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

New Zealand Defence Force

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

∴ Prepared for

New Zealand Defence Force

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PATTLE DELAMORE PARTNERS LTD
Level 4, PDP House
235 Broadway, Newmarket, Auckland 1023
PO Box 9528, Auckland 1149, New Zealand

Tel +64 9 **523 6900** Fax +64 9 **523 6901**
Website **http://www.pdp.co.nz**
Auckland Tauranga Wellington Christchurch

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DOCUMENT CONTRIBUTORS

Prepared by

SIGNATURE PP

Kate Walker

Peter Callander

Reviewed by

SIGNATURE

Nerena Rhodes

Approved by

Hamish Wilson

Limitations:

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Executive Summary

This report documents a sampling investigation undertaken on private properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Woodbourne (the 'site') for the New Zealand Defence Force (NZDF) to investigate the potential for surface water and groundwater contamination relating to the historic use of products which contained per- and poly-fluoroalkyl substances (PFAS) at the site. This report follows three previous stages of the sampling investigation undertaken in December 2017, February 2018 and May 2018. These sampling investigations are referred to as Stage A, Stage B and Stage C respectively which have been reported individually.

This report refers to the most recent stage in the investigation, Stage D which was undertaken in September 2018. This investigation included the sampling and laboratory analysis of 113 groundwater samples, 20 surface water samples and 12 chicken eggs and has confirmed the presence of PFAS at some locations.

Groundwater

Groundwater samples were obtained from 113 groundwater bores over the week beginning 10 September 2018. Additional groundwater sampling of the Marlborough District Council (MDC) groundwater supply bores (GW114 to GW121, and GW135) has taken place on a monthly basis since the previous monitoring round.

Replicate analysis of one groundwater sample has shown anomalous results. The reason for this is currently being investigated with follow-up sampling planned in November. As such, the results for this sample are not included in the summary below.

Therefore, of 112 groundwater samples collected:

- PFAS[1] was reported by the laboratory in 78 samples (70%).
- PFAS was reported in 70 bores where landowners/occupants confirmed that the water is used for drinking water and / or domestic supply.
- Two of the samples were found to contain PFAS concentrations above the interim drinking water guidelines (MoH, 2017).
- Of the samples where PFAS was reported, 30 samples were collected from wells where landowners/occupants reported water was used for stock watering, domestic, irrigation and / or fodder irrigation. Twenty-seven samples exceeded the milk consumption (home grown) screening values for stock watering and fodder irrigation, and 25 of these samples

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

exceeded the milk consumption (home grown) screening values for stock watering only[2]. The screening values for beef consumption (home grown) and egg consumption (home grown) were not exceeded for these samples.

Surface Water

Surface water samples were collected from 20 locations.

Of these:

- PFAS was reported by the laboratory in 14 samples.
- PFAS concentrations in 11 surface water samples (55%) were above the adopted screening values for milk consumption (home grown) (stock watering and fodder irrigation), and in eight of those surface water samples (40%) PFAS concentrations were above the adopted screening values for milk consumption (home grown) (stock watering only). No landowners/occupants have indicated that these sites are used for stock watering or irrigation.
- None of the surface water samples reported concentrations of PFAS above the screening values for beef or egg consumption (home grown) for stock water and/or fodder irrigation.

Egg Samples

A total of 12 eggs were collected from three properties. Of these, PFAS was detected in eight samples (67%), however concentrations were below the Food Standards Australia and New Zealand trigger points for further investigation.

[2] Although these samples were found to exceed the stated guidelines, in most cases these were not applicable as the water is not used for these purposes.

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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 a sampling investigation to assess the potential for surface water and groundwater contamination by per- and poly-fluoroalkyl substances (PFAS) at properties adjacent to the Royal New Zealand Air Force (RNZAF) Base Woodbourne.

This investigation follows three previous rounds of sampling, Stage A, Stage B, and Stage C. These sampling stages were undertaken during December 2017, February 2018, and May 2018 respectively. A final round of sampling, referred to as Stage D, was completed during September 2018.

