via Material Safety Data Sheets (MSDS), which could inform future reporting.

Steve agreed to revise the section to reflect these nuances and confirmed that data collection and environmental sampling for the final report is already underway. This includes identifying which formulations were used and when, to support broader environmental assessments beyond mains water.

Tony Fletcher raised a question about whether Angus Fire products were used in Jersey, given their prominence in PFAS-related contamination elsewhere, such as at the Bentham Angus Fire site. Steve responded that the primary products used were 3M Lightwater and some telomer-based foams, but deferred to Ian for confirmation. Ian noted that Angus Fire products were used, but clarified they were telomer-based and did not contain PFOS. However, contamination at Bentham likely resulted from testing other PFOS-containing foams, not from Angus's own formulations.

The discussion then turned to the interpretive challenges of contamination data. Tony cautioned against taking manufacturer claims at face value, citing conflicting reports about PFOS presence near Angus Fire's training site. Ian agreed, suggesting that high PFAS levels likely stemmed from testing external products rather than Angus's own.

To resolve these complexities, Steve proposed making the section manufacturer-agnostic for now, omitting specific brand names until more definitive data is available. This approach would allow the section to remain relevant and accurate for the interim report, with the option to add manufacturer-specific details in the final report once the MSDS analysis is complete.

The panel agreed with this approach, and Steve confirmed he would revise the section accordingly and include it in the interim report. No further comments were raised.

3. Testing for PFAS

The panel engaged in a comprehensive and technically nuanced discussion about the challenges and considerations involved in testing for PFAS environmental samples. This section was prompted by the realisation that key analytical concepts—such as limit of detection (LOD) and limit of quantification (LOQ)—were being referenced in expert discussions but had not yet been clearly explained in the report. Steve Hajioff initiated the drafting of this section to provide a foundational understanding for readers, especially in anticipation of upcoming deliberations on appropriate regulatory thresholds.

The draft outlines the sampling process, including how samples are collected, stored, extracted, and analysed. It introduces LOD as the threshold at which a lab can detect the presence of a substance, and LOQ as the level at which the quantity of that substance can be reliably measured. Steve emphasised the importance of aligning regulatory standards with measurable thresholds, noting that setting limits below detection capabilities would be impractical.

Ian Cousins reviewed and heavily edited the draft to ensure technical accuracy, appreciating its accessibility for non-specialist readers. He suggested a final review and possibly sharing it with a specialist in analytical chemistry for further validation. Tony Fletcher added that the concept of reporting level, used in Jersey Water reports, should also be defined. This level is typically higher than both LOD and LOQ and may reflect stricter criteria for data reliability.

The panel also discussed the different approaches to summing PFAS concentrations, including:

- Summing individually named PFAS compounds (e.g., EU's list of 20 or 48 PFAS).
- The broader concept of total PFAS, which aims to capture all PFAS compounds, including those not individually identified.

Ian explained that while the total organic fluorine approach is conceptually valuable, it is methodologically inconsistent. Techniques like extractable organic fluorine (EOF) and adsorbable organic fluorine (AOF) rely on combustion and ion chromatography, but results vary significantly depending on the extraction method, solvent used, and lab protocols. He noted that short-chain PFAS, which are often present in high concentrations, are particularly difficult to capture reliably. Steve proposed summarising this complexity in a brief paragraph acknowledging the lack of consensus on a standardised method.

The conversation then shifted to sampling integrity and independence, prompted by public concerns raised in a recent meeting. Kelly Whitehead highlighted the issue of who conducts the sampling, questioning whether government officers are sufficiently independent and whether potential conflicts of interest are adequately mitigated. Steve acknowledged the tension between ensuring independence and maintaining efficiency, noting that outsourcing sampling to third parties would significantly delay reporting. He expressed confidence in the professionalism of government staff and suggested that transparency and adherence to strict protocols could provide sufficient reassurance.

Ian elaborated on the protocols required by accredited laboratories, including the use of specific sampling containers and procedures. He noted that Jersey's environmental staff follow these protocols rigorously, and that labs supply the necessary equipment and enforce strict standards. Tony added that transparency is key, especially under the polluter pays principle, which holds that entities responsible for contamination should also fund monitoring and remediation. He emphasised that clear documentation of sampling procedures, equipment, and lab processes can help build public trust.

The panel agreed that while the issue of independence is important, it falls outside their primary scientific remit. Nonetheless, they decided to include a brief explanation of traceability protocols—akin to chain of custody in forensic contexts—to clarify how sample integrity is maintained. Steve concluded by thanking the team for the thoughtful discussion and confirmed that the section would be revised to reflect these insights.

4. Treatment Technologies for Removing PFAS from Drinking Water

This draft paper reviewed a summary of mature technologies for removing PFAS from drinking water, with a particular focus on their applicability in Jersey. The document, originally much longer, was condensed to around seven pages to ensure accessibility while retaining technical accuracy. It draws on both published literature and insights from subject matter experts and is intended to inform future decision-making rather than prescribe specific solutions.

