Minutes of public meeting of the PFAS Scientific Advisory Panel on Teams
From 10.00am to 12pm on Monday 4 March 2024

Panel Members present:	Dr Steve Hajioff – Independent Chair Dr Tony Fletcher – PFAS and Health member Professor Ian Cousins – PFAS and Environment member
In attendance:	Sarah Tyler – Senior Policy Officer Anita De La Cour – Executive Assistant
Apologies:	Grace Norman, Deputy Director Public Health

Welcome
The Chair welcomed everyone to the Panel meeting, and reminded people the meeting was being recorded and that the recordings are available afterwards on request (*by emailing publichealth@gov.je).*

Introductions
The Chair and Panel members introduced themselves.

Dr Steve Hajioff, is the Independent Panel Chair, with a background as a GP and a retired Director of Public Health from an area of London with two major international airports and a variety of other environmental challenges. Steve is not an expert in PFAS but has extensive experience in helping turn science into policy. He led the Health Impact Assessment at the Greater London Authority and has chaired policy development groups for a range of organisations.

Dr Tony Fletcher is the PFAS and Health Panel Member, and he is an environmental epidemiologist at the London School of Hygiene and Tropical Medicine, and a long-term researcher on the health effects of PFAS.

Professor Ian Cousins is the PFAS and Environment Panel Member. A Professor at Stockholm University, whose expertise on PFAS is on the sources, transport, fate, and exposure of PFAS.

Grace Norman gave apologies for the meeting. Support staff for programme management and administration were also in attendance.

Declarations of Interest
None.

Minutes of the previous meetings
The minutes of the meeting of 16 November 2023 were agreed, with no matters arising.

The minutes of the meetings of 18 January and 8 February 2024 are still being finalised, due to the complexities of capturing the subject matter expert's content. These meetings were recorded and are available online for people who wish to watch them. Please email publichealth@gov.je to request the recordings.

Additional findings since the last meeting
To date, two public meetings had taken place and several private meetings held with Islanders regarding their health experiences, and written testimonies were submitted by Islanders which had identified a list of key conditions to be investigated as part of report 2.

Rare conditions had not been included as clinical confidentiality of those concerned could not be guaranteed due to the low numbers involved. These areas will however still be looked at.

Key conditions to be researched:

- A range of cancers
- High cholesterol
- Fertility issues
- Inflammatory of the stomach and gut disorders
- Liver disorders
- Impacts on children
- Impact on mental health, psychological and physiological effects

Presenting drafts of parts of the literature reviews to inform report 2; An assessment of the impact on PFAS exposure on health

The Chair explained the running order of the meeting. The Panel will give three presentations on areas they have been working on. Ian Cousins will present on the chemistry of PFAS as it was noted that there was some confusing and seemingly contradictory information about PFAS, and the presentation would seek to clarify some of this information. Tony Fletcher will be speaking about the literature review and preliminary findings, as a starting point for their report. The Chair will then present on the mental health effects of environmental contamination.

Introduction to the chemistry of PFAS
Ian Cousins shared a presentation entitled “Introduction to the Chemistry of PFAS”.
A summary of the key points from the presentation are outlined below:

<u>What are PFAS?</u>
PFAS stands for per- and polyfluorinated alkyl substances (also written as PFASs and means the same thing). 'Perfluorinated’ means a fully fluorinated carbon chain and all the hydrogens replaced by fluorine While ‘polyfluorinated’ means that not all of the hydrogens in the chain have been replaced by fluorine. ‘Alkyl’ means substances that contain chains of fully saturated carbon atoms and not unsaturated aromatic rings.

In 2021, the OECD *(Organisation for Economic Co-operation and Development)* made a broad definition of what PFAS is “…the fluorinated substances that contain at least one fully fluorinated methyl or methylene carbon atom…” i.e. substances are PFAS that have at least one $-CF_2-$ or $-CF_3$ moiety in their structure. This expands the PFAS definition to cover over 10,000 PFAS in use in Europe.

The diversity of PFAS means the group comprises a very wide range of substances, some of which you may not expect, and there are many thousands in use, for example:

- Fluoxetine (better known under the tradename Prozac), is an antidepressant and a type of PFAS
- Polytetrafluoroethylene (PTFE, known under its tradename Teflon), is a fluoropolymer used in non-stick cookware, etc. and meets the PFAS definition due to its structure
- Hydrofluoroolefin is a gas used as a refrigerant and in air conditioning. It also meets the PFAS definition.