Stage D consisted of repeat sampling of locations from previous sampling rounds and the addition of new sample locations. Based on the absence of detection results from previous stages, a number of sample locations were removed from the investigation, decreasing from 159 groundwater samples and 30 surface water samples collected in Stage C to the 113 groundwater samples and 20 surface water samples that were collected during Stage D. Of these 113 groundwater samples, 11 were from new groundwater sample locations targeting the area between the previous area of investigation and the Marlborough District Council (MDC) water supply bores.

The sampling of animal tissue (eggs) was also included during Stage D. A total of 12 chicken eggs were collected from three properties with groundwater bores that have detected PFAS in all previous sampling events.

This report provides the results and findings of the Stage D sampling round undertaken during September 2018. Individual landowner reports have also been reported to the landowners of the properties relevant to this investigation. These reports include the results of the sampling undertaken on their property along with recommendations regarding the ongoing use of their water.

1.1 Project Objectives

The key objectives for this sampling investigation were:

- To assess groundwater and surface water from sites adjacent to Base Woodbourne 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 eggs from sites adjacent to Base Woodbourne where PFAS has been detected in water sources in previous sampling rounds; and

- Provide further data to update preliminary estimates of PFAS plume extent in groundwater made following the last sampling round undertaken in May 2018 (PDP, 2018a).

1.2 Scope of Summary Report

The scope of work undertaken to achieve the project objectives involved:

- Collecting representative samples of groundwater, surface water and chicken eggs from sites adjacent to RNZAF Base Woodbourne, and analyses of these samples for PFAS.
- Comparison of the laboratory results to guideline and screening value criteria (where available).
- Update of the area in the Woodbourne sampling investigation with PFAS concentrations above the limit of reporting.

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 bio accumulative and toxic properties to humans and wildlife (CONCAWE, 2016).

PFAS are 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 Woodbourne have identified PFAS in surface water and groundwater at the base.

Woodbourne is surrounded by productive land, predominantly vineyards. Shallow (and deep) groundwater is used relatively extensively surrounding the base for water supply. Grape sampling was undertaken in a separate investigation and PFAS was not detected above the laboratory limit of reporting (LOR) in any of the grape samples. A description of the geology and hydrogeology for the area is contained within Appendix A.

3.0 Methodology

Sampling was undertaken in groundwater supply wells and 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, 2018b) and the guidance documents referenced therein.

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

Samples were collected during the week of 10 September to 14 September. Additional sampling MDC groundwater supply bores (GW114 to GW121, and GW135) has taken place on a monthly basis since Stage C. All samples were sent to AsureQuality laboratories, Wellington, under standard chain of custody procedures and 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. Additional screening criteria have been prepared by NZDF consultants EnRisks, for water supply for animals/products grown and consumed at home (home-grown produce).

Chicken eggs, are compared to the Food Standards Australia New Zealand's (FSANZ) trigger points (for further investigation); these are provided in Table 2.

Guidelines are provided for three PFAS compounds only. These compounds are known to be associated with certain types of AFFF. Henceforth results are discussed for these three compounds only. 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

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 Quality	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	

Notes:

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: 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

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 PFASs in groundwater from groundwater bores.
2. Determine the presence or absence (less than 0.005 µg/L) of PFASs in surface water.
3. Determine the presence or absence (less than 0.5 µg/kg) of PFASs in animal tissue.

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

A summary of the QA/QC check is provided in Appendix B. No PFAS compounds were detected in the field, trip or rinsate blanks. All but two field duplicate sample pairs reported RPDs within the acceptable reporting range. One sample and the associated duplicate had a RPD of 82% for the Sum of Total PFHxS + PFOS. The parent sample was reported at below the limit of reporting while the duplicate was reported as 0.0024 µg/L. However as this result is very close to the limit of reporting, this may reflect uncertainty of measurement, as described in section 5.2 below. The second sample had a RPD of 0 as the parent result for Perfluorotetradecanoic Acid (PFTeDA) was non reportable due to failing the laboratory quality assurance procedures. The associated duplicate result was detected below the limit of laboratory reporting, hence an appropriate RPD could not be calculated

Two wells (GW55 and GW56) were resampled shortly after the initial sampling due to apparent mislabelling of the sample bottles and associated paperwork (e.g. field sheet) by the sampling consultant. The second set of results was more reflective of the data from previous sampling rounds and therefore is discussed in this report.

