



PATTLE DELAMORE PARTNERS LTD

NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage D

New Zealand Defence Force



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Executive Summary

This report documents Stage D of a sampling investigation undertaken on private properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea ('the site') for the New Zealand Defence Force (NZDF) to investigate the potential for contamination relating to the use of per- and poly-fluoroalkyl substances (PFAS) at the site.

The surface water and groundwater investigation areas did not change significantly from Stage C. A slightly lower number of surface water samples were analysed (39 in Stage C versus 30 in Stage D). Some bores were unable to be resampled; therefore the overall number of groundwater samples was slightly less than Stage C (70 in Stage C versus 65 in Stage D).

In addition to groundwater and surface water sampling, the Stage D investigation scope included sampling and analysis of soil and eggs. Summaries of Stage A, Stage B and Stage C are provided in previous reports (PDP, 2018a; PDP 2018b; PDP 2018c).

Groundwater

Groundwater sampling was undertaken over one week, from 10 September to 14 September, 2018. Based on bore use information provided by the landowners, 22 of the sample locations are currently or potentially used for potable (drinking) water supply.

Of the 65 groundwater samples collected:

- ∴ PFAS¹ compounds reported in 29 samples.
- ∴ Fourteen samples exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017). These bores are no longer, or have never been, used for potable supply and NZDF has installed rain water tanks at some of these properties where groundwater was identified as the primary drinking water source.
- ∴ Two samples exceeded the recreational water quality guideline for the sum of total PFOS + PFHxS.

For the Stage D results:

- ∴ Fourteen samples exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption. This screening value is also applicable to home-grown sheep meat consumption.

¹ For the purposes of this report PFAS refers to the following compounds only: perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulphonate (PFHxS).

- ∴ Twelve samples exceeded the Stock Watering Only SV for home-grown beef consumption. This screening value is also applicable to home-grown sheep consumption.
- ∴ Eighteen samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Fifteen samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Eleven samples exceeded the Stock Watering Only SV for home-grown egg consumption.

Based on the above results, there has been no change to the site specific advice given by the Ministry for Primary Industries (MPI) to landowners where groundwater samples exceeded the screening values developed by EnRisks (2017) for stock watering.

Comparing Stage D groundwater results to those collected from the same location during Stage C:

- ∴ Samples from 17 locations show decreased total PFOS + PFHxS concentrations (Median drop = 21% | Median absolute drop = 0.021 µg/L);
- ∴ Samples from 11 locations show increased total PFOS + PFHxS concentrations (Median rise = 30% | Median absolute rise = 0.006 µg/L);
- ∴ Samples from 34 locations show no change (i.e. concentration has not changed or has remained less than the limit of reporting (LOR));
- ∴ Nine sites were not re-sampled.

Surface Water

A total of 30 surface water samples were collected from stream and pond locations (compared to 39 samples collected during Stage C).

Of the 30 surface water samples collected:

- ∴ PFAS compounds were reported in 24 surface water samples.
- ∴ Two samples exceeded the recreational water quality guideline, however water from these locations is not used for recreational purposes.
- ∴ Twenty-three surface water samples exceeded the Stock Watering and Fodder Irrigation SV variously for home-grown beef, milk and/or eggs. Of these samples, eight sites indicated water use for stock.

Soil

Of the 16 soil samples collected:

- ∴ Two soil samples exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS, however there are no residential dwellings in the vicinity of these samples.
- ∴ No soil samples exceed the public open space human health screening value for the sum of total PFOS + PFHxS or for PFOA.

Egg Samples

Seven chicken egg samples were collected. PFAS compounds, including total PFOS + PFHxS, were detected at concentrations above the LOR in all samples. Five samples contained concentrations of total PFOS + PFHxS at or slightly above the Food Standards Australia New Zealand (FSANZ) trigger point value. Based on these results, MPI has provided updated advice to the owner of the chickens to limit consumption of home-grown eggs from chickens on this property.

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1.0 Introduction

Pattle Delamore Partners Ltd (PDP), in conjunction with a number of other Environmental Consultancies, has been engaged by the New Zealand Defence Force (NZDF) to undertake an external sampling campaign to investigate the potential for surface water and groundwater contamination by the use of per- and poly-fluoroalkyl substances (PFAS) at properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Ohakea.

Stage A, Stage B and Stage C sample results, from sampling undertaken in December 2017, February/March 2018 and May 2018 respectively, have been reported in previous Summary Reports (PDP, 2018a; PDP, 2018b; PDP, 2018c).