The technologies are grouped into two main categories: adsorption technologies and membrane technologies. Adsorption technologies include granular activated carbon (GAC) and ion exchange resins (IX), while membrane technologies encompass nanofiltration (NF) and reverse osmosis (RO). A third method, foam fractionation, is also discussed, typically used as part of a treatment train—where multiple technologies are combined sequentially to enhance performance.

Granular activated carbon is a well-established method, particularly effective at removing long-chain PFAS such as PFOS, which are of primary concern in Jersey. However, GAC has limitations. Over time, it becomes saturated, leading to breakthrough, where PFAS begin to pass through untreated. At this point, the GAC must be either reactivated or replaced. Reactivation is environmentally preferable but requires off-island transport, as Jersey lacks the necessary facilities. Disposal of spent GAC on-island is possible but raises regulatory and logistical challenges. Additionally, GAC requires long contact times, necessitating large treatment vessels, which may be impractical in space-constrained settings.

Ion exchange resins offer a broader spectrum of PFAS removal, including some short-chain compounds. They require shorter contact times and smaller vessels than GAC, making them more space-efficient. However, they too experience breakthrough and must be regenerated or replaced. Like GAC, regeneration facilities are not available on Jersey, and disposal of spent resin presents similar challenges. IX systems are also susceptible to fouling from organic matter, often necessitating pre-treatment with GAC. These technologies can be used in tandem to improve performance and resilience.

Membrane technologies, including nanofiltration and reverse osmosis, are highly effective at removing both long- and short-chain PFAS. Nanofiltration is generally more water-efficient and less costly than RO, while still achieving strong removal rates. Reverse osmosis, although the most comprehensive in terms of contaminant removal, is also the most expensive and energy-intensive. It results in significant water loss—up to 25%—which is a serious concern in water-scarce regions like Jersey. RO also removes beneficial minerals, requiring costly remineralisation of the treated water. Both NF and RO produce a stream of highly contaminated reject water, which must be managed carefully. A recent study raised concerns about fluoropolymer membranes potentially leaching PFAS, though this is likely minimal with modern materials.

Foam fractionation is a less common but promising method that exploits PFAS's surfactant properties. By bubbling air through water, PFAS are concentrated in the resulting foam, which can be skimmed off. While effective, this method generates a highly contaminated foamate that requires further treatment or disposal, adding complexity and cost.

The panel emphasised that no single technology can be recommended without site-specific testing. Jersey Water is already conducting pilot-scale trials of various combinations, such as GAC followed by NF or IX. These trials are essential to determine which configurations are most effective under local conditions. Waste management is a critical consideration, as both solid and liquid waste streams must be handled within Jersey's limited infrastructure. Incineration is possible for solids but not for liquids, and the disposal of reject water and foamate remains a significant challenge.

Upgrade pathways were also discussed. Technologies like GAC and IX offer flexibility to transition to novel sorbents, such as bentonite-based materials like RemBind, as they become commercially viable. These newer materials may offer broader PFAS removal, including short-chain compounds, and can often be used in the same infrastructure. In contrast, membrane systems require entirely new builds, limiting adaptability. The panel noted that future regulations may impose stricter limits on short-chain PFAS, making it important to choose technologies that are both effective now and adaptable in the future.

Strategic considerations include water loss, physical space constraints, cost, environmental impact, and public health implications. For example, RO's removal of essential minerals could have unintended health consequences unless properly managed. The panel agreed that while specific recommendations are premature, the review provides a strong foundation for future discussions. Ian will expand the section on reject water and foamate disposal, and the panel will revisit the topic in the next meeting to align technical feasibility with Jersey's unique constraints.

5. Review of International Regulation of PFAS in Drinking Water

Tony began by acknowledging the challenge of balancing conciseness with the complexity of the topic. He noted that historically, many regulatory standards were based on animal toxicity data or practical feasibility, which tended to yield more lenient thresholds. In contrast, more recent and stringent standards—such as those adopted in parts of Europe and the United States—are increasingly based on human epidemiological data, particularly immunological effects.

A key point of discussion was the newly finalised Australian standard, which diverges significantly from the trend toward stricter limits. Australia's regulators reviewed both animal and human data but ultimately dismissed the human epidemiological evidence as unreliable, opting instead to base their risk assessments solely on animal studies. This led to a proposed limit of 200 nanograms per litre for PFOA—substantially higher than the limits set by other countries. Tony raised the question of whether the panel should engage with the rationale behind Australia's rejection of human data, but Steve Hajioff advised against delving into the motivations of individual governments, suggesting that the panel should focus instead on summarising the regulatory levels and the types of evidence they are based on.

The discussion also touched on the U.S. Environmental Protection Agency (EPA), which has proposed extremely low limits based on presumed carcinogenicity and human epidemiological data. These limits are significantly lower than those derived by the European Food Safety Authority (EFSA), despite both agencies reviewing similar datasets. The discrepancy arises from differences in benchmark dose modelling and the application of uncertainty factors. Tony asked whether such methodological differences should be explored in the report, but the consensus was to avoid excessive technical detail that might obscure the report's clarity and purpose.

Steve suggested standardising all concentration units to nanograms per litre to improve readability and consistency, a recommendation Tony agreed to implement. Ian Cousins supported the current level of detail in the paper and did not see a need for further elaboration.