A replicate sample for GW91 was analysed due to a significant increase in concentration in comparison to previous results. The replicate results revealed the concentration for the Sum of Total PFOS + Total PFHxS to be 0.0022 µg/L which is an order of magnitude lower than the original result of 0.054 µg/L. The reason for this is currently being investigated with follow-up sampling planned in November. Therefore, the results for this sample will not be discussed further in this report.

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

The following samples were collected during the September sampling round:

- 112 groundwater samples.
- 20 surface water samples.
- 12 chicken egg samples.

The groundwater, surface water and egg results are summarised in the sections below.

6.1 Groundwater Samples

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 guidelines and the screening values for stock watering and fodder irrigation developed by EnRisks (2017). Screening values defined for beef could also be conservatively adopted for the consumption of home-grown sheep meat (EnRisks, 2017).

6.1.1 Drinking Water Interim Guideline Value

Of 112 groundwater samples collected:

- PFAS was detected above the LOR in 78 samples (70%).
- Two samples (2%) were found to exceed the interim drinking water guideline for the Sum of Total PFOS + PFHxS (MoH, 2017).
- 76 samples (68%) returned concentrations of the Sum of Total PFOS + PFHxS above the LOR but below the interim drinking water guideline (MoH, 2017).
- PFOA was detected in 53 samples (47%) above the LOR but below the interim drinking water guideline (MoH, 2017).
- 34 samples (30%) were reported as less than the LOR for the Sum of Total PFOS + PFHxS.
- 59 samples (52%) were reported as less than the LOR for PFOA.

6.1.2 Recreational, Stock Watering and Fodder Irrigation Screening Values

Of the 112 groundwater samples collected:

- No samples exceeded the recreational water quality guideline (AGDoH, 2017).
- 58 (52%) samples were equal to or exceeded the screening value for milk consumption (home grown) (stock watering and fodder irrigation) for Total PFHxS (EnRisks, 2017).
- 51 (46%) samples were equal to or exceeded the screening value for milk consumption (home grown) (stock watering only) for Total PFHxS (EnRisks, 2017).
- One sample (1%) exceeded the screening value for beef consumption (home grown) (stock watering and fodder irrigation) for Total PFHxS (EnRisks, 2017).
- 51 (46%) samples exceeded the screening value for milk consumption (home grown) (stock watering and fodder irrigation) for Total PFOS (EnRisks, 2017).
- Eight samples were equal to or exceeded the screening value for milk consumption (home grown) (stock watering only) for Total PFOS (EnRisks, 2017).

6.1.3 Groundwater Results Summary

A summary of the results described in sections 6.1.1 and 6.1.2 is provided in Table 3 below. 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 lesser number of samples obtained and new sample locations during this sampling event (Stage D) compared to the Stage C sampling event (112 in Stage D vs 159 in Stage C). Values in brackets denote results from the previous May 2018 sampling event (PDP, 2018a).

Table 3: Guideline and Screening Value Exceedances – Groundwater Samples (n=112)			
Guideline	**Number Exceeding the Relevant Guideline**	**Percent Exceeding the Relevant Guideline**	**Source**
Interim Drinking Water Guidelines	2 (0 during previous sampling event)	2% (0% during previous sampling event)	MoH[1]
Recreational Water Quality Guideline	0 (0 during previous sampling event)	0% (0% during previous sampling event)	AGDoH [2]
Site Specific Screening Value – Beef Consumption (home grown)			
Stock Watering and Fodder Irrigation	1 (0 during previous sampling event)	1% (0% during previous sampling event)	EnRisks [3]
Stock Watering Only	0 (0 during previous sampling event)	0% (0% during previous sampling event)	EnRisks [3]
Site Specific Screening Value – Milk Consumption (home grown)			
Stock Watering and Fodder Irrigation	58 (47 during previous sampling event)	52% (30% during previous sampling event)	EnRisks [3]
Stock Watering Only	51 (30 during previous sampling event)	46% (19% during previous sampling event)	EnRisks [3]
Site Specific Screening Value – Egg Consumption (home grown)			
Stock Watering Only	0 (0 during previous monitoring event)	0% (0% during previous monitoring event)	EnRisks [3]

Notes:

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. *The same locations were not necessarily sampled in each round, therefore a direct comparison of the number of exceedances with the previous monitoring event may not be applicable.*

6.1.4 Comparison with Stage C May 2018 Groundwater Sampling Results

In general, the bores where PFAS was detected during the previous May 2018 Stage C sampling event also showed detects of PFAS during this Stage D sampling. It is noted that four groundwater sample locations that detected PFAS in the previous sampling event were not sampled during Stage D due to a mixture of operational and logistical reasons.