The surface water and groundwater investigation areas did not change significantly from Stage C. A slightly lower number of surface water samples were analysed (39 in Stage C versus 30 in Stage D). Some bores were unable to be resampled due to faulty pumps and/or dry conditions; therefore the overall number of bore samples was slightly less than Stage C (70 in Stage C versus 65 in Stage D).

In addition to groundwater and surface water sampling, the Stage D investigation scope included sampling and analysis of soil and chicken eggs. Summaries of Stage A, Stage B and Stage C are provided in previous reports (PDP, 2018a; PDP 2018b; PDP 2018c).

Soil samples were collected during Stage D from a number of properties where overland flow and/or flooding of streams and drains have occurred.

In summary, Stage D sampling has involved:

- ∴ Repeat sampling of most locations sampled during Stage A, Stage B and Stage C;
- ∴ Shallow soil sampling at select locations to further delineate areas of soil containing PFAS identified during Stage C sampling or where overland flow/flooding has been identified; and
- ∴ Sampling of chicken eggs, from a property where previous sampling in Stage C had shown elevated concentrations of PFAS in eggs.

The Stage D sample results for landowners of properties adjacent to RNZAF Base Ohakea have been reported in individual landowner reports, with recommendations regarding ongoing use of the water provided in those reports.

This summary report provides a summary of the Stage D sampling results in the context of the entire investigation area.

1.1 Project Objectives

The key project objectives for this sampling investigation were:

- ∴ To assess groundwater and surface water from sites adjacent to Base Ohakea and determine if PFAS compounds are present;
- ∴ To compare the concentrations of PFAS compounds present against interim drinking water guideline values and applicable screening values;
- ∴ To assess whether PFAS compounds are present in other sample media from sites adjacent to Base Ohakea where applicable; and
- ∴ Provide further data to update preliminary estimates of PFAS plume extent in groundwater made following Stage A, Stage B and Stage C sampling.

1.2 Scope of Summary Report

The scope of this report involved:

- ∴ Collecting representative samples of groundwater, surface water, soil, and chicken eggs from adjacent sites and analyses of these samples for PFAS.
- ∴ Comparison of the laboratory results to guideline and screening value criteria (where available).
- ∴ Update of the estimated extent of the shallow groundwater plume with the new results.

2.0 Background

PFAS compounds, such as perfluorooctane sulfonate (PFOS), perfluorohexane sulphonate (PFHxS) and perfluorooctanoic acid (PFOA) are a group of manufactured chemicals used since the 1950s. PFAS are used in a wide range of industrial and commercial products including aqueous film forming foam (AFFF) used for fighting fuel fires. Recently PFAS have gained increasing scientific and regulatory interest due to their widespread use, their environmental persistence and because some PFAS (primarily PFOS and PFOA) display bioaccumulative and toxic properties to humans and wildlife (CONCAWE, 2016).

PFAS are considered to be emerging contaminants. NZDF is investigating the potential for contamination of ground and water associated with the use and storage of products including AFFF containing PFAS at its camps and bases. Investigations at Ohakea have identified PFAS in the soil and water on the base.

Ohakea is surrounded by pastoral land predominantly used for grazing cattle and dairy farming. Shallow (and deep) groundwater is used relatively extensively on properties surrounding the base for water supply. A description of the geology and hydrogeology for the area is contained within Appendix A.

3.0 Methodology

Sampling was undertaken in groundwater supply bores and in surface water at selected locations adjacent to the base following the methodology outlined in the *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force* (PDP, 2018d) and the guidance documents referenced therein.

Soil sampling was undertaken following the procedures outlined in *Sampling and Analysis Plan for Protocols for Polyfluorinated Compounds at RNZAF Ohakea* (PDP, 2018e).

Sampling of chicken eggs was undertaken following procedures developed by PDP.

Stage D Sampling was completed over one week, from 10 September to 14 September, 2018. All samples were sent toASUREQuality laboratories, Wellington under standard chain of custody procedures and were analysed for their PFAS suite.

4.0 Guidelines and Screening Values

The interim guidelines for drinking water and recreational water quality currently used in New Zealand to compare with the water sample data collected during this project are presented in Table 1 along with additional screening criteria that have been prepared by NZDF consultants EnRisks. The screening criteria have been developed for water and soil and apply to animals/products grown and consumed at home (home-grown produce). The soil guidelines used during this project are presented in Table 2.