Tony then explained the structure of the paper, which begins with health-based guidance values derived from EFSA's work. These values typically translate to target concentrations in the range of 2–4 nanograms per litre, depending on assumptions about water consumption, body weight, and the proportion of PFAS exposure attributed to drinking water. For example, regulators often assume a daily intake of 2 litres of water and attribute 10–20% of total PFAS exposure to water. These assumptions vary slightly between countries, leading to differences in regulatory thresholds.

Germany's approach was highlighted as particularly pragmatic. Although German authorities accepted EFSA's data, they concluded that the resulting thresholds were so low that most people would already exceed them through food alone. As a result, Germany set a higher, more achievable limit of 20 nanograms per litre, which Tony described as not really a health-based standard. He noted that he had contacted German specialists for clarification but received only cautious responses.

The Netherlands' use of Relative Potency Factors (RPFs) was also discussed. While the Dutch guidance is not legally binding, it introduces a method of weighting different PFAS compounds based on their relative toxicity. However, the panel expressed scepticism about recommending RPFs due to their complexity, variability over time, and the difficulty of applying them consistently. Steve noted that the panel would formally discuss the merits of RPFs in the next meeting.

Tony summarised that health-based goals derived from immunological data generally support very low PFAS limits (2–4 ng/L), while higher limits, such as Germany's, are based on feasibility. The U.S. EPA's limits are even lower but are subject to political change, and the UK's current guidance is in flux. The UK currently uses a tiered advisory system, recommending investigation above 10 ng/L and action above 100 ng/L, now applied to the sum of 48 PFAS compounds rather than individual ones. However, most of these compounds are typically undetectable, and the few that are detectable account for the vast majority of total PFAS levels.

The UK's Committee on Toxicity (COT) is conducting a detailed review of EFSA's data and is expected to issue updated guidance in early 2026. Meanwhile, the European Union has set a binding limit of 100 ng/L for the sum of 20 PFAS compounds, with a secondary goal of 500 ng/L for total PFAS, although the latter is not yet enforceable due to the lack of a standardised analytical method.

Tony also mentioned Canada's standard of 30 ng/L for the sum of 20 PFAS, which he plans to elaborate on further. The paper concludes with a comprehensive table comparing international standards and a breakdown of which PFAS compounds are included in each jurisdiction's regulatory framework.

The panel agreed that the paper provides a solid foundation for the next meeting, where they will decide whether to recommend a specific PFAS limit, whether to use RPFs, and whether any recommendations should be mandatory or aspirational. Tony also clarified that he had intentionally excluded the diverse and evolving standards of individual U.S. states, citing their limited relevance and the availability of detailed summaries elsewhere.

In closing, the panel acknowledged the complexity and diversity of international PFAS regulations and agreed to defer any recommendations until all evidence had been reviewed and discussed collectively in the following session.

6. Modelling Blood Concentrations from Drinking Water

The panel discussed a modelling exercise aimed at estimating PFAS blood concentrations in Jersey residents based on drinking water exposure. The model serves two primary purposes: first, to estimate background PFAS levels in the general population—particularly those living outside known contamination plumes—and second, to assess the relative contribution of drinking water to overall PFAS body burden. This modelling is intended to inform both the interpretation of blood test results and the potential impact of regulatory standards on public health.

Tony explained that, in the absence of local data on PFAS contamination in food, the model uses average blood concentrations from recent European biomonitoring studies as a proxy for background exposure. These studies, which exclude known contamination hotspots, report average serum levels of 1.8 ng/mL for PFOS, 1.1 ng/mL for PFOA, and 0.4 ng/mL for PFHxS. Based on existing literature, it is estimated that 80–90% of these background levels are attributable to non-drinking water sources such as food, food packaging, dust ingestion, and inhalation of PFAS precursors.

To estimate the contribution of drinking water, Tony used historical data from Jersey Water on PFAS concentrations at the two main treatment plants, noting that levels have generally declined over time. He modelled three scenarios: (1) continued exposure at current average water concentrations, (2) a worst-case scenario based on the highest recorded concentrations, and (3) a future scenario in which water is treated to reduce PFAS levels to 4 ng/L. The model assumes average values for body weight, water consumption, and PFAS half-lives, acknowledging that individual variability introduces significant uncertainty.

The results suggest that under current conditions, the average total PFAS concentration in blood would be around 5 ng/mL. In the worst-case scenario, this could rise to 16 ng/mL, while in the improved water quality scenario, levels could fall to 3–4 ng/mL. Tony concluded that the current average in Jersey is likely somewhere between 5 and 16 ng/mL, possibly around 9–10 ng/mL, with considerable individual variation.

Steve Hajioff emphasised the utility of the model for future adjustments as more data become available, particularly regarding locally produced food and smaller-scale water supplies. He noted that the model could be adapted to estimate serum levels in residents using private boreholes or living in areas with different water quality profiles.

