Greater Wellington
Te Pane Matua Taiao

7 November 2023

File Ref: OIAPR-1274023063-23975

[redacted]

Tēnā koe [redacted]

Request for information 2023-259

I refer to your request for information dated 12 October 2023, which was received by Greater Wellington Regional Council (Greater Wellington) on 12 October 2023. You have requested the following:

"We would like to request access to any PFAS sampling and analysis data undertaken by the Council (such as landfills, wastewater treatment plants, etc.) or received by Council through resource consent applications."

Greater Wellington's response follows:

Certain information has been deleted in **Attachment 1** on the basis that it is not relevant or does not fall within the scope of your request.

We searched our consent database and found one consent that had Per- and Polyfluoroalkyl Substances (PFAS) data. In addition, PFAS samples were collected from groundwater bores as part of the 4-yearly National Pesticide and Emerging Contaminant Study funded by the Institute of Environmental Science and Research (ESR). This year the Environmental Protection Agency (EPA) funded PFAS sampling. You will see four sites where 1H,1H,2H,2H-perfluoro-1-octanesulfonic acid (6:2 FTS) was originally recorded. We resampled the bores and no PFAS compounds were detected.

Please find attached:

- **Attachment 1** – PFAS results from the Silverstream Landfill.
- **Attachment 2** – EPA report with the initial results.
- **Attachment 3** – Results of the re-sampled bores

If you have any concerns with the decision(s) referred to in this letter, you have the right to request an investigation and review by the Ombudsman under section 27(3) of the Local Government Official Information and Meetings Act 1987.

Please note that it is our policy to proactively release our responses to official information requests where possible. Our response to your request will be published shortly on Greater Wellington's website with your personal information removed.

Nāku iti noa, nā

Lian Butcher
Kaiwhakahaere Matua Taiao | Group Manager Environment

[redacted]

Response to information requested

PFAS

6. *Section 8.3 of the Landfill Design report discusses leachate quality. It is understood that the existing site leachate has been tested for per- and poly-fluoroalkyl substances (PFAS). Please provide the results of this PFAS testing, for the last 3 years if available.*

   Response: Please find attached as **Appendix 1A** our letter report with the sampling and analysis results, dated May 2023. Sampling was undertaken in December 2022. WCC does not have 3 years of PFAS sampling results. There are many potential contaminants that could potentially be present in landfill leachate. As part of the consent for the current landfilling operation, a suite of parameters are analysed on a regular basis as indicators of the presence of leachate. PFAS is not included in this suite, however, GWRC indicated that they would be considering PFAS monitoring in their review of the SLEPO consent. The round of PFAS testing was undertaken to address that consideration. PFAS concentrations would be expected to fluctuate over time, however it is long term trends that are key and so ongoing monitoring is proposed in the SLEPO application.

7. *Regarding the discharge of leachate to the Moa Point Wastewater Treatment Plant (WWTP) as trade waste:*

   a) Please clarify if there is an agreement in place with the Moa Point WWTP to accept the future leachate from SLEPO.

   b) Please clarify if the Moa Point WWTP is aware that there is the potential for an increase in the PFAS concentration in the leachate from SLEPO, as the SLEPO leachate will not be diluted by groundwater. Note: please provide evidence of liaison with the Moa WWTP.

   c) Please clarify if the Moa Point WWTP has maximum allowable concentration and/or mass discharge limits for accepting PFAS.

   Response: As follows:

   a) There is no specific agreement with the Moa Point WWTP to accept the future leachate from SLEPO, however WCC does hold a trade waste consent which will also apply to the SLEPO leachate discharges. Trade waste consents authorise the disposal of leachate and other materials into the wastewater network. No additional approval is required.

   b) Recent testing by WCC has not identified PFAS as a concern. A copy of the report prepared on this matter (and provided as Appendix 1A to this letter) has been forwarded to Wellington Water Limited.

   c) We are not aware of Wellington Water Limited working to any criteria or limits relating to PFAS, however the Environmental Protection Authority (EPA) has issued interim guidance on this.

25. *During the pre-application correspondence it was mentioned that: The current water quality monitoring has not included sampling and testing for PFAS. However, WCC has confirmed that PFAS management will be addressed in the SLEPO application. Please provide further details on that item.*

   Response: WCC undertook PFAS sampling in groundwater, surface water and leachate at Southern Landfill in December 2022. WCC agrees to add PFAS to the suite of parameters for annual water quality sampling at the relevant locations as part of the future water quality monitoring regime, to be set out in the Landfill Management Plan.

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Appendix 1A PFAS Report

Tonkin+Taylor

16 May 2023
Job No: 85635.8000

Wellington City Council
By email

Attention: Stefan Borowy

Dear Stefan

Southern Landfill Water Quality testing - PFAS results

Tonkin & Taylor Ltd (T+T) is pleased to provide the results of our PFAS sampling and analysis at the above site. The work has been carried out in accordance with the terms and conditions of our contract "Southern Landfill Stage IV Expansion – Technical Services" of 15 August 2019.

1 Background

Samples of leachate, surface water and groundwater were taken on 12th December 2022. The results are summarised in the tables below and the locations for surface/groundwater samples are shown on the figure attached in Appendix A. Transcripts are enclosed as Appendix B.

Samples were collected using the "clean hands / dirty hands" method, as per the guidelines outlined in the draft PFAS sampling protocols (https://environment.govt.nz/assets/publications/land/draft-sampling-protocols-guidance.pdf):

- Fresh gloves were worn for collection and placement of each sample into laboratory supplied containers.
- A duplicate sample, field blank and trip blank were collected / used for QA / QC purposes during the sampling event.
- Non dedicated equipment (including the mighty gripper) was decontaminated between sampling locations using clean water and decon-90.
- Preservation of samples for chemical analysis with ice during transport from the field to the laboratory.
- Transportation of samples with accompanying chain of custody (COC) documentation.
- Compliance with sample holding times.
- Laboratory testing by accredited laboratories.

Tonkin & Taylor Ltd | Harbour Tower, Level 4, 2 Hunter Street, Wellington 6011, New Zealand
PO Box 2083, Wellington 6140 P +64-4-381 8560 F +64-9-307 0265 E wlg@tonkintaylor.co.nz

2 Results

Table 2.1 and Table 2.2 below compare the surface and groundwater testing results with guideline values for protection of human health and ecology. These guidelines were derived from the PFAS National Environmental Management Plan[1]:

- Table 1, Recreational water quality guideline value.
- Table 5, Guidelines for the protection of 80% Freshwater/interim marine species – highly disturbed systems.

Table 2.3 compares the leachate testing results with interim trade waste acceptance criteria (maximum concentration) for PFAS discharges recommended by the NZ EPA[2].

Only PFAS congeners with at least one detection are shown on the tables.

All the surface and groundwater results are below the recreational and ecological guidelines. The leachate results are at or below the interim guideline values, for PFOA and PFOS. The total PFAS criterion of 1µg/L is exceeded for Stage 3 leachate, however, NZ EPA note that the total PFAS criterion is for information as only PFOS and PFOA are restricted compounds under the HSNO Act.

Table 2.1: Surface water results (µg/L)

Congeners	Upstream	Stage 2/3				Guideline values	
	Upstream	SW2	Weir	DEMODs	Downstream at gate	Recreation	Ecological
PFBA	ND	0.0063	0.0048	0.042	0.023	-	-
PFPeA	ND	0.0063	0.016	0.12	0.046	-	-
PFHxA	ND	0.015	0.014	0.081	0.04	-	-
PFHpA	ND	0.002	0.0032	0.035	0.015	-	-
PFOA	ND	0.0039	0.009	0.04	0.015	10	1824
PFOS	ND	ND	0.001	0.02	0.0089	-	31
PFOS + PFHxS	ND	0.0016	0.001	0.041	0.018	2	-
PFBS	ND	0.0045	ND	0.07	0.025	-	-
PFHxS	ND	0.0016	ND	0.021	0.0092	-	-
6:2 FTS	ND	0.0016	ND	0.0053	0.0024	-	-
FPrPA	ND	0.0012	ND	ND	ND	-	-
FPePA (5:3FTA)	ND	0.033	ND	0.0035	0.011	-	-
PFPrS	ND	ND	ND	0.0033	ND	-	-
PFPeS	ND	ND	ND	0.0035	0.0013	-	-
PFNA	ND	ND	ND	0.0026	0.0011	-	-
FHpPA (7:3FTA)	ND	ND	ND	ND	ND	-	-

Note: ND = Non-detect; Greyed cell is the highest result on table.

[1] PFAS National Environmental Management Plan Version 2.0', Heads of EPA Australia and New Zealand 2020. A draft version 3 of the PFAS National Environmental Management Plan is presently undergoing consultation. At present there is no proposed change in this draft version to either sets of recreational or ecological values

[2] Disposal of PFAS containing wastewater to trade waste, Environmental Protection Authority | Te Mana Rauhī Taiao - https://environment.govt.nz/assets/publications/land/PFOS-disposal-to-trade-waste-guidance.pdf.

Table 2.2: Groundwater results (µg/L)

Congeners	Upstream	Stage 3	Stage 2/3		Guideline values	
	BH1A	BH 6	BH 103A	BH 103B	Recreation	ANZECC
PFBA	ND	0.025	ND	0.0023	-	-
PFPeA	ND	0.0019	ND	0.0014	-	-
PFHxA	ND	0.0023	ND	0.0043	-	-
PFHpA	ND	0.0018	ND		-	-
PFOA	ND	0.0012	ND	0.0012	10	1824
PFOS	ND	ND	0.0026	0.0023	-	31
PFOS + PFHxS	ND	ND	0.0026	0.0023	2	-
PFBS	ND	ND	ND	ND	-	-
PFHxS	ND	ND	ND	ND	-	-
6:2 FTS	ND	ND	ND	ND	-	-
FPrPA	ND	ND	ND	ND	-	-
FPePA (5:3FTA)	ND	ND	ND	ND	-	-
PFPrS	ND	ND	ND	ND	-	-
PFPeS	ND	ND	ND	ND	-	-
PFNA	ND	ND	ND	ND	-	-
FHpPA (7:3FTA)	ND	ND	ND	ND	-	-

Note: ND = Non-detect; Greyed cell is the highest result on table.

Table 2.3: Leachate results (µg/L)

Congeners	Stage 2	Stage 3	Acceptance Criteria
	Stage 2 pumping well chamber	Stage 3 leachate chamber	Tradewaste
PFBA	ND	0.17	-
PFPeA	ND	0.13	-
PFHxA	0.034	0.31	-
PFHpA	ND	0.057	-
PFOA	0.03	0.1	0.1
PFOS	0.026	ND	0.1
PFOS + PFHxS	0.06	0.04	-
PFBS	ND	0.29	-
PFHxS	0.034	0.04	-
6:2 FTS	ND	ND	-
FPrPA	ND	ND	-
FPePA (5:3FTA)	0.085	1.9	-
PFPrS	ND	ND	-
PFPeS	ND	ND	-
PFNA	ND	ND	-
FHpPA (7:3FTA)	ND	0.063	-
Total PFAS	0.27	3.1	1

Note: ND = Non-detect; Greyed cell is the highest result on table. Total PFAS calculated as the sum of all detected PFAS.

3 Conclusions

Testing has identified the presence of PFAS within the landfill leachate, surface water and groundwater at the landfill.

The leachate results are at or below the available interim trade waste acceptance criteria for PFOS and PFOA (although the Stage 3 total PFAS exceeds the “for information” 1µg/L criterion).

The surface and groundwater PFAS results are all below available guidelines for recreation and ecological protection. Our interpretation of the guidance is that the results do not indicate the need for special precautions to be taken to protect human health or the environment from PFAS within surface water, groundwater or leachate from the site (although this doesn’t necessarily reflect the quality of the water downstream of Southern after cumulative inputs from other industries).

4 Applicability

This report has been prepared for the exclusive use of our client Wellington City Council, with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose, or by any person other than our client, without our prior written agreement.

Tonkin & Taylor Ltd

Authorised for Tonkin & Taylor Ltd by:

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Chris Hillman
Project Director

16-May-23
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National Survey of Per- and Polyfluoroalkyl Substances (PFAS) in Groundwater 2022

May 2023

Prepared by:

Murray Close and Laura Banasiak

PREPARED FOR: **Environmental Protection Authority & Regional & Unitary Authorities**

CLIENT REPORT No: **CSC23006**

ACKNOWLEDGEMENTS

Manager	Peer reviewer	Authors
Louise Weaver	**Matt Ashworth**	**Laura Banasiak**
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DISCLAIMER

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1. EXECUTIVE SUMMARY

In 2022 ESR coordinated a survey of pesticides in groundwater throughout New Zealand. The survey has been completed every four years since 1990 with 2022 being the ninth consecutive survey. Regional and Unitary Authorities carried out the well sampling. Emerging Organic Contaminants (EOCs) were also included and the 2022 survey was the first time that Per- and Polyfluoroalkyl Substances (PFAS) were included in the suite of compounds analysed. This report will focus on the results of the PFAS sampling. The analysis for PFAS was carried out by AsureQuality and funding for the additional analyses and data analysis was provided by the Environmental Protection Authority (EPA). ESR's role was to coordinate the survey, advise on well selection as needed, collate and interpret the results and provide a national summary report.

Wells were selected based on the importance of an aquifer to a region, known application and storage of pesticides in the area, and the vulnerability of the aquifer to contamination. The majority of the selected wells were from unconfined aquifers, recognising that shallower, unconfined aquifers would be more at risk than deeper aquifers.