Egg samples are compared to the Food Standards Australia New Zealand's (FSANZ) trigger points (for further investigation); these are provided in Table 3.

Guidelines are provided for three PFAS compounds only (PFOS, PFHxS and PFOA). These compounds are known to be associated with certain types of AFFF, and they are currently the only compounds for which suitable guidelines are available. Results for the full analytical suite of 28 PFAS are available in the laboratory reports. These are provided in a separate electronic file.

Table 1: Environmental and Human Health Guidelines – Water					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Drinking Water	0.07 µg/L	0.56 µg/L	-	-	MoH ¹ , AGDoH ²
Recreational Water	0.7 µg/L	5.6 µg/L	-	-	AGDoH ²
Stock Watering Only (home grown consumption)	-	Beef 150 µg/L	Beef 0.1 µg/L	Beef 0.1 µg/L	EnRisks ³
	-	Milk 30 µg/L	Milk 0.02 µg/L	Milk 0.02 µg/L	
	-	Eggs 4 µg/L	Eggs 0.2 µg/L	Eggs 0.09 µg/L	
Stock Watering and Fodder Irrigation (home grown consumption)	-	Beef 60 µg/L	Beef 0.06 µg/L	Beef 0.05 µg/L	EnRisks ³
	-	Milk 14 µg/L	Milk 0.008 µg/L	Milk 0.008 µg/L	
<p>Notes:</p> <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. Screening values calculated using a scenario of 10% of the tolerable daily intake. This is the most conservative scenario developed. 					

Table 2: Environmental and Human Health Trigger Values – Soil					
Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Soil (residential 10% with garden / accessible soil)	9 µg/kg	100 µg/kg	-	-	HEPA ^{1, 2}
Soil (public open space)	1,000 µg/kg	10,000 µg/kg	-	-	HEPA ^{1, 3}
<p>Notes:</p> <ol style="list-style-type: none"> 1. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018. 2. Assumes home-grown produce providing up to 10% of fruit and vegetable intake (no poultry). Does not include home-grown poultry/egg. 3. Assumes public open space such as parks, playgrounds, playing fields, secondary schools and footpaths. 					

Table 3: Human Health Trigger Points for Investigation – Plant and Animal Tissue

Media	Sum of Total PFOS + PFHxS	PFOA	Total PFHxS	Total PFOS	Source
Poultry eggs	11 µg/kg	85 µg/kg	11 µg/kg	11 µg/kg	FSANZ ¹

Notes:

1. Assessment of potential dietary exposure to perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) occurring in foods sampled from contaminated sites – Table 8, Supporting Document 2. Food Standards Australia New Zealand (FSANZ), April 2017.

5.0 Quality Assurance/Quality Control

Due to the very low detection limits of PFAS required for this investigation, a robust quality assurance/quality control (QA/QC) programme was required.

5.1 Project Data Quality Objectives

The project data quality objectives (DQOs) were to:

1. Determine the presence or absence (less than 0.005 µg/L) of PFAS compounds in groundwater from groundwater bores.
2. Determine the presence or absence (less than 0.005 µg/L) of PFAS compounds in surface water.
3. Determine the presence or absence (less than 0.005 mg/kg) of PFAS compounds in soil.
4. Determine the presence or absence (less than 0.5 µg/kg) of PFAS compounds in animal tissue.

To determine if the DQOs were met, the internal QA/QC function ('QAChecker'), in the environmental database software ESdat, was used to calculate relative percent differences between sample duplicates and to check for detections of PFAS in blanks.

The results of the QA/QC check indicate that all samples meet the DQOs. A summary of the QA/QC check is provided in Appendix B. Additional information relating to the QA/QC results can be provided upon request.

5.2 PFAS Concentrations at the Limit of Reporting

Where low detections (sum of total PFHxS + PFOS < 0.005 µg/L) have been reported in groundwater and surface water samples, this may not represent a real presence of PFAS in the sampled water but may reflect uncertainty of measurement or sampling and/or analysis error.

6.0 Results Summary and Comparison to Guidelines

The following were collected during the September sampling round:

- ∴ 65 groundwater samples;
- ∴ 30 surface water samples;
- ∴ 16 soil samples; and
- ∴ Seven egg samples.