A comparison of the groundwater analysis data from the May 2018 and September 2018, where the same bores were re-sampled, shows that:

- 57 samples have increased in concentration (with a median increase of 34% and a median absolute increase of 0.009µg/L).
- Two samples had the same concentration in both Stage C and Stage D.
- Nine samples decreased in concentration (with a median decrease of 21% and a median absolute decrease 0.006 µg/L).

The notable changes between the May 2018 and September 2018 monitoring rounds with respect to individual groundwater bores were:

- Five samples have PFAS detected above the LOR that were below LOR in Stage C.
- One sample that had detected PFAS above the LOR in Stage C was below the LOR in Stage D.
- Two samples exceeded the interim drinking water guideline (MoH, 2017) during Stage D however no samples exceeded this guideline during Stage C. It is noted that that both samples have previously exceeded the interim drinking water guideline(MoH, 2017) during the Stage A sampling event in December 2017.

It is noted that when comparing results between stages where one result is below the LOR, the LOR is included in the calculations of absolute and percentage change.

6.2 Surface Water Samples

A summary of the surface water sample results is presented below. It is highly likely that the surface water sampled within the investigation area is not used for drinking water (based on landowner feedback). Therefore, results have been compared to the recreational water quality guideline (AGDoH, 2017) and the stock watering and fodder irrigation screening values (EnRisks, 2017).

Of the 20 surface water samples collected:

- PFAS was detected in 14 samples (70%).
- No samples exceeded the recreational water quality guideline (AGDoH, 2017).
- 11 samples exceeded the screening value for milk consumption (home grown) (stock watering and fodder irrigation) (EnRisks, 2017) for the Total of PFHxS.
- Eight samples exceeded the screening value for milk consumption (home grown) (stock watering only) (EnRisks, 2017) for the Total of PFHxS.
- 10 samples exceeded the screening value for milk consumption (home grown) (stock watering and fodder irrigation) (EnRisks, 2017) for the Total of PFOS.

- One sample exceeded the screening value for milk consumption (home grown) (stock watering only) for the Total of PFOS.
- PFOA was detected above the LOR in 10 samples which were below both guideline and screening values (EnRisks, 2017).
- Thirteen samples have increased in concentration since the Stage C sampling round (with a median increase of 48% and a median absolute increase of 0.009 µg/L).
- Two samples have decreased in concentration since the Stage C sampling round (one of these samples has decreased to <LOR in the Stage D sampling round).

6.3 Egg Samples

Twelve chicken egg samples were collected from three properties that have reported PFAS concentrations over the LOR in groundwater samples for all previous sampling rounds that the properties in question were involved in. PFAS was detected above the LOR in eight (67%) samples, however concentrations were below the FSANZ trigger point value for further investigation (FSANZ, 2017). The median concentration for the Sum of Total PFHxS + PFOS was 1.55 µg/L for all samples. No PFOA was detected above the LOR in any samples. It is noted that all median calculations are calculated using detections only.

Each property had at least one egg that had detected PFAS above the LOR. One property (EG2) in particular had relatively higher concentrations of PFAS detected in eggs with a median of 4 µg/kg for the Sum of Total PFHxS + PFOS. PFAS was detected in three out of four eggs from this property. PFAS was detected in all four eggs collected from EG1 however at lower concentrations also with a median of 1.55 µg/kg. PFAS was only detected in one out of four eggs at the third property, EG3, at a much lower concentration of 0.29 µg/kg.

It is noted that the median was calculated using only the results that reported PFAS above the LOR.

