Investigation of the Potential for Perfluorochemical (PFCs) Contamination at Queensland Fire and Emergency Services Sites

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Acronyms and Abbreviations

AFFF	Aqueous Film Forming Foam
ANZECC	Australia and New Zealand Environment and Conservation Council
ASC NEPM	National Environmental Protection Measure – Assessment of Site Contamination
CoPC	Chemical of Potential Concern
CSM	Conceptual Site Model
DER	West Australian Department of Environment and Regulation
DES	Queensland Department of Environment and Science
DQOs	Data Quality Objectives
EnHealth	Commonwealth Environmental Health Standing Committee
FFFP	Film Forming Fluoro Protein foam
FSANZ	Food Standards Australia and New Zealand
HBGV	Health-based Guidance Values
HHRA	Human Health Risk Assessment
In-ground tank	Water only tanks used for training and testing appliance water pumps.
LOR	Limit of Reporting
NEPC	National Environment Protection Council
NHMRC	National Health and Medical Research Council
PFAS	Per- or Poly-fluoroalkyl Substances
PFAS EHP	PFAS Expert Health Panel
PFAS NEMP	PFAS National Environmental Management Plan
PFAA	Perfluoroalkyl acids
PFCA	Perfluorocarboxylic acids
PFSA	Perfluorosulfonic acids
PFT	Perfluorotelomer
PFHxS	Perfluorohexanesulfonic acid
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctanesulfonic acid
QA/QC	Quality Assurance/Quality Control
QCESA	Queensland Combined Emergency Services Academy
QFES	Queensland Fire and Emergency Services
QHFSS	Queensland Health Forensic and Scientific Services
RSB	Queensland Fire and Emergency Services Research and Scientific Branch
SAQP	Sampling, Analysis and Quality Plan
TOPA	Total Oxidisable Precursor Assay
UFUQ	United Firefighters Union of Employees Queensland
USEPA	United States Environmental Protection Agency

Executive Summary

Perfluoroalkyl substances (PFAS) are a ubiquitous group of chemicals found throughout the environment due to their extensive use in everyday items, including clothing, furniture, floor coverings, lubricants and fire-fighting foams. In recent years, the environmental fate and potential for adverse human health impacts from PFAS have raised concerns within the community. Aqueous Film Forming Foams (AFFF) have been used extensively to extinguish flammable and combustible liquid fires in testing, training, and emergencies. Three components of concern in AFFF foams are perfluoro-octane sulfonate (PFOS), perfluoro-hexane sulfonate (PFHxS)nand perfluoro-octanoic acid (PFOA).

The Queensland Fire and Emergency Services (QFES) ceased purchasing AFFF foams and exchanged the majority of stock with non-fluorinated foams in 2003. Since that date any remaining stock identified has been progressively removed from service. Historically, the QFES applied these foams to extinguish fires involving flammable and combustible liquids, and during training exercises. However, their use was infrequent, and small volumes used especially in training.

The QFES Research and Scientific Branch has undertaken a testing regime in two parts to determine the concentration and distribution of PFAS including TOPA (Totally Oxidisable Precursor Assay) within water from in-ground water tanks, and/or soil at identified QFES Fire Stations and the Queensland Combined Emergency Services Academy (QCESA). Microbiological testing was also undertaken at specific sites. These results provide an environmental snapshot about the concentration and distribution of PFAS and microbiological distribution at these locations. The results also inform the development of a risk-based approach to manage the issue from a QFES perspective.

Phase One focused on Enoggera, Cairns, Townsville, Rockhampton, Yeppoon, Oakey and Southport Fire Stations. It involved analysing water and soil samples, where they could be obtained, for PFAS contamination. Microbiological testing of the water was also undertaken in this phase.

Phase Two focussed on Enoggera, Cairns, Cairns South, Atherton, Gordonvale, Mt Isa, Forrest Beach, Ayr, Home Hill, Airlie Beach, Proserpine, Mackay, Sarina, Dysart, Moranbah, Rockhampton, Gladstone, Bundaberg, Maryborough, Noosa Heads, Caloundra, Charleville, Toowoomba, Crows Nest, Arana Hills, Windsor, Roma St, Kemp Place, Annerley, and Cleveland Stations, and QCESA. This phase included water and TOPA results where they could be obtained but not soil samples. In addition, tap water sourced from these locations was also characterised.

Results were compared to the Australian health-based recreational and drinking water quality guidelines for PFOA, sum of PFOS and PFHxS [∑(PFOS + PFHxS)], and the Queensland Government environmental water discharge criteria as per the Department of Environment and Science (DES) Operational Policy Environmental Management of Firefighting Foam. The soil results were compared to the DES value for PFOS/PFOA and PFAS in soil at which it can be applied as cover materials for landfills. Results were also compared to the PFAS National Environmental Management Plan (NEMP) Human health-based guidance values for soil in an industrial/commercial setting.

Eight sites could not be sampled for water. Five of these sites; Toowoomba, Moranbah, Atherton, Cleveland, and Gordonvale, as the in-ground water tanks were empty. The remaining three sites; Crows Nest, Oakey and Yeppoon contained no in-ground tank.

The highest PFAS water concentrations were observed at Gladstone Fire Station (PFOA 1.4 µg/L, (∑(PFOS + PFHxS) 41.9 µg/L and TOPA (incl C4-C8 sulfonates) 78 µg/L). Mackay and Enoggera Fire Stations exhibited the next two highest PFAS water concentrations. The results for PFOA concentration in water demonstrated all Fire Stations, except Gladstone Fire Station, met the Australian health-based PFOA drinking water quality guideline value. The results for Gladstone, Mackay, Enoggera, Cairns, Cairns South and Proserpine Stations exceeded ∑(PFOS + PFHxS) Australian health-based recreational water quality guideline value, and the Queensland Government environmental water discharge criteria for TOPA.

Results for Townsville, Home Hill, Ayr, Airlie Beach, Bundaberg, Maryborough, Noosa Heads, Caloundra, Arana Hills, Kemp Place and Southport Fire Stations were greater than the ∑(PFOS + PFHxS) Australian health-based drinking water quality guideline value, but less than the recreational water quality guideline value. The PFAS water results for Ayr, Caloundra and Kemp Place also exceeded the Queensland Government environmental water discharge criteria for TOPA or the ∑(PFOS + PFHxS) release value. The PFAS results of the other Fire Stations were less than the Queensland Government environmental water discharge criteria for TOPA. The PFAS results for the other seven remaining Fire Stations were less than the ∑(PFOS + PFHxS) Australian health-based drinking water quality guideline value.

The PFAS water concentrations obtained for the majority of sites tested at QCESA also exceeded the ∑(PFOS + PFHxS) Australian health-based recreational water quality guideline value, and the Queensland Government environmental water discharge criteria for TOPA. QCESA has unique circumstances where the water is continuously recycled for use at the facility. During the study opportunities were identified to consider enhancing water treatment approaches at QCESA.

Soil testing showed that contamination levels of PFOS/PFOA and PFAS at all Fire Stations were less than the DES ERA60: Material used in Capping criteria at which soil can be applied as cover materials for landfills and the NEMP Human health-based guidance values for soil in an industrial/commercial setting.

The results of the microbiological testing of water sampled in Phase One showed that concentration of microbiological organisms met the standards for Class A water.

A series of recommendations were provided to the QFES for consideration to inform the development of a risk-based approach to the issue and manage the in-ground water tanks tested in the study. These recommendations include:

- Remove the in-ground tank water for destruction in accordance with established standards and regulations at Gladstone Fire Station, Enoggera Fire Station and Mackay Station as the highest priority. In addition, consider filling the tanks with a suitable gravel, or similar material, and cap with concrete (of suitable thickness and strength) to render them inoperative;

- Review the current water quality monitoring program at QCESA to include PFAS and compare levels against established water quality standards.
- Review, and if appropriate improve water purification arrangements at QCESA to ensure the water meets established water quality standards. This should also include removal of PFAS using a cost effective and suitable treatment system;
- Remove the in-ground tank water for destruction in accordance with established standards and regulations at Proserpine, Cairns, Cairns South, Kemp Place, Ayr and Caloundra Fire Stations on a risk basis. In addition, consider filling the tanks with a suitable gravel, or similar material, and cap with concrete (of suitable thickness and strength) to render them inoperative;
- Establish a water management program for the remaining in-ground water tanks. This may include: status quo; removal of the in-ground tank water for destruction in accordance with established standards and regulations, discharge of the in-ground tank water directly to the environment; and rendering the tanks inoperative;
- Out of approximately 242 Fire Stations there were in-ground water tanks identified at 31 Fire Stations. There is merit to reviewing QFES doctrine about foam training, and activities requiring access to these tanks. In addition, consider the purpose of the in-ground water tanks, their suitability and ultimate fate. If appropriate the arrangements should be modified to reflect contemporary practices;
- Consider the merits of an education program across QFES to highlight QFES policy regarding foam training arrangements, acceptance of foam and other materials at fire stations, as well as appliance pump testing and drafting exercises; and
- Communicate the findings of the AFFF testing program to QFES staff.

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Introduction

Firefighting Foam

The National Fire Protection Association[1] (NFPA) defines foam as a stable aggregation of bubbles of lower density than oil or water. Foams were first developed around the turn of the 20th Century by Loran[2]. However, widespread use did not occur until the 1940's with the development[2] of protein-based foams. Further rapid advances were made with the development of fluoroprotein foams in the 1960's by National Foam Inc[3] and aqueous film forming foams (AFFF) by Tuve and Jablonski.[4,5] Internationally, AFFF was for decades the most widely used foam. The NFPA defined fluoroprotein foam and AFFF[1] as:

- Film forming fluoroprotein foam concentrate (FFFP): a protein foam concentrate that uses fluorinated surfactants to produce a fluid aqueous film for suppressing hydrocarbon fuel vapours; and
- Aqueous film forming foam (AFFF) concentrate: a concentrate based on fluorinated surfactants plus foam stabilisers to produce a fluid aqueous film for suppressing hydrocarbon vapours and usually diluted to 1-6 percent.