6.1 Groundwater

A summary of the groundwater sample results is presented below along with a comparison of the results to the interim drinking water guidelines, the recreational water quality guidelines, and the screening values for stock watering and fodder irrigation developed by EnRisks (2017). Screening values defined for beef would also be conservative for the consumption of home-grown sheep meat (EnRisks, 2017). Currently there is no information of the applicability of these screening values to the consumption of home-grown goat meat or milk.

6.1.1 Drinking Water Guideline

Of the 65 groundwater samples collected:

- ∴ PFAS compounds were detected in 29 samples.
- ∴ Fourteen samples exceeded the interim drinking water guideline for the sum of total PFOS + PFHxS (MoH, 2017).
- ∴ Fifteen samples returned concentrations of the sum of total PFOS + PFHxS above the LOR but below the interim drinking water guideline (MoH, 2017).
- ∴ Thirty-six samples were reported as less than the LOR for the sum of total PFOS + PFHxS.
- ∴ PFOA was reported in 21 samples, however no samples were found to exceed the interim drinking water guideline for PFOA.

6.1.2 Recreational Water Quality, Stock Watering and Fodder Irrigation Screening Values

- ∴ Two of the 65 groundwater samples exceeded the recreational water quality guideline for the sum of total PFOS + PFHxS.
- ∴ Fourteen groundwater samples exceeded the Stock Watering and Fodder Irrigation Screening Value (SV) for home-grown beef consumption.
- ∴ Twelve groundwater samples exceeded the Stock Watering Only SV for home-grown beef consumption.

- ∴ Eighteen groundwater samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Fifteen groundwater samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Eleven groundwater samples exceeded the Stock Watering Only SV for home-grown egg consumption.

6.1.3 Groundwater Results Summary

A summary of the groundwater results compared to the relevant drinking water and the recreational water quality guidelines, and the stock watering and fodder irrigation screening values is provided in Table 4. The number of previous exceedances from Stage C sampling is provided in brackets, 70 samples were collected during Stage C, vs 65 in the current Stage D round. Note that the current and previous exceedances shown in the Tables below are not necessarily for samples from the same locations; therefore a direct comparison between Stage C and Stage D results is not applicable.

Table 4: Guideline and Screening Value Exceedences – Groundwater Samples (n=65)			
Guideline	Number Exceeding the Relevant Guideline	Percent Exceeding the Relevant Guideline	Source
Interim Drinking Water	14 (previously 18)	22% (previously 25%)	MoH ¹ , AGDoH ²
Recreational Water	2 (previously 3)	3% (previously 4%)	AGDoH ²
Site Specific Screening Value – Beef Consumption (home grown)			
Stock Watering and Fodder Irrigation	14 (previously 17)	22% (previously 24%)	EnRisks ³
Stock Watering Only	12 (previously 15)	18% (previously 21%)	EnRisks ³
Site Specific Screening Value – Milk Consumption (home grown)			
Stock Watering and Fodder Irrigation	18 (previously 22)	28% (previously 31%)	EnRisks ³
Stock Watering Only	15 (previously 19)	23% (previously 27%)	EnRisks ³
Site Specific Screening Value – Egg Consumption (home grown)			
Stock Watering Only	11 (previously 12)	17% (previously 17%)	EnRisks ³
Notes: <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. 			

6.2 Surface Water

A summary of the surface water sample results is presented below. Based on information of water use collected during sampling rounds, surface water sampled within the investigation area is not understood to be used for drinking water. Therefore results have been compared to the recreational water quality guideline and the stock watering and fodder irrigation screening values.

6.2.1 Recreational Water Quality, Stock Watering and Fodder Irrigation Screening Values

Of the 30 surface water samples collected:

- ∴ Two surface water samples exceeded the recreational water quality guidelines for the sum of total PFOS + PFHxS.
- ∴ Seventeen surface water samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown beef consumption.
- ∴ Seven surface water samples exceeded the Stock Watering Only SV for home-grown beef consumption.
- ∴ Twenty-three surface water samples exceeded the Stock Watering and Fodder Irrigation SV for home-grown milk consumption.
- ∴ Twenty-two surface water samples exceeded the Stock Watering Only SV for home-grown milk consumption.
- ∴ Seven surface water samples exceeded the Stock Watering Only SV for home-grown egg consumption.

6.2.2 Surface Water Results Summary

A summary of the surface water results compared to the relevant recreational water quality guidelines, stock watering and fodder irrigation screening values, is provided in Table 5. It is noted that changes in the numbers, and percentages of samples found to exceed guideline or screening values must be considered in the context of the difference in the number of surface water samples that were obtained during the Stage D sampling event, compared to the Stage C sampling event (30 in Stage D vs 39 in Stage C). The number of previous exceedances from Stage C sampling is provided in brackets.