Tony also referenced a U.S. study that used a similar modelling approach but incorporated uncertainty analysis through Monte Carlo simulations. He included a figure from that study to illustrate the range of possible outcomes due to variability in parameters like half-life and water intake. While acknowledging the value of such uncertainty modelling, Tony opted not to include it in the current report to maintain clarity and avoid overwhelming readers with technical detail.

Ian Cousins contributed by pointing out that the model simplifies exposure pathways, omitting specific contributions from dust ingestion and inhalation of PFAS precursors. While Tony agreed that these pathways are included in the 80–90% non-water exposure estimate, Ian suggested that explicitly naming them would improve clarity. He also referenced several studies, including the A-Team project and a 2015 Dutch study, which quantified multiple exposure routes using detailed sampling and biomonitoring.

The panel discussed the importance of communicating complex concepts like “steady state” in accessible language. Ian noted that while the concept is central to the model, it is often misunderstood or confused with equilibrium. Tony agreed to consider adding a visual aid from another U.S. model to help illustrate the concept. Steve suggested that the final report include a glossary to explain technical terms and that the discussion from the meeting could be used to frame the section in a more reader-friendly way.

Finally, the panel agreed that while the model is technically sound and useful for policy planning, it should be presented with clear caveats about its assumptions and limitations. Tony committed to reviewing the text for terminology and improving clarity where possible, while also considering the inclusion of additional figures or explanatory notes to aid understanding.

Any other business

Tony Fletcher raised a query regarding the status of Report 3A, which had previously been completed and submitted. He noted that a colleague from another country had expressed interest in the report's official release, anticipating that it could prompt discussion in relation to PFAS exposure cases in their jurisdiction. Tony also mentioned he had identified a typographical error in the report and asked about the timeline for its final publication.

Steve Hajioff clarified that the report had already been finalised by the panel and does not require ministerial approval. However, in line with the panel's "no surprises" approach, the government has been given advance access to the report to prepare a response. This ensures that officials are equipped to respond to public or media inquiries upon release. Steve invited Tony to send details of the typo so it could be corrected in the master copy and confirmed he would follow up with the public health team to confirm the expected publication timeline.

Date of next meeting

Wednesday 24th July 2025. It will be held 10am - 1pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)

Draft Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams 10:00 on 24 July 2025

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Standing Observer (Regulation) - Kelly Whitehead - Group Director of Regulation, Infrastructure and Environment Department Programme support team from I&E

Welcome:

The Chair welcomed everyone to the Panel meeting and reminded people the meeting was being recorded.

Introductions

The Chair and Panel members introduced themselves.

Dr Steve Hajioff, Independent Panel Chair: A retired Director of Public Health from an area of London with two major international airports and a variety of other environmental hazards and challenges, with 35 years in clinical medicine. An expert on translating science into policy, he has worked with Nice, the Greater London Authority, the EU, WHO and World Bank, several UK government departments and several international governments. Dr Hajioff has also worked extensively in the pharmaceutical industry.

Dr Tony Fletcher, PFAS and Health Panel Member: Environmental Epidemiologist at the London School of Hygiene and Tropical Medicine, working on PFAS since 2006 and member of the panel with experience of epidemiological studies on the health effects of PFAS in contaminated communities in West Virginia in the United States, in the Veneto region, in Italy, and in Ronneby, and is the health expert on the panel.

Professor Ian Cousins, PFAS and Environment Panel Member: A Professor in Environmental Chemistry at Stockholm University, an expert on PFAS, appointed as the environmental expert on this Panel and whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Kelly Whitehead, Group Director for Regulation in the in the Infrastructure and Environment Department, leading on the Water Quality and Safety Programme, coordinating Government's response.

Declaration of Interests

- No new interests declared.

Minutes

- Minutes from 29 May 2025 meeting approved as a true and accurate record by the panel.
- Minutes from 26 June 2025 meeting approved as a true and accurate record by the panel following these changes:
    - **Page 9 – Quotation Clarification:**

Tony Fletcher noted that the quote attributed to him about Germany's approach was inaccurate. The original quote: "a compromise dressed up as a health based standard."

Tony suggested it should be revised to: "not really a health based standard."

- **Top of Page 10 – Source Clarification:**

Tony clarified that he had contacted German specialists, not German regulators as stated in the minutes.

Matters Arising

- Nothing to report

Additional Findings Since the Last Meeting

Ian Cousins shared a recent publication in *Nature* magazine that offers a balanced and accessible review of concerns surrounding trifluoroacetic acid (TFA). Although not directly related to the committee's current scope, Ian felt the article was relevant and informative. TFA is one of the smallest PFAS compounds and has garnered increasing attention in recent media, including coverage in *The Guardian*. The article stands out for incorporating perspectives from both academic researchers and industrial scientists, presenting a nuanced view of whether TFA poses a significant environmental or health concern. Ian emphasised that the article is written in plain language and fairly represents both sides of the debate. He offered to share a PDF copy with the panel, acknowledging that some members might not have access through university subscriptions.

Tony Fletcher raised a question about the sources of TFA, recalling that it can originate from pesticides and pharmaceutical precursors. Ian clarified that while these can be local sources, the primary global source of TFA is the atmospheric breakdown of fluorinated refrigerants. This process has led to rising TFA levels across various environmental media worldwide. Ian reiterated that the article discusses whether this rise constitutes a global problem, noting that opinions differ significantly.