There were a total of 131 wells sampled (blind duplicates not included in this total) and analysed for PFAS. The largest number of wells sampled in a region was 53 from Waikato Region, with between 2 and 17 wells being sampled in other participating regions. There were 15 wells (11%) with PFAS detected, with 6 of these wells having two or more PFAS detected. The maximum number of PFAS detected in one well was eight. Perfluoroalkylcarboxylic acids (PFCAs) were the group of PFAS most frequently detected with 21 detections (51.2%) of 5 different PFCAs. Of these PFCAs, the most frequently detected compound was perfluoro-n-butanoic acid (PFBA), which was detected in 9 wells, then perfluoro-n-pentanoic acid (PFPeA), which was detected in 5 wells. This was followed by perfluoroalkylsulfonic acids (PFSAs) with 9 detections (22%) of 4 different PFSAs. A total of 4 detections (9.8%) of one group of fluorotelomer sulfonic acids (FTSAs) was detected in 4 wells. The maximum value for sum of PFHxS and PFOS (Sum PFHxS+PFOS) was 16.5 ng/L in a well from the Waikato region, followed by 9.5 ng/L in a well from the Canterbury region, with the remainder of wells being < 1.5 ng/L. All detected PFAS were below the available NZ human health-based Maximum Acceptable Values for drinking water.

These results indicate that some PFAS compounds, sourced from human and industrial activities (e.g., degradation of non-stick, and stain-resistant consumer products; paper food packaging; use of class B fire-fighting foam etc.) or as breakdown products of other PFAS, are making their way into some shallow groundwater systems and can be detected at low concentrations. Currently there is limited knowledge of the fate and effect of PFAS and whether the levels measured in this study are likely to have impacts for ecological systems. We recommend that monitoring of PFAS in groundwater resources is extended across New Zealand and that research is carried out to quantify the likely risks for the PFAS compounds most frequently detected in this study.

There is limited discussion in this report about temporal variation of PFAS in groundwater with time, and the correlation of PFAS detections with parameters such as well depth and groundwater chemistry. It was felt that it was more important to provide the actual results of the survey of PFAS concentrations in groundwater as soon as possible. Further analysis of the data is continuing, and more extensive discussion will be provided in a journal paper that will be prepared for publication and sent to the EPA and all the councils as soon as it is ready.

2. INTRODUCTION

When the series of pesticide surveys began in 1990, groundwater was, and it continues to be, an important source of drinking water in New Zealand. Around 40% of New Zealanders rely on groundwater for their drinking water (LAWA, 2022). Careful management of the source aquifers and their recharge zones is required to maintain their high quality.

Regional councils and unitary authorities are responsible for managing groundwater quantity and quality and regularly carry out monitoring programmes. There has been growing interest from these councils, authorities and from the community about whether per- and poly-fluoroalkyl substances (PFAS) are reaching the groundwater systems. Commonly termed as ‘forever chemicals’, PFAS are organic, man-made chemicals, used for various applications. Due to their wide use and persistence, PFAS are becoming ubiquitous in the environment including groundwater and surface water.

For the first time PFAS have been included to determine their prevalence in groundwater. We know little about their occurrence in New Zealand groundwater systems. However, some studies have been undertaken at point sources of groundwater contamination by PFAS due to historic use of products containing PFAS (PDP, 2018a, 2018b, 2019, 2021). Since late 2017, the Ministry for the Environment (MfE) has been leading an all-of-Government programme to help councils and landowners to investigate PFAS contamination in New Zealand. Crown sites, such as New Zealand Defence Force (NZDF) bases have been leading investigations. The historical use of firefighting foam between the 1970s and 2000 has left traces of PFAS at several Defence Force bases around New Zealand. Sampling of groundwater conducted in November 2017 within Devonport Naval Base confirmed the presence of PFAS in six groundwater monitoring wells, which was related to the historic use of PFAS-containing products in several activities (e.g., Aqueous Film Forming Foam (AFFF), fire prevention foam blankets, maintenance of vessels) (PDP, 2018a). The highest concentration of a single compound was total PFOS (66,000 ng/L). The sum of total PFHxS + PFOS ranged from 9.8 to 61 ng/L in the wells in the area where several activities were associated with historical PFAS usage and 30,000-78,000 ng/L in the wells in the firefighting training area. The PFAS compound 1H,1H,2H,2H-perfluoro-1-octanesulfonic acid (6:2 FTS) was detected above the limit of reporting in all the wells in the firefighting training area. Three samples in the fire training area exceeded the ecological freshwater level at the 90% (2000 ng/L) and 95% (130 µg/L) protection levels for total PFOS. The shallow groundwater at this site is less than 10 m above the first water bearing unit of the underlying aquifer and the shallow groundwater is sensitive due to the proximity to the nearby Waitematā Harbour. Groundwater containing PFAS is likely to be migrating off-site to Ngataringa Bay and Waitematā Harbour near Stanley Bay (PDP, 2018a).

Sampling investigations undertaken at RNZAF Base Woodbourne between December 2017 and September 2018 identified PFAS in soil and water on-site and in groundwater across an area extending seven kilometres east of the site (PDP, 2019). A total of 100 groundwater samples were collected on-site and one or more of the PFAS of interest were above the LOR (68% of samples). PFOS (53 detections, concentration range <1-76 ng/L) and PFHxS (67 detections, concentration range <1-28 ng/L) were the most prevalent compounds found, followed by PFOA with 46 detections (concentration range <1-10 ng/L). On-site groundwater samples were not compared to drinking water guidelines as the wells were not used for drinking water. A total of 537 groundwater samples were collected from 210 off-site locations and 252 (47%) of the samples had concentrations above the LOR for one or more PFAS. Five samples exceeded the drinking water Maximum Acceptable Values (MAV) for drinking waters of 70 ng/L for the sum of PFHxS+PFOS (concentration range <1-110 ng/L) (Water Services Regulations, 2022). Note that when these investigations were carried out the MAVs were interim drinking water guideline values (MoH, 2017; HEPA, 2020) but are the same values in the recent Water Services Regulations (2022). One sample also exceeded the MAV for PFHxS (concentration range <1-74 ng/L). A total of 11 groundwater samples from seven wells had a concentration of PFOS+PFHxS greater than 60 ng/L (five of these wells were used for drinking water purposes at the time of sampling), which may have been above the drinking water guideline value. Nine Marlborough District Council water supply wells were sampled and no PFAS were reported above the LOR. Modelling of the PFAS groundwater plume (~ 200 hectares) showed that some of the contaminated groundwater discharges into springs feeding nearby Fairhill creek, Fairhill Co-op Drain, and into the confined aquifer beneath Blenheim (at a reduced volume and lower PFAS concentration).

Sampling of six groundwater bores (shallow and deep) adjacent to the RNZAF Base Auckland (Whenuapai Airbase) was completed between July and August 2018 (PDP, 2018b). Three of the groundwater samples contained PFAS with concentrations above the LOR, but below the drinking water MAVs (Water Services Regulations, 2022) and the recreational water guideline values (AGDoH, 2017) for the sum of PFHxS+PFOS (concentration range 13-14 ng/L) and

PFOA (concentration range 4.4-7.4 ng/L). No PFAS were detected in samples collected from deeper groundwater bores.

In 2018, Fire and Emergency New Zealand (FENZ) engaged Pattle Delamore Partners (PDP) to assess the potential for residual soil and groundwater contamination by PFAS from past use of firefighting foam at 8 of their sites (Woolston Fire Training Centre and Fire Station, Silverdale, Feilding Fire Station, Masterton Fire Station, Dunedin Fire Station, Washdyke Fire Station, Napier Fire Station, and Hastings Fire Station) out of a total of over 650 operational sites. Preliminary sampling was undertaken with no evidence of PFAS or PFAS levels below, or well below, guideline levels (FENZ, 2022). In general, PFOS, PFHxS, and PFOA were detected in soil, but all were well below guidelines levels for industrial/commercial sites. Sampling of groundwater in bores in the deep aquifer in Hastings by Hawkes Bay Regional Council in May 2019 did not detect any PFAS. Note that 95 per cent of firefighting foams used by FENZ are of the 'Class A' type and do not contain PFAS.

Moreau et al. (2019) conducted the first baseline regional survey on emerging organic contaminants (EOCs) occurrence in New Zealand groundwater from 51 baseline sites from the State of the Environment (SOE) network in the Waikato region and 10 targeted sites in the vicinity of known EOC sources for comparison. Amongst the compounds analysed were several PFAS including perfluoro-n-decanoic acid (PFDA), perfluoro-n-heptanoic acid (PFHpA), perfluoro-n-hexanoic acid (PFHxA), perfluoro-n-nonanoic acid (PFNA), perfluoro-n-octanoic acid (PFOA), perfluoro-n-pentanoic acid (PFPeA), perfluoro-1-butanesulfonic acid (PFBS), PFHxS, and PFOS. The most frequently detected PFAS were PFHpA, PFHxA and PFPeA, which were all detected at 10 groundwater sites. This was followed by PFOA and PFHxS, which were found at 9 groundwater sites. The maximum concentration detected in groundwater was 820 ng/L for PFHxS.

Horizons Regional Council carried out a survey of PFAS in groundwater and surface water between September and October 2020 (PDP, 2021) in association with the RNZAF Base Ohakea PFAS Investigation: Long Term Monitoring Plan (LTMP) (PDP, 2020). The study included the collection of groundwater from 13 taps or wells on the RNZAF Base Ohakea and on other (non-NZDF) private and public land. PFAS was detected at levels above the relevant guideline values in five groundwater samples. Four on-base groundwater samples exceeded the drinking water MAV of 70 ng/L (Water Services Regulations, 2022), with the sum of perfluorohexanesulfonic acid (PFHxS) + perfluorooctane sulfonic acid (PFOS) concentration ranging from 92 – 31,700 ng/L. One off-base groundwater sample also exceeded the drinking water MAV, with the sum of PFHxS and PFOS ranging from 92 to 140 ng/L. Concentrations of PFOS at three locations also exceeded the protection screening value for 95% of freshwater species protection (130 ng/L) (ANZG, 2018). None of the wells were used for drinking water supply.

It is important to note that this current survey is the first national-scale survey in New Zealand that focusses on general resource sampling, not targeted sampling to identify and quantify point-source PFAS contamination. The sampling for this survey was mostly carried out mid-late 2022, mostly between September and December. The analysis for PFAS was carried out by AsureQuality and funding for the additional analyses and data analysis was provided by the Environmental Protection Authority (EPA). ESR's role was to coordinate the survey, advise on well selection as needed, collate and interpret the results and provide a national summary report.

There is limited discussion in this report about temporal variation of PFAS in groundwater with time and the correlation of PFAS detections with parameters such as well depth and groundwater chemistry. It was felt that it was more important to provide the actual results of the survey of PFAS concentrations in groundwater as soon as possible. Further analysis of the data is continuing, and more extensive discussion will be provided in a journal paper that will be prepared for publication and sent to the EPA and all the councils as soon as it is ready.

3. METHODOLOGY

3.1 WELL SELECTION

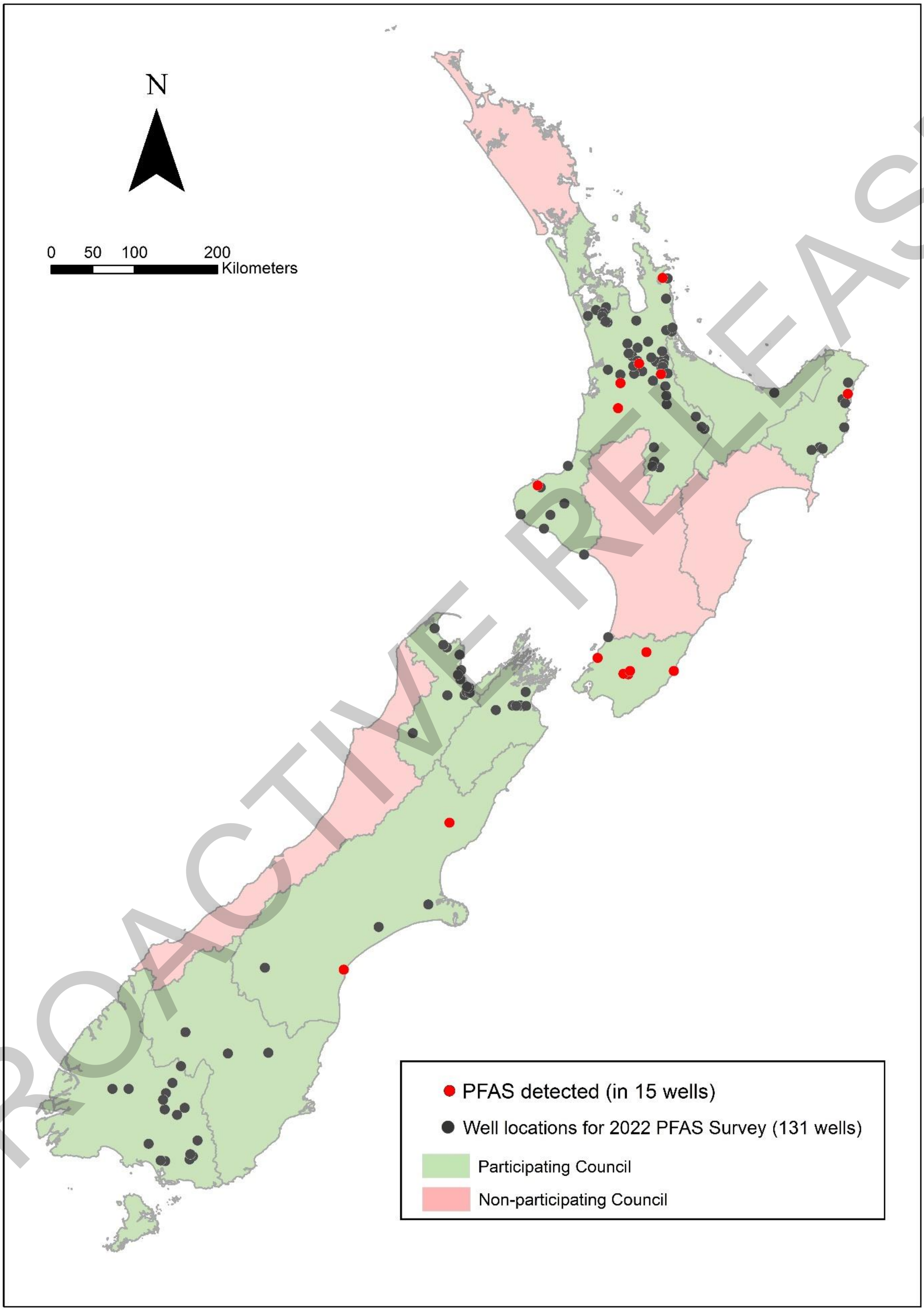
In collaboration with ESR, wells were selected by each participating council using the following criteria:

- shallow, unconfined, and vulnerable aquifers
- significant and important aquifers
- past or present land use

For each well the following information was requested from the council: well location, water level, depth of the well screen, the type of aquifer, and the general land use in the area. A balance was sought between selecting wells that were most vulnerable to contamination (shallow and screened near the water table) and wells that reflected the general usage of the aquifer. Most of the selected wells were from unconfined aquifers.