There are many thousands of structurally diverse PFAS used in society; solids, liquids and gases, reactive and inert, soluble and insoluble, volatile and involatile, mobile and immobile, high toxic and relatively nontoxic. We don't know the properties and toxicities for most of them. However, they are all highly environmentally persistent themselves or and even when they breakdown they form persistent breakdown products which stay in the environment.

Regulation of PFAS

The authorities of Denmark, Germany, Netherlands, Norway and Sweden published a REACH restriction proposal for all PFAS meeting the OECD definition. There is also a separate restriction proposal on restricting PFAS in firefighting foams which is nearly finalised, which will lead to a 10-year phase out plan for PFAS in firefighting foams.

The PFAS that most people conduct research on are perfluoroalkyl carboxylic acids (PFCAs, also known as carboxylates, from 2 to >20 carbons) and perfluoroalkane sulfonic acids (PFSAs, also known as sulfonates, with typically 4, 6, 8 or 10 carbons, but other chain lengths are also present). When a hydrogen is lost from the sulfonic acid or carboxylic acid groups, the PFAS become negatively charged anions.

There are many acronyms for the different types of PFAS. A typical list of PFCAs and PFSAs which might be analyzed in an environmental include:

C4 – C12 perfluoroalkyl carboxylic acids (PFCAs) ***C =carbon***
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)
C4, C6, C8 and C10 perfluoroalkane sulfonates
perfluorbutanesulfonic acid (PFBS)
perfluorohexanesulfonic acid (PFHxS)
perfluorooctanesulfonic acid (PFOS)
perfluordecanes ulfonic acid (PFDS)

The Panel discussed linear and branched structural isomers and the complexities involved; e.g. linear isomers are more bioaccumulative than branched. There are other types of isomers. Steve pointed out that isomers can react differently in the body, for example Thalidomide drugs created in the 1950s/60s were tested, however when it went into manufacture there were 2 isomers and the second isomer caused issues for unborn babies. Ian responded that Steve was mentioning chiral isomers known as enantiomers (mirror images of each other). Ian was talking about the different levels of branching on the alkyl chains which are different types of isomers. There are also chiral isomers of PFAS (e.g. there are chiral isomers of PFOS), but the research on enantiomers of PFOS is very limited.

AFFF (Aqueous Film Forming Foam) is most relevant to the Jersey context, and has a mixture of linear and branched PFAS (e.g. linear and branched PFOS and PFOA).

Other terminology used includes ultra short-chain, short-chain, and long-chain PFCAs and PFSAs:

- Short- and long-chain definitions are based on their ability to bioaccumulate
- Definitions complicated by the fact that PFCAs and PFSAs bioaccumulate to different extents
- For PFCAs, PFOA and all longer chain length PFCAs (>C7) are considered "long-chain" and bioaccumulative
- For PFSAs, PFHxS and all longer chain length PFSAs (>C5) are considered "long-chain" and bioaccumulative
- There are also ultra short-chain PFCAs (1-3 carbons) and PFSAs (1-3 carbons). These have been defined as a special class as they are very mobile in water and difficult and expensive to remove from drinking water

There are no agreed definitions for short- and long-chain PFAS, although the terms are often used in the literature.

Properties of PFCAs and PFSAs:

- They are powerful "surfactants" i.e. detergents

Post meeting note – Surfactants are chemical compounds which decrease surface tension of a liquid in which it is dissolved. They can form foams and help facilitate the detachment of dirt (e.g. non-PFAS surfactants are used in household cleaning products). They are very important chemicals used for a wide variety of purposes and can also be found naturally.

  - They lower surface tension of liquids; i.e. increase spreading and wetting properties
  - AFFF: rapidly spread aqueous film blanket over fuel fires (used in firefighting foams)
- They have a hydrophobic "tail" and hydrophilic "head"
- They are acids, so they lose a hydrogen from the acid head group and become (anionic) sulfonates and carboxylates with a negative charge.