The incorporation of fluorinated surfactants into AFFF is the reason they are film forming and mostly explains their fire extinguishment performance.[6,7] They belong to a group of chemicals commonly described as polyfluoroalkyl substances (PFAS).[8]

Finished foam or foam solution is defined by the NFPA[1] as a homogenous mixture of foam concentrate and water, in the mix ratio required for the application. Typically, the finished foam has about 1 - 6% of the foam concentrate and the remainder is water.

More recently, the environmental fate[9-18] of AFFF has become an area of global concern due to the PFAS components within these foams. Two PFAS of interest are perfluoro-octane sulfonic acid[19,20] (PFOS) and perfluoro-octanoic acid[21-22] (PFOA). To counter this, a new group of fluorine free foams have been developed[23-25] and commercialised, such as the foam currently used by the Queensland Fire and Emergency Services (QFES). Foams are further categorised into their specific use and of interest in this report are Class A and Class B foams:

- Class A foam for use on ordinary combustible materials such as wood, cloth, paper, and many plastics; and
- Class B foam for use on fuels such as flammable liquids, combustible liquids, petroleum greases, alcohols and flammable gases.

Foam concentrate properties and constituents are modified to suit the specific application. They typically contain a mixture of ingredients[13,26-28] such as:

- Diluent –water;
- Surfactants such as fluorosurfactants, or hydrocarbon based surfactants;
- Solvents such as propanol, propylene glycol and propylene glycol tert butyl ether;
- Foam stabilisers such as sodium lauryl sulfate;
- Corrosion inhibitors and biocides; and
- Additional additives such as sodium chloride.

The ingredients may add up to 35% of the foam concentrate. In recent years the nature of the fluorosurfactants used within the AFFF foams[29-31] has changed from PFOS/PFOA or similar fluorosurfactants to 8:2 fluorotelomer, and more recently, 6:2 fluorotelomer in response to regulatory concerns. Many of the foam ingredients are classified as dangerous goods and/or hazardous chemicals. However, the foam concentrate typically does not meet the criteria to be described as a dangerous good or hazardous chemical.[26] Nonetheless, all foams pose a short term or long term environmental risk if released because of their inherent physico-chemical properties and toxicity such as chemical oxygen demand (COD), biochemical oxygen demand (BOD), and environmental persistence.

Polyfluoroalkyl substances (PFAS)

Polyfluoroalkyl substances are described as chemicals that contain one or more perfluoroalkyl moieties.[31,32] Whilst they do not occur naturally, there are more than 3000 available on the global market.[33-35] PFAS were first synthesised in 1938 by Plunket[36] when teflon was prepared. To aid classification and reduce confusion Buck[8] separated PFAS into polymers and non-polymers. The non-polymer group, which is of particular interest is further separated non-polymers into four further groups, (Figure 1).

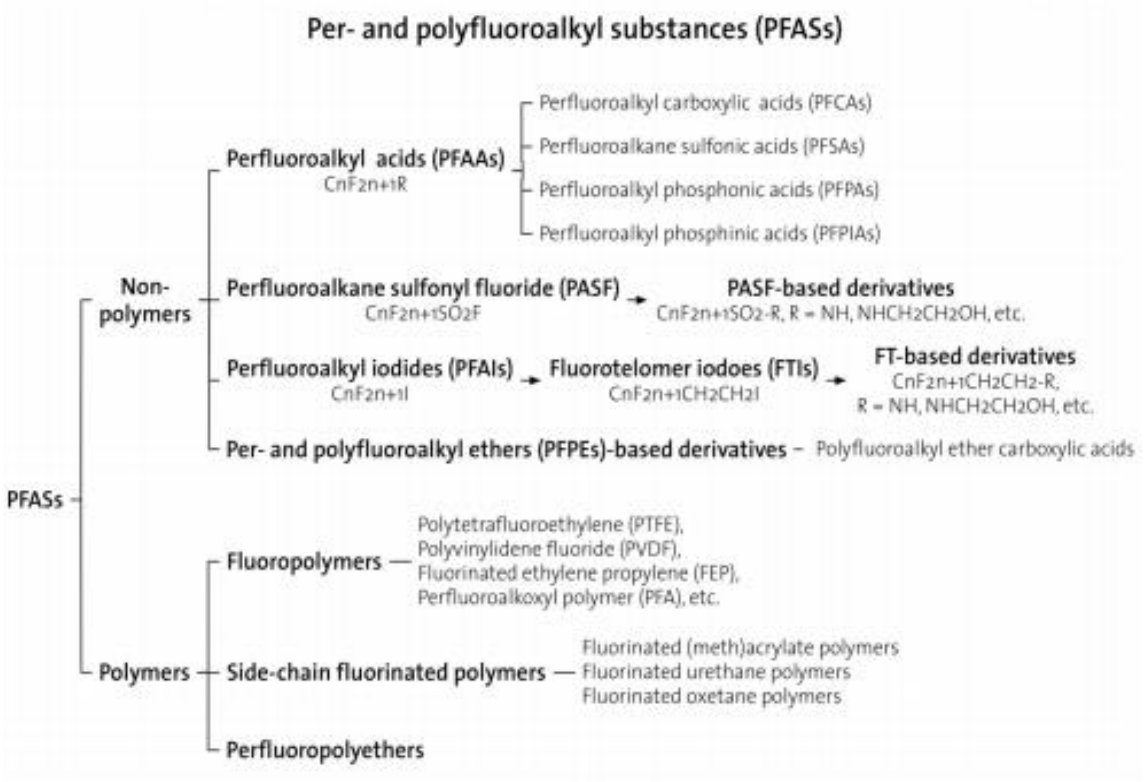


Figure 1.
General classification of PFAS substances.[8]

Perfluorinated chemicals are those where all carbons are completely fluorinated. However, in this context there is often a functional group attached to the molecule. Polyfluorinated chemicals where the molecule contains only some carbon fluorine moieties are typically of the fluorinated surfactants

used within the AFFF foams. The difference between perfluorinated chemicals and polyfluorinated chemicals is shown in the Figure 2.

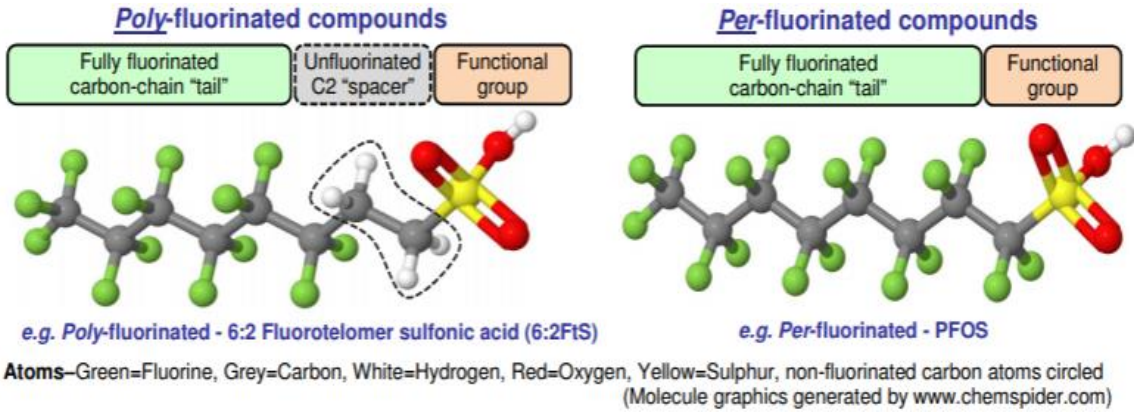


Figure 2

Perfluorinated and polyfluorinated chemicals.[31] Note the variation by attaching the functional group.

PFAS are attractive as additives within firefighting foams because of their physico-chemical properties. However, PFAS are also often highly persistent if they are released to the environment.[9,13,15,17, 37-42] Some PFAS will partially degrade in the environment and transform to highly stable end products[42] which are usually perfluoroalkyl or perfluoroalkyl(poly)ether acids. The environmental fate was not realised when these chemicals were first developed and used industrially.[43]

The manufacture of PFAS has been extensively reviewed[7,8,43] and highlights two main processes briefly described in the following section to inform the subsequent debate about their environmental and health concerns. PFAS used in foam was originally manufactured using electrochemical fluorination[7,8] where raw materials such as octane sulfonyl fluoride underwent electrolysis in anhydrous hydrogen fluoride to produce a mixture of linear and branched perfluorinated isomers and homologues of the raw material and other perfluorochemicals,[44] (Figure 3).

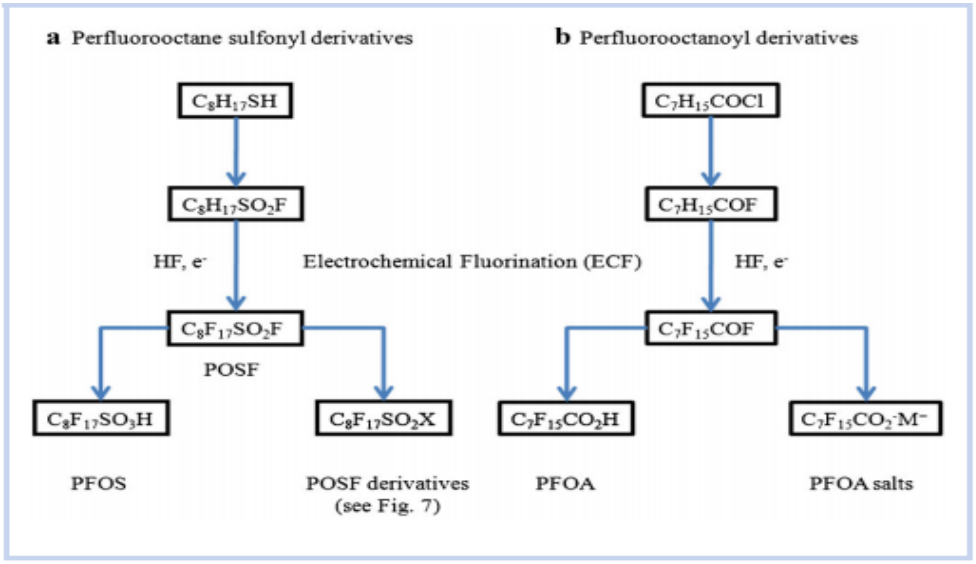


Figure 3

Illustration of ECF process to prepare PFOS and PFOA. Taken from Reference 8.