While fifteen of the Regional and Unitary Authorities with groundwater management responsibilities participated in the 2022 survey, only eleven undertook sampling for PFAS. The main reasons for non-participation by other four regions was the availability of sampling staff (a two person “clean hands/dirty hands” protocol was required), a short time frame to sort out the sampling protocol, and other commitments. A total of 131 wells were selected and sampled for a suite of PFAS. The distribution of wells sampled for PFAS is shown in Figure 1.

Figure 1: Regions and sampling locations for the 2022 survey of per-and-polyfluoroalkyl substances in groundwater



3.2 SAMPLING

Samples were collected according to the ESR procedure for sampling PFAS (Appendix A) which adapted information from the draft MfE Sampling Protocols for PFAS (MfE, 2018). The purging procedures are based on *"A National protocol for State of the Environment Groundwater Sampling in New Zealand"* (Daughney et al., 2006). According to these procedures each council was asked to purge three well volumes where possible before sampling. Samples were collected by either portable pumps or in-situ pumps as close to the well head as possible. In most cases field measurements of pH, dissolved oxygen, conductivity, and temperature were recorded and a water sample only taken when these parameters had stabilised. Samples from 15% of wells were collected in duplicate as blind duplicate samples for Quality Assurance (QA) purposes.

Care was taken to avoid potential contamination of the groundwater and QA samples with PFAS during all steps of the sample collection. There needed to be 2 people in the sampling team to be able to implement a "Clean Hands/Dirty Hands" protocol. Field staff undertaking the sampling were required to avoid drinking coffee or other caffeine containing drinks on the day of sampling. The same staff were also required to refrain from using spray deodorants, perfume, insect repellent, sunscreen, and cosmetics. Disposable nitrile gloves were supplied by ESR for use in collection of the PFAS samples.

For each well sampled a field sheet was filled out and returned to ESR (Appendix B). Bottles for PFAS analysis were supplied by AsureQuality.

3.3 LABORATORY ANALYSIS

All samples for the PFAS analysis suites were sent to AsureQuality in Wellington and analysed for a suite of PFAS. Upon receipt by AsureQuality in Wellington, the bottles of groundwater samples, were checked for damage, correlated against the supplied inventory and sampling details, and immediately transferred into a walk-in chiller and stored in the dark below 6°C until extraction. The groundwater samples were analysed using Liquid Chromatography with tandem mass spectrometry (LC-MS/MS). AsureQuality's PFAS methods comply with US DoD/DoE QSM 5.3 (2019) requirements. AsureQuality's PFAS analysis methods meet the requirements in Section 8.6 of the PFAS National Environmental Management Plan (NEMP) Version 2.0 (HEPA, 2020). The method used is the 2018 USEPA Method 537.1-1. This method is for identifying and measuring selected per- and polyfluorinated alkyl acids in drinking water by Solid Phase Extraction (SPE) and LC-MS/MS. Some laboratories may use a modified USEPA Method 537 or 537.1 to obtain additional analytes, such as 6:2 and 8:2 fluorotelomers. The limitation of this method is that it only analyses for specific PFAS and does not require results to be corrected for Internal Standard recovery. AsureQuality reports the recoveries for internal standards for each sample and method blanks for each batch of samples and does not report sample results if the internal standard recoveries are outside defined limits.

3.3.1 Method limits of reporting.

The PFAS assayed and their LOR are provided in Appendix C. AsureQuality is confident of achieving a PFOS limit of reporting (LOR) in water samples to allow for assessment against the 99% ecological water quality guideline value of 0.23 ng/L (HEPA, 2020). Most of the PFAS sampled have a LOR of 0.0010 µg/L (1 ng/L). However, perfluoro-1-decanesulfonic acid (PFDS) and perfluoro-n-tridecanoic acid (PFTrDA) were not reportable (NR) during the analysis period for this study.

4. RESULTS

4.1 ASSESSMENT OF SURVEY METHODOLOGY

Blind duplicate samples from 21 wells (16%) were submitted to the analytical laboratory as an additional quality control measure. A slightly higher number of blind duplicate samples were collected for the PFAS analyses compared to the pesticide and EOC suites as there were no previous national survey information, so the expected detection frequency was unknown. Most of the blind duplicate samples did not have detectable PFAS besides one sample from Waikato Regional Council (Well ID 60_12) (Table 1). For this well, there was very good agreement for all the duplicate analyses (Table 1) with 9 different PFAS (perfluoro-n-pentanoic acid (PFPeA) was below the LOR) detected in the sample and 10 different PFAS detected in the duplicate with reasonably similar concentrations in each sample.

4.2 APPLICABLE GUIDELINES

The guidelines presented in Table 2 were used to evaluate the results of data collected as part of this study. There are health-based drinking water Maximum Acceptable Values (MAV) for drinking water and recreational guidelines available for PFOA and the sum of PFHxS and PFOS (Water Services Regulations, 2022; HEPA, 2020). The health-based guideline values are levels at which the chemicals may be present in drinking or recreational water without presenting a risk to public health. Results were compared to the recreational guidelines to assess the potential risk to human health associated with incidental ingestion of the groundwater e.g., during excavation. Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) ecological freshwater guideline values for species protection were also compared. The guidelines provide screening levels for PFOS and PFOA. Due to the bio-accumulative nature of PFAS analytes, the 95% and 99% species protection levels were adopted, as opposed to the 90% species protection levels.

Table 1: Comparison of Blind Duplicate samples for PFAS suite.

ND = not detected; LOR = 1.0 ng/L

COUNCIL	WELL ID (BLIND DUPLICATE)	PFAS CONCENTRATION (ng/L)	
Auckland Council	7419121 (Blind duplicate)		ND (ND)
Waikato Regional Council	70_453 (Blind duplicate)		ND (ND)
	72_9084 (Blind duplicate)		ND (ND)
	60_12 (Blind duplicate)	PFBS mono-PFOS L-PFOS Total PFOS Sum PFHxS+PFOS PFBA PFPeA PFHxA PFHpA PFOA	4.2 (4.5) 2.0 (1.6) 14.0 (15.0) 16.0 (17.0) 16.0 (17.0) 2.3 (2.2) <1.0 (1.0) 1.2 (1.1) 1.3 (1.5) 2.8 (2.8)
	63_328 (Blind duplicate)		ND (ND)
	63_74 (Blind duplicate)		ND (ND)
	66_58 (Blind duplicate)		ND (ND)
	69_62 (Blind duplicate)		ND (ND)
Gisborne District Council	GTA044 (Blind duplicate)		ND (ND)
Taranaki Regional Council	GND3093 (Blind duplicate)		ND (ND)
Greater Wellington Regional Council	BN32/0062 (Blind duplicate)		ND (ND)
Tasman District Council	GW 508 (Blind duplicate)		ND (ND)
	GW 8036(Blind duplicate)		ND (ND)
	GW 23759 (Blind duplicate)		ND (ND)
	GW 23806 (Blind duplicate)		ND (ND)
Marlborough District Council	3120 MDC Springlands (Blind duplicate)		ND (ND)
Otago Regional Council	H42/0214 (Blind duplicate)		ND (ND)
Environment Southland	E43/0065 (Blind duplicate)		ND (ND)
	E46/0097 (Blind duplicate)		ND (ND)
	E46/0867 (Blind duplicate)		ND (ND)
	F46/0239 (Blind duplicate)		ND (ND)

Notes: PFBS = Perfluoro-1-butanesulfonic acid; mono-PFOS = Perfluorohexanesulfonic acid (mono-branched); L-PFOS = Perfluorohexanesulfonic acid (linear); Total PFOS = The numerical sum of di-PFOS (di-branched PFOS), mono-PFOS, and L-PFOS; Sum PFHxS+PFOS = The numerical sum of Total PFHxS and Total PFOS; PFBA = Perfluoro-n-butanoic acid; PFPeA = Perfluoro-n-pentanoic acid; PFHxA = Perfluoro-n-hexanoic acid; PFHpA = Perfluoro-n-heptanoic acid; PFOA = Perfluoro-n-octanoic acid.

TABLE 2: Environmental and Human Health Guidelines for detected PFAS.

Note that ng/L = µg/m³ = ppt.

PFAS	DRINKING WATER (ng/L)	RECREATION (ng/L)	95% ECOSYSTEM PROTECTION (ng/L)	99% ECOSYSTEM PROTECTION (ng/L)
Perfluoroalkylcarboxylic acids (PFCAs)				
PFBA	NGV	NGV	NGV	NGV
PFPeA	NGV	NGV	NGV	NGV
PFHxA	NGV	NGV	NGV	NGV
PFHpA	NGV	NGV	NGV	NGV
PFOA	560[1,2]	10,000[2]	220,000[3]	19,000[3]
Perfluoroalkylsulfonic acids (PFSAs)				
PFBS	NGV	NGV	NGV	NGV
L=PFHxS	NGV	NGV	NGV	NGV
mono-PFOS	NGV	NGV	NGV	NGV
L-PFOS	NGV	NGV	NGV	NGV
Total PFOS	NGV	NGV	130[3]	0.23[3]
Sum PFHxS+PFOS	70[1,2]	2000[3]	NGV	NGV
Fluorotelomer sulfonic acids (FTSAs)				
6:2 FTS	NGV	NGV	NGV	NGV

Notes: NGV = No Guideline Value; [1] NZ Ministry of Health (Water Services Regulations, 2022) for PFOA, PFOS and PFHxS; [2] The Heads of EPAs Australia and New Zealand (HEPA, 2020) PFAS National Environmental Management Plan Version 2.0; [3] Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018).

4.3 SURVEY RESULTS

A total of 131 wells were sampled and the samples sent for analysis to AsureQuality in Wellington. The largest number of wells sampled in a region was 53 from Waikato Region, with between 3 and 17 wells being sampled in other participating regions. There was a total of 41 detections of PFAS in 15 wells (Table 3). Overall, ten different PFAS were detected in the sampled wells (Table 4). There were one or more wells with PFAS detected in 5 of the 11 participating regions, with regional detection rates varying from 0 to 75% (note that the higher rates were for a small number of sampled wells). PFAS were not detected in sampled wells from Auckland Council (3 wells), Bay of Plenty Regional Council (2 wells), Tasman District Council (17 wells), Marlborough District Council (7 wells), Otago Regional Council (4 wells), and Environment Southland (15 wells). In 6 of the total wells sampled in this study (4.4%) two or more PFAS were detected (Table 3). The maximum number of PFAS detected in a well was eight (Total PFOS, Sum PFHxS+PFOS not included in this total).

Perfluoroalkylcarboxylic acids (PFCAs) were the group of PFAS most frequently detected with 21 detections (51.2%) of 5 different PFCAs. Of these PFCAs, the most frequently detected compound was perfluoro-n-butanoic acid (PFBA), which was detected in 9 wells, then perfluoro-n-pentanoic acid (PFPeA), which was detected in 5 wells. Perfluoro-n-hexanoic acid (PFHxA) was only detected in one of the sampled wells and perfluoro-n-heptanoic acid (PFHpA) was detected in 4 wells. There are no New Zealand derived human health or species protection guideline values for PFBA, PFPeA, PFHxA or PFHpA. The PFCA with the highest maximum concentration was PFOA. However, detections of PFOA (2 detections) were below the drinking water MAV of 560 ng/L (Water Services Regulations, 2022) at a maximum concentration of 2.8 ng/L, which was 0.5% of the MAV. The maximum concentration of PFOA was also below the recreational and species protection guideline values.

The next group of PFAS most frequently detected were perfluoroalkylsulfonic acids (PFSAs) with 9 detections (22%) of four different PFSAs. The most common PFSA detected was perfluoro-1-butanesulfonic acid (PFBS), which was detected in 3 wells (7.3% detection rate). The maximum concentration of PFBS was 4.8 ng/L. There are no New Zealand derived human health or species protection guideline values for PFBS. Perfluorohexanesulfonic acid (linear, L-PFHxS), mono-PFOS and L-PFOS each had two detections (4.9%). The maximum concentration of L-PFHxS, mono-PFOS and L-PFOS was 2.2 ng/L, 3.4 ng/L, and 15 ng/L, respectively. The maximum concentration of total-PFOS in one well was 16.5 ng/L (Table 3, Well ID 60_12), which is below the 95% ecosystem protection screening value of 130 ng/L (ANZG, 2018) but significantly above the 99% ecosystem protection screening value of 0.23 ng/L (ANZG, 2018). The maximum value for sum of PFHxS and PFOS (Sum PFHxS+PFOS) was 16.5 ng/L for well 60_12, followed by 9.5 ng/L in a well from the Canterbury region, with the remainder of wells being < 1.5 ng/L. All the values for the sum of PFHxS and PFOS were significantly below the drinking water MAV of 70 ng/L (Water Services Regulations, 2022).

A total of 4 detections (9.8%) of 1 group of fluorotelomer sulfonic acids (FTSAs) was detected in 4 wells. The concentration of 1H,1H,2H,2H-perfluoro-1-octanesulfonic acid (6:2 FTS) ranged from <1 ng/L to 4 ng/L. There are no New Zealand derived human health or species protection guideline values for 6:2 FTS.