Uses of PFCAs and PFSAs:

- They have been used for their powerful surfactant properties for making fluoropolymers (e.g. PFOA for making Teflon), in fire fighting foams, and other industrial and consumer users (e.g. paints, inks).
- They are impurities in, and break down products of, a wide range of other PFAS (the substances which break down are known as "precursors" which means they can breakdown and form these acids) used in multiple applications, such as in textiles and food packaging
- The long-chain PFCAs and PFSAs, which were more problematic because of being more bioaccumulative and toxic, so they have been phased out (transition between 2002 & 2015) and replaced with shorter-chain alternatives or non-PFAS alternatives.

Further detail on precursors

Precursors are substances which break down in the environment or inside organisms to form PFCAs and PFSAs. They are used in products such as waterproof jackets and food packaging. They can degrade in our bodies and in the environment into these acids. The acids are the end degradation products.

- Perfluoroalkyl sulfonamido ethanols (form PFCAs and PFSAs in environment and PFSAs in organisms);

- Perfluoroalkyl sulfonamides (form PFCAs and PFSAs in environment and PFSAs in organisms);
- Fluorotelomer alcohols (form only PFCAs in environment and in organisms)
- PFSAs and PFCAs are not the major surfactants in firefighting foams – there are other, non PFSA and PFCA surfactants in these foams. It is a complex mixture of surfactants. PFSA and PFCA are degradation products of these surfactants.

- There are 40 classes of PFAS (many are "precursors" to PFCAs and PFSAs) in AFFF products

Why most research focuses on PFCAs and PFSAs:

- There are reliable analytical methods for them
- They are stable degradation products of many other substances
  - They are unreactive and cannot interconvert, e.g. PFOA cannot transform into PFHxS
  - The many precursors in AFFF ultimately are converted to PFCAs and PFSAs
  - The precursors are released, but ultimately many will not be present in drinking water
- There is toxicity data for them
  - In fact, among all PFAS we have the most extensive and reliable toxicity data for PFOS, PFHxS, PFOA and PFNA

There are two main types of aqueous film forming foams (AFFFs):

- 3M Lightwater products have been used since 1967 in the US, and were also used in Jersey. These contained PFSAs (PFOS and PFHxS) and lower levels of PFOA, and also precursors to PFOS, PFHxS and PFOA
- Fluorotelomer-based products (used generally since 1973 onwards)
  - contained PFCAs: PFHxA, PFOA, etc.
  - contained fluorotelomer-based precursors (e.g. fluorotelomer sulfonates) which degrade to PFCAs (and not PFSAs)
  - never contained PFSAs or their precursors
  - always predominantly based on C6 chemistry, but more recent formulations contain less C8 impurities
- Most users transitioned away from 3M Lightwater to fluorotelomer-based products in the early 2000s because 3M stopped making these products in 2002. Some later transitioned to fluorine-free foams (3F). 3F are used widely at commercial airports in Sweden for example

Chemical "fingerprints" of the two main types of AFFFs:

Fingerprinting is a pattern seen in the environment or human plasma which can identify the type of AFFF which has been used (i.e. AFFF products have unique marker substances).

PFOS and PFHxS are only markers of 3M Lightwater AFFF products

- PFOA is present in, or generated in the environment from precursors present in, both 3M Lightwater and fluorotelomer-based AFFF products
- Fluorotelomer sulfonates (e.g. 6:2 fluorotelomer sulfonate) are unique markers of fluorotelomer-based AFFF products
- Structural isomers (linear versus branched) of PFOA can also be used as markers. If only linear PFOA is present then fluorotelomer-based AFFF has been used.

- Cross-contamination of AFFF products during storage creates a problem for "fingerprinting". If AFFF is stored in old vats which have been previously used for storing other AFFF, then the material can become contaminated from the storage container, introducing uncertainty in fingerprinting during analysis

Fluorotelomer sulfonates are quite stable and can be found in water. These can be analyzed by labs. A key question for report 4 can include a better understanding of fluorotelomer sulfonates. It will indicate if fluorotelomer-based AFFF has been used in Jersey.

The Chair thanked Ian Cousins for his presentation.

Introduction to Health effects review
Dr Fletcher then presented an Introduction to Health effects review.