Steve Hajioff responded by clarifying that the committee's current report is focused specifically on PFAS compounds associated with firefighting foam, not TFA. While there have been discussions about expanding the scope in the future, Steve stressed the importance of completing the current work before branching out, to avoid delaying progress on more immediate concerns.

The conversation then shifted to a new multi-site PFAS exposure report from the United States, which Ian had previously shared. This report examines PFAS levels in blood samples from individuals living near sites with known histories of AFFF (aqueous film-forming foam) use, such as airports and firefighting training centres. Although the committee had referenced similar studies in their earlier review, the full report had only recently become available. Ian noted that the report provides extensive data on exposure levels across different locations.

Tony added that while average PFAS levels in the report were not significantly elevated, there were individuals with very high concentrations, particularly of PFHxS, a PFAS compound strongly linked to firefighting foam exposure. He found it notable that the highest levels were observed near known point sources, despite the overall averages being modest.

Steve asked whether the report accounted for differences in water supply, specifically whether individuals were using borehole water versus mains water. He pointed out that water source could significantly influence exposure levels, especially if mains water is piped in from less contaminated areas. Tony admitted he hadn't checked that detail but agreed it was an important consideration.

The panel briefly mentioned the Bentham study discussed in the previous meeting, which focused on PFAS exposure near a foam manufacturing site in Yorkshire. No further updates were provided on that topic, and the discussion concluded with no additional findings raised under item four.

Discussions

3. Is there a need for new guidance/regulations on drinking water levels?

The panel began by considering whether the current approach to managing PFAS in drinking water is sufficient, without yet debating what specific form new measures should take. Steve Hajioff clarified that the focus was on PFAS in mains water and whether existing indicative levels are appropriate for protecting public health and aligning with international best practices. He framed the discussion as a "thought experiment" to assess whether the current framework is adequate or if more action is needed.

Ian Cousins confirmed the focus on PFAS and suggested that any evaluation should also consider the current intentions and practices of Jersey Water. However, Steve proposed setting aside those specifics for the moment to focus on whether the existing standards themselves are adequate.

Tony Fletcher asked for clarification on what the current guidance and regulations actually are. Steve and Kelly Whitehead explained that Jersey does not have its own formal PFAS regulations. Instead, Jersey Water voluntarily follows UK guidance, specifically that of the Drinking Water Inspectorate (DWI). PFAS is not listed as a chemical parameter in Jersey's water law, so the UK's standards are used as a reference rather than being legally mandated.

Ian noted that the UK's guidance has recently changed. The Tier 1 threshold is now set at 10 nanograms per litre for total PFAS, rather than for individual compounds. This is considered an aspirational target for water companies. However, it is not always achieved in practice.

Steve expressed concern that the absence of formal regulation or even strong local guidance leaves Jersey in a vulnerable position. He argued that relying on voluntary adherence to another country's standards is insufficient both for reassuring the public and for ensuring compliance with international best practices. Ian agreed, stating that stronger guidance is clearly needed.

Tony added that current PFAS levels in Jersey often exceed the Tier 1 threshold of 10 nanograms per litre. While this threshold is not based on a robust toxicological standard, it is a pragmatic target chosen in the UK to represent a reasonable level of protection. He emphasised that if current efforts had successfully kept PFAS levels well below this threshold, there might be no need for additional guidance. However, since exceedances are occurring, this provides a strong rationale for implementing stricter guidance or regulation.

Steve concluded by summarising the panel's consensus: the current regulatory and guidance framework is unclear and likely inadequate, and there is a shared view that clearer and tighter measures are needed. This conclusion sets the stage for further discussion on what specific actions or standards should be considered.

4. Should there be separate health regulations or a single level approach?

The next discussion point was based around whether Jersey should adopt a dual-level approach to PFAS regulation; one aspirational health-based goal and one practical, enforceable limit or whether a single regulatory level would be more appropriate. Steve Hajioff opened the discussion by framing the issue, noting that while some countries like the US and Germany distinguish between a stricter health goal and a more achievable legal limit, many others opt for a single figure, often with a phased implementation period. Tony Fletcher supported the latter approach, suggesting that Jersey should aim for a single number, as it simplifies communication and implementation.

Ian Cousins agreed, citing examples from Denmark and Sweden, where legally binding PFAS limits are being introduced. He acknowledged that while a single, legally binding number is ideal, the implications—particularly within Jersey's legal and regulatory framework—are complex and not fully understood. Ian emphasised that while the panel can make recommendations, the practicalities of enforcement, monitoring, and legal responsibility would need to be carefully considered by local authorities.

Steve expressed concern that having multiple regulatory figures could be confusing for the public and regulators alike. He proposed an approach based on the environmental health principle of "as low as reasonably practicable" (ALARP), suggesting that a single enforceable level, combined with a commitment to continual improvement as technology and understanding evolve, might strike the right balance. Tony responded by clarifying that ALARP can be interpreted in two ways: either as a guiding principle in setting the standard or as an ongoing duty to reduce levels further. He cautioned against the latter, noting that it could lead to legal ambiguity and frequent disputes over what is "reasonable." Instead, he advocated embedding the principle of practicability into the process of setting a single, clear limit.

