Introduction
Groundwater contamination near some Defence establishments is being associated with the use of chemical substances for fire-fighting preparedness at those sites. The following information is provided for reference.

What are Aqueous Film Forming Foams (AFFFs)?
AFFFs are water-based fire fighting foam products used to suppress flammable liquid fires by cooling the fire and coating the fuel, preventing its contact with oxygen.

What do the terms PERFLUOROALKYLS, PFOA, PFOS and PFAS mean?
Perfluoroalkyls are a class of stable chemical substances containing carbon and fluorine in chemically combined form. These substances are unique because they repel oil, grease, and water.

PFOA (also known as perfluorooctanoic acid) and PFOS (also known as perfluorooctane sulfonate) are examples of perfluoroalkyls.

Perfluorinated chemical substances, previously known as PFCs, are now referred to as ‘per- and poly-fluoroalkyl substances’, or PFAS. Perfluorooctanoic acid (PFOA), perfluorooctane sulfonate (PFOS) and perfluorohexane sulfonate (PFHxS) belong to this group of chemical substance.

PFAS are a class of stable man-made chemical substances containing carbon and fluorine in chemically combined form.

What substances do AFFF products contain?
AFFF products contain mixtures of different chemical substances. These chemical substances include perfluoroalkyls such as PFOA and PFOS, surfactants, solvents, foam stabilisers and corrosion inhibitors.

Surfactants, or surface-active agents, are chemical substances that can act as detergents, wetting agents, emulsifiers, foaming agents, and dispersants.

Fire fighting services throughout Australia and the world used fire-fighting foams containing high levels of PFOS and PFOA from the early 1970s until the late 2000s, due to their lifesaving effectiveness in rapidly extinguishing chemical aviation fires.
Do other products contain perfluoroalkyls such as PFOS and PFOA?

Perfluoroalkyls have been used in surface protection products such as carpet and clothing treatments and coatings for paper and cardboard packaging. As previously noted, perfluoroalkyls have also been used in fire-fighting foams.

PFOA has been used industrially in the manufacture of polytetrafluoroethylene (PTFE), which is used in some non-stick cookware. PTFE is not chemically the same as PFOA.

Many of the perfluoroalkyls that have been used in the above applications have been replaced with other substances which do not accumulate in the environment.

How do Perfluoroalkyls such as PFOA get into the environment?

Perfluoroalkyls are not found naturally in the environment, but are there because of the action of humans. Perfluoroalkyls such as PFOA can be released into the environment when facilities and people use products that contain them. Perfluoroalkyls such as PFOA have been released into the environment near facilities that made or used these substances, and in many cases, have contaminated the groundwater. These types of releases appear to be decreasing based on reports provided by these facilities.

Perfluoroalkyls may be formed in the environment when other related chemicals degrade. Perfluoroalkyls break down very slowly in air, but are expected to fall out of the air to the ground within days to weeks. Perfluoroalkyls are very stable in water and are not known to break down in water. These chemicals may be carried over great distances by ocean currents.

Perfluoroalkyls are also not known to break down in soil. These substances may be carried through soil by groundwater.

How could exposure to Fluoroalkyls such as PFOA occur?

Consumer products - Perfluoroalkyls have been widely used in many consumer products. The presence of these substances in carpet treatments could be an important source of exposure to perfluoroalkyls, especially for children.

Air - Perfluoroalkyls have been found in both air and dust. People may be exposed to perfluoroalkyls by breathing air containing these substances. Ingestion of dust may also be a source of exposure.

Water and soil - Perfluoroalkyls such as PFOA have been found in surface water, groundwater, soil, and sediment, especially near facilities that have made or used these substances. They have also been found at remote locations such as the Arctic and the open ocean. In one reported case, drinking water contaminated with PFOA released from a nearby fluorochemical facility was found to be a major source of exposure to that substance.

Perfluoroalkyls have also been detected in bird eggs, fish, polar bears, and top predators.

Food and human breast milk - In addition to drinking water, food is a potential source of exposure to perfluoroalkyls, most notably fish.

Human breast milk may contribute to the exposure of infants to perfluoroalkyls since these substances have been detected in human breast milk in some studies.

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Workplace - People who work where perfluoroalkyls are manufactured or used in their raw form may be exposed to these substances. Levels of PFOS and PFOA measured in the blood of some people who have worked at these locations were much higher than levels in people from the same communities who did not work at these locations.

People who work with products that contain perfluoroalkyls may be exposed to these substances. Some historical formulations of AFFFs used by Defence from the 1970s to the 2000s used to include perfluoroalkyls such as PFOS and PFOA. Any assessment of the risk of exposure to PFOS and PFOA through working with AFFFs should consider the routes by which perfluoroalkyls can enter the body, noting that ingestion (swallowing) is understood to be the primary mode of exposure, rather than exposure through skin contact.

How can perfluoroalkyls enter and leave the body?

Entering the body:

- **Inhalation** - When air containing perfluoroalkyl compounds is breathed in, some will enter the body through the lungs, but there is limited information on how fast, how much, or what specific perfluoroalkyl may preferentially enter the body.