This industrial process was the major source of PFAS used in AFFF until recently. In 2001, 3M announced it would no longer use this process to manufacture PFAS. Consequently, numerous changes to the manufacturing approaches to prepare PFAS occurred in the past two decades particularly across the United States and Europe. Nonetheless, there remains significant manufacture of PFOS *via* this method within China where it is estimated 100-200 tonnes is prepared annually.

The alternative manufacturing process[8] currently adopted in the United States is telomerisation. The raw material, typically a perfluoroalkyl iodide, is reacted with tetrafluoroethylene to prepare a mixture of perfluoroalkyl iodides and perfluorinated chains. The product is then reacted further with ethylene to form fluorotelomer iodides. The fluorotelomer iodides are reacted again to create the surfactants and other products, (Figure 4). Manufacturers offer short chain products that do not contain PFOS or PFOA. The 6:2 telomer based surfactant has found widespread use within AFFF foams. Nonetheless, recent research has raised questions about the ultimate environmental fate of these products as well.

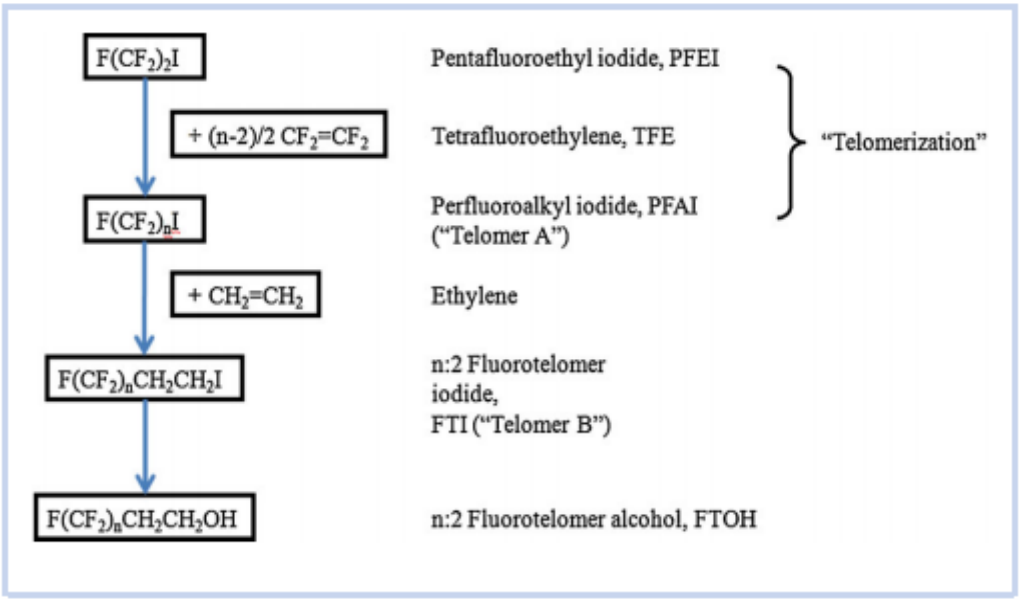


Figure 4
Illustration of Telomerisation process to prepare PFAS.[8]

Why the interest?

Taves[54,57] suspected in 1968 there was organic fluorine in blood. Guy and Taves[55] showed almost a decade later PFOA was present in blood after improvements in analytical approaches. In early 1980's PFOA was first found[51] in drinking water. In the past two decades studies[11,40,86-88] have been published highlighting the escape from and release of PFAS-containing AFFF foams into the environment from firefighting training grounds and other sites where there has been significant foam use. In the past few years within Australia significant environmental contamination[96-99] by PFAS released from firefighting training grounds principally used by the Australian Defence Force and Aviation Airport Fire Services has been reported. Releases from State Fire Services have also been reported[148,160], but the extent of the issue has not been well characterised. Key dates have been illustrated in Figure 5.

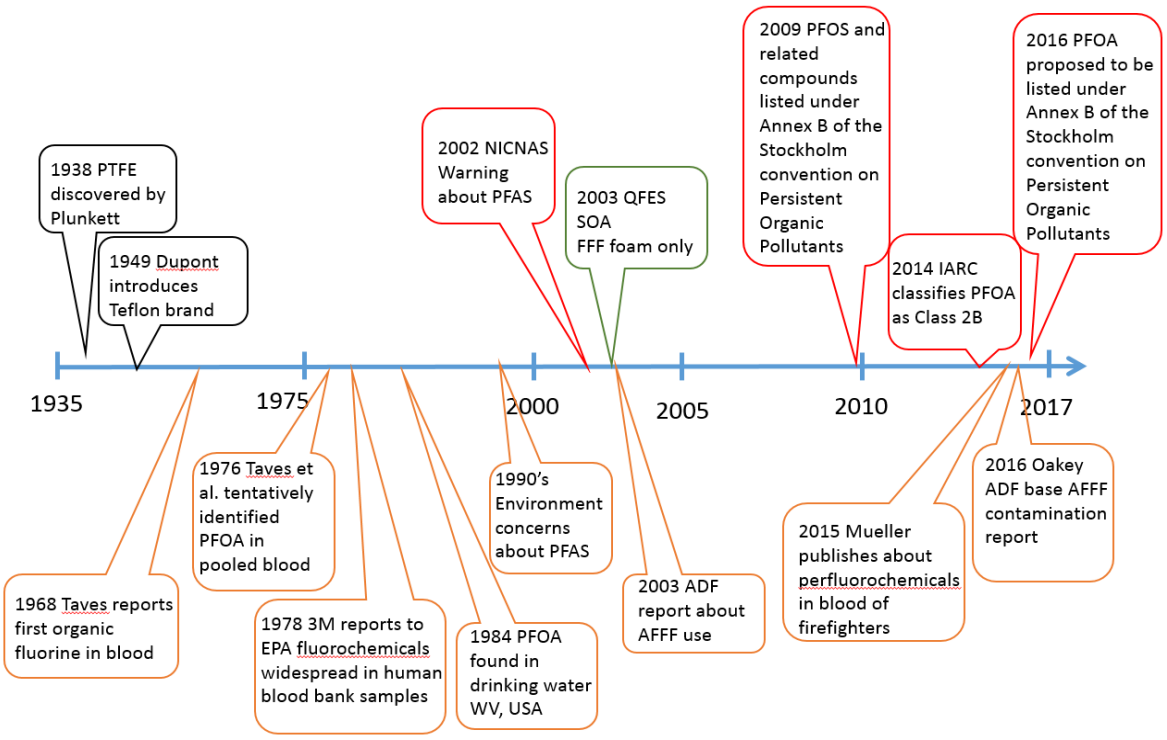


Figure 5

Timeline of important events in history of PFAS within Australian/Queensland context.

In recent years firefighter, community and regulatory concern about potential for long term health impacts arising from the use of AFFF has increased. Releases of fluorinated chemicals, including foams, into the environment have generated increased concern about the environmental fate and persistence of PFAS. In the 2000's a number of regulatory programs[10,19,22,32] started to restrict the manufacturing approaches and use of PFAS. Unfortunately, despite the research efforts,[100-159] there remain many uncertainties about their chemistry and distribution in the environment. The uncertainty also extends to understanding the exposure and health impacts on people.

Exposure and Exposure Pathway

It is not intended to review the complete area of human health and environmental impacts of PFAS particularly associated with AFFF releases since there are numerous publications addressing these questions[59-91, 117]. Instead the following sections will briefly summarise the exposure pathways of PFAS to provide further context for the QFES study. These chemicals are not naturally found in the environment and their sources of emissions to the environment are typically:

- Manufacture, use and disposal;
- Presence as impurities in substances emitted to the environment; and
- Precursor substances that degrade in the environment.

People can have both direct and indirect exposure to these PFAS. Indirect exposure occurs from a precursor PFAS that undergoes environmental breakdown or metabolises in the body to form perfluoroalkyl acids (PFAAs). Direct exposure occurs when the PFAAs are absorbed in the body. As a

consequence of the variety of PFAS emission pathways and the exposure pathways, the relationship to an exposure within people and the environment is complex as illustrated in Figure 6.