The panel also discussed the scientific uncertainty surrounding PFAS toxicity thresholds. Tony noted that while guidance such as the EFSA's tolerable weekly intake is useful, it is not a definitive boundary between safe and unsafe exposure. He compared this to the use of ALARP in radiation protection, where risks are known to exist at all exposure levels. In contrast, PFAS may involve biological thresholds, making the application of ALARP less straightforward. Steve added that for certain PFAS compounds like PFOA, which has been classified as a carcinogen by IARC, the assumption of no safe level might still apply, reinforcing the need for caution.

Despite these complexities, the panel reached a consensus that a single regulatory level is preferable. Tony emphasised that this number should be chosen with practicability in mind and should not be seen as fixed indefinitely. Steve and Ian agreed, suggesting that the regulation should include a narrative of openness to future revision, particularly in response to new scientific evidence or international standards. Tony noted that while frequent reviews would be burdensome, updates could be triggered by significant developments from bodies like the WHO or the EU.

In conclusion, the panel agreed to recommend that Jersey adopt a single numerical target for PFAS in drinking water. This target should be clear, enforceable, and based on current best evidence, while also allowing for future improvements as knowledge and technology advance. The specifics of the number and its scope would be addressed in subsequent discussions.

7. If there is going to be guidance, should it be guidance or regulation?

The panel went on to discuss whether any future recommendations on PFAS levels in drinking water should take the form of guidance or regulation. Steve Hajioff introduced the topic by acknowledging the legal complexities specific to Jersey, noting that while both options are legally feasible, regulation would involve a more intricate and time-consuming process. He emphasised that the purpose of the discussion was not to limit the panel's recommendations but to ensure everyone understood the implications of each route.

Kelly Whitehead provided a comprehensive overview of Jersey's legal framework for water regulation. She explained that the Water (Jersey) Law 1972 governs the supply of water, with Article 9 requiring Jersey Water to provide "sufficient and wholesome water." The definition of "wholesome" is tied to a schedule of chemical parameters in the law, which currently does not include PFAS. Adding PFAS would require amending this schedule—a change to primary legislation. Kelly outlined the legislative process, which includes ministerial instruction, law drafting, public consultation (8–12 weeks), debate in the States Assembly, and ultimately Royal Assent from the monarch. Once approved and registered in the Royal Court, the law comes into force, and any breach becomes a criminal offence, subject to fines and legal proceedings.

Kelly also clarified that guidance, by contrast, could be issued more swiftly as a policy decision by the Minister. However, it would carry no legal enforcement power. Steve asked whether breaches of regulated standards would require proof "beyond reasonable doubt," and Kelly confirmed that this is indeed the case, as with any criminal matter. She explained that enforcement would involve evidence gathering, witness statements, and a decision by the Attorney General on whether prosecution is in the public interest.

Tony Fletcher and Steve Hajioff both acknowledged the clarity of the legal process but raised concerns about the practicality of using criminal law to enforce PFAS standards. Steve noted that while regulation offers strong sanctions, it also introduces a high burden of proof and limited flexibility. He suggested reframing the discussion away from a binary choice between guidance and regulation and instead focusing on whether the standard should be advisory or enforceable. This would allow for alternative enforcement mechanisms, such as contractual obligations, which would operate under civil law and be easier to implement.

Tony expressed uncertainty about the best approach, noting that Jersey's unique context—with a single water provider and close government involvement—might not require the same level of legal force as in larger jurisdictions. He suggested that if a ministerial guidance note were sufficient to achieve compliance, then regulation might be unnecessary. However, he acknowledged that this was difficult to judge without knowing how the system would function in practice.

Ian Cousins offered a contrasting view, arguing that an enforceable standard would likely inspire greater public confidence. He noted that in his experience, public trust in government varies between countries, and in Jersey, enforceability might be key to ensuring credibility. Ian also pointed out that other contaminants like mercury are already regulated, so adding PFAS to the list should be feasible.

The panel ultimately agreed that while they were not in a position to determine the specific legal mechanism, they should recommend that any PFAS level be enforceable in some form. Steve emphasised that the panel's role was to set the principle, not to dictate the legal route. Kelly confirmed that any change to primary legislation would be a decision for the Minister and the States Assembly, and that the panel's recommendation would be considered as part of that process.

In conclusion, the panel agreed that any recommended PFAS level should be enforceable, but they would not specify whether this should be through regulation, contractual means, or another mechanism. This approach allows for flexibility in implementation while maintaining a clear commitment to accountability and public reassurance.

8. Is that level based on RPFs or not?

The panel discussed whether Relative Potency Factors (RPFs) should be used in determining acceptable PFAS levels in Jersey's drinking water. Steve Hajioff introduced the topic by explaining that RPFs are a method of weighting different PFAS compounds based on their relative toxicity. He cautioned that while RPFs may indicate how harmful a compound is in one context—such as liver toxicity in rats—they may not accurately reflect risks in other contexts, such as cancer in humans. This variability raises concerns about the applicability and reliability of RPFs in regulatory settings.