7.0 Discussion

Results from this groundwater and surface water sampling investigation indicate that a ‘plume’ of PFAS contaminated groundwater exists to the east of the RNZAF Base Woodbourne. The Stage D sample results have been used to produce an interpreted ‘plume’ extent of concentrations of PFAS above LOR within the shallow groundwater system at Woodbourne (noting that fewer samples were collected during this stage).

70% of the groundwater samples (n=112) were detected above the LOR and 2% exceeded the interim drinking water guideline. The distribution of these samples indicates a predominantly easterly direction beyond the RNZAF Base.

7.1 Groundwater Users

Where the landowner/occupant specified that bore water was not used for drinking water / domestic supply, or for stock watering purposes, the use of the bore water has conservatively been presumed to be for produce / crop irrigation.

7.1.1 Drinking Water

Of the 78 samples (70%) that detected PFAS concentrations above the LOR, 70 samples were collected from bores that landowners/occupants indicated were used for drinking water and / or domestic supply.

Two samples exceeded the interim drinking water guideline (MoH, 2017). Both of these locations have previously exceeded the guideline and have had an alternative water supply provided.

7.1.2 Recreational, Stock Watering and Fodder Irrigation

Sample results have been compared to the site specific screening values (EnRisks, 2017). These screening values are used to assess the need for further investigation relating to the potential risk of on-farm consumption of farm grown products (e.g. home kill) only. This is a more likely exposure pathway given the potential for consumption of larger quantities of beef, milk or eggs from a single animal. These screening values are not applicable for produce supplied to the general market. Screening values defined for beef would also be a conservative screening value for the consumption of sheep meat (EnRisks, 2017).

Of the 78 groundwater samples that detected PFAS above the LOR, 25 samples were obtained from bores that were identified as being used for stock watering and / or domestic irrigation purposes. Of these, 21 samples were found to exceed the screening value for milk consumption (home grown) (stock watering and fodder irrigation) and 19 samples were found to exceed the screening value for milk consumption (home grown) (stock watering only) (EnRisks, 2017). Currently none of these sites are understood to be raising animals for home grown milk consumption.

One sample exceeded the screening value for beef consumption (home grown) (stock watering and fodder irrigation) (EnRisks, 2017). This sample was obtained from a bore that is not used for stock water or fodder irrigation, however it is noted that it has been used for garden irrigation.

7.2 Surface Water Users

PFAS concentrations have been reported in 14 of the 20 surface water samples collected. None of these samples exceeded the recreational water quality guideline (AGDoH, 2017). No landowners/occupants have indicated that these sites are used for recreational purposes.

Of the surface water samples, 11 exceeded the screening value for milk consumption (home grown) (stock watering and fodder irrigation) (EnRisks, 2017). Eight of which also exceeded the screening value for milk consumption (home grown) (stock watering only) (EnRisks, 2017). No landowners/occupants have indicated that these sites are used for stock watering or irrigation.

7.3 Discussion of Detection of PFAS in Groundwater

The results of the groundwater samples collected during the September Stage D monitoring round in comparison with results from previous round (May 2018) continues to show a predominant easterly flow direction, with the high concentrations extending from the base through to Battys Road in the vicinity of the Old Fairhall Creek/Yelverton Stream. Both the Old Fairhall Creek and the Fairhall Co-op Drain act as drains on the shallow groundwater and draw the plume towards them, which will contribute to the relatively high concentrations in this eastern area. It is expected that the highest PFAS concentrations will occur in the shallowest groundwater given that the source of PFAS originates from the ground surface and the spring fed streams and drains in this eastern area will draw the shallowest groundwater towards them.

The number of samples with PFAS detected over 0.05 µg/L in this area has increased compared to the last sampling event. The addition of 11 new groundwater samples immediately east of this area shows PFAS concentrations ranging from 0.02 – 0.049 µg/L reaching past Battys Road in Blenheim. Whilst detectable PFAS concentrations can be expected to occur east of Battys Road, the extent of the plume in that direction is difficult to define as there are much fewer bores due to the presence of the Blenheim reticulated water supply.

There are three MDC bores (GW114, GW115 and GW116) within close proximity to the north east of the new sample locations. These MDC bores have shown no PFAS detected in all sampling events. The remaining MDC bores (GW117, GW118, GW119, GW120, GW121 and GW135), are located further to the north east and have also had no PFAS detected in all sampling events (with the exception of a single sample from GW117 in Stage B).