TABLE 3: Summary of results from the 2022 per- and polyfluoroalkyl substances (PFAS) in groundwater survey detailing 41 detections in 15 wells out of a total of 131 wells sampled.

COUNCIL REGION (# wells with detections / # wells sampled, % detected)	WELL ID	PFAS DETECTED	PFAS CONCENTRATION (ng/L)
Northland Regional Council (0/0)			
Auckland Council (0/3)			
Waikato Regional Council (5/53, 9.4%)	64_879	PFBA	1.4
		PFPeA	1
	69_1809	PFBA	1
	71_59	PFBA	2
		PFPeA	2
		PFHxA	2
	60_12	PFBS	4.40*
		mono-PFOS	2.00*
		L-PFOS	14.5*
		Total PFOS	16.5*
		Sum PFHxS+PFOS	16.5*
		PFBA	2.3*
		PFPeA	0.8*
		PFHxA	1.2*
		PFHpA	1.4*
		PFOA	2.8*
	70_74	PFBS	4.8
Bay of Plenty Regional Council (0/2)			
Gisborne District Council (1/9, 11%)	Waipiro Spring	PFBA	1.88
Hawkes Bay Regional Council (0/0)			
Taranaki Regional Council (1/8, 12.5%)	GND0508	PFBA	1.2
		PFPeA	3.1
		PFHxA	1.2
Horizons (0/0)			
Greater Wellington Regional Council (6/8, 75%)	BP33/0056	6:2 FTS	4
	BP34/0229	6:2 FTS	1.6
	BP33/0057	6:2 FTS	1.4
	BP34/0236	6:2 FTS	1.4
	T27/0063	PFBA	1.4
	R26/6503	PFBA	1.5

Tasman District Council (0/17)			
Marlborough District Council (0/7)			
Environment Canterbury (2/5, 40%)	Culverden	L-PFHxS	1.4
		Total PFHxS	1.4
	Washdyke	PFBS	1.6
		L-PFHxS	2.2
		Total PFHxS	2.2
		Mono-PFOS	3.4
		L-PFOS	3.9
		Total PFOS	7.3
		Sum PFHxS+PFOS	9.5
		PFBA	1.9
		PFPeA	1.1
		PFHxA	1.1
		PFOA	1.9
Otago Regional Council (0/4)			
Environment Southland (0/15)			
West Coast Regional Council (0/0)			
	15 wells		**41 detections**

Notes: * Average of sample and blind duplicate; < DL set to 0.5 DL for calculation of average. PFBA = Perfluoro-n-butanoic acid; PFPeA = Perfluoro-n-pentanoic acid; PFHxA = Perfluoro-n-hexanoic acid; PFHpA = Perfluoro-n-heptanoic acid; PFBS = Perfluoro-1-butanesulfonic acid; L-PFHxS = Perfluorohexanesulfonic acid (linear); L-PFOS = Perfluorooctanesulfonic acid (linear); mono-PFOS = Perfluorooctanesulfonic acid (mono-branched); Total PFOS = The numerical sum of di-PFOS (di-branched PFOS), mono-PFOS, and L-PFOS; PFOA = Perfluorooctanoic Acid; Sum PFHxS+PFOS = The numerical sum of Total PFHxS and Total PFOS; 6:2 FTS = 1H,1H,2H,2H-perfluoro-1-octanesulfonic acid.

The range of concentrations found, and the mobility characteristics of each PFAS detected is given in Table 4. The classification of the PFAS and information on their use comes from Buck et al. (2011). Water solubility data was sourced from Concawe (2016) and the Interstate Technology Regulatory Council database (ITRC, 2021). Reported values for solubility of individual PFAS may vary depending upon the method used to determine its solubility, the form of the analyte (i.e., acid or salt), pH, salinity, and whether the value is empirical or obtained through modelling. Currently, experimentally measured data for the solubility of PFAS in water are available for just a few of the more studied compounds such as the PFAAs, perfluoroalkane sulphonamido ethanols (FASEs), perfluoroalkane sulfonamides (FASAs), and fluorotelomer alcohols. As can be seen in Table 4, the solubility values for the detected PFCAs vary between 3.4 g/L to fully miscible. The solubility of the PFSAs vary between 0.52 g/L to 56.6 g/L. The high solubilities for the PFCAs and PFSAs are due to the carboxylate and sulfonate groups on the compounds and the act that they are hydrophilic (Concawe, 2016).

Due to their solubility in water and resistance to breakdown of the PFCAs and PFSAs detected in this survey, they are environmentally mobile and persistent, and can, thus be found in almost all environmental media. The FTSA detected in this survey (6:2 FTS) has a relatively low solubility in water (1.3 g/L) compared to some of the PFCAs and PFSAs detected.

The degree to which a PFAS sorbs to organic carbon particles in sediment or soil during transport i.e., its mobility, in water is estimated by the PFAS-specific organic-carbon partition coefficient (*K*oc) and the PFAS-specific octanol-water partition coefficient (*K*ow) or the PFAS- and soil-specific distribution coefficient (*K*d). The K_{ow} is a useful descriptor of the tendency of a compound to associate with hydrophobic or hydrophilic substances. Details of these values are given in Table 4. Note that *K*ow values are difficult to measure as they do not follow the typical lipid partition dynamics due to their anionic or cationic charge; thus, *Kow* is not a good parameter to predict sorption of PFAS to organic carbon (Concawe, 2016). *K*oc is calculated by measuring the ratio, *K*d, of sorbed to solution PFAS concentrations after equilibrium of a PFAS in a water/soil slurry and then dividing by the weight fraction of organic carbon present in the soil. High *K*oc values indicate compounds with high absorption to soils and low mobility. There will be some sorption of the detected PFAS to soils, sediment, and aquifer media, which means that they will persist in an aquifer or groundwater system for some time and will not be removed from a groundwater system as rapidly as they might if they were totally miscible with water.

TABLE 4: Characteristics of detected per- and polyfluoralkyl substances (PFAS)

Family classification and uses information from Buck *et al*. (2011). Water solubility data sourced from Concawe (2016) and the Interstate Technology Regulatory Council (ITRC, 2021) database on the physical and chemical properties of PFAS.

NAME	ACRONYM	FAMILY	USES	WATER SOLUBILITY (20-25°C, g/L)	ORGANIC CARBON-WATER PARTITION COEFFICIENT (log *Koc* (L/kg))	OCTANOL-WATER PARTITION COEFFICIENT (log *Kow*, (-))	SOIL DISTRIBUTION COEFFICIENT (*Kd*) (pH 7)	# WELLS	RANGE (ng/L)
Perfluoroalkylcarboxylic acids (PFCAs)									
Perfluoro-n-butanoic acid	PFBA	Perfluorinated	Degradation product	Miscible 0.447	1.88	2.82§	-	9	<1-2.3
Perfluoro-n-pentanoic acid	PFPeA	Perfluorinated	Degradation product	112.6	1.37	3.43§	-	5	<1-2.3
Perfluoro-n-hexanoic acid	PFHxA	Perfluorinated	Degradation product	21.7	1.91	4.06§	-	4	<1-2
Perfluoro-n-heptanoic acid	PFHpA	Perfluorinated	Degradation product	4.2	2.19	4.67§	0.4-1.1	1	<1-1.5
Perfluoro-n-octanoic acid	PFOA	Perfluorinated	Degradation product, surfactant	3.4-9.5	1.31-2.35	5.30§	0-3.4	2	<1-2.8
Perfluoroalkylsulfonic acids (PFSAs)									
Perfluoro-1-butanesulfonic acid	PFBS	Perfluorinated		46.2-56.6	1.00	3.90§	-	3	<1-4.8
Linear Perfluorohexanesulfonic acid	L-PFHxS	Perfluorinated		2.3*	1.78*	5.17§	0.6-3.2	2	<1-2.2
Perfluorooctanesulfonic acid (mono-branched)	mono-PFOS	Perfluorinated	Surfactant	0.91*	2.5-3.1*	6.43*§	0.7-97*	2	<1-3.4
Perfluorooctanesulfonic acid (linear)	L-PFOS	Perfluorinated		0.52-0.57*	2.5-3.1*	6.43*§	0.7-97*	2	<1-15
Fluorotelomer sulfonic acids (FTSAs)									
1H,1H,2H,2H-perfluoro-1-octanesulfonic acid	6:2 FTS	Polyfluorinated	Intermediate environmental transformation product	1.3	-	4.44§	-	4	<1-4

Notes: * Data not specified for L-PFOS, mono-PFOS or L-PHHxS isomer so data given for PFOS and PFHxS; § log *Kow* estimated with published equations, and they are based on the neutral forms of the PFAS (and not the conjugate base, which predominates for some PFAS at neutral pH).

5. DISCUSSION

All the PFAS detected in this survey were below the NZ drinking water MAVs (Water Services Regulations, 2022) (See Table 2). The maximum concentration of total-PFOS in one well in this survey was 16.5 ng/L (Table 3, Well ID 60_12, Cooks Beach Fire Station, Waikato), which is significantly above the 99% ecosystem protection screening value of 0.23 ng/L (ANZG, 2018). PFAS was also measured at this site (Cooks Beach Fire Station) in the 2018 survey of EOCs in the Waikato Region (Moreau et al., 2019). The concentration of total-PFOS and the sum PFHxS+PFOS measured in the current survey are considerably lower than the concentrations of total-PFOS (110 ng/L) and the sum PFHxS+PFOS (680 ng/L) in in the 2018 survey. As mentioned in the introduction, 95% of firefighting foams used by FENZ are of the 'Class A' type and do not contain PFAS. FENZ is currently in the process of replacing all their 'Class B' type foams containing PFAS with a fluorine-free alternative. In 2018, FENZ withdrew all foams containing PFOS and PFOA that did not comply with the previous version of the HSNO Fire Fighting Chemicals Group Standard 2017. The HSNO Fire Fighting Chemicals Group Standard 2021 sets out a timetable for staged withdrawal of PFAS foams. The reduction in usage of firefighting foams containing PFAS probably accounts for the reduction in concentration of PFAS in the groundwater at the Cooks Beach Fire Station well. It is important to note that this well is not used for drinking water purposes.

The Cooks Beach Fire station well (60_12) was re-sampled in March 2023 following the positive detections of PFAS in this well in December 2022, as were 3 other wells in the close vicinity. The PFAS concentrations in well 60_12 had decreased significantly from the levels detected in 2018, with most concentrations less by a factor of about 9. However, the decrease in concentration for total PFHxS was much greater than this with 570 ng/L being detected in 2018 and no PFHxS being detected in 2022 (LOR = 1 ng/L) and 1.2 ng/L detected in March 2023. PFAS concentrations detected in well 60_12 in March 2023 were mostly slightly higher and generally within a factor of 3, with factors ranging from 1 to 9 times higher in March 2023 compared to December 2022. Well 72_1878, also located at the Cooks Beach Fire Station about 20 m up-gradient from well 60_12, had 7 different PFAS compounds detected in March 2023 at similar but slightly lower concentrations compared to well 60_12. Two other wells, well 60_436 located approximately 90 m away from well 60_12 and at least 70 m to the right of the assumed groundwater flow path, and well 60_436 located approximately 115 m away from well 60_12 and at least 80 m to the left of the assumed groundwater flow path, had no PFAS compounds detected in March 2023. None of these wells are used for drinking water purposes.

The 2018 regional survey of PFAS in groundwater for the Waikato region (Moreau et al., 2019) collected samples from SOE sites as well as groundwater sites targeted around known or likely point sources and wastewater treatment plants. Comparing the overall results from this current survey compared to the SOE wells from the 2018 Waikato survey (Moreau et al., 2019), the maximum concentrations of all the detected PFAS is greater for the 2018 Waikato survey (Table 5). Note that the number of sites with PFAS detections differs between the surveys with 15 wells with PFAS detections in this current national survey and 5 wells with PFAS detections in the 2018 Waikato survey.

TABLE 5: Comparison the concentration of PFAS in groundwater in current 2022 PFAS survey with 2018 Waikato PFAS survey

2018 Waikato PFAs survey sourced from Moreau et al. (2019). n = number of wells with PFAS detections.

PFAS ACRONYM	THIS SURVEY (n = 15)		2018 WAIKATO SURVEY (n = 5)	
	AVERAGE (ng/L)	RANGE (ng/L)	AVERAGE (ng/L)	RANGE (ng/L)
PFBA	1.7	<1-2.3	ND	ND
PFPeA	1.7	<1-2.3	8.4	0.8-16
PFHxA	1.3	<1-2.0	6.1	1.2-11
PFHpA	1.4	<1-1.5	5.2	0.3-10
PFOA	2.5	<1-2.8	6.6	1.2-12
PFNA	< DL	< DL	6.0	6.0
PFBS	3.8	<1-4.8	16.7	2.3-31
L-PFHxS	1.8	<1-2.2	-	-
Total- PFHxS	1.8	<1-2.2	293*	15-570*
mono-PFOS	2.4	<1-3.4	-	-
L-PFOS	11.0	<1-15	-	-
Total-PFOS	13.4	<1-17	36.9	0.2-110
6:2 FTS	2.1	<1-4	ND	ND

Notes: ND = not detected; * Isomer not specified so data allocated to total concentration of PFAS.