Tony Fletcher elaborated on the origins and limitations of RPFs. He noted that initial RPFs were derived from studies on liver weight changes in rats, and later extended to immune effects in rodents. While these studies showed some consistency, they also highlighted the challenge of applying RPFs to standards driven by different health concerns. Tony pointed out that RPFs can be calculated based on either body burden (serum concentrations) or intake levels (dietary or water exposure), and the results differ depending on the method used. He expressed uncertainty about which approach had been adopted in existing models and emphasised that this arbitrariness complicates their use.

Tony also noted that RPFs have only been formally adopted in a limited context—specifically in the Netherlands—and even there, they remain advisory rather than enforceable. He argued that while RPFs may be useful for risk assessment, they are problematic for setting fixed exposure limits, especially when the mix of PFAS compounds varies. In Jersey's case, the two main PFAS of concern—PFOS and PFHxS—have RPFs that effectively cancel each other out, making the use of RPFs irrelevant to the final exposure calculation. He concluded that RPFs are an interesting scientific tool but not suitable for regulatory implementation in Jersey.

Ian Cousins supported this view, adding that while RPFs are valuable in research for their scientific accuracy, they introduce significant uncertainty and communication challenges in practical applications. He emphasised that the relevance of RPFs depends heavily on which PFAS compounds are included in the regulatory sum. For example, if only four long-chain PFAS are considered, their similar toxicities and elimination rates make simple summation acceptable. However, if a broader set of 48 PFAS is included, the lack of RPF data for many compounds makes the approach unworkable. Ian highlighted the risk of skewed results if low-potency but high-concentration compounds like PFBA or TFA are included without proper weighting.

Steve agreed with both Tony and Ian, stating that implementing RPFs in regulation or contractual terms would be highly complex, potentially leading to legal disputes without offering meaningful public health benefits. He advocated for a simpler approach: setting a total PFAS concentration limit based on a defined set of compounds. This method would be easier to monitor, enforce, and communicate, while still providing adequate protection for Jersey residents.

In conclusion, the panel unanimously agreed that RPFs should not be used in determining PFAS levels in Jersey's drinking water. Instead, they recommended a straightforward summation approach based on a selected group of PFAS compounds.

9. At what Level do we believe it is appropriate to be set?

The next discussion point is based around what PFAS concentration level should be recommended for Jersey's drinking water and which specific PFAS compounds should be included in that calculation. Steve Hajioff opened the discussion by outlining the main international approaches: the sum of four PFAS (used in countries like Sweden and Denmark), the sum of 20 PFAS, and the sum of 48 PFAS (used in broader European guidance and recently adopted in the UK). He invited the panel to consider which of these frameworks would be most appropriate for Jersey.

Tony Fletcher began by cautioning against attempting a full primary review or risk assessment, suggesting instead that Jersey should draw on existing international syntheses, particularly the EFSA tolerable weekly intake (TWI). He noted that different jurisdictions have interpreted this TWI differently, resulting in thresholds of 2, 4.4, and 4 nanograms per litre for the sum of four PFAS. Tony recommended the 4 ng/L threshold, which aligns with the Swedish model and includes three PFAS compounds known to be present in Jersey. He also proposed using the 10 ng/L threshold for the sum of 48 PFAS as a secondary, broader reference point, though he acknowledged this would introduce a second number.

Ian Cousins agreed with the 4 ng/L threshold for the sum of four PFAS, noting that it is both scientifically justified and practically achievable. He highlighted that this level is already enforceable in Sweden and is within the detection capabilities of modern laboratories. Ian emphasised that the four PFAS included—particularly PFOS and PFHxS—are the most relevant for Jersey's water profile and health concerns. He also noted that while the 10 ng/L threshold for the sum of 48 PFAS could be useful, it should be treated as supplementary guidance rather than a primary standard. He noted that this was based on the proportion of PFAS daily intake that is believed to be from food and most countries agreed on that, although Denmark had chosen a different proportion.

Steve supported this consensus, expressing concern that relying solely on the 10 ng/L threshold for 48 PFAS could be misleading. For example, a high concentration of a single harmful PFAS like PFOA could still fall within the 10 ng/L limit, potentially masking a significant health risk. He agreed that the Swedish model of 4 ng/L for the sum of four PFAS offers a clearer, more protective, and enforceable standard for Jersey. The panel formally agreed to recommend this as the primary threshold.

The discussion then turned to whether the 10 ng/L threshold for the sum of 48 PFAS should be included as a secondary monitoring tool. Ian argued that it would be valuable for tracking emerging PFAS compounds, especially shorter-chain variants that may become more prevalent in the future. Tony added that Jersey Water already publishes annual data on individual PFAS and their sums, so incorporating this broader threshold into ongoing monitoring would be consistent with current practice. He proposed that this threshold be used as a guidance value, with exceedances prompting further investigation rather than enforcement.