Concentrations in bores closer to the base have shown higher PFAS concentrations than the last sampling event, indicating fluctuation in concentrations within the plume area.

Compared to the previous sampling events, this most recent sampling also shows lower concentrations in the area of PFAS detections to the northeast of the Base (around Old Renwick Road) and higher concentrations in the Old Fairhall Creek area. These differences may reflect differences in the groundwater flow patterns at the time of, and in the weeks prior to, the time of sample collection. The pattern of detections suggests that at the time of the Stage D sampling the groundwater was showing less influence from Southern Valleys runoff, which would push the contaminants in a north easterly direction (towards Old Renwick

Road), and more influence from the typical easterly flow direction that occurs across this area of the Wairau Plain. Although at a localised scale on the order of 10s' to 100's of metres, variable flow directions can occur due to meandering alluvial processes that have shaped the zones of differing permeability within the strata. This localised variability in flow contributes to differing concentrations between different bores in close proximity to each other.

A separate area of PFAS detections continues to be present to the south-east of Base Woodbourne, around New Renwick Road. This is not expected to be associated with RNZAF Base Woodbourne as the groundwater elevations and the geological strata do not indicate that groundwater flow from the Base would occur in that direction. It suggests that a separate localised source of PFAS may occur in this vicinity of New Renwick Road.

7.4 Discussion of Detection of PFAS in Surface Water

The Stage D sampling round has shown PFAS detections in surface water in areas similar to that of the Stage C sampling round. The results show PFAS detections in surface water being limited to Old Fairhall Creek, the Fairhall Co-op Drain and the reach of Doctors Creek immediately downstream of its confluence with the Fairhall Co-op Drain. The highest concentrations of the Sum of Total PFOS + Total PFHxS occur in the Old Fairhall Creek, which shows concentrations around 0.055 µg/L from its headwaters in the west through to David Street, with a slight decrease to 0.04 µg/L at Battys Road. This indicates a zone where groundwater affected by elevated PFAS concentrations is continuing to supply water into the creek through to David Street, with slightly lower concentration groundwater diluting the concentration by Battys Road. Sampling sites downstream of Battys Road show even lower concentrations which reflect diluting inflows of surface waterways and groundwater with lower PFAS concentrations (i.e. the Southern Valleys reach of Doctors Creek and the Taylor River).

7.5 Results Interpretation Limitations

Due to their physiochemical 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.

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Appendix A

Site Description

Appendix A: Site Description

Geology – the Wairau Plain

RNZAF Base Woodbourne occurs on the Wairau Plain, which is an extensive deposit of unconsolidated sediments formed by glacial and river processes and derived primarily from the sediments of the Wairau River Valley, with smaller contributions from the valleys along the southern margin of the Wairau Plain.

The deposited sediments are originally derived from the erosion of rock fragments from mountainous catchments, and therefore cover a wide range of particle sizes, from gravels and larger sizes down to sands, silts and clay sized particles.

The Wairau Plain has built up over deposits formed throughout the ice ages over the last several hundred thousands of years, which comprised a successive sequence of colder glacial periods, separated by warmer interglacial periods. During the glacial periods, large volumes of gravel, sand, silt and clay were eroded from the Wairau River's mountainous catchment in the south-west and deposited as a poorly sorted mixture of grain sizes over the area by the alluvial processes of gravel bed rivers. During the interglacial periods, the contribution of new sediment to the plain was significantly less and many of the glacial deposits were reworked by the gravel bed river processes of the Wairau River and the Southern Valley rivers.

These gravel bed rivers are characterised by multiple, interlinking braided channels of flowing water within a broad active bed. Course changes over time periods of hundreds of thousands of years have built up the Wairau Plain, which contain gravelly strata extending to thicknesses of a few hundred metres.

As a result of these processes, the Wairau Plain is comprised of a complex mixture of gravels, sand, silt and clay originating from the higher catchment areas to the west and south of the Plain. These sediments are sorted to varying degrees ranging from poorly sorted mixtures of all grain sizes, through to better sorted deposits with gravels and coarse sand (with a lesser amount of finer sized particles) in some zones and fine sand, silt and clays in other zones.