Table 5: Guideline and Screening Value Exceedences – Surface Water Samples (n=30)			
Guideline	Number Exceeding the Relevant Guideline	Percent Exceeding the Relevant Guideline	Source
Recreational Water	2 (previously 2)	7% (previously 5%)	AGDoH ²
Site Specific Screening Value – Beef Consumption (home grown)			
Stock Watering and Fodder Irrigation	17 (previously 12)	57% (previously 31%)	EnRisks ³
Stock Watering Only	7 (previously 6)	23% (previously 15%)	EnRisks ³
Site Specific Screening Value – Milk Consumption (home grown)			
Stock Watering and Fodder Irrigation	23 (previously 21)	76% (previously 54%)	EnRisks ³
Stock Watering Only	22 (previously 20)	73% (previously 51%)	EnRisks ³
Site Specific Screening Value – Egg Consumption (home grown)			
Stock Watering Only	7 (previously 5)	23% (previously 13%)	EnRisks ³
Notes: <ol style="list-style-type: none"> 1. Ministry of Health (MoH, 2017) Interim Guidance Level for Drinking Water, PFOA, PFOS and PFHxS. 2. Australian Government Department of Health (AGDoH, 2017) Health Based Guidance Values for PFAS for Use in Site Investigations in Australia. 3. Site specific screening values from Livestock Uptake Modelling and Screening Criteria Development for PFAS. EnRisks, November 2017. 4. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018. 			

6.3 Soil

A summary of the soil sample results is presented below. Soil samples are compared to human health screening values for residential and public open space land uses (guidelines for agricultural land use are not currently available).

6.3.1 Human Health Screening Values

Of the 16 soil samples collected:

- ∴ Two soil samples exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS.

- ∴ No soil samples exceed the residential 10% human health screening value for PFOA.
- ∴ No soil samples exceed the public open space human health screening value for the sum of total PFOS + PFHxS or for PFOA.

Table 6: Screening Value Exceedences – Soil Samples (n=16)		
Human Health Screening Value	Number Exceeding the Relevant Criteria	Source
Soil (residential 10% with garden / accessible soil)	2	HEPA ¹
Soil (public open space)	0	HEPA ¹
Notes: 1. PFAS National Environmental Management Plan. Heads of EPAs Australia and New Zealand (HEPA), January 2018.		

6.4 Egg Samples

Seven chicken egg samples were collected from a single property. The eggs were provided by the landowner, from four chickens living on one property. PFAS compounds were detected at concentrations above the LOR in all samples. Five samples contained concentrations of total PFOS + PFHxS at, or slightly above, the FSANZ trigger point value. Based on the results from Stage D sampling, MPI has provided updated advice to the owner of the chickens to limit consumption of home-grown eggs from chickens on this property.

7.0 Ohakea Groundwater Assessment

The Stage D sample results have been used to produce an interpreted plume extent of total PFOS + PFHxS concentration $\geq 0.05^2$ $\mu\text{g/L}$ within the shallow groundwater system at Ohakea (note that the approach taken for the RNZAF Base Woodbourne investigation was to assess the plume extent above the LOR). The interpreted plume was developed based on the returned groundwater and surface water sample results from this sampling round as well as the previous sampling round. Qualitative use of the previously developed 3D numerical groundwater flow model is also incorporated, primarily in areas where there is a paucity of data (PDP, 2017b).

Of the 65 groundwater bore locations sampled in Stage D, 27 bores have information on bore depth, which has been used to assume a sample depth. Seventeen bores have a depth less than 20 m below ground level (bgl) and 10

² Plume extent is based on estimated extent of concentrations above 0.05 $\mu\text{g/L}$. This value is lower than the interim drinking water guideline to account for uncertainty of measurement.

bores have a recorded depth greater than 20 m bgl. For the remaining 38 bores without depth information, it has been assumed that these samples are from shallow bores <20 m bgl – if conservative to do so. It should be noted that the ‘shallow’ groundwater system at Ohakea as a whole, is considered to extend to ~50 m bgl. Sample depth is a very important aspect for interpreting the results. This is due to the hydrogeological understanding that shallow groundwater is likely to contain higher concentrations of PFAS than deeper groundwater. Surface water is also a very important aspect as there is a significant degree of groundwater – surface water interaction within the Ohakea system.

