PFAS in Plants – 2017 Study Findings
Army Aviation Centre Oakey Stage 2C Environmental Investigation
PFAS Investigation and Management Program

Background to the Plant Study

In April 2017, Defence released a Sensitivity Assessment as an addendum to the Human Health Risk Assessment (HHRA) completed in 2016 to better understand the potential risks posed by per- and poly-fluoroalkyl substances (PFAS) to people in the Oakey Investigation Area.

The Sensitivity Assessment suggested additional precautions that residents living in the Oakey Investigation Area could follow to minimise PFAS exposure (as recommended by Queensland Health). These recommendations included minimising the consumption of home grown vegetables irrigated with PFAS-impacted water, or grown in soil irrigated with PFAS-impacted water until further data could be collected.

To inform the 2017 HHRA and contribute to addressing data gaps identified in the 2016 HHRA, a study was undertaken to better understand the PFAS concentrations that might be present in home grown fruit and vegetables irrigated with water containing a range of PFAS concentrations.

The study aimed to:

- refine the exposure concentrations to estimate potential exposure risks to people in the Oakey and Williamtown HHRAs;
- inform potential HHRAs at other Defence sites; and
- support Government to provide advice to the local community about irrigating with groundwater and consuming edible home grown plants.

Study Methodology

The study involved a 120-day greenhouse trial where seven targeted plant species, including fruit and vegetables, were grown in four greenhouses under specific conditions. The plants were irrigated with water containing different concentrations of PFAS, including PFAS-impacted groundwater from the Investigation Areas at Oakey and Williamtown.

The types of PFAS targeted in the study were:

- Perfluorooctane sulfonate (PFOS),
- Perfluorooctanoic acid (PFOA),
- Perfluorohexane sulfonate (PFHxS), and
- Perfluorohexanoic acid (PFHxA)

The seven plant species used in the study were:

- Alfalfa
- Beet
- Cucumber
- Tomato
- Radish
- Lettuce
- Strawberry

The plants in the study were irrigated with doses of water that contained different concentrations (doses) of PFAS. Together with water extracted from the Investigation Areas at Oakey and Williamtown, there were six different dosage groups used in the four greenhouses. Each dosage group contained six replicate pots of each of the seven plant species.

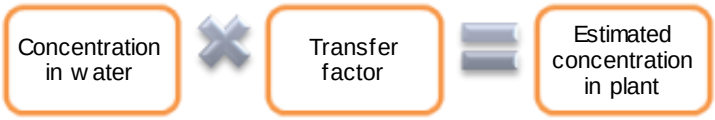
Table 1: Dosage groups

Greenhouse	Dosage group (PFAS concentration in irrigation water)
Greenhouse 1 (control)	PFAS-free groundwater (i.e. no detectable PFAS) pumped from a regional groundwater extraction bore in the Newcastle area and transported to RAAF Base Williamtown
Greenhouse 2	1 microgram per litre (µg/L) – PFHxS, PFOS, PFHxA and PFOA
	10 µg/L – PFHxS, PFOS, PFHxA and PFOA
Greenhouse 3	100 µg /L – PFHxS, PFOS, PFHxA and PFOA
Greenhouse 4 ("Real World Trials")	PFAS-impacted groundwater from Oakey Investigation Area (37 µg/L total PFAS concentration)
	PFAS-impacted groundwater from Williamtown NSW EPA Investigation Area (138 µg/L total PFAS concentration)

Transfer factors

The study aimed to develop PFAS transfer factors, to better understand the potential for PFAS in irrigation water to accumulate in plant tissue.

The diagram below represents how transfer factors are used to estimate the concentration of a substance in a plant, based on the concentration in the irrigation water.



Key findings

The study successfully developed transfer factors for the four targeted PFAS in the plant species outlined in Table 2.

Table 2: Transfer factors from study used in HHRA

Plant	Average Transfer Factor from water to edible parts (mg PFAS/ kg plant tissue per mg PFAS/ L water)			
	PFOS	PFOA	PFHxS	PFHxA
Leafy Green Vegetables				
Alfalfa	0.8	2.6	4.0	25.5
Beet	1.2	8.2	6.9	22.4
Lettuce	0.9	1.9	1.4	4.0
Radish Leaf	8.1	9.7	5.3	13.8
Root Vegetables				
Radish root	1.5	2.3	1.3	1.2

The study did not yield sufficient data to develop transfer factors for fruit.

Influencing factors

The study found that a number of variables can influence the uptake of PFAS into plant tissue, including:

- *PFAS concentration* – the higher the concentrations of PFAS in water, the higher the uptake into the plant tissue.
- *Plant type* – Uptake of PFAS into leafy green vegetables is typically greater than uptake into fruit. Although transfer factors could not be developed, samples of fruit taken during the study had lower concentrations of the four targeted PFAS than vegetables. This finding was consistent with other published plant uptake studies. The plant species studied varied in the rate at which they accumulate PFAS.
- *Water quality* – Published literature has indicated that the pH, salinity and temperature of the irrigation water can affect plant PFAS uptake. In this study, the uptake of PFAS into plants irrigated with salty water was lower than in plants irrigated with fresh water.
- *Soil type* – The study used a single soil type, with low clay content and low organic matter content. Soils with higher clay and organic matter content could be expected to have lower transfer factors.

Other variables that were observed to influence the uptake of PFAS in plants included the carbon chain length of the particular PFAS, the specific chemical structure of each PFAS (functional group) and the mixture of different types of PFAS in the irrigation water.

The plants in the study were only irrigated with PFAS-contaminated water, which is likely to result in greater PFAS uptake than for plants in a home garden setting that also receive rainfall.

Outcomes

The findings of this study have contributed to addressing data gaps in the 2016 HHRA and informed the development of the 2017 HHRA. The findings of this study will also be combined with site-specific information to complete future HHRAs at other Defence sites.

Contact the Investigation Project Team

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