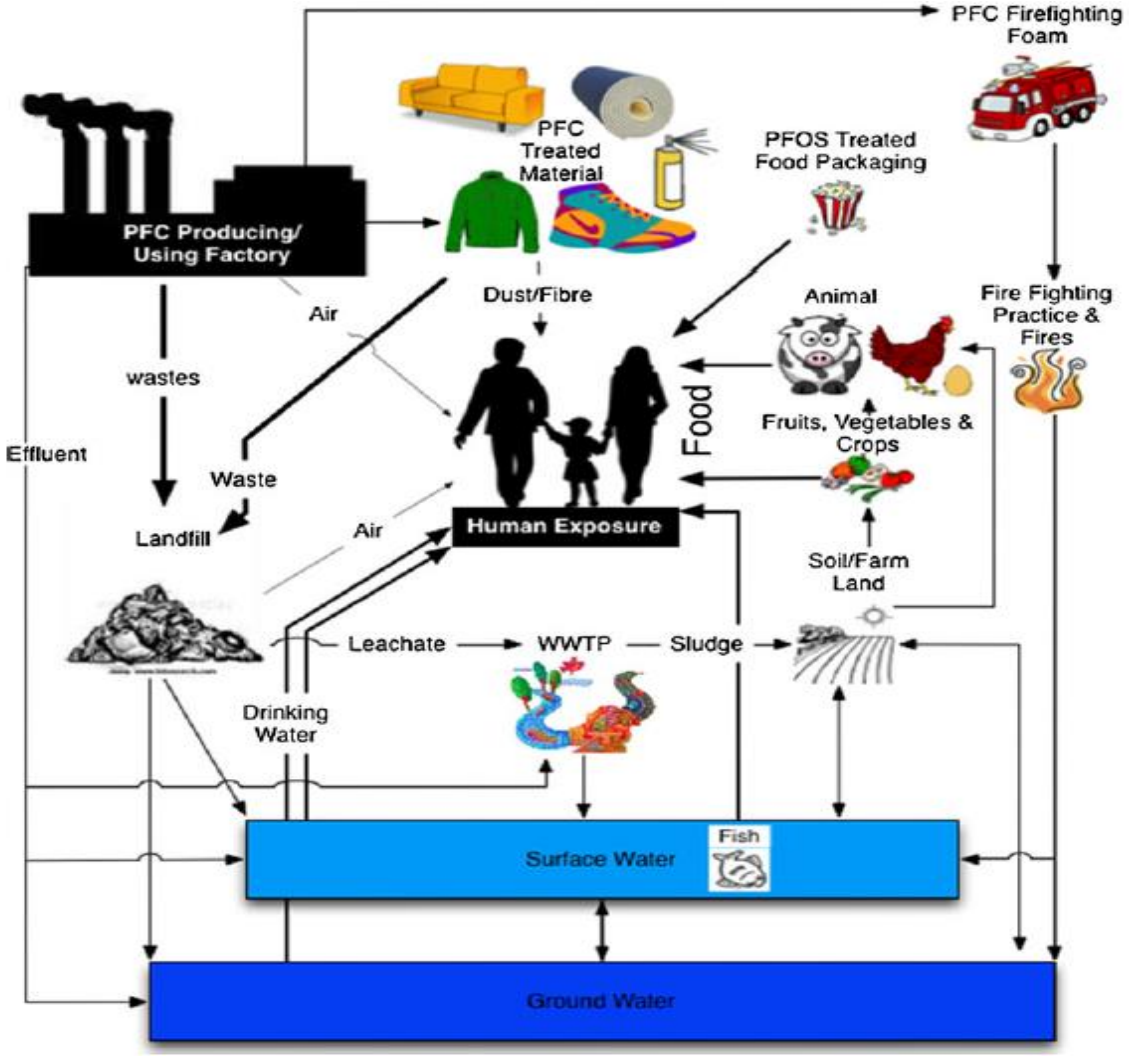


Figure 6.

PFAS release from the technosphere, contamination pathways to the environment and exposure pathways to humans.[60]

The most obvious exposure pathways are:

- Air;
- Ingestion;
- Injection; and
- Skin.

PFAS are not routinely monitored in the air, however there have been sporadic measurements reported[59] for some PFAS, such as PFOA. In contrast, there are numerous published reports[60-66,80-96] concerning the quantities of PFAS in water (surface, subsurface and ocean). It has been reported PFAS[60-66,80-96] are ubiquitous in the environments, and routinely found in food and dust within typical indoor environments. The most significant pathway[43,59] proposed is ingestion through sources such as food, water and dust.

Health Impacts

Taves reported[54-57] in 1968 organic fluorine was detected in blood. More recently, Olsen[77] retrospectively tested blood from 1974 for PFAS and identified a variety of PFAS. 3M reported[58] in 1999 that PFAS were common in human blood, and more recent studies[67-79] have also reported PFAS in the blood within both specific and general populations. PFAS are present in all persons and the general population values vary across the globe. As the use of PFAS have been restricted, more recent studies reported the PFAS serum concentrations[68,76] decreased. The typical serum levels for PFAS in particular PFOS and PFOA of South East Queenslanders[68] have decreased by around 63% and 66% respectively from 2002-2003 to 2010-2011. However, Olsen[73-78] reported specific occupationally exposed groups had significantly higher PFAS serum levels, with levels varying according to job type. Nonetheless there remains much uncertainty about the pathways to account for the presences of PFAS in blood[89].

The highest concentrations of PFAS are found in apex predators, such as polar bears[43]. This is indicative of substances that biomagnify in the food chain. The bioaccumulation potential of PFAS is reported to increase with increasing chain length.[61,62] Olsen and others have reported[43, 45,68-79] the fate of PFAS varies across species as a result of many factors including biotransformation, elimination and excretion differences. Of interest is the elimination half-life in humans for PFAS such as PFOS and PFOA. Olsen[78] further reported these values were 8.5 years and 3.5 years respectively for PFOS and PFOA. These long residence times pose other concerns, particularly about long term health impacts as a result of their resistance to degradation and potential for bioaccumulation. There has been a plethora of epidemiological studies[45, 67-79, 89,117] using various endpoints that have shown varying results. Definitive health risks have not been reported in humans, with studies of people occupationally exposed to high concentrations[43,45] showing varying results. Nonetheless, several studies have reported associations[43,45,53] between PFAS concentrations and adverse health effects such as fetal development, alterations to lipid metabolism, and thyroid disease. Barry[70] reported a link to kidney and testicular cancer, and more recently the IARC classified[67] PFOA as a Class 2B carcinogen, i.e. possibly carcinogenic to humans. Further information about the toxic effects of perfluorochemicals has been published by de Witt[45] and more recently by the Expert Health Panel for Per and Poly fluoroalkyl Substances.[117]

The significance of firefighter exposures may vary from the general population due to their activities and the nature of the materials they have access to. In the occupational setting there are no Workplace Exposure Standards (WES) established for AFFF or the constituent PFAS. Generally, the most significant firefighter exposure pathway for hazardous chemicals is the respiratory system.[102] Despite the importance of this exposure pathway, its significance within the firefighting environment should be considered in the context of fire-fighters' use of self-contained breathing apparatus (SCBA) and their tactical methods. Determining the significance of skin as an entry route for PFAS in a firefighting context is essential to understanding the exposure of firefighters compared with the general population. Recently, Kirk[102] reported skin as an exposure pathway for firefighters that needed to be considered in the context of firefighting.

There is little, if any data reported in the literature characterising the extent of firefighter exposures and the significant of the exposure pathways in the context of PFAS and AFFF use including whether

PFAS skin absorption poses a significant risk to firefighters. Franko[95] reported dermal penetration of PFOA occurred. However, penetration was slow (ca. 48-69% over 24 hours), and the penetration rate was dependent on its ionisation state.

Mueller[101] recently reported PFOS/PFHxS serum levels in Australian Airport firefighters. They found many factors were associated with the exposures, and the PFOS/PFHxS serum concentrations were associated with the time of their job contact with AFFF. The highest serum levels were one order of magnitude higher compared to the serum levels of the general Australian population, whilst the serum levels within firefighters with less than 10 years' experience were only slightly above those of the general population. It was inferred these latter results reflected the phase-out of AFFF use from training activities. They also found no relationship between skin exposure and PFOS levels.

Environmental Impacts

A significant concern[8,9,12, 13,15,17,34,80-95,113,129-159] about AFFF foams, and in particular PFAS is their fate within the environment. PFAS are readily released into the environment from manufacturing sites, waste sites, sewerage treatment works, consumer products, biosolids, and firefighting.[124] Indeed 95% of PFAS are used in activities other than firefighting,[125] but the significance of PFAS contamination from non AFFF sources is not well understood in Australia, particularly PFAS contamination and fate from biosolids and landfill leachate.[126] Many initial studies focused on discharges from manufacturing sites, however, it became apparent[12,13,15,17] that PFAS were also present on and near former military bases where AFFF foams were used. In the past decade many studies[12,13,15,17] have been published highlighting the spread of the PFAS within the environment. The most prevalent sources include waste water, and sewerage works and biosolid disposal. Consequently, it has been shown[20,22,33,43,49] PFAS were ubiquitous within the environment and their environmental fate has been extensively reported elsewhere.

PFAS are usually water soluble and thus easily distributed within the environment. These chemicals are environmentally persistent[9] and thus are not readily degraded by photo-oxidation, hydrolysis, or biodegradation to environmentally benign substances. As an example: PFOS has an environmental half-life of 42 years,[16] and has been classified[20] as a persistent organic pollutant. PFOA is even more stable, with an estimated half-life[64] of greater than 92 years. It has also been proposed[22] to be classified as persistent organic pollutant. There is a complex relationship[58] between PFOS and PFOA within the environment and moreover, many PFAS degrade in the environment to PFOA. These materials are not only environmentally persistent, but they have been demonstrated[9,61,81-88,108] to be bio-accumulative and biomagnify within the food chain. The highest concentrations of PFAS tend to be found in apex predators. However, much uncertainty remains about the fate of PFAS within the environment.

The typical analytical approach used to estimate PFAS targets a select group of analytes. This approach has been applied[112] to other environmental contaminants such as polycyclic aromatic hydrocarbons (PAHs). However, several publications[40,80,103] have highlighted there are many PFAS within the environment beyond the traditional select group of analytes targeted. Houtz[42,103] developed an analytical method, total oxidisable organic precursor (TOPA), which measures PFAS precursors not detected using standard analytical approaches that transform to perfluoroalkyl acids.