Appendix E presents a table of the concentrations of the PFAS detected in this study that have also been detected in previous studies worldwide. It is difficult to compare between studies as the number of wells surveyed can vary widely and detection limits for the studied PFAS can differ. It is also important to note that all the studies in the table in Appendix E are studies of source-based contamination e.g., AFFF-impacted groundwater, manufacturing-impacted groundwater, landfill leachate-impacted groundwater, recycled wastewater (partially treated)-

impacted groundwater and biosolids application. The concentrations of the detected PFAS in other studies worldwide is generally higher than the concentrations detected in this survey, as would be expected since this current survey is the first survey in New Zealand that focusses on general groundwater resource sampling, not targeted sampling to identify point source PFAS contamination. Compared to concentrations found, the range of concentrations for all the detected compounds can be orders of magnitude higher than the range of concentrations found in the current survey. Bräunig et al. (2017) investigated the leaching of PFAAs from a local point source, a fire-fighting training area, which led to extensive contamination of a groundwater aquifer underneath part of Oakey, Queensland, Australia. The range of concentration of PFBS for example in groundwater were found to be <50 to 100 ng/L, which is significantly higher than the range of concentration of PFBS in this survey (<1-4.8 ng/L, Table 5. Similarly, the range of concentration of L-PFOS found by Bräunig et al. (2017) was <170 to 13,000 ng/L, which is significantly greater than the range of concentrations found in this survey (<1-15 ng/L, Table 5. The average concentration of PFBS and L-PFHxS in the well in this current survey impacted by firefighting foams (Well ID 60_12, Cooks Beach Fire Station) was only 4.3 ng/L and 14.5 ng/L, respectively.

New Zealand health-derived MAVs for drinking water are available for PFOA and the Sum of PFHxS+PFOS, so the other detected PFAS from this current survey have been compared to international guidelines. For the other tested PFAS, available guidelines vary widely between country and agency/department. These screening values have not been adopted by New Zealand; thus, they have only been applied to PFAS where there is no current New Zealand guideline. New Zealand and international guidelines for human health and species protection are given in Appendix D. There is a trend with decreasing concentration in the guideline values with more recent years and as detection limits or LOR for a particular PFAS decreases. Food Standards Australia New Zealand (FSANZ) developed recommended tolerable daily intakes which the Australian National Health and Medical Research Council (NHMRC). NHMRC used these values to derive the drinking water levels which were then adopted by the Australian Department of Health. The New Zealand Ministry of Health also adopted these values as 'interim drinking water levels' in 2017, which have now been included in the recent drinking water regulations (Water Services Regulations, 2022). The Australian National Health and Medical Research Council (NHMRC) issued drinking water quality and recreational water quality guideline values for use in site investigations in Australia (AGDoH, 2017). The recreational guideline value indicates the amount of PFAS, specifically the sum of PFOS+PFHxS and PFOA, in water that a person can accidently consume while in contact with water for recreational purposes and assumes that a person ingests 200 mL of PFAS contaminated water per day, 150 events per annum, over a lifetime.

The New Zealand Ministry of Health has health-based maximum acceptable values (MAV) for drinking water available for PFOA (560 ng/L), PFOS (70 ng/L), and PFHxS, 70 ng/L (Water Services Regulations 2022). The detection of PFOA (2 detections, maximum concentration 2.8 ng/L) in this survey as a percentage of the MAV was only 0.5%. Considering the maximum total-PFOS concentration (16.5 ng/L), the detection of PFOS (2 detections) as a percentage of the MAV was 24.3%. The highest detection of PFHxS (2 detections) as a percentage of the MAV, which was detected at a concentration of 2.2 ng/L, was also low at 3.1%. The maximum detected concentration of PFHxA (2 ng/L) and PFHpA (1.5 ng/L) were below all available guideline values (Table in Appendix D).

There are no New Zealand derived drinking water guideline values for PFBA and PFPeA, so results have been compared to guidelines from Canada and Italy. Health Canada proposed a drinking water screening value for PFBA of 30,000 ng/L (Canada Health, 2018), which is significantly above the maximum concentration of PFBA found in this survey. The only other available drinking water guideline value for PFBA, which is the health-based screening value of 7,000 ng/L from Italy (Valsecchi et al., 2017), is similarly well above the maximum concentration of PBFA found in this study.

The only available drinking water guideline for 6:2 FTS is the drinking water screening value (DWSV) of 200 ng/L from Health Canada (2018). The highest detection as a percentage of the DWSV for 6:2 FTS (4 detections), which was detected at a maximum concentration of 4 ng/L, was 2% of the DWSV.

On March 14, 2023, the U.S. EPA announced the proposed National Primary Drinking Water Regulation (NPDWR) for six PFAS in drinking water including PFOA and PFOS. The proposed PFAS NPDWR does not require any actions until it is finalised. However, the U.S. EPA is proposing the NPDWR to establish legally enforceable levels, called Maximum Contaminant Levels (MCLs), of 4.0 parts per trillion or 4 ng/L (U.S. EPA, 2023). The PFCA with the highest maximum concentration was PFOA. Detections of PFOA (2 detections) were below this proposed MCL at a maximum concentration of 2.8 ng/L, which was 70% of the proposed MCL.

Detections of mono branched-PFOS (2 detections) were also below the proposed MCL at maximum concentration of 3.4 ng/L, which was 85% of the proposed MCL. The highest detection of linear-PFOS as a percentage of the proposed MCL was 15 ng/L that was 375% of the proposed MCL of 4 ng/L. The maximum total-PFOS concentration as a percentage of the proposed MCL was 17 ng/L that was 425% of the proposed MCL of 4 ng/L. Note that ng/L = $\mu g\ m^{-3}$ = ppt.

Most of the PFAS detected in the current survey are degradation products (PFBA, PFPeA, PFHxA, PFHpA, and PFOA) from parent PFAS, are a surfactant (PFOS) or are an intermediate environmental transformation product (6:2 FTS) (Table 4). The results from the survey indicate that the PFAS, sourced from human or industrial activities, are making their way into shallow groundwater systems, and can be detected at low concentrations in groundwater. Currently there is a lack of knowledge of the fate and effects of many PFAS and whether the concentrations measured in this study are likely to have serious impacts for ecological systems. We recommend that monitoring of PFAS in groundwater resources is extended to the remainder of regions in New Zealand, that the frequency of PFAS monitoring is increased, and that research is carried out to quantify the potential risks to ecosystems from the PFAS most frequently detected in this study.

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APPENDIX A: ESR 2022 PROCEDURES FOR SAMPLING PFAS

National Survey of Pesticides, EOCs & PFAS in Groundwater 2022 - Sampling Procedures

To: The Regional or Unitary Authority

Thank you for participating in the National Survey of Pesticides in Groundwater 2022. The survey has occurred every four years since 1990 with this year being the 9th survey.

This document contains details of the required sampling procedures for this year's survey. This set of instructions are for councils that are also collecting samples for PFAS analysis in addition to samples for pesticides and EOC analysis. Four organisations are involved in the survey, ESR, Hill Laboratories, Northcott Research Consultants, and AsureQuality laboratories, with details of their role and what support and services you will receive from them below:

ESR:

- Management of the nationwide survey and full technical support
- Field sampling form
- Analysis of the results and a final report

Hill Laboratories *(Pesticide analysis laboratory)*

- x1 500ml amber glass sample bottle unpreserved (Org500)
- **NOTE: For all Hill Laboratories samples, there are holding time requirements that must be met. Samples must be refrigerated after collection and received at Hill's Hamilton Laboratory within 3 calendar days of collection. Samples should not arrive at the laboratory on a Friday due to sample extraction requirements.**
- Sample submission form
- Polystyrene boxes, ice packs and packing material for the return trip (i.e. bubble wrap)

Northcott Research Consultants *(Emerging Organic Contaminants (EOCs) analysis laboratory)*

- x1 4L amber glass sample bottle
- Sample submission form

- Polystyrene boxes, ice packs and packing material for the return trip (i.e. bubble wrap)

AsureQuality Laboratories *(PFAS analysis laboratory)*

- x1 250ml HDPE sample bottle unpreserved (supplied double-bagged in ziplock bags)
- Sample submission form
- Polystyrene boxes, ice packs and packing material for the return trip

GEAR LIST

- Council Health and Safety Form, first aid kit and cell phone
- Personal Protection Equipment (PPE)
- Sampling gloves (nitrile)
- Sample bottles (x5 bottles for each well)
- Chilly bins, ice packs and packing material (i.e. bubble wrap)
- Portable pump (i.e. Grundfos MP1 or SuperTwister) and power source if needed
- Courier tickets and address information for Hill Laboratories, Northcott Research Consultants Ltd, and AsureQuality.

SOME IMPORTANT THINGS TO REMEMBER WHEN SAMPLING

1. Please do not sample on a Thursday or Friday. If it is unavoidable then please send samples with a weekend delivery ticket or refrigerate until Monday. If at all possible, please sample on Monday to Wednesday and then send the samples back to Hill Laboratories, Northcott Research Consultants, and AsureQuality immediately via courier.
2. For PFAS sampling there needs to be 2 people in the sampling team to be able to implement a "Clean Hands/Dirty Hands" protocol. Disposable nitrile gloves have been supplied by ESR for use in collection of the PFAS samples. Note that the PFAS samples are collected in replicate. If a Blind Duplicate sample is being collected from the well, there will be a total of 4 HPDE bottles collected from the well.
3. Overalls (100% cotton and washed using water only) should be stored in plastic bags while travelling in the vehicle and put on at each site. A separate set of overalls is **not** required for each site.
4. NOTE: For all Hill Laboratory samples, there are holding time requirements that must be met. Samples must be refrigerated after collection and received at the laboratory within 3 calendar days of collection.
5. Field staff **please strictly avoid the following** on the day of sampling if sampling for EOCs or PFAS:

- Spray deodorants
- Perfume
- Insect repellent
- Smoking
- Coffee and other caffeine containing drinks such as tea, V, coke, pepsi, etc. (no drinking of these caffeine containing drinks on the day of sampling as caffeine is exuded in breath and will influence the results for nicotine and cotinine)

- Sunscreen
- Makeup/cosmetics (these products contain UV filters that are being analysed and will affect the results)

6. Please try to avoid sampling in the pouring rain so that the risk of contamination is minimised.

WELL SAMPLING PROCEDURE

1. Before putting on gloves, the sampling team removes the bags containing the gloves, 10 L bucket and the plastic groundsheet from the storage containers in which they are packed.

2. Select a flat suitable area for sampling and place groundsheet on the ground. Remove sampling equipment from the bags and place on the groundsheet. Place the decontamination equipment, and chilly bin onto the groundsheet.

3. Take the 100% cotton overalls from the plastic bag and put them on.

4. **CLEAN HANDS** and **DIRTY HANDS** put on a new pair of disposable nitrile gloves. (A hint is to put on 2-3 pairs of gloves so that putting on a fresh pair of gloves (as in step 12 or if they get contaminated) only involves taking off the uppermost pair of gloves).

5. **CLEAN HANDS** labels the preserved sample bottles and places them back into the zip lock plastic bags.

6. DIRTY HANDS measures the **static water level** within the well. This information can be very important for interpreting the results. The static water level is to be taken from a known or historical council recorded measuring point (i.e. typically the top of the well casing).

Make sure that **x3 times the casing volume of water** has been purged from the well before a sample is taken. This is to ensure that a representative sample is taken from the surrounding aquifer and not from the stagnant water within the well casing. If the well is a domestic/agricultural water supply fitted with a submersible pump, make sure the pump is running and allow it to run so that x3 well volumes are removed from the well. Take your sample as close to the well head as possible before it enters into a pressure tank or storage tank (**NEVER sample down gradient of a pressure tank or storage tank**).

7. **DIRTY HANDS** opens the tap and allows the water to run for approximately two minutes into a bucket.

8. **DIRTY HANDS** undertakes the physicochemical measurements using a multi-parameter water meter (i.e. pH, temperature, conductivity, dissolved oxygen etc) from the water collected into the bucket and records the readings and site observations. Make sure that these **readings have stabilised** before taking the sample.

9. **CLEAN HANDS** opens the sample and replicate bottles lids and collects the samples by alternately filling 25-33% of each bottle from the running tap.

10. **DIRTY HANDS** operates the tap to ensure the correct flow is maintained.

11. **CLEAN HANDS** replaces the lid on the sample bottles, returns the bottles to their inside bag, and zip-locks the bag.

12. **DIRTY HANDS** turns off the tap and places on a fresh set of gloves.

13. **CLEAN HANDS** then places the zipped bag into the outer bag held by **DIRTY HANDS**.

14. **DIRTY HANDS** zips the outer bag, places the double-bagged sample bottle into a clean chilly bin.

15. Once the PFAS samples are stored away, clearly label the glass bottles for Pesticide and EOC analyses before you get your hands or the bottles wet with the date, time and well ID number.

16. Make sure your hands are clean and once the lid is off do not touch the top of the sample bottle or the inside of the lid.

17. **Hill Laboratories bottles:** The amber glass sample bottles have been washed and rinsed according to a strict protocol. It is important that the samples are collected directly into the bottles and not into a bucket or other container before filling the sample bottles.

18. **Northcott Research Consultants bottles:** The glass 4L bottles need to be pre-rinsed twice with approximately 0.5 L of sample before filling with the collected sample. It is important that the samples are collected directly into the bottles and not into a bucket or other container before filling the sample bottles.

19. Make sure that you fill the correct number of bottles for each well that is sampled. If your council has opted to sample Pesticides, EOCs and PFAS for the well, there will be a total of 2 glass bottles and 2 HDPE bottles to fill.

11) Once your samples have been collected immediately store them in a chilly bin with ice packs (keep them stored at approx. 4°C) in preparation for transportation to the labs. **DO NOT FREEZE THE BOTTLES, OTHERWISE THEY WILL BREAK.**

BLIND DUPLICATES

For councils that are sampling more than 7 wells, there is an additional set of sample bottles. This is for the collection of blind duplicate samples, which is a quality control measure for the laboratory analysis. There is no additional cost for the collection of the blind duplicate sample. Please collect the blind duplicate samples as an extra sample from one of the wells at the same time as collecting the normal sample. Instructions are below:

- Pick at random which well will be chosen to provide the blind duplicate sample.
- The blind duplicate sample should be labelled the same as the well sample but the well ID number on the bottle should be **fictitious** and the time should be omitted. On the ESR sampling sheet identify the well ID number that is associated with the fictitious blind duplicate well number. **On the Hill Laboratories and the AsureQuality chain of custody forms do not indicate which sample is the blind duplicate sample.**
- For example, if you are sampling between 8 and 21 wells for pesticides then 1 blind duplicate sample is required. If you are sampling more than 21 wells then 2 blind duplicate samples are required. We will advise you regarding the number of blind duplicate samples that you should collect.
- When you are sampling the well collect the water for the sample and the blind duplicate as outlined below. This will ensure that the sample and the blind duplicate are representative of the whole sampling period when both samples are being taken.
- For the PFAS samples we are aiming to collect blind duplicate samples for 10% of the wells being sampled to provide additional quality control and assurance.