This was the first overview of the approach for health evidence for Report 2, and will cover source data, sources of evidence and most common contaminants. A summary of the main points of the presentation is below:

Sources of evidence
- Epidemiology linking PFAS to health in people
- Animal experiments exposing, for example, mice to specific PFAS
- Mechanistic data on modes of action. Previously assembled information in reports by authoritative bodies, including:
  - The World Health Organization's International Agency for Research on Cancer (IARC) for cancer
  - European Food Safety Authority (EFSA) and European Chemicals Agency (ECHA)
  - Many US bodies – USA Environmental Protection Agency (EPA), State Health Departments, and the National Academy of Science (NAS)

It should be noted there are more than 12,000 PFAS Health/Science publications a year on PubMed, and 10,000 a year on Science Direct, so the Panel need to focus on well-established studies, and are targeting the reviews most relevant to Jersey.

Sources of evidence – Epidemiology 1
Types of study design, such as cross-sectional studies, which are helpful for effects on clinical markers like cholesterol, however not so helpful for disease.
Sources of evidence – Epidemiology 2
Types of exposure situation: for example, the background levels using serum PFAS (a general mix of long chain long half-life PFAS) *(Half-life is the time it takes for the concentration of a substance in the body or in the environment to reduce to half its initial value).*
High level occupationally exposed groups- may be specific PFAS: PFOA, PFOS, Gen-X
Third source is following up in affected communities.
Community exposures in exposed hotspots due to AFFF contamination or factory emissions.

Outcomes of interest
For this report, many health outcomes have been identified as of interest to Jersey, either through published academic literature, input from subject matter experts, and concerns

raised by islanders as experts by experience. One topic area that has been of major public interest is cancer related to PFAS exposure.

The sources of evidence include:

- Epidemiological studies of the individual PFAS of concern
- Reviews of the Epidemiology plus other evidence for these same PFAS
- Epidemiological studies targeting the AFFF mixture

Sources of evidence looking at the epidemiology of AFFF exposures. Although AFFF mixtures vary between products and over time, they are characterised by a complex mixture of specific PFAS compounds. Serum levels in people marked with raised PFHxS and PFOS. Follow up studies of AFFF regarding exposed people are particularly informative for health effects of these mixtures. Good examples are some of the work in Ronneby, Sweden, and subject matter experts Kristina Jakobsson and Christel Nielsen have presented some of this work to the Panel previously.

Findings from the Ronneby research suggested there was some evidence for health conditions such as kidney cancer, testicular cancer being linked to PFAS, and less evidence for such as prostate cancer and breast cancer. Tony explained the median serum levels in Ronneby, which had a highly exposed population. The population data was linked to health records and compared the rate of cancer incidents in this population. The conclusion was that kidney cancer was associated with a 20% greater risk in the Ronneby population compared to the wider population. Higher proportions of rare cancers could have other explanations, such as that they could be due to chance. Some association with brain and bone cancers were found in Ronneby but this has not been found in other studies. Therefore, it could be concluded that there is less risk of cancer from AFFF exposure than from the PFOA exposures in other exposure studies.

Tony then mentioned the summary of the IARC PFOA and PFOS classifications of carcinogenicity from December 2023 which, in summary, concluded;

PFOA ***carcinogenic to humans*** **(Group 1)** on the basis of:

- *sufficient* evidence for an association between PFOA and cancer in experimental animals
- *strong* mechanistic evidence that PFOA exhibits key characteristics of carcinogens in exposed humans
- There was limited evidence in humans for cancer of the testis and for renal cell carcinoma.

PFOS ***possibly carcinogenic to humans*** **(Group 2B)** on the basis of

- limited evidence for cancer in experimental animals
- strong mechanistic evidence
- There was inadequate evidence for cancer in humans for PFOS.

Details are summarised on the IARC website and Lancet Oncology article found at [Carcinogenicity of perfluorooctanoic acid and perfluorooctanesulfonic acid - The Lancet Oncology]

In conclusion

There is suggestive evidence of mixed AFFF being associated with several cancers however, none are strongly statistically significant. There is supportive evidence for

PFOA for kidney and testicular cancer from other studies but the evidence is inadequate for PFOS. There is no data at all for cancers and PFHxS.
The Panel will summarise the evidence for all health concerns raised with them by Islanders.