In recent years there has been a concerted effort[33,44,48,8,66,109] to shift to PFAS that are not environmentally persistent or bioaccumulative, and that exhibit low environmental toxicity. This is illustrated by the shift to lower molecular weight PFAS telomers[109] used in firefighting foams. The PFAS telomers[87,94] degrade to perfluorocarboxylic acids in the environment. For example: 6:2 fluorotelomer sulfonate degrades[110] to perfluorohexanoic acid. However, the environmental fate[30,66] of fluorotelomers and their degradation products has received significantly less attention than PFOA and PFOS and there remain significant gaps.

Applicable Regulatory Standards

There are numerous environmental and human health criteria applied by various international and Australian regulatory frameworks.[104-107] For example, the Biomonitoring Commission of German Federal Environmental Agency[104] established preliminary references values for PFOA/PFOS in blood for children and adults, whilst the United States Environmental Agency Office of Water[111] applies lifetime drinking water health advisory values for PFAS. These latter values were recently revised.[111] Within Australia, the Food Standards Australia New Zealand published revised guidelines concerning PFOS, PFOA and PFHxS within water. The Commonwealth Department of Health adopted health-based guidance values which were intended to be used in site investigations and human health risk assessments. The values are:

Toxicity Reference value	**PFOS/PFHxS**		**PFOA**	
	ng/L	*µg/L*	*ng/L*	*µg/L*
Drinking water quality value	70	0.07	560	0.56
Recreational water quality value	700	0.7	5600	5.6

The DES (Department of Environment and Science) has published interim water release concentrations for PFAS. These value for PFOS and PFOA are 0.3 µg/L. The value of Total Oxidisable Precursor Assay (TOPA) including C4-C8 sulfonates (PFBS, PFHxS, PFOS, PFOSA, PFDcS) is 1 µg/L. The alternative measure also applied is ∑ (PFOS + PFHxS) is 0.3 µg/L. They also apply further values for water leaching from landfills and for soil applied to cap landfills. These Australian based values and the DES release criteria have been applied in this report.

Experimental

The QFES endorsed a two-staged plan presented by its Research and Scientific Branch (RSB) to investigate in-ground tank water for contamination by PFAS. Phase One investigations involved sampling and analysing water and/or soil from six Fire and Rescue stations (Cairns, Townsville, Rockhampton, Yeppoon, Enoggera, Oakey, and Southport) that had in-ground tanks used for testing drafting pumps and training of personnel for emergency situations where water supply is limited.

Phase Two investigations involved sampling and analysing water from all remaining Fire and Rescue stations identified as containing an in-ground water tank, namely Cairns (repeat), Cairns South, Atherton, Mareeba, Mt Isa, Forrest Beach, Ayr, Home Hill, Airlie Beach, Proserpine, Mackay, Sarina, Dysart, Moranbah, Rockhampton (second in-ground tank), Gladstone, Bundaberg, Maryborough, Noosa Heads, Caloundra, Arana Hills, Windsor, Enoggera (repeat), Roma Street, Kemp Place, Annerley, Cleveland, Anzac Avenue (Toowoomba), Crows Nest, and Charleville.

Sampling Quality Control Strategies

To manage PFAS cross contamination the following modified sampling strategies,[126] were adopted.

1. All personnel within 5m of the sampling and preparation areas wore clothing pre-washed at least seven times prior to sampling. Sunscreen and insect repellent were not applied during the sampling or preparation stages. No food was permitted on-site during the sampling or preparation activities. No Teflon® or Teflon®-coated materials/equipment, including aluminium foil, were used or allowed to come into contact with the samples.

2. Prior to sampling, personnel washed their hands with soap and rinsed them thoroughly before donning a clean, new pair of disposable non-powdered nitrile gloves. A new pair was worn for each sample collected.

3. Sampling equipment and tools were decontaminated prior to use *via* scrubbing and rinsing thoroughly with soap and tap water. The equipment was then triple-rinsed with deionised water, with the final rinse sampled and analysed for PFAS, to ensure no contamination was introduced.

4. Sample containers were supplied ready for use by the QHFSS NATA certified laboratory:

5. Samples were then packed into portable coolers together with ice in polyethylene bags to keep cool for transport to the laboratory. A sample of the laboratory supplied deionised water was transported as a travel blank.

Sampling Method

In-ground water tanks were measured to calculate their capacities and determine the current water level at all identified stations. PFAS and biological samples were collected in 1L polypropylene bottles attached to a cleaned aluminium sampling pole and stoppered with a polypropylene cork. The pole was then lowered to 75% of the water depth within the in-ground tank, and the water collected by dislodging the polypropylene cork using an aluminium drawing pole attached to the end of the cork. Once the sampling was complete (as determined by no visible bubbles or 1 minute after dislodging the cork) the sample was retrieved, and the original polypropylene lid screwed onto the bottle.

Biological samples were decanted from the 1L polypropylene collection bottle into a 250mL sterile polyethylene terephthalate bottles containing 25 mg sodium thiosulfate with unlined polypropylene lids.

Town water samples at each station were collected directly into 1L polypropylene sample bottles from a tap adjacent to the in-ground tank that had been flushed for 2 minutes prior to sample collection.

Soil samples were collected from station locations identified as having the highest previous loading of firefighting foam through training and maintenance activities. Soil samples were also collected from land outside the station confines and adjacent to the Fire and Rescue station sampling site. The sampling area was prepared by removing the grass layer and digging a 200mm wide and 300 mm deep hole using the washed stainless-steel spade. Sample (*ca*. 300 g) was placed into a 375mL glass bottles with unlined polypropylene lids using a new sterile polypropylene scope that was disposed of after collecting each sample.

Collected water and soil samples were packed into portable coolers together with ice in polyethylene bags to keep cool for transported to the laboratory for analysis.

PFAS Analysis Methods[114-116, 127]

Water and soil samples were analysed for PFAS by the Queensland Health Forensic and Scientific Services (QHFSS) laboratory using a NATA accredited method based on the United States Environmental Protection Agency Compendium Method 537.

PFAS (Perfluoroalkyl substances) Water Samples

Water samples were extracted using a weak anion exchange cartridge, followed by elution with 10:89:1 Isopropyl/ Acetonitrile/Ammonium hydroxide (v/v). Samples were concentrated to 1mL (nitrogen blower) for LC-MS/MS analysis. The PFAS of interest were analysed using high performance liquid chromatography (HPLC, Shimadzu Corp., Kyoto Japan) coupled to a tandem mass spectrometer (QTrap 4000 or 5500, AB-Sciex, Concord, Ontario, Ca). The targeted PFASs were separated on a C18 column and through gradient elution using mobile phases made of 10% and 90% methanol, respectively, with 5 mM ammonium acetate. The mass spectrometer was operated in negative electrospray ionisation mode using scheduled multiple reaction monitoring (SMRM). An extra guard column (C18) was installed between the solvent reservoirs and the injector to exclude PFASs that originated from the HPLC system. All the compounds are reported as acids (sulfonate ion – difference of one hydrogen from the equivalent acid). Particularly for PFOS, the various compounds were present as various salts in the standards. Appropriate corrections were made to determine the equivalent amount of acid.

TOPA (Total oxidisable precursor assay) Water Samples

The total oxidisable precursor assay (TOPA) used a standardised pre-treatment of the water samples using a hydroxyl radical to oxidise the precursors to perfluoroalkyl carboxylic acids. Perfluorinated carboxylates and sulfonates remain intact under these pre-treatment conditions. Water samples were incubated with potassium persulfate (60mM) and sodium hydroxide (125mM) at 85°C for 6 hours. Samples were neutralised and then extracted by solid phase extraction and analysed on the LC-

MS/MS. TOPA were reported as Total (C4-C14) Perfluoroalkyl carboxylic acids, Total (C4-C10) Perfluoroalkyl sulfonic acids and Total Fluorinated Organics.

PFAS (Perfluoroalkyl substances) Soil Samples

Soil samples were pre-treated with freeze drying and homogenisation. Samples were extracted from the soil using 99:1 MeOH/ Ammonium Hydroxide (v/v) through sonication and centrifugation. Extracts were blown down to dryness and made up in deionised water. Analytes in the soil extracts were extracted by weak anion exchange cartridges (same as water), followed by elution with 10:89:1 IPA/ ACN/Ammonium hydroxide (v/v). The PFAS compounds were determined using LCMSMS. Conditions for the LCMSMS are the same for soil and water.

TOPA (Total oxidisable precursor assay) Soil Samples

This method covers also the total oxidisable precursor assay (TOPA, where a standardised pre-treatment of the water samples exposes underlying precursors. The pre-treatment method used a hydroxyl radical to oxidise the precursors to perfluoroalkyl carboxylic acids. Perfluorinated carboxylates and sulfonates remain intact under these pre-treatment conditions.

The soil samples were extracted through ENVI-Carb before they were incubated with potassium persulfate (60mM) and sodium hydroxide (125mM) at 85ºC for 6 hours. Samples are neutralised and then extracted by solid phase extraction and analysed on the LCMSMS.