- 250 mL HDPE bottle for the well sample
- 250 mL HDPE bottle for the well sample (2nd bottle in ziplock bag)
- 250 mL HDPE bottle for the Blind Duplicate

- 250 mL HDPE bottle for the Blind Duplicate (2nd bottle in ziplock bag)
- 500 mL amber glass bottle for the well sample
- 500 mL amber glass bottle for the Blind Duplicate
- 4L amber glass bottle for the well sample
- 4L amber glass bottle for the Blind Duplicate

FORMS

Please fill in the forms for each well sampled:

- **ESR Field Sampling form** (i.e. the well details and parameters). Record if there has been a blind duplicate sample taken and record the fictitious well ID number along with which well the blind duplicate belongs to.

- **Hill Laboratories Environmental sample submission form** (please place the form in a waterproof plastic bag inside the chilly bin)

- **Northcott Research Consultants Ltd sample submission form** (please place the form in a waterproof plastic bag inside the chilly bin)

- AsureQuality sample submission form (please place the form in a waterproof plastic bag inside the chilly bin)

Scan and email copies of the ESR Field Sampling forms to Laura Banasiak: laura.banasiak@esr.cri.nz, copy to Murray Close, murray.close@esr.cri.nz

COURIERING SAMPLES

The glass bottles should be packed in the chilly bins and packaging received in and couriered to Hill Laboratories and Northcott Research Consultants Ltd (addresses are provided at the end of this document). The HDPE bottles should be packed in the chilly bins and packaging received in and couriered to AsureQuality Laboratories (address provided at the end of this document).

Please advise Hill Laboratories of any breakages at mail@hill-labs.co.nz so that replacement bottles can be sent.

Please advise Northcott Research Consultants Ltd of any breakages nrcltd@hotmail.co.nz or 021 2268474 so that replacement bottles can be sent.

If you have any questions about sampling or if the procedures conflict with your current sampling protocols, please do not hesitate to contact us and we can try to resolve the issues as quickly as possible.

Thanks for participating in the programme; it could not exist without your support. Any questions or comments are welcome.

APPENDIX B: ESR PFAS SAMPLING FIELD SHEET

E/S/R Science for Communities He Pūtaiao, He Tāngata	**Field Sampling Form: 2022 National Survey of Pesticides, EOCs & PFAS in Groundwater** *(please use one form per well)*	
Regional/District Council:		
Person collecting sample:		
Grid reference (NZTM):		
Council well number/ID:		
Blind Duplicate number if appropriate:		
Well owners name:		
Address:		
Weather:		
Surrounding land use:		
Well use:		
Well diameter (mm):		
Well depth (m):		
Screened interval (m):		
Pumped (circle one):	*YES / NO*	
Sampling point description:		
Water level (m):		
Date and time of sampling:	*Date:*	*Time:*
Time of pumping before sampling:		
Well volumes removed:		
Field measurements:	*DO (mg/L)*	
	Conductivity	
	Temperature	
	pH	
Type of aquifer:		
Name of aquifer (if any):		
Comments:		

APPENDIX C: LIST OF PFAS AND LIMITS OF REPORTING (LOR)

Units are µg/L (ppb).

(1) PFAS Screen	
(i) Perfluoroalkylsulfonic acids:	
Perfluoro-1-propanesulfonic acid (PFPrS)	0.0010
Perfluoro-1-butanesulfonic acid (PFBS)	0.0010
Perfluoro-1-pentanesulfonic acid (PFPeS)	0.0010
Total Perfluorodimethylbutane sulfonic acids (di-PFHxS (1))	0.0010
Total Perfluoromethylpentane sulfonic acids (mono-PFHxS (1))	0.0010
Linear Perfluorohexanesulfonic acid (L-PFHxS (1))	0.0010
Total PFHxS (3)	0.0010
Perfluoro-1-heptanesulfonic acid (PFHpS)	0.0010
Total Perfluorodimethylhexane sulfonic acids (di-PFOS (5))	0.0010
Total Perfluoromethylheptane sulfonic acids (mono-PFOS (5))	0.0010
Linear Perfluorooctanesulfonic acid (L-PFOS (5))	0.0010
Total PFOS (7)	0.0010
Sum PFHxS+PFOS (1)	0.0010
Perfluoro-1-nonanesulfonic acid (PFNS)	0.0010
Perfluoro-1-decanesulfonic acid (PFDS)	NR
Perfluoro-4-ethylcyclohexanesulfonic acid (PFECHS)	0.0010
(ii) Perfluoroalkylcarboxylic acids:	
Perfluoro-n-butanoic acid (PFBA)	0.0010
Perfluoro-n-pentanoic acid (PFPeA)	0.0010
Perfluoro-n-hexanoic acid (PFHxA)	0.0010
Perfluoro-n-heptanoic acid (PFHpA)	0.0010
Perfluoro-n-octanoic acid (PFOA)	0.0010
Perfluoro-n-nonanoic acid (PFNA)	0.0010
Perfluoro-n-decanoic acid (PFDA)	0.0010
Perfluoro-n-undecanoic acid (PFUnDA)	0.0010
Perfluoro-n-dodecanoic acid (PFDoDA)	0.0010
Perfluoro-n-tridecanoic acid (PFTrDA)	NR
Perfluoro-n-tetradecanoic acid (PFTeDA)	0.0010
Perfluoro-3,7-dimethyloctanoic acid (P37DMOA)	0.0010
(iii) Perfluorooctanesulfonamides:	
Perfluoro-1-octanesulfonamide (PFOSA)	0.0010
N-ethylperfluoro-1-octanesulfonamide (NEtFOSA-M)	0.0010
N-methylperfluoro-1-octanesulfonamide (NMeFOSA-M)	0.0010
(iv) Perfluorooctanesulfonamidoacetic acids:	
N-ethylperfluoro-1-octanesulfonamidoacetic acid (NEtFOSAA)	0.0010
N-methylperfluoro-1-octanesulfonamidoacetic acid (NMeFOSAA)	0.0010
(v) Perfluorooctanesulfonamidoethanols:	
2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol (NEtFOSE-M)	0.0010
2-(N-methylperfluoro-1-octanesulfonamido)-ethanol (NMeFOSE-M)	0.0010
(vi) Telomere Sulfonic acids:	
1H,1H,2H,2H-perfluoro-1-hexanesulfonic acid (4:2 FTS)	0.0010
1H,1H,2H,2H-perfluoro-1-octanesulfonic acid (6:2 FTS)	0.0010
1H,1H,2H,2H-perfluoro-1-decanesulfonic acid (8:2 FTS)	0.0010
1H,1H,2H,2H-perfluorododecanesulfonic acid (10:2 FTS)	0.0010

(vii) Telomere Carboxylic acids:	
3-Perfluoropropyl propanoic acid (FPrPA (3:3FTA))	0.0010
3-Perfluoropentyl propanoic acid (FPePA (5:3FTA))	0.0010
3-Perfluoroheptyl propanoic acid (FHpPA (7:3FTA))	0.0010
(viii) Miscellaneous:	
9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (F-53B (major))	0.0010
11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (F-53B (minor))	0.0010
Sum of F-53B components (major + minor) (Sum F-53B)	0.0010
Dodecafluoro-3H-4,8-dioxanonanoic acid (ADONA)	0.0010
Tetrafluoro-2-(heptafluoropropoxy)propanoic acid (HFPO-DA (GenX))	0.0010

Notes:
di-PFHxS (1) = Concentration determined using a branched di-PFHxS isomer standard (399>80 transition)
mono-PFHxS (1) = Concentration determined using a branched mono-PFHxS isomer standard (399>80 transition)
L-PFHxS (1) = Concentration determined using the linear PFHxS isomer standard (399>80 transition)
Total PFHxS (3) = The numerical sum of di-PFHxS (1), mono-PFHxS (1), and L-PFHxS (1)
di-PFOS (5) = Concentration determined using a branched di-PFOS isomer standard (499>80 transition)
mono-PFOS (5) = Concentration determined using a branched mono-PFOS isomer standard (499>80 transition)
L-PFOS (5) = Concentration determined using the linear PFOS isomer standard (499>230 transition)
Total PFOS (7) = The numerical sum of di-PFOS (5), mono-PFOS (5), and L-PFOS (5)
Sum PFHxS+PFOS (1) = The numerical sum of Total PFHxS (3) and Total PFOS (7)
Sum F-53B = The numerical sum of 9Cl-PF3ONS (F-53B major) and 11Cl-PF3OUdS (F-53B minor)
NR: Not Reportable

APPENDIX D: NZ AND INTERNATIONAL ENVIRONMENTAL AND HUMAN HEALTH GUIDELINES FOR DETECTED PFAS

Note that ng/L = µg/m³ = ppt; International drinking water guideline values sourced from the Interstate Technology and Regulatory Council (ITRC) website (https://pfas-1.itrcweb.org/fact-sheets/). [+] U.S. EPA Proposed maximum concentration level (U.S. EPA, 2023).

PFAS	DRINKING WATER GUIDELINE VALUE (ng/L)	HUMAN HEALTH GUIDELINE – RECREATION (ng/L)	ECOLOGICAL FRESHWATER GUIDELINE 95% ECOSYSTEM PROTECTION (ng/L)	ECOLOGICAL FRESHWATER GUIDELINE 99% ECOSYSTEM PROTECTION (ng/L)
Perfluoroalkylcarboxylic acids (PFCAs)				
PFBA	30,000[a] 7,000[b]	NGV[1]	NGV[2,3]	NGV[2,3]
PFPeA	200[a] 3,000[b] 90[c]	NGV[1]	NGV[2,3]	NGV[2,3]
PFHxA	200[a] 1,000[b] 90[c]	NGV[1]	NGV[2,3]	NGV[2,3]
PFHpA	200[a] 90[c]	NGV[1]	NGV[2,3]	NGV[2,3]
PFOA	0.004[d] 2[f] 4[+] 60[e] 90[c] 200[a] 300[g] 390[h] 500[b] 560[2]	2,000[1]	220,000[2,3]	19,000[2,3]
Perfluoroalkylsulfonic acids (PFSAs)				
PFBS	2,000[d] 6,000[e] 15,000[a]	NGV[1]	NGV[2,3]	NGV[2,3]
L=PFHxS	390[e,*] 600[a]	NGV[1]	NGV[2,3]	NGV[2,3]
mono-PFOS	0.02[d,*] 40[e,*] 4[+]	NGV[1]	NGV[2,3]	NGV[2,3]
L-PFOS	0.02[d,*] 40[e,*] 4[+]	NGV[1]	NGV[2,3]	NGV[2,3]
Sum PFHxS+PFOS	70[1,2]	700[1,2]	31,000[2]	0.23[2]

		10,000[1]		
Fluorotelomer sulfonic acids (FTSAs)				
6:2 FTS	200[a]	NGV[1]	NGV[2,3]	NGV[2,3]

Notes: NGV = No Guideline Value; [1]Australia Government Department of Health (AGDoH, 2017); [2] NZ Ministry of Health (Water Services Regulations, 2022); [3] Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018); Department/agency/country source (ITRC, 2023): [a] Health Canada (2018); [b] Italy (Valsecchi et al., 2017); [c] Sweden (Concawe, 2016); [d] U.S. EPA Office of Water; [e] U.S. EPA Regions (USEPA, 2022) ; [f] Ministry of Environment Denmark (Danish EPA, 2021); [g] Germany Ministry of Health (GMH, 2006); [h] Netherlands (RIVM, 2020). * isomer details not given.