The results from Stage D have been used to further refine the estimated shallow groundwater plume extent for total PFOS + PFHxS that was developed following completion of Stage A (and refined following completion of Stage B and Stage C).

In summary:

- ∴ The estimated plume extent remains an overall similar shape and area to that produced for the Stage B and Stage C sample data.
- ∴ Surface water monitoring returned concentrations of total PFOS + PFHxS >0.07 µg/L at over 5 km downstream (south-west) from Base Ohakea.
- ∴ A groundwater sample approximately 2.3 km downstream (south-west), is the furthest groundwater sample from the base with a concentration of total PFOS + PFHxS >0.07 µg/L.
- ∴ The southern/south-western extent of the plume i.e. the region between Speedy Rd, Taylor Rd and further south to Makowhai Stream remains uncertain as it is not well delineated by field sampling. There are a number of bore samples, with many showing concentrations <LOR, however the majority of these bores are either deep (>100 m bgl) or of unknown depth. Consequently, uncertainty remains on the shallow groundwater PFAS concentrations in this area. It should be noted however that OHA_GW73 (10 m depth) and OHA_GW65 (27 m depth), which are both located approximately 5 km down-gradient have returned concentrations <LOR for total PFOS + PFHxS in the Stage B, Stage C (for OHA_GW65 only, as OHA_GW73 was not sampled in Stage C because of a faulty pump) and Stage D sampling round; and this is providing some delineation of plume extent in the south to south-west direction.
- ∴ The eastern extent of the plume remains relatively unchanged. Previously it has been noted that this particular area (near OHA_GW33 and OHA_GW71) appears to be somewhat dynamic and concentrations are altering seasonally and/or due to surface water flow volume variations at the time of sampling. However, the current results indicate the plume area is similar to that estimated from the Stage C data, and there is some level of delineation in this direction from the available field data.

- ∴ The western extent of the plume remains essentially unchanged from the Stage A and Stage B estimate i.e. does not extend across (west of) the Rangitikei River. Samples from the Rangitikei River were sampled in Stage D and returned results below the LOR. As previously reported, there remains a paucity of field data for much of the interpreted western extent and consequently the actual plume may differ significantly in this direction. Further data is required to provide further delineation in this direction.
- ∴ The northern-north eastern extent of the plume has, for the time being, remained unchanged from previous plume estimates, and no new field data has become available to provide any further delineation in this direction.
- ∴ Detectable concentrations of PFAS within four shallow bores used for the Bulls township water supply across (north of) the Rangitikei River have been observed within the Stage B, Stage C and Stage D monitoring results. The source area for these is not thought to be related to Base Ohakea and is subject to a separate investigation.
- ∴ Surface water samples SW14, SW17, SW18, and SW19 (which are all 'ponds' with no permanent surface inflow or outflow route) remain at generally similar concentration to that of all previous sample rounds. The source /source area for these remains undetermined. Concentrations in these ponds are higher than expected, and overall not in keeping with the concentrations of nearby, up-gradient shallow groundwater and surface water samples.

Summary statistics for off-site sample locations of the Stage C (May 2018) and Stage D (September 2018) monitoring rounds are provided below:

For groundwater samples only:

- ∴ Samples from 17 locations show decreased total PFOS + PFHxS concentrations (Median drop = 21% | Median absolute drop = 0.021 µg/L);
- ∴ Samples from 11 locations show increased total PFOS + PFHxS concentrations (Median rise = 30% | Median absolute rise = 0.006 µg/L);
- ∴ Samples from 34 locations show no change (i.e. concentration has not changed or has remained less than the limit of reporting (LOR));
- ∴ Nine sites were not re-sampled.

Two bores that were previously above the drinking water guideline for total PFOS + PFHxS, measured below the guideline in Stage D. Both of these bores have decreased in concentration by approximately an order of magnitude.

8.0 Discussion

This section discusses groundwater, surface water and soil results. With respect to egg samples, MPI has reviewed the results and has provided updated specific advice to the owner to limit the consumption of eggs from chickens on this property. They are not discussed further below.

8.1 Groundwater Users

8.1.1 Drinking Water

Results from this surface water and groundwater sampling investigation indicate that the 'plume' of PFAS contaminated groundwater (i.e. based on results $>0.05 \mu\text{g/L}$) extends for a distance 5 km from the boundary of Base Ohakea in a general south to south west direction with no significant change in extent between sampling stages.