The Chair commented that it could be impossible to establish if there is an increased risk of very rare cancers from PFAS as there may not be enough cases to show a statistical difference. It is also difficult to prove this in just a small increase in the number of cases. There could be risks in other cancers from PFAS exposure, although the research is not yet available.

The Chair gave a health example of smoking regarding population data, where you are twice as likely to get heart disease if you smoke, however, heart disease is very common in the wider population. Therefore, separating the causal factors from other factors presents some challenges. The Panel acknowledged the difficulty of attributing specific cancers to PFAS in a small population such as Jersey, and recognised there was still more research needed.

Dr Fletcher was thanked for his presentation.

Environmental Contamination and Mental Health
The Chair gave a presentation on environmental contamination and mental health, a summary of which is below:

A variety of sources were explored for the evidence review. The evidence on mental health and environmental contamination was particularly limited to 23 research papers.

The research focussed on psychological distress and somatisation, which is when a person has physical symptoms in response to a psychological stress. The most interesting study was from Australia on PFAS exposed population with AFFF, and the population's wellbeing was compared to other non-exposed communities. Psychological distress, somatisation and anxiety were higher in the exposed community in this research. Additionally, the research looked at serum concentrations and found that there was not a dose-response relationship between PFAS exposure and blood concentrations, which suggests that the higher levels of distress are likely to be caused by the psychological impact rather than the direct chemical effect on the body.

Reference: Health and social concerns about living in three communities affected by per- and polyfluoroalkyl substances (PFAS): A qualitative study in Australia | PLOS ONE

Depression
A large study in the Netherlands looked at characteristics of neighbourhoods, including pollution, on rates of depression. Depression was associated with pollution in both working and resident populations. However, it was difficult to know how much of this relationship is due to other characteristics, such as poverty which can also have an impact on rate of depression.

Perinatal mental health (depression or anxiety in pregnancy or after giving birth)
There was a Californian study which found that there was an increase in perinatal depression among women exposed to PFAS, especially non-US born mothers. However, this was a small study so it is not appropriate to draw strong conclusions.

In a study from China, researchers found an association between PFAS exposure and postpartum depression in twin pregnancies. Also, a further study looked at postpartum depression in a range of other substances, but not with PFAS.

Stress and post traumatic stress

There are several papers exploring stress, and the strongest findings were found from a Dutch depression study that found pollution was strongly associated with stress. One review found some evidence of symptoms consistent with PTSD *(post-traumatic stress disorder),* however it was not clear that these were PTSD specific or symptoms of depression and anxiety, which are both features of PTSD.

Qualitative findings

In the Australian study described above, the researchers undertook focus groups to find out what factors were responsible for the increased stress levels.

Key findings included:

- Mistrust of the measurements provided by the military and people did not trust the water treatment was taking place, nor did they trust the Government advice about irrigation and livestock
- There was uncertainty about disease attributability (i.e. would it have happened anyway?) There is also contradictory scientific literature, with thousands of papers, so people were unsure of the facts
- There were feelings of guilt for example parents feeling guilty that their children had been exposed
- Health anxiety, with people thinking will they get better or worse
- A financial anxiety, for example, could their health impact their ability to work
- A stigma at a community level, is the area seen as blighted
- Lack of agreement on what to do to help or improve the situation

In summary, there was less research than the Chair expected about mental health due to environmental contamination. There is reasonable evidence for psychological distress, stress, anxiety, and somatisation in areas of environmental contamination. There is some weaker evidence for depression, perinatal depression, and a potential indication in PTSD however, the evidence was not found to be clear.

The Chair asked if there were questions.

Tony Fletcher commented on the research on risk perception and what it is that underlies people's perception of risk which may be useful to review. Both Tony and Ian were familiar with the Australian case and the subsequent legal cases.

The Panel acknowledged that people in these situations could be stressed and anxious and referenced cases in Australia and in Liverpool *(River Mersey contamination)*.

The Chair commented that the papers found with a link but not relevant to this review would also be explored. The Panel agreed this was thought provoking and needed to be factored into the work in Jersey.

Any other business

There was no other business.

Date of next meeting
17 April 2024 *at 10.00am.*

The Chair thanked everyone for attending and reminded people they can request the meeting recording.

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)