Display Name	Abbreviation
Perfluoroalkylcarboxylic Acids/perfluoroalkylsulfonates	
Perfluorobutanoic acid, Perfluoropentanoic acid, Perfluorohexanoic acid, Perfluoroheptanoic acid, Perfluorooctanoic acid, Perfluorononanoic acid, Perfluorodecanoic acid, Perfluoroundecanoic acid, Perfluorododecanoic acid, Perfluorotridecanoic acid, Perfluorotetradecanoic acid, Perfluorohexadecanoic acid, Perfluorooctadecanoic acid, Potassium Perfluorobutanesulfonate * (factor 0.89), Sodium Perfluorohexanesulfonate * (factor 0.95), Sodium Perfluorooctanesulfoate * (factor 0.96), Sodium Perfluorodecanesulfonate *	PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA, PFDoA, PFTrDA, PFTeDA, PFHxDA, PFODA, L-PFBS, L-PFHxS, L-PFOS, L-PFDS
2-Perfluorohexyl ethanoic acid, 2-Perfluorooctyl ethanoic acid, 2-Perfluorodecyl ethanoic acid	FHEA, FOEA, FDEA
Sodium 1H,1H,2H,2H-perfluorohexane sulfonate* (factor 0.94), Sodium 1H,1H,2H,2H-perfluorooctane sulfonate* (factor 0.95), Sodium 1H,1H,2H,2H-perfluorodecane sulfonate* (factor 0.96)	4:2FTS, 6:2FTS, 8:2FTS
Perfluoroalkylcarboxylic Acids/perfluoroalkylsulfonates mass labelled	
Perfluoro-n-[13C4]butanoic acid, Perfluoro-n-[1,2-13C2] hexanoic acid, Perfluoro-n-[1,2,3,4-13C4]octanoic acid, Perfluoro-n-[1,2,3,4,5-13C5] nonanoic acid, Perfluoro-n-[1,2-13C2]decanoic acid, Perfluoro-n-[1,2-13C2]undecanoic acid, Perfluoro-n-[1,2-13C2]dodecanoic acid, Sodium perfluoro-1-hexane[18O2]sulfonate, Sodium perfluoro-1-[1,2,3,4-13C4]octanesulfonate,	MPFBA, MPFHxA, MPFOA, MPFNA, MPFDA, MPFUdA, MPFDoA, MPFHxs, MPFOS
Mass-labelled telomere Acids/sulfonates	
2-Perfluorohexyl-[1,2-13C2]ethanoic acid, 2-Perfluorooctyl-[1,2-13C2]ethanoic acid, 2-Perfluorodecyl-[1,2-13C2]ethanoic acid, Sodium 1H,1H,2H,2H-perfluoro-1-[1,2-13C2]-octane sulfonate (6:2)	MFHEA, MFOEA, MFDEA, M2-6:2FTS
*Correction factors were included to convert the sulphonate to the acid	

Table 7

PFAS targeted analytes in Queensland Health Forensic and Scientific Services analyses.

Quantification was achieved using isotope dilution of PFAC and PFAS. Calibration standards were made up in the range between 0.1 and 100 ngmL^{-1} (0.1; 0.2; 1; 4; 10; 20; 40; 100). Branched and linear isomers of individual PFAS were quantified using linear standards.

Quality Assurance and Quality Control

Extraction of water samples (PFAS)
For each 10 samples a minimum of one duplicate sample was prepared as well as one blank and blank spike. A matrix spike was performed on every 20 samples.

For each sampling event a trip blank (Milli Q water as supplied by Laboratory) and rinsate water sample (to check cleaning of sampling equipment between samples) were prepared and submitted with the samples for analysis. All sample identifications were coded and submitted to the laboratory in a random order.

Calibration standards were injected multiple times in each batch of samples, including after every 10 samples to check for instrument drift. Quantification of PFASs was performed using a linear regression fit analysis weighted by 1/x of the calibration curve. The quantitation of PFASs was based upon comparison with calibration curves constructed using only the linear isomer of each compound.

The following checks were applied:

- If blanks report values are greater than the limit of quantitation, samples from the batch should be repeated or blank corrected when the blank is more than one tenth the LOR.
- Spike as well as isotope results are plotted in a program called NWA Quality Analyst and results should fall within a set acceptable recovery range.
- When using the LCMSMS the concentration of the analytes in both MRM transitions should be within 30%.
- When validating the method 10 spiked samples were run at the expected LOQ (3x LOD). 10 blanks were also run along 10 NESS (non-extracted spike). With this procedure the repeatability, reproducibility, LOQ/LOR and uncertainty (including the effect of bias) are determined for all analytes. The approach to measurement uncertainty is standard deviation of replicate analyses multiplied by 2.26 to give a 95% confidence level.

Microbiological Analysis Methods

Water samples were analysed for coliforms and Escherichia coli by the Queensland Health Forensic and Scientific Services (QHFSS) laboratory using a NATA accredited *Method 20902: Water microbiology - coliforms and Escherichia coli - enzyme hydrolysable substrate method.*

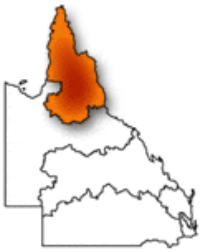
Microorganisms were grown in a defined liquid medium containing substrates for the specific detection of the enzymes β -galactosidase and β -glucuronidase. The dehydrated medium was dissolved in 100 mL of sample, or dilution of sample, which was then added to a 51 or 97 well reaction tray. This was then sealed and incubated at 36°C for 18-22 hours. If, within the tray, some of the wells exhibited no growth in the medium after incubation, while other wells exhibited some growth with appropriate reactions, then the most probable number of target organisms in 100 mL was estimated from appropriate probability tables.

Water samples were analysed for Enterococci by the Queensland Health Forensic and Scientific Services (QHFSS) laboratory using a NATA accredited *Method 23144: Water microbiology – Enterococci – membrane filtration method.*

A measured volume of water sample was passed through a membrane filter, retaining the bacteria in the sample on or near the surface of the membrane. The membrane was placed onto the surface of an m-enterococcus agar plate and incubated under the required conditions. The plate was then examined for typical enterococci colonies, which are counted. A proportion of presumptive colonies was confirmed by testing for aesculin hydrolysis.

Investigation of Potential PFAS and Microbiological Contamination of QFES Far Northern Region Fire and Rescue Stations with In-ground Water Tanks

The Queensland Fire and Emergency Services (QFES) Far Northern Region (FNR) is a large geographically and economically diverse area that extends from Cardwell in the southeast to the Torres Strait Islands in the north and the Gulf of Carpentaria in the west. Significant industries including tourism, cattle grazing, agriculture and mining operate within the Region, which is considered a premier tourist destination in Australia.



Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. This capability is provided by a mix of 25 permanent, composite and auxiliary Fire and Rescue stations located throughout the Region. The region is staffed by 135 full time employees and 317 auxiliary employees.

QFES Emergency Management supports Local Government areas within the region. The QFES Emergency Management FNR team has a total of five staff who work closely with all local governments to meet the Queensland Disaster Management legislative arrangements.

Rural Fire Service (RFS) regional operations is co-located with the F&R Far Northern Region but led by the RFS Assistant Commissioner. RFS FNR operates with 206 brigades, and is staffed by approximately 4,475 personnel, including regional QFES personnel, Volunteer Firefighters, and Volunteer Community Educators.

State Emergency Service (SES) regional operations is co-located with the F&R Far Northern Region but led by the SES Assistant Commissioner. SES FNR operates with 52 groups, and is staffed by approximately 1,143 personnel, including regional QFES personnel and volunteers.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, of perfluoroalkyl substances (PFAS) contamination at QFES FNR stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected

and analysed for PFAS contamination. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
  - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
  - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS. Water samples were collected from two stations. The following criteria were adopted and used for Phase Two of the study:

- The Australian health-based water quality guidelines for
  - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
  - ∑PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all Far Northern Region Fire and Rescue stations that contained in-ground water tanks. Cairns station was sampled and analysed in Phase One of the tests and re-sampled in Phase Two based on the results from Phase One tests. Four stations (Cairns South, Atherton and Gordonvale) were identified for Phase Two of these investigations. Samples were collected from Cairns and Cairns South stations, but not from Atherton and Gordonvale stations because the tanks were empty at the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Two water samples were collected from the Cairns Fire and Rescue station - one from the Cairns in-ground tank and one from an adjacent town water tap. Two soil samples, one from behind the station tower and one from adjacent nature strip outside the station, for PFAS analysis. Two further water samples were collected, one from the in-ground tank and one from an adjacent town water tap, for biological analysis.

Phase Two investigations

Six water samples were collected from the Cairns in-ground tank - two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank, for PFAS and TOPA analyses.

Five water samples were collected from the Cairns South in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

Cairns Fire and Rescue Station

Cairns Fire and Rescue station is an older style building built prior to 1970. It is the major station in Cairns and is located on a major road within a residential area. The station houses five appliances and support vehicles and is crewed by six firefighters in the standard QFES 10/14 shift system. The area office, BA-HazMat complex, training and emergency management centre, and regional maintenance workshops are all co-located on-site. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A concrete in-ground water tank (1200 mm diameter x 3300 mm deep, capacity of 3730 L) adjacent to the tower is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover that does not prevent water ingress. Water was collected on two occasions from the in-ground tank that was 100% full each time of sampling.

Figure FNR 1

Cairns Fire and Rescue station location and surrounding suburban setting.

Cairns Results

Cairns Fire and Rescue station was one of the four sites identified in Far Northern Region that contained an in-ground water tank. This study investigated the in-ground tank water and on-site soil for the presence of PFAS contamination.

Phase One investigation

Two water samples from the in-ground tank and two from an adjacent town water tap were collected for PFAS and biological analyses. One soil sample from behind the station tower and one from adjacent nature strip outside the station were also collected for PFAS analysis, (Table FNR 1).