Based on information gathered during this investigation, 22 groundwater bores have been confirmed as being used or potentially used for drinking/potable water supply. A further seven groundwater bores were previously used for drinking water or were used as back-up supplies (i.e. to top up rainwater tanks when running low).

The seven bores that were previously used for drinking water supply reported concentrations of total PFOS + PFHxS exceeding the interim drinking water guideline. These bores are no longer used for potable supply and NZDF has installed five rain water tanks at these properties to provide a long-term source of drinking water.

Seven bores used for potable supply reported concentrations of total PFOS + PFHxS above the LOR, but below the drinking water guideline. These bores are located to the north and west of Base Ohakea.

Fifteen bores used for potable supply reported concentrations of total PFOS + PFHxS below the LOR. These bores are located to the west and southwest of the site. As with previous sampling rounds, a deeper bore (57 m deep) located approximately 800 m to the west of the Base did not contain PFAS at reportable concentrations, despite being approximately 400 m down gradient of a number of bores with concentrations of PFAS above the drinking water guideline.

8.1.2 Recreational Water Quality, Stock Watering and Fodder Irrigation

Sample results have been compared to the recreational water quality guidelines (AGDoH, 2017) and the site specific screening values (EnRisks, 2017) (refer Table 1). The EnRisk screening values are used to assess the risk of on-farm consumption of farm grown products (e.g. homekill) only (which are assumed to drink groundwater), which is a more conservative exposure pathway given the potential for consumption of larger quantities of beef, milk or eggs from a single

animal. These screening values are not relevant for produce supplied to the general market. Screening values defined for beef would also be conservative for the consumption of sheep meat (EnRisks, 2017).

Two samples exceeded the recreational water quality guideline for the sum of PFOS + PFHxS. However neither of these is likely to be used for recreational purposes.

Eighteen samples exceeded the screening value for home-grown milk consumption and fourteen samples exceeded the screening value for home-grown beef consumption. Of these samples, 11 sites indicated water use for stock and two indicated water use for stock and irrigation.

Eleven samples exceeded the screening value for home-grown eggs. One of these sites indicated water was previously used for chickens, however after advice following the Stage B sampling round, this water is no longer used for chickens.

8.1.3 Site Specific Advice from MPI

Following the results of the Stage A sampling, MPI provided independent site specific advice to landowners of 16 bores located on twelve properties where concentrations of PFAS in groundwater were found to exceed some or all of the screening values developed by EnRisks. Based on the results of subsequent monitoring stages, there has been no change in the advice given to these landowners.

Fourteen of the bores MPI provided specific advice for in Stage A are included in the samples discussed above in Section 8.1.2.

8.2 Surface Water Users

PFAS compounds have been reported in 24 of the 30 surface water samples collected. Two of these samples exceeded the recreational water quality guideline for the sum of PFOS + PFHxS. However water from these sites was not indicated as being used for recreational purposes. Twenty-three samples exceeded the screening value for home-grown milk consumption and seventeen samples exceeded the screening value for home-grown beef consumption. Of these samples, eight sites indicated water is sometimes used for stock. It is noted that there are no properties which rely on surface water as a primary stock water drinking source.

In general, the surface water samples are located on streams that have been identified as the receiving environment for the main stormwater discharge points for Base Ohakea.

8.3 Soil

PFAS compounds were reported in seven of the sixteen soil samples collected. Two of these samples exceeded the residential 10% human health screening value for the sum of total PFOS + PFHxS; however there are currently no residential dwellings in the vicinity of these samples.

8.4 Results Interpretation Limitations

Due to their physicochemical properties, the fate and transport of PFAS is complicated and poorly understood. As such, extrapolation of these results, particularly to locations down-gradient, is uncertain and may not represent the actual conditions present. On this basis, any assessment of risk to receptors located outside the current investigation area is limited.