- **Ingestion** - Perfluoroalkyl compounds such as PFOA/PFOS in food or water may enter the body through the digestive tract.

- **Dermal contact** - If the skin comes into contact with dusts or aerosols of perfluoroalkyl, or with liquids containing perfluoroalkyls, it is possible that a small amount may enter the body through the skin. Dermal absorption is poor and is not a major pathway for intake of these chemicals.

Leaving the body:

- Once in the body, perfluoroalkyls tend to remain unchanged for long periods of time. The most commonly used perfluoroalkyls (PFOA and PFOS) stay in the body for many years. It takes approximately 4 years for the level in the body to go down by half (the ‘half-life’), even if no more is taken in. It appears that, in general, the shorter the carbon-chain length, the faster the perfluoroalkyls leave the body.

- Estimates of half-lives in humans PFOS and PFOA range from 2 to 9 years, depending on the study. It takes approximately 2 to 9 years for the level in the body to go down by half (the ‘half-life’), even if no more is taken in.

How could perfluoroalkyls such as PFOA and PFOS affect health?

**Workforce** - Long-term inhalation or skin exposure to perfluoroalkyls at work has not been shown to cause significant adverse health effects.

**General population** - PFOA, PFOS and other perfluoroalkyls are measurable in the blood serum of most Australian and US citizens. However, limited human research has been done on the general population to determine if perfluoroalkyls can cause adverse health effects. There have been studies on communities exposed to PFOA in the drinking water. It is difficult to interpret the results of these studies because they are not consistent, as some studies have found associations between levels of perfluoroalkyls in the blood and a health effect, while other studies looking at the same health effect have not found these associations. It is also important to note that an association is not the same as causation.
Laboratory animals - Tests with laboratory animals that inhaled perfluoroalkyls caused effects ranging from eye and nose irritation to liver damage and weight loss. High-dose feeding of perfluoroalkyls to laboratory animals caused some liver changes. Short-term application of large amounts of PFOA and PFOS to the skin of animals caused skin irritation and some liver changes.

Cancer - The available population health data do not prove that perfluoroalkyls cause cancer in humans. Feeding PFOA and PFOS in high doses to rats caused them to develop tumours, but these studies cannot be directly applied to the humans, due to the species differences between rats and humans. More research is needed to clarify this issue.

The International Agency for Research on Cancer (IARC) has recently evaluated PFOA. Based on limited evidence for carcinogenicity in animals, together with limited evidence for carcinogenicity in humans, IARC has classified PFOA as possibly carcinogenic to humans (Group 2B). IARC has not published any determination at this stage for PFOS.

Children. A US study showed no short-term adverse effects due to PFOA, but the highest levels of PFOA in blood were for young children and older adults.

Human breast milk. Perfluoroalkyls have been found in human breast milk, but there are no studies that looked at whether the health of the babies was affected by drinking this milk. US data indicates that levels of perfluoroalkyls in breast milk are much lower than in the mother’s blood, indicating that perfluoroalkyls are not concentrated into breast milk.

Is there a medical test to determine whether a person has been exposed to perfluoroalkyls such as PFOA and PFOS?

Perfluoroalkyl compounds can be measured in blood by specialist laboratories however the accuracy of these levels requires further refinement. As most people in the community have background levels of these chemicals in their blood the concept of persons getting reassurance from a zero level is not viable.

The presence of perfluoroalkyl compounds in the blood does not necessarily mean that there will be adverse health effects. Neither does a level equate to a particular health management approach.

A low level reading can lead to anxiety and therefore have a negative impact.

For these reasons blood testing is generally not recommended by Defence.

What are the regulatory requirements for Perfluoroalkyls such as PFOA and PFOS?

There are no established regulatory control measures in place in Australia for these products.

Various drinking water health advisory standards have been established in the United States. The US Environmental Protection Agency (EPA) provisional health advisory values for drinking water are 0.2 µg/L for PFOS and 0.4 µg/L for PFOA. In the absence of Australian regulatory values, Defence has adopted the USEPA provisional health advisory values.
First Aid and Emergency Treatment

People who believe that they have been exposed to high levels of perfluoroalkyls should seek medical advice. If there are any immediate symptoms after exposure to a product containing perfluoroalkyls, seek medical attention.

Other information

All AFFF products used in Defence must meet and be used in accordance with the requirements of the Work Health and Safety Act 2011 and the Work Health and Safety Regulations 2011, WHS Manual and Defence WHS policy. Products must be classified in accordance with the Globally Harmonized System of Classification and Labelling of Chemicals (GHS). Safety Data Sheets for all chemical-based products used in Defence are required to be included in ChemAlert.

AFFF products currently in use in Defence are essentially free of PFOS and PFOA, but trace levels may remain in some formulations. A new AFFF Procurement and Use Policy is being developed by Defence which will inform the product “approval” process from an environmental perspective.

Technical Information

- Per-and poly-fluorinated alkyl substances (PFASs) [Department of Health, National Industrial Chemicals Notification and Assessment Scheme] - https://www.nicnas.gov.au/chemical-information/factsheets/chemical-name/perfluorinated-chemicals-pfcs
- United States Environmental Protection Agency - PFASs in Your Environment - https://www.epa.gov/pfas