The panel agreed to a second recommendation: that the sum of 48 measurable PFAS should remain below 10 ng/L on average, and that this data should continue to be published transparently. This would provide an additional layer of oversight and help identify trends in emerging contaminants. Tony emphasised that the list of 48 PFAS should be treated as evolving, reflecting new scientific knowledge and regulatory developments.

In conclusion, the panel agreed on two key recommendations:

- A primary enforceable threshold of 4 ng/L for the sum of four key PFAS, similar to the Swedish model.
- A secondary guidance threshold of 10 ng/L for the sum of 48 PFAS, to be used for monitoring and transparency, with the understanding that the list of PFAS may change over time.

10. What would be the necessary lead time to implementation? & What treatment technologies are appropriate, and do we make recommendations?

The panel began by acknowledging the interconnected nature of items 10 and 11, deciding to address them together in a broader discussion. Steve Hajioff introduced the idea of considering PFAS treatment strategies across three timeframes: immediate actions, medium-term implementation, and long-term horizon scanning. He suggested that some measures could be implemented quickly without major infrastructure changes, while others would require more substantial planning and investment.

One immediate option discussed was the use of powdered activated carbon (PAC) as a short-term measure to reduce PFAS levels. Ian Cousins supported the idea in principle, noting that any intervention that lowers PFAS concentrations is beneficial. However, he emphasised the need for pilot-scale testing before implementation, as lab-scale results may not translate directly to real-world conditions. He also noted that full-scale treatment plant upgrades would take years to complete.

Steve proposed framing PAC as a “consideration” rather than a formal recommendation, similar to how healthcare guidelines sometimes suggest exploratory measures. He also raised concerns about the waste by-products of PAC treatment, particularly the disposal of treatment sludge, which had not yet been formally addressed by the panel and will be considered in the coming months.. Tony Fletcher expressed scepticism about prioritising interim solutions, arguing that resources should be focused on developing a robust long-term strategy. Ian agreed, suggesting that while interim measures are welcome, they should not detract from the primary goal of implementing effective, permanent treatment technologies.

The panel then shifted to discussing long-term treatment options, emphasising the need for Jersey to develop sustainable methods for treating freshwater at scale. Steve stressed that relying solely on dilution with desalinated water is not a viable strategy for future water security and is a massive waste of natural resources. Ian outlined the main technologies considered in the report: granular activated carbon (GAC), ion exchange resins (IX), and membrane technologies such as reverse osmosis (RO) and nanofiltration. He noted that GAC and IX are widely used and effective for long-chain PFAS, while RO was ruled out due to high water loss and energy costs. Nanofiltration was seen as a promising future option but not yet mature enough for immediate deployment.

The panel discussed the practical challenges of each technology in the Jersey context. Steve highlighted that GAC’s advantages—such as regeneration—may not apply locally due to the lack of on-island facilities and the difficulty of transporting contaminated waste internationally. He suggested that IX might be more suitable, given its smaller footprint and lower waste volume. Ian agreed that both GAC and IX are viable but emphasised the need for site-specific pilot testing and a whole-system cost-effectiveness appraisal, including waste disposal and infrastructure requirements.

The panel agreed that while they could not definitively rank the technologies, they could recommend a detailed cost-effectiveness analysis and options appraisal between GAC and IX, tailored to Jersey’s unique conditions, looking at the whole lifecycle of the product and including ancillary costs, wherever they are borne. Other technologies, such as foam fractionation and novel sorbents, were acknowledged as potential components of a treatment train or future developments but not primary solutions at this point. These could be considered in future upgrades, especially if regulations expand to include short-chain PFAS.

Regarding implementation timelines, the panel recognised the complexity of estimating how long it would take to deploy new treatment systems. Ian suggested that, based on international examples, a committed effort could achieve results in three years, but acknowledged that Jersey’s specific challenges—such as infrastructure limitations and land acquisition—could extend this to five or more years. Tony noted that large projects often take longer than planned and emphasised the link between regulatory enforcement and realistic lead times.

Ultimately, the panel agreed on a compromise recommendation: PFAS treatment should be implemented “as soon as is reasonably practicable, ideally within five years.” This phrasing provides a clear target while allowing flexibility for unforeseen obstacles. The panel emphasised the importance of honesty and transparency in their recommendations, avoiding overly optimistic timelines that could lead to future setbacks.

In conclusion, the panel recommended:

- A primary focus on long-term treatment solutions, with GAC and IX as the leading candidates.
- A site-specific options appraisal to determine the most suitable technology for Jersey.
- Interim measures like PAC are welcome but not prioritised.
- Monitoring and consideration of emerging technologies for future upgrades.
- An implementation timeline of ideally five years, acknowledging practical constraints.

Any other business

Date of next meeting

Wednesday 14th August 2025. It will be held 10am - 1pm online.

The Chair thanked everyone for their contributions, those watching the meeting and those offering support throughout the whole process.

A reminder to the public that this meeting has been recorded, and the video will be available online on request by emailing the Regulation Enquiries mailbox on RegulationEnquiries@gov.je. This will take a couple of days to make sure the observers are anonymised.

There being no further business, the meeting was closed.

To note that the Panel can be emailed via PFASpanel@gov.je.

Details of meeting dates and times can be found at PFAS in Jersey (gov.je)