9.0 References

- AGDoH, 2017. *Final Health Based Guidance Values for PFAS for use in site investigations in Australia*. The Department of Health, Australian Government, Canberra, Australia. Sourced 15/05/2017
[https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/\\$File/fs-Health-Based-Guidance-Values.pdf](https://www.health.gov.au/internet/main/publishing.nsf/Content/2200FE086D480353CA2580C900817CDC/$File/fs-Health-Based-Guidance-Values.pdf)
- CONCAWE, 2016. *Environmental Fate and Effects of Poly- and Perfluoroalkyl Substances (PFAS)*. Report No. 8/16. 23 June 2016.
- EnRiskS, 2017. *Livestock Uptake Modelling and Screening Criteria Development for PFAS, draft*. Revision C. Environmental Risk Sciences Pty Ltd. 1 November 2017.
- FSANZ, 2017. *Assessment of potential dietary exposure to perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA) and perfluorohexane sulfonate (PFHxS) occurring in foods sampled from contaminated sites – Table 8, Supporting Document 2*. Food Standards Australia New Zealand, April 2017.
- HEPA, 2018. *PFAS National Environmental Management Plan*. Heads of EPAs Australia and New Zealand, January 2018.
- MoH, 2017. *Poly-fluoroalkyl substances (PFASs), also called perfluoroalkyl substances (PFASs) draft*, Ministry of Health November 2017.
- PDP, 2018a. *NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage 1*. Pattle Delamore Partners Ltd. February 2018.
- PDP, 2018b. *NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage B*. Pattle Delamore Partners Ltd. April 2018.
- PDP, 2018c. *NZDF PFAS Investigation – Summary Report: RNZAF Base Ohakea, Stage C*. Pattle Delamore Partners Ltd. June 2018.
- PDP, 2018d. *Sampling Protocols for Monitoring Per and Poly-fluorinated Compounds in Groundwater and Surface Water for New Zealand Defence Force*. Pattle Delamore Partners Ltd. February 2018.
- PDP, 2018e. *Sampling and Analysis Plan for Protocols for Polyfluorinated Compounds at RNZAF Ohakea*. Pattle Delamore Partners Ltd. May 2018.
- PDP, 2017b. *NZDF Ohakea – Groundwater Assessment and PFAS Fate Prediction*. Pattle Delamore Partners Ltd. November 2017.

Appendix A

Site Description

1

Appendix A: Site Description

Geology and Hydrogeology

The Geological Map of the Taranaki Area (Townsend et al., 2008) indicates that the area is underlain by Late Pleistocene river deposits; poorly to moderately sorted gravel with minor sand and silt underlying terraces and includes minor fan deposits and loess.

Regional groundwater flow direction is expected to be in a west to southwest direction towards the Rangitikei River and the west coast. Close to the Rangitikei River, local groundwater will be primarily influenced by the river and therefore flow direction is inferred to be towards the Rangitikei River.

Based on the geology, it is possible that variations in groundwater level may be due to discontinuous lenses of low permeability silt and clay layers acting as an aquitard beneath coarser sand and gravel layers.

Topography and Hydrology

The regional topography near the Rangitikei River is dominated by a succession of paleo river terraces that step down to the current level of the river. As such, the majority of the area is flat; except in the west of the investigation area where the land slopes steeply to the lower river terrace approximately 8 m below.

The Rangitikei River borders the north and west boundary of the investigation area. The Makowhai Stream runs along the eastern boundary of the investigation area, eventually discharging to the Rangitikei River. Numerous open drainage ditches run through the investigation area, particularly alongside the roads and eventually discharge in to the Rangitikei River (in the south east this is via the Makowhai Stream).

Reference

Townsend, D.; Vonk, A.; Kamp, P.J.J. (compilers), 2008: *Geology of the Taranaki area: scale 1:250,000*. Lower Hutt: GNS Science. Institute of Geological & Nuclear Sciences 1:250,000 geological map 7. 77 p.

Appendix B

Quality Assurance / Quality Control
Summary

ESDAT QA Checker

Project: A02684802_Combined_Database

Filter: [Sampled_Date-Time] >= #01 Sep 2018# and [Sampled_Date-Time] <= #17 Oct 2018#

Overview Summary

[Count of Samples](#)

[Count of Results](#)

Holding Times

Blanks

[Field Blanks](#)

Detects in Lab Blanks (0)

Duplicates

[All Field Duplicates \(1080\)](#)

All Field Inter-lab Duplicates (0)

[Field Duplicates with high RPDs \(0\)](#)

Field Inter-lab Duplicates with high RPDs (0)

[Lab Duplicates with high RPDs \(0\)](#)

Lab Control Samples

SDG's without a Laboratory Control Sample (0)

Laboratory Control Samples, Error > 25% (0)

Certified and Standard Reference Materials

Certified Reference Materials - Error > 25% (0)

Matrix Spikes

Trip Spikes with invalid Control Sample (0)

Matrix Spike Recoveries outside lab LCL or UCL (0)

Inorganic

Other

OriginalChemNames Requiring Validation (0)

Samples with no Results (0)