APPENDIX E: MEASURED AND REPORTED CONCENTRATIONS OF DETECTED PFAS IN GROUNDWATER

REGION	n	AVERAGE CONCENTRATION (ng/L)										SOURCE
		PFBS	L-PFHxS	PFOS	L-PFOS	PFBA	PFPeA	PFHxA	PFHpA	PFOA	6:2 FTS	
AFFF-impacted groundwater												
Australia	13 (gw 10, sw 3)	500 ± 300 (<50-100)	2400 ± 1900 (<70-6000)	-	2600 ± 2400 (<170-13,000)	200 ± 100 (<80-300)	200 ± 100 (80-300)	600 ± 500 (80-1400)	200 ± 100 (100-200)	200 ± 200 (50-600)	-	1
Europe	3	30 ± 7 (23-37)	227 ± 87 (142-315)	481 ± 198 (287-682)	-	12 ± 0.6 (11-12)	-	52 ± 19 (36-73)	12 ± 4 (9-16)	29 ± 11 (19-40)	19 ± 13 (7-33)	2
	16	-	848 ± 1206 (<0.5-3470)	145 ± 173 (1.3-2080)	-	-	-	135 ± 289 (<0.5-900)	-	496 ± 1267 (<1-4470)	-	3
North America	24	28,729	-	34,796	-	16,346	-	-	-	33,596	-	4
				21,000 (0.01-4,600,000)			3700 (0.0211-300,000)					5
Central America	80	1.3 ± 5.7 (<0.01-38)	4.6 ± 22 (<0.01-143)	-	2.4 ± 7.9 (<0.01-38)	2.9 ± 9.4 (<0.27-63)	8.2 ± 34 (<DL-213)	7.3 ± 27 (<DL-158)	33 ± 14 (<DL-87)	1.1 ± 2.8 (<0.01-14)	- (max. 150)	6
Manufacturing-impacted groundwater												
Asia	37	1.3-7.0) (0-43)	0.3 ± 0.9 (0-4.6)	2.4 ± 8.3 (0-37.8)	-	1,521 ± 4,432 (0-24,178)	929-2,309 (0-10,586)	832 ± 1,921 (0-8,878)	369 ± 853 (0-3,734)	22,966 ± 55,514 (0.5-239,644)	-	7
	52	2.9 ± 1.8 (<0.5-7.4)	1.0 ± 0.5 (<0.5-1.9)	17 ± 29 (<0.5-94.9)	-	10 ± 15 (<0.1-58.5)	7.4 ± 13 (0.8-56.6)	22 ± 39 (<0.2-132)	14 ± 24 (<0.5-99.7)	67 ± 127 (<0.1-475)	-	8
	102	12.2 ± 24.0 (<0.2-143)	0.8 ± 0.6 (<0.2-4.0)	4.4 ± 10.5 (0.3-79)	-	2.5 ± 4.2 (<0.1-33)	11.1 ± 31.9 (<0.2-290)	2.6 ± 4.3 (<0.1-31)	2.1 ± 3.8 (<0.1-31)	5.2 ± 8.6 (<0.2-49)	2.5 ± 14.9 (0.3-151)	9
	3	-	-	-	-	-	-	-	-	(99.8–392)	-	10
	15	5190 ± 4810 (20.2-12,420)	1.63 ± 1.82 (0.04-7.15)	14.6 ± 24.3 (0.26-100)	-	4925 ± 4216 (56-13,148)	73.4 ± 106 (1.74-387)	38.3 ± 42.3 (2.26-136)	8.51 ± 6.16 (1.96-25.2)	155 ± 105 (23.2-367)	-	11

	88	1.0 ± 1.4 (<0.02-6.9)	0.7 ± 3.6 (<0.01-22)	1.9 ± 5.8 (<0.01-34)	-	20 ± 31 (<0.1-90)	8.4 ± 12 (0.2-49)	2.8 ± 4.0 (<0.1-27)	2.4 ± 5.6 (<0.1-44)	2.7 ± 7.0 (<0.03-55)	3.4 ± 15 (<0.06-118)	12
Landfill leachate-impacted groundwater												
Australia	13	9 (2-31)	34 (2.6-280)	26 (1.3-4,800)	-	11 (<0.2-49)	<0.2 (<0.2-15)	19 (<0.2-46)	<0.2 (<0.2-22)	12 (2-74)	<0.2 (<0.2-10)	13
Ireland	10	<0.1 (<0.1-0.22)	<0.1 (<0.1-0.28)	0.21 (<0.1-1.3)	-	-	-	-	-	30 (1.6-96)	-	14
Europe	15	15 ± 29 (<0.01-91)	14 ± 34 (<0.22-99)	-	-	110 ± 306 (1.3-1200)	-	44 ± 146 (0.22-570)	45 ± 111 (<0.25-320)	-	-	15
Asia	15	2.1 ± 1.8 (0.6-6.8)	0.4 ± 0.2 (0.1-0.8)	1.2 ± 0.8 (0.2-2.4)	-	20 ± 11 (6.5-39)	5.7 ± 5.0 (1.4-20)	4.5 ± 3.6 (0.8-13)	4.8 ± 5.2 (0.5-18)	22 ± 16 (2.8-54)	0.2 ± 0.1 (0.1-0.5)	16
Canada	48	(max. 710)	(max. 1300)	(max. 2800)	-	(max. 290)	(max. 210)	(max. 670)	(max. 270)	(max. 850)	-	17
Recycled wastewater (Partially treated)-impacted groundwater												
Australia	28	4.4 (<0.09-9.1)	5.9 (<0.03-18)	11 (<0.03-34)	-	6.1 (<0.1-13)	1 (<0.03-8.4)	3.7 (<0.03- 27.2)	0.8 (<0.03-5.3)	2.2 (<0.09-6.9)	1.3 (<0.58-14)	18
Europe	164	0 (max. 25)	1 Max. 19)	4 (max. 135)	-	-	-	-	1 (max. 21)	3 (max. 39)	-	19
	17	-	-	<0.08	-	-	-	-	-	<0.06	-	20
Asia	16	-	-	24 (0.28-133)	-	-	-	-	-	13 (0.47-60)	-	21
	53	-	<0.25-56	<0.25-990	-	-	-	-	<0.25-61	<0.25-1800	-	22
North America	20	-	-	(<1-97)	-	-	-	-	-	(<10-22)	-	23
	104	11 ± 3.1 (<2-18)	20 ± 10 (<2-46)	89 ± 81 (<2-340)	-	-	-	25 ± 6.1 (<2-42)	8.7 ± 3.0 (<2-16)	18 ± 7 (<2-30)	-	24
Biosolids application												
North America	2	(max. 4.1)	(max. 1.9)	(max. 65)	-	-	(max. 30)	(max. 40)	(max. 2.6)	(max. 16)	-	25
	9	(<DL-3.6)	(<DL-7.7)	(<DL-16)	-	-	-	(<DL-6.9)	(<DL-1.9)	(<DL-5.0)	-	26
Asia	30	-	-	-	-	-	-	-	-	6.42 (0.41-99.9)	2.0 (0.04-14.3)	27

Background												
Asia	22	-	3.1 ± 4.2 (<0.05-6)	1.1 ± 2.5 (<0.05-8.2)	-	0.7 ± 0.5 (<0.05-1.0)	-	-	0.7 ± 0.5 (<0.05-1.3)	1.1 ± 1.6 (<0.05-4.5)	-	28
Other												
Asia PFAS leakage	36	1.7 ± 0.6 (<DL-3.2)	4.6 ± 2.6 (<DL-10.4)	-	-	-	2.4 ± 1.7 (ND-6.2)	3.7 ± 2.9 (<DL-10.5)	2.3 ± 0.7 (<DL-3.5)	3.0 ± 1.5 (ND-6.7)	-	29

Notes: Concentrations in brackets is the range of concentration found; Source: 1 Bräunig et al. (2017); 2 Wagner et al. (2013); 3 Filipovic et al. (2015); 4 Houtz et al. (2013); 5 Nickerson et al. (2021); 6 Munoz et al. (2017); 7 Liu et al. (2016); 8 Chen et al. (2016); 9 Wei et al. (2018); 10 Sun et al. (2018); 11 Wang et al. (2019); 12 Wang et al. (2022); 13 Hepburn et al. (2019); 14 Harrad et al. (2020); 15 Eschauzier et al. (2013); 16 Xu et al. (2021); 17 Propp et al. (2021); 18 Szabo et al. (2018); 19 Loos et al. (2010); 20 Pignotti et al. (2017); 21 Murakami et al. (2009); Kuroda et al. (2014); 23 Schaider et al. (2014); 24 Cáñez et al. (2021); 25 Johnson (2022); 26 Pepper et al. (2021); 27 Zhou et al., (2021); 28 Duong et al. (2015); 29 Yong et al. (2021).

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Certificate of Analysis

Final Report

Shaun Presow
Environmental Protection Authority
Private Bag 63002
Wellington 6140
New Zealand

Report Issued: 09-Oct-2023 | **AsureQuality Reference: 23-254933** | **Sample(s) Received:** 25-Sep-2023 13:35

Testing Period: 25-Sep-2023 to 06-Oct-2023
Date of analysis is available on request.

Results

The tests were performed on the samples as received.

Customer Sample Name: Silicon tubing + nylon — **Lab ID:** 23-254933-1

Sample Description: Passed through componebts attached to peristaltic pump

Sample Condition: Acceptable — **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	109	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	110	%	AsureQuality Method (LC-MS/MS)
M8PFOS	113	%	AsureQuality Method (LC-MS/MS)
M4PFBA	106	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	104	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	108	%	AsureQuality Method (LC-MS/MS)
MPFHpA	104	%	AsureQuality Method (LC-MS/MS)
M8PFOA	106	%	AsureQuality Method (LC-MS/MS)
M9PFNA	114	%	AsureQuality Method (LC-MS/MS)
M6PFDA	117	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	106	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	81	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	53	%	AsureQuality Method (LC-MS/MS)
MPFOSA	81	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	8 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	37	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	109	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	113	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	57	%	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
DNMeFOSE	89	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	120	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	107	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	119	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	102	%	AsureQuality Method (LC-MS/MS)

R = Recovery outside method limits

Customer Sample Name: Silicon tubing **Lab ID:** 23-254933-2

Sample Description: Passed through component attached to peristaltic pump

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	79	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	43	%	AsureQuality Method (LC-MS/MS)
M8PFOS	30	%	AsureQuality Method (LC-MS/MS)
M4PFBA	100	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	97	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	87	%	AsureQuality Method (LC-MS/MS)
MPFHpA	73	%	AsureQuality Method (LC-MS/MS)
M8PFOA	54	%	AsureQuality Method (LC-MS/MS)
M9PFNA	45	%	AsureQuality Method (LC-MS/MS)
M6PFDA	29 (R)	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	30	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	27 (R)	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	31	%	AsureQuality Method (LC-MS/MS)
MPFOSA	56	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	35	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	46	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	22 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	31	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	25 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	69	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	98	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	80	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	45	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	115	%	AsureQuality Method (LC-MS/MS)

R = Recovery outside method limits

Customer Sample Name: BP34/0236 **Lab ID:** 23-254933-3

Sample Description: Sample collected from bove using submersible pump

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			

PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	92	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	76	%	AsureQuality Method (LC-MS/MS)
M8PFOS	68	%	AsureQuality Method (LC-MS/MS)
M4PFBA	102	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	102	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	98	%	AsureQuality Method (LC-MS/MS)
MPFHpA	90	%	AsureQuality Method (LC-MS/MS)
M8PFOA	85	%	AsureQuality Method (LC-MS/MS)
M9PFNA	83	%	AsureQuality Method (LC-MS/MS)
M6PFDA	83	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	71	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	49	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	39	%	AsureQuality Method (LC-MS/MS)
MPFOSA	78	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	31	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	96	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	60	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	78	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	63	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	81	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	109	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	98	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	105	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	95	%	AsureQuality Method (LC-MS/MS)

Customer Sample Name: BP33/0056 **Lab ID:** 23-254933-4

Sample Description: Sample collected from bove using submersible pump

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	106	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	141	%	AsureQuality Method (LC-MS/MS)
M8PFOS	291 (R)	%	AsureQuality Method (LC-MS/MS)
M4PFBA	101	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	106	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	107	%	AsureQuality Method (LC-MS/MS)
MPFHpA	112	%	AsureQuality Method (LC-MS/MS)
M8PFOA	119	%	AsureQuality Method (LC-MS/MS)
M9PFNA	166 (R)	%	AsureQuality Method (LC-MS/MS)
M6PFDA	253 (R)	%	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
M7PFUnDA	379 (R)	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	370 (R)	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	194 (R)	%	AsureQuality Method (LC-MS/MS)
MPFOSA	158 (R)	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	108	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	119	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	292 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	248 (R)	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	130	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	132	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	104	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	112	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	169 (R)	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	103	%	AsureQuality Method (LC-MS/MS)

R = Recovery outside method limits

Customer Sample Name: BP34/0229 **Lab ID:** 23-254933-5

Sample Description: Sample collected from bove using submersible pump

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	97	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	98	%	AsureQuality Method (LC-MS/MS)
M8PFOS	107	%	AsureQuality Method (LC-MS/MS)
M4PFBA	97	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	101	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	102	%	AsureQuality Method (LC-MS/MS)
MPFHpA	95	%	AsureQuality Method (LC-MS/MS)
M8PFOA	96	%	AsureQuality Method (LC-MS/MS)
M9PFNA	103	%	AsureQuality Method (LC-MS/MS)
M6PFDA	134	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	121	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	103	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	49	%	AsureQuality Method (LC-MS/MS)
MPFOSA	93	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	66	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	126	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	93	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	112	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	92	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	69	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	101	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	100	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	118	%	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
M3HFPO-DA	99	%	AsureQuality Method (LC-MS/MS)

Customer Sample Name: BP33/0057 **Lab ID:** 23-254933-6

Sample Description: Sample collected from bove using submersible pump

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	113	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	145	%	AsureQuality Method (LC-MS/MS)
M8PFOS	351 (R)	%	AsureQuality Method (LC-MS/MS)
M4PFBA	103	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	108	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	106	%	AsureQuality Method (LC-MS/MS)
MPFHpA	110	%	AsureQuality Method (LC-MS/MS)
M8PFOA	126	%	AsureQuality Method (LC-MS/MS)
M9PFNA	171 (R)	%	AsureQuality Method (LC-MS/MS)
M6PFDA	291 (R)	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	487 (R)	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	571 (R)	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	192 (R)	%	AsureQuality Method (LC-MS/MS)
MPFOSA	141	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	156 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	206 (R)	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	324 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	259 (R)	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	131	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	125	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	98	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	118	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	185 (R)	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	120	%	AsureQuality Method (LC-MS/MS)

R = Recovery outside method limits

Customer Sample Name: Dupl.of 23-254933-6A **Lab ID:** 23-254933-7

Sample Description: 22873572_Duplicate

Sample Condition: Acceptable **Sampled Date**: 30-Aug-2023

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	0 0010	µg/L	AsureQuality Method (LC MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	103	%	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
M3PFHxS	116	%	AsureQuality Method (LC-MS/MS)
M8PFOS	187 (R)	%	AsureQuality Method (LC-MS/MS)
M4PFBA	105	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	109	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	103	%	AsureQuality Method (LC-MS/MS)
MPFHpA	104	%	AsureQuality Method (LC-MS/MS)
M8PFOA	105	%	AsureQuality Method (LC-MS/MS)
M9PFNA	131	%	AsureQuality Method (LC-MS/MS)
M6PFDA	187 (R)	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	225 (R)	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	181 (R)	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	47	%	AsureQuality Method (LC-MS/MS)
MPFOSA	96	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	45	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	47	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	168 (R)	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	170 (R)	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	77	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	68	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	106	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	106	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	152 (R)	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	121	%	AsureQuality Method (LC-MS/MS)