Geological units in the vicinity of, and downgradient of, Woodbourne

The upper 50 m of strata in the Woodbourne area comprises three geologic formations – the older Speargrass Formation, and the overlying Early Rapaura Formation and Late Rapaura Formation.

The Speargrass Formation represents sediments that are generally of a lower permeability compared to the overlying, better sorted Rapaura Formation. The Speargrass Formation has a thickness of around 40 m in the area east of Woodbourne. Some of the older sedimentary deposits on the Wairau Plain were reworked by river processes to form the Rapaura Formation which varies from around 0–15 m thick in the area east of Woodbourne.

The shallowest geological unit in the area is the recent gravel deposits associated with the present day river channels.

Hydrogeology

With regard to groundwater flow, more rapid movement occurs through the more permeable coarser grained well-sorted zones of strata, whilst slower movement occurs through the sandy and silty zones.

Due to the nature of the river depositional processes these strata typically have a greater permeability in the direction of flowing water at the time of sediment deposition, with a lower permeability at right angles to the direction of deposition and the lowest permeability in the vertical direction.

These river-derived zones of strata are laid down in lenses parallel to the topography at the time of deposition (i.e. roughly horizontal). The lenses of finer grained sand and silt restrict the vertical permeability, but do not totally inhibit it, due to their lack of consistency and lateral continuity. This depositional behaviour encourages lateral groundwater flow through the strata, particularly in the direction in which the strata were deposited.

Due to the meandering pattern of many of these river processes, there can be variable orientations of the deposited strata on a small to medium scale (e.g. less than around 200 m). However, on a larger scale of a few hundred metres and more, the general direction of the highest permeability is expected to coincide with the direction of strata deposition.

Hydrology

The rate and direction of groundwater flow through these gravel deposits is determined by the location and rate of inflow to the aquifer (recharge), the location and rate of discharge from the aquifer and the hydraulic conductivity (related to permeability) of the strata through which the groundwater flows between the recharge and discharge areas.

At the eastern (downgradient) end of the Woodbourne Road area, the groundwater originates from seepage losses from surface waterways and infiltration of rainfall on the gravel plain. Sources of river seepage come primarily from the Southern Valley outflows from the Omaka River, Mill Stream, the Fairhall River, Golf Course Creek and Doctors Creek. Surface flows in these rivers readily infiltrate water to the aquifers and the length of flowing water in the surface channel varies depending on the amount of flow in the upper catchment and the groundwater level surrounding the river channel.

At a more localised scale, seasonal variations in groundwater flow direction will occur. Davidson and Wilson (2011) address seasonally varying groundwater flow directions entering the Woodbourne area. During wetter months, the groundwater flow direction reflects the contour of the land, i.e. southwest to northeast. During the summer months, the source of recharge to the Woodbourne area changes from the southwest to the northwest, and creates a more easterly groundwater flow direction.

A further influence to groundwater flow direction is the springfed streams that typically emerge east of Bells Road. These flow at rates of a few tens of L/s to 100s of L/s and act as drains which draw groundwater towards them.

Consequently the typical groundwater flow direction leaving RNZAF Base Woodbourne, as determined by groundwater elevations and the orientation of the strata is expected to be in a general easterly direction with the potential for variations due to heterogeneity of the strata and the variable influences of streams, seasonal variations and pumping bores.

References

Davidson, P and Wilson, S, 2011, Groundwaters of Marlborough, ISBN 978-1-927159-03-3, Published by Marlborough District Council.

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 (2)
- 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)

Contents

Field Duplicates with high RPDs

SDG	Matrix_Type	Dupe_Field_ID	Parent_Field_ID	Sampled_Dat	Compound	Parent_Result	Dupe_Result	Result_Unit	EQL	RPD
A02684802	Water	WBN_ADJ_GWGAZ_4_100918	WBN_ADJ_GW84_3_100918	10/09/2018	PFTeDA	-999.0	<0.1	-		0
A02684802	Water	WBN_ADJ_GWGCH_4_140918	WBN_ADJ_GW90_3_140918	14/09/2018	Sum PFHxS+PFOS (1)	<0.001	0.0024	µg/L	0.001 µg/L	82