Analyte Name	PFAS Sample Analyses						Biological Analyses	
	Water (µg/L)			Soil (mg/kg)			Water Samples (CFU/100ml)	
	LOR	Tap	Sample	LOR	Street	Yard	Tank	Tap
Biological Test								
E. coli							<1	<1
Coliforms							>100	<1
Enterococci							3	<1
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.027	0.005	<LOR	<LOR		
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.08	0.002	<LOR	<LOR		
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.11	0.001	<LOR	<LOR		
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.045	0.001	<LOR	<LOR		
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.065	0.002	<LOR	<LOR		
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluoroundecanoic acid (PFUDA)	0.01	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	0.007	<LOR	<LOR		
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	0.01	<LOR	<LOR		
Perfluorohexadecanoic acid	0.05	<LOR	<LOR	Not Reported				
Perfluorooctadecanoic acid	Not Reported							
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	0.18	0.001	<LOR	<LOR		
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	0.21	0.001	<LOR	<LOR		
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	0.3	0.001	<LOR	<LOR		
Perfluorodecanesulfonic acid (PFDS)	0.005	< LOR	<LOR	0.002	<LOR	<LOR		
2-perfluorohexyl ethanoic acid (FHEA)	Not Reported			0.002	< LOR	<LOR		
2-Perfluoroocty ethanoic acid (FOEA)	Not Reported			0.02	< LOR	<LOR		
2-Perfluorodecyl ethanoic acid (FDEA)	Not Reported			0.02	< LOR	<LOR		
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	Not Reported			0.002	< LOR	<LOR		
6:2 fluorotelomer sulfonate (6:2 FTS)	0.001	<LOR	0.15	Not Reported				
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	0.002	<LOR	0.13	0.005	<LOR	<LOR		
Total PFAS		<LOR	1.30	0.09	<LOR	<LOR		

Table FNR 1

Phase One water and soil sample analyses from Cairns Fire and Rescue station.

The Phase One in-ground tank water analysis (Table FNR 1) shows the total PFAS (1.3 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFT (telomer) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure FNR 2).

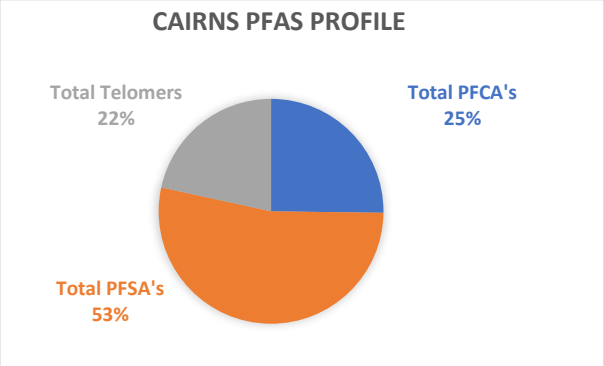


Figure FNR 2

PFAS molar profile of the Cairns in-ground tank.

The in-ground tank water analysis shows that PFOA (0.065 µg/L) was below the interim Australian health-based guidelines for both drinking and recreational water, but the ∑(PFOS + PFHxS) (0.51 µg/L) was above the drinking water and below the recreational water guidelines, (Figure FNR 3). Similarly, PFOA was below the Queensland Government environmental water discharge criteria , but ∑(PFOS + PFHxS) was above the environmental discharge guideline, (Figure FNR 4).

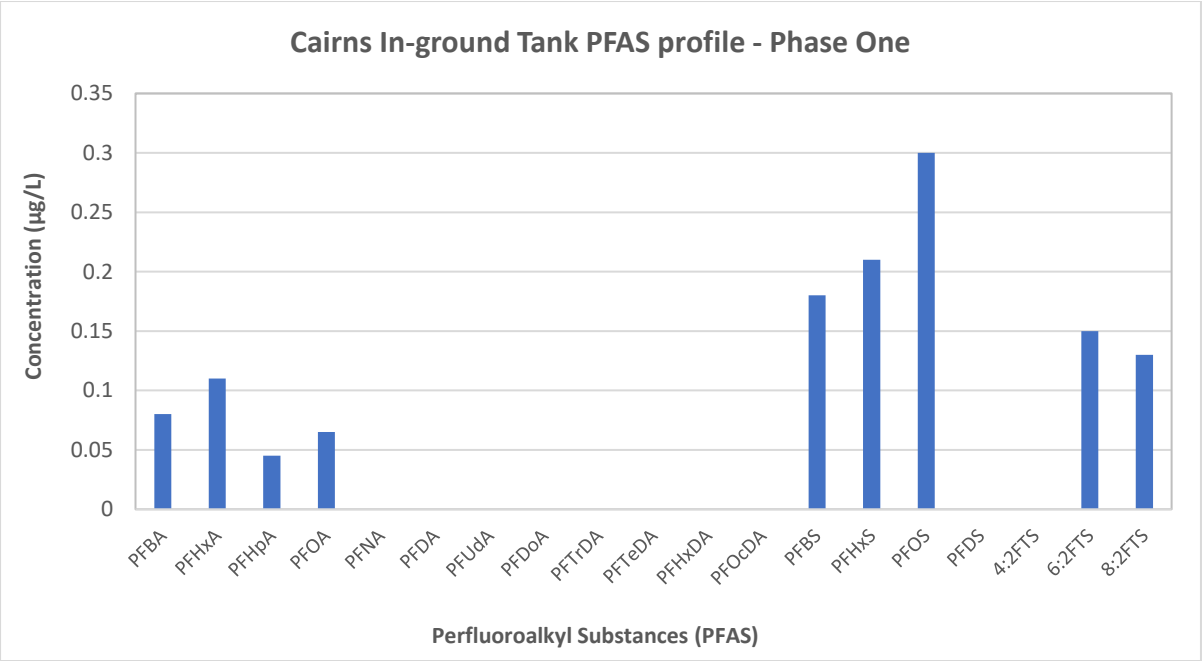


Figure FNR 3

Perfluoroalkyl substances (PFAS) profile of the Cairns Fire and Rescue station in-ground tank – Phase One.

The biological results (< 1 org/100mL of water for *E. coli*, >100 CFU for total coliforms, and 3 CFU for Enterococci) show water was equivalent to A+ recycled water for *E. coli*. The soil analyses showed no reportable levels of PFAS (<LOR) and were therefore below the DES ERA60: Material used in Capping and NEMP human health-based soil criteria for industrial/commercial land.

Phase Two investigation

Six water samples were collected from the Cairns Fire and Rescue station for PFAS and TOPA analyses - two in-ground water tank samples, two town water samples, one sample of rinsate collected from

the sample probe pre-use cleaning wash, and a travel blank. The results for the four in-ground and tap samples are shown in Table FNR2.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.07	<LOR	0.43	0.36	6
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.14	<LOR	0.34	0.20	2.5
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.34	<LOR	1.6	1.26	4.7
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.096	<LOR	0.21	0.11	2.9
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.12	<LOR	0.43	0.31	3.6
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.008	<LOR	0.038	0.030	4.8
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	0.02	0.02	-
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.04	<LOR	0.054	0.014	1.35
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.62	<LOR	0.65	0.030	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.67	<LOR	0.57	-0.100	0.85
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.42				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	0.11				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**2.6**				
TOPA C_4-C_{14} Carboxylic acids				<LOR	3		
TOPA C_4-C_{10} Sulfonic acids				<LOR	1.3		
Total TOPA				**<LOR**	**4.3**		

Table FNR 2

Phase Two water sample analyses from Cairns Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table FNR 2) shows the total PFAS (2.6 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFT (telomer) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure FNR4).

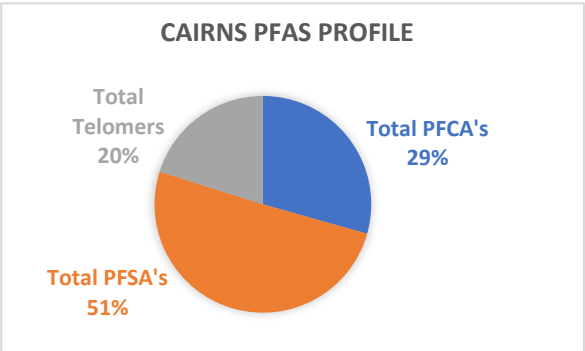


Figure FNR 4

PFAS molar profile of the Cairns In-ground tank.

The in-ground tank water analysis shows that PFOA (0.12 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) (1.29 µg/L) was above both drinking and recreational water guidelines, (Figure FNR 5).

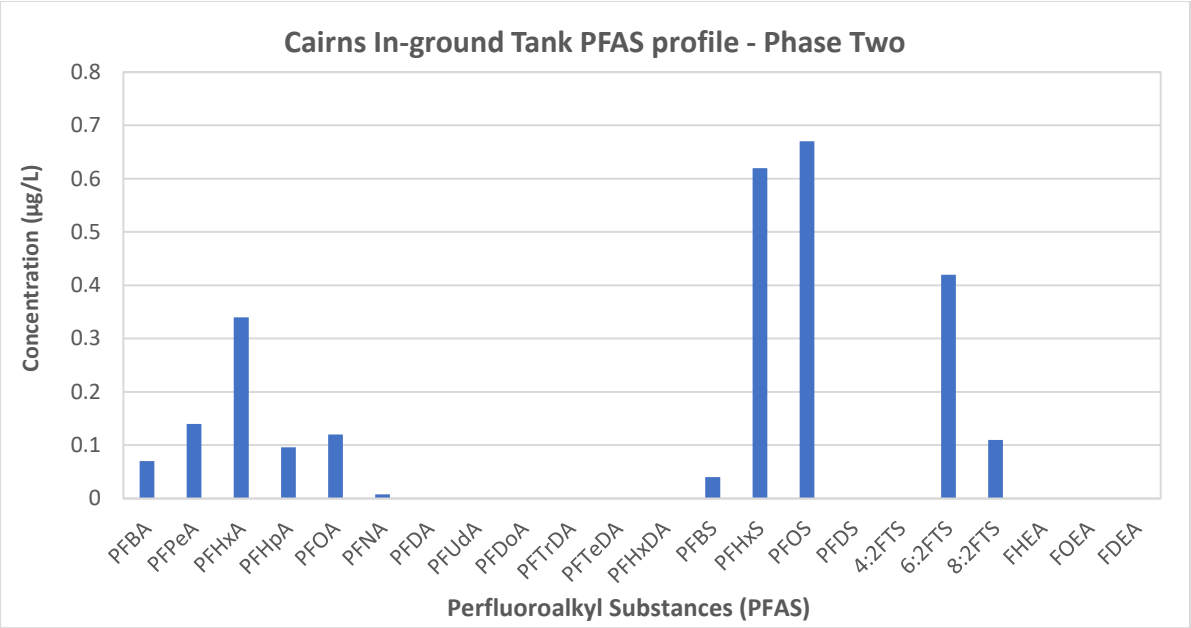


Figure FNR 5

Perfluoroalkyl substances (PFAS) profile of the Cairns Fire and Rescue station in-ground tank – Phase Two.