R = Recovery outside method limits

QC Results

Blank

Relates to sample(s) 23-254933-1, 23-254933-2, 23-254933-3, 23-254933-4, 23-254933-5, 23-254933-6, 23-254933-7

Test	Result	Unit	Method Reference
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
Perfluoroalkylsulfonic acids			
PFPrS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFBS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFPeS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFHxS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFHxS (3)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
di-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
mono-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
L-PFOS (5)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Total PFOS (7)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Sum PFHxS+PFOS (1)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
PFDS	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFECHS	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)

Perfluoroalkylcarboxylic acids			
PFBA	<0.0050	µg/L	AsureQuality Method (LC-MS/MS)
PFPeA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHxA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFHpA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFNA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFUnDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFDoDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
PFTrDA	NR	µg/L	AsureQuality Method (LC-MS/MS)
PFTeDA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
P37DMOA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamides			
PFOSA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NEtFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSA-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoacetic acids			
NEtFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSAA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Perfluorooctanesulfonamidoethanols			
NEtFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
NMeFOSE-M	NR	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Sulfonic acids			
4:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
6:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
8:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
10:2 FTS	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Telomere Carboxylic acids			
FPrPA (3:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FPePA (5:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
FHpPA (7:3FTA)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Miscellaneous			
F-53B (major)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
F-53B (minor)	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
Sum F-53B	<0.0020	µg/L	AsureQuality Method (LC-MS/MS)
ADONA	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
HFPO-DA (GenX)	<0.0010	µg/L	AsureQuality Method (LC-MS/MS)
Internal Standards			
M3PFBS	91	%	AsureQuality Method (LC-MS/MS)
M3PFHxS	64	%	AsureQuality Method (LC-MS/MS)
M8PFOS	48	%	AsureQuality Method (LC-MS/MS)
M4PFBA	100	%	AsureQuality Method (LC-MS/MS)
M5PFPeA	101	%	AsureQuality Method (LC-MS/MS)
M5PFHxA	95	%	AsureQuality Method (LC-MS/MS)
MPFHpA	84	%	AsureQuality Method (LC-MS/MS)
M8PFOA	70	%	AsureQuality Method (LC-MS/MS)
M9PFNA	61	%	AsureQuality Method (LC-MS/MS)

Test	Result	Unit	Method Reference
M6PFDA	52	%	AsureQuality Method (LC-MS/MS)
M7PFUnDA	68	%	AsureQuality Method (LC-MS/MS)
MPFDoDA	69	%	AsureQuality Method (LC-MS/MS)
MPFTeDA	51	%	AsureQuality Method (LC-MS/MS)
MPFOSA	81	%	AsureQuality Method (LC-MS/MS)
DNEtFOSA	65	%	AsureQuality Method (LC-MS/MS)
DNMeFOSA	122	%	AsureQuality Method (LC-MS/MS)
DNEtFOSAA	55	%	AsureQuality Method (LC-MS/MS)
DNMeFOSAA	65	%	AsureQuality Method (LC-MS/MS)
DNEtFOSE	85	%	AsureQuality Method (LC-MS/MS)
DNMeFOSE	102	%	AsureQuality Method (LC-MS/MS)
M4:2FTS	97	%	AsureQuality Method (LC-MS/MS)
M6:2FTS	87	%	AsureQuality Method (LC-MS/MS)
M8:2FTS	72	%	AsureQuality Method (LC-MS/MS)
M3HFPO-DA	93	%	AsureQuality Method (LC-MS/MS)

Analysis Summary

Wellington Laboratory

Analysis	Method	Accreditation	Authorised by
Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water			
DX-PFCS01, 03-SUITE_B	AsureQuality Method (LC-MS/MS)	IANZ	Amelie Sellier

di-PFHxS (1) = Concentration determined using a branched di-PFHxS isomer standard (399>80 transition)

mono-PFHxS (1) = Concentration determined using a branched mono-PFHxS isomer standard (399>80 transition)

L-PFHxS (1) = Concentration determined using the linear PFHxS isomer standard (399>80 transition)

Total PFHxS (3) = The numerical sum of di-PFHxS (1), mono-PFHxS (1), and L-PFHxS (1)

di-PFOS (5) = Concentration determined using a branched di-PFOS isomer standard (499>80 transition)

mono-PFOS (5) = Concentration determined using a branched mono-PFOS isomer standard (499>80 transition)

L-PFOS (5) = Concentration determined using the linear PFOS isomer standard (499>230 transition)

Total PFOS (7) = The numerical sum of di-PFOS (5), mono-PFOS (5), and L-PFOS (5)

Sum PFHxS+PFOS (1) = The numerical sum of Total PFHxS (3) and Total PFOS (7)

Sum F-53B = The numerical sum of 9Cl-PF3ONS (F-53B major) and 11Cl-PF3OUdS (F-53B minor)

For all Totals, where a component is detected below the LOR, the value of zero is used in the calculation of the sum. The result represents the lower-bound concentration present in the sample.

Reported results are corrected for internal standard recovery

Results that are prefixed with '<' indicate the lowest level at which the analyte can be reported, and that in this case the analyte was not observed above this limit.

NR = Not Reportable

Amelie Sellier
Scientist

Accreditation

Appendix

Analyte LOR Summary

Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water - AsureQuality Method (LC-MS/MS)

Analyte	LOR
Perfluoroalkylsulfonic acids	
PFPrS	0.0010 µg/L
PFBS	0.0010 µg/L
PFPeS	0.0010 µg/L
di-PFHxS (1)	0.0010 µg/L
mono-PFHxS (1)	0.0010 µg/L
L-PFHxS (1)	0.0010 µg/L
Total PFHxS (3)	0.0010 µg/L
PFHpS	0.0010 µg/L
di-PFOS (5)	0.0010 µg/L
mono-PFOS (5)	0.0010 µg/L
L-PFOS (5)	0.0010 µg/L
Total PFOS (7)	0.0010 µg/L
Sum PFHxS+PFOS (1)	0.0010 µg/L
PFNS	0.0010 µg/L
PFDS	NR µg/L
PFECHS	0.0010 µg/L
Perfluoroalkylcarboxylic acids	
PFBA	0.0010 µg/L
PFPeA	0.0010 µg/L
PFHxA	0.0010 µg/L
PFHpA	0.0010 µg/L
PFOA	0.0010 µg/L
PFNA	0.0010 µg/L
PFDA	0.0010 µg/L
PFUnDA	0.0010 µg/L
PFDoDA	0.0010 µg/L
PFTrDA	NR µg/L
PFTeDA	0.0010 µg/L
P37DMOA	0.0010 µg/L
Perfluorooctanesulfonamides	
PFOSA	0.0010 µg/L
NEtFOSA-M	NR µg/L
NMeFOSA-M	NR µg/L
Perfluorooctanesulfonamidoacetic acids	
NEtFOSAA	0.0010 µg/L
NMeFOSAA	0.0010 µg/L
Perfluorooctanesulfonamidoethanols	
NEtFOSE-M	NR µg/L
NMeFOSE-M	NR µg/L
Telomere Sulfonic acids	
4:2 FTS	0.0010 µg/L
6:2 FTS	0.0010 µg/L
8:2 FTS	0.0010 µg/L
10:2 FTS	0.0010 µg/L
Telomere Carboxylic acids	
FPrPA (3:3FTA)	0.0010 µg/L
FPePA (5:3FTA)	0.0010 µg/L

FHpPA (7:3FTA)	0.0010 µg/L
Miscellaneous	
F-53B (major)	0.0010 µg/L
F-53B (minor)	0.0010 µg/L
Sum F-53B	0.0010 µg/L
ADONA	0.0010 µg/L
HFPO-DA (GenX)	0.0010 µg/L

Analyte Definitions

Poly- and Perfluorinated Alkyl Substances (PFAS) in Potable Water - AsureQuality Method (LC-MS/MS)

Analyte	Full Name
Perfluoroalkylsulfonic acids	
PFPrS	Perfluoro-1-propanesulfonic acid
PFBS	Perfluoro-1-butanesulfonic acid
PFPeS	Perfluoro-1-pentanesulfonic acid
di-PFHxS (1)	Total Perfluorodimethylbutane sulfonic acids
mono-PFHxS (1)	Total Perfluoromethylpentane sulfonic acids
L-PFHxS (1)	Linear Perfluorohexanesulfonic acid
PFHpS	Perfluoro-1-heptanesulfonic acid
di-PFOS (5)	Total Perfluorodimethylhexane sulfonic acids
mono-PFOS (5)	Total Perfluoromethylheptane sulfonic acids
L-PFOS (5)	Linear Perfluorooctanesulfonic acid
PFNS	Perfluoro-1-nonanesulfonic acid
PFDS	Perfluoro-1-decanesulfonic acid
PFECHS	Perfluoro-4-ethylcyclohexanesulfonic acid
Perfluoroalkylcarboxylic acids	
PFBA	Perfluoro-n-butanoic acid
PFPeA	Perfluoro-n-pentanoic acid
PFHxA	Perfluoro-n-hexanoic acid
PFHpA	Perfluoro-n-heptanoic acid
PFOA	Perfluoro-n-octanoic acid
PFNA	Perfluoro-n-nonanoic acid
PFDA	Perfluoro-n-decanoic acid
PFUnDA	Perfluoro-n-undecanoic acid
PFDoDA	Perfluoro-n-dodecanoic acid
PFTrDA	Perfluoro-n-tridecanoic acid
PFTeDA	Perfluoro-n-tetradecanoic acid
P37DMOA	Perfluoro-3,7-dimethyloctanoic acid
Perfluorooctanesulfonamides	
PFOSA	Perfluoro-1-octanesulfonamide
NEtFOSA-M	N-ethylperfluoro-1-octanesulfonamide
NMeFOSA-M	N-methylperfluoro-1-octanesulfonamide
Perfluorooctanesulfonamidoacetic acids	
NEtFOSAA	N-ethylperfluoro-1-octanesulfonamidoacetic acid
NMeFOSAA	N-methylperfluoro-1-octanesulfonamidoacetic acid
Perfluorooctanesulfonamidoethanols	
NEtFOSE-M	2-(N-ethylperfluoro-1-octanesulfonamido)-ethanol
NMeFOSE-M	2-(N-methylperfluoro-1-octanesulfonamido)-ethanol
Telomere Sulfonic acids	
4:2 FTS	1H,1H,2H,2H-perfluoro-1-hexanesulfonic acid
6:2 FTS	1H,1H,2H,2H-perfluoro-1-octanesulfonic acid
8:2 FTS	1H,1H,2H,2H-perfluoro-1-decanesulfonic acid
10:2 FTS	1H,1H,2H,2H-perfluorododecanesulfonic acid
Telomere Carboxylic acids	
FPrPA (3:3FTA)	3-Perfluoropropyl propanoic acid

Analyte	Full Name
FPePA (5:3FTA)	3-Perfluoropentyl propanoic acid
FHpPA (7:3FTA)	3-Perfluoroheptyl propanoic acid
Miscellaneous	
F-53B (major)	9-chlorohexadecafluoro-3-oxanonane-1-sulfonic acid
F-53B (minor)	11-chloroeicosafluoro-3-oxaundecane-1-sulfonic acid
Sum F-53B	Sum of F-53B components (major + minor)
ADONA	Dodecafluoro-3H-4,8-dioxanonanoic acid
HFPO-DA (GenX)	Tetrafluoro-2-(heptafluoropropoxy)propanoic acid
Internal Standards	
M3PFBS	Perfluoro-1-[2,3,4-13C3]butanesulfonic acid
M3PFHxS	Perfluoro-1-[1,2,3-13C3]hexanesulfonic acid
M8PFOS	Perfluoro-1-[13C8]octanesulfonic acid
M4PFBA	Perfluoro-n-[1,2,3,4-13C4]butanoic acid
M5PFPeA	Perfluoro-n-[1,2,3,4,5-13C5]pentanoic acid
M5PFHxA	Perfluoro-n-[1,2,3,4,6-13C5]hexanoic acid
MPFHpA	Perfluoro-n-[-1,2,3,4-13C4]heptanoic acid
M8PFOA	Perfluoro-n-[13C8]octanoic acid
M9PFNA	Perfluoro-n-[13C9]nonanoic acid
M6PFDA	Perfluoro-n-[1,2,3,4,5,6-13C6]decanoic acid
M7PFUnDA	Perfluoro-n-[1,2,3,4,5,6,7-13C7]undecanoic acid
MPFDoDA	Perfluoro-n-[1,2-13C2]dodecanoic acid
MPFTeDA	Perfluoro-n-[1,2-13C2]tetradecanoic acid
MPFOSA	Perfluoro-1-[13C8]octanesulfonamide
DNEtFOSA	N-ethyl-D5-perfluoro-1-octanesulfonamide
DNMeFOSA	N-methyl-D3-perfluoro-1-octanesulfonamide
DNEtFOSAA	N-ethyl-D5-perfluoro-1-octanesulfonamidoacetic acid
DNMeFOSAA	N-methyl-D3-perfluoro-1-octanesulfonamidoacetic acid
DNEtFOSE	2-(N-ethyl-D5-perfluoro-1-octanesulfonamido)ethan-D4-ol
DNMeFOSE	2-(N-methyl-D3-perfluoro-1-octanesulfonamido)ethan-D4-ol
M4:2FTS	1H,1H,2H,2H-perfluoro-1-[1,2-13C2]-hexane sulfonic acid
M6:2FTS	1H,1H,2H,2H-perfluoro-1-[1,2-13C2]-octane sulfonic acid
M8:2FTS	1H,1H,2H,2H-perfluoro-1-[1,2-13C2]-decane sulfonic acid
M3HFPO-DA	Tetrafluoro-2-(heptafluoropropoxy)-13C3-propanoic acid

LOR = Limit of Reporting LOD = Limit of Detection NR = Not Reportable