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (4.3 µg/L) were both significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (3.07 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (1.27 µg/L from PFBS, PFHxS, PFOS) and PFT (0.53 µg/L from 6:2 FTS, 8:2 FTS)] that may oxidise or biotransform over time, (Table FNR 2, Figure FNR 6).

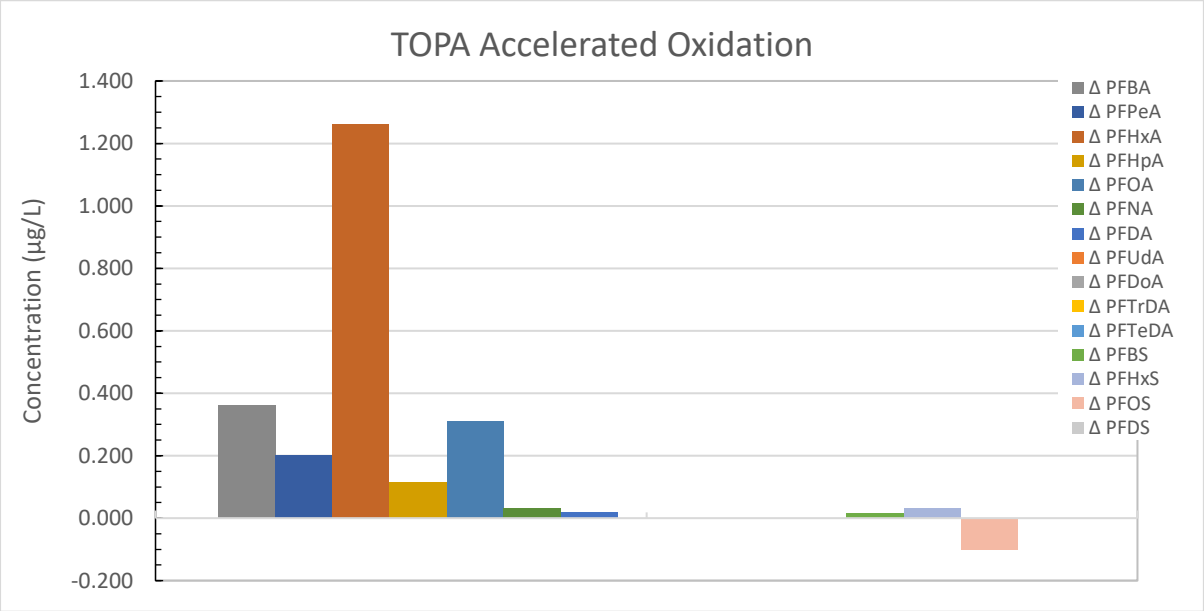


Figure FNR 6

TOPA perfluoroalkyl substances (PFAS) profile of the Cairns Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.67 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.67 x 3730 x 1.00

= 2499.1 µg (= 0.0024991 g) of PFOS

= 0.0024991 x 100 / 1 (1% PFOS) = 0.2499 g = 250 mg

or

= 0.00024991 x 100 / 5 (5% PFOS) = 0.04998 g = 50 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Cairns Fire and Rescue station in-ground water tank is between 0.05 to 0.3 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Cairns South Fire and Rescue Station

Cairns South Fire and Rescue station is a newer style single storey, two engine bay station built in the late 1990's. It is the major station in the Edmonton area and located on a major road within a residential area. The station houses one fire-fighting appliance and is staffed by four firefighters in the standard QFES 10/14 shift system. All training activities are conducted on a large open space at the rear of the station where a concrete in-ground water tank (1200 mm diameter x 2500 mm deep, 2826 L capacity) is used for pump testing and water drafting training. The tank has a raised lip and is covered by a steel cover plate to prevent water ingress. Water was collected from the in-ground tank that was 70% full at the time of sampling.

Figure FNR 7

Cairns South Fire and Rescue station in-ground water tank and surrounding suburban setting.

Cairns South Results

Cairns South Fire and Rescue station was one of the four sites identified in Far Northern Region that contained an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Cairns South Fire and Rescue station -two samples from the in-ground water tank, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses. The results are shown in Table FNR 3 below.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample 1	Tap	Sample 2		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.02	<LOR	0.08	0.06	4
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.028	<LOR	0.053	0.025	1.9
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.075	<LOR	0.33	0.26	4.4
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.023	<LOR	0.027	0.004	1.2
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.044	<LOR	0.069	0.025	1.6
Perfluorononanoic acid (PFNA)	0.007	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.036	<LOR	0.038	0.002	1.1
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.29	<LOR	0.29	0.000	1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.93	<LOR	0.83	-0.100	0.89
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	< LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	< LOR				
Total PFAS		**<LOR**	**1.5**				
TOPA C_4-C_{14} Carboxylic acids				<LOR	0.6		
TOPA C_4-C_{10} Sulfonic acids				<LOR	1.2		
Total TOPA (incl C_4-C_{10} Sulfonic acids)	**0.05**			**< LOR**	**1.8**		

Table FNR 3

Water sample analyses from Cairns South Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table FNR 3) shows the total PFAS (1.45 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA moieties are both representative of the older style fluorinated foams, (Figure FNR 8).

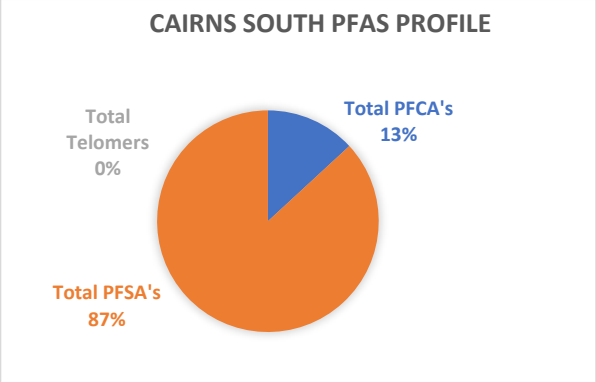


Figure FNR 8
PFAS molar profile of the Cairns South In-ground tank.

The in-ground tank water analysis shows that PFOA (0.044 µg/L) was below the Australian health-based guidelines for both drinking and recreational water, but the ∑(PFOS + PFHxS) (1.22 µg/L) was above both drinking and recreational water guidelines, (Figure FNR 9).

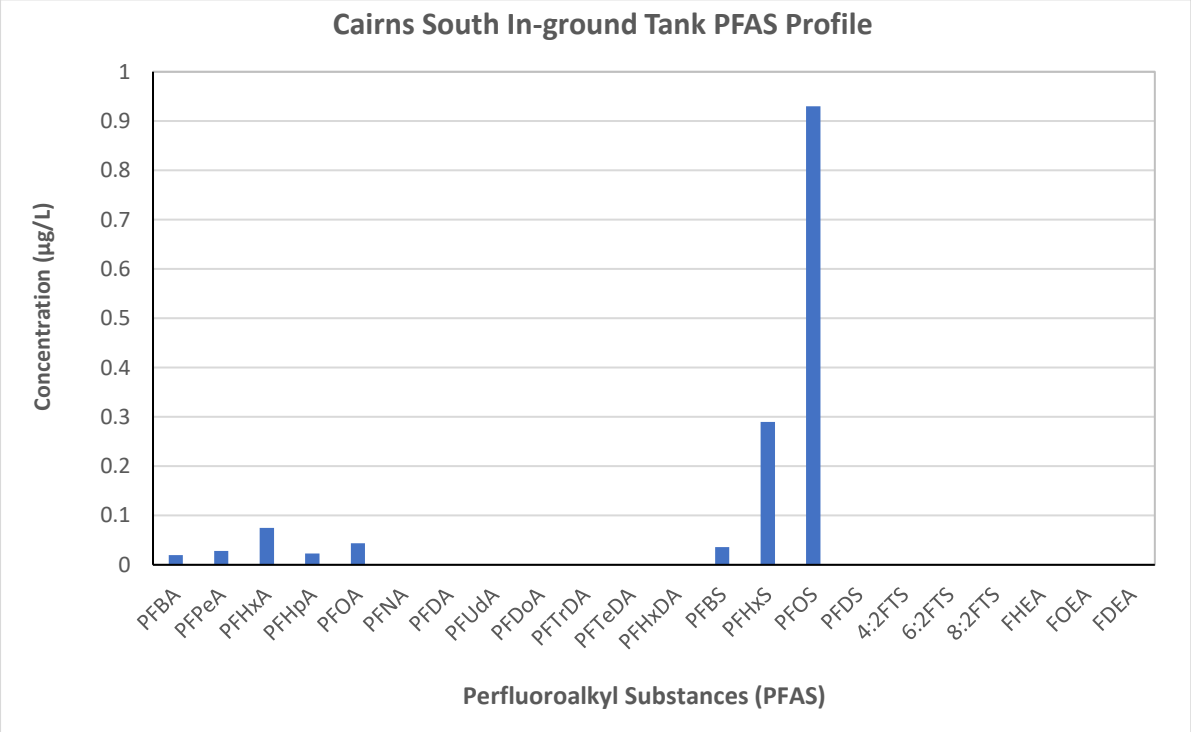


Figure FNR 9
Perfluoroalkyl substances (PFAS) profile of the Cairns South Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (1.8 µg/L) were both significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.49 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA) and PFSA (1.26 µg/L from PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table FNR 3, Figure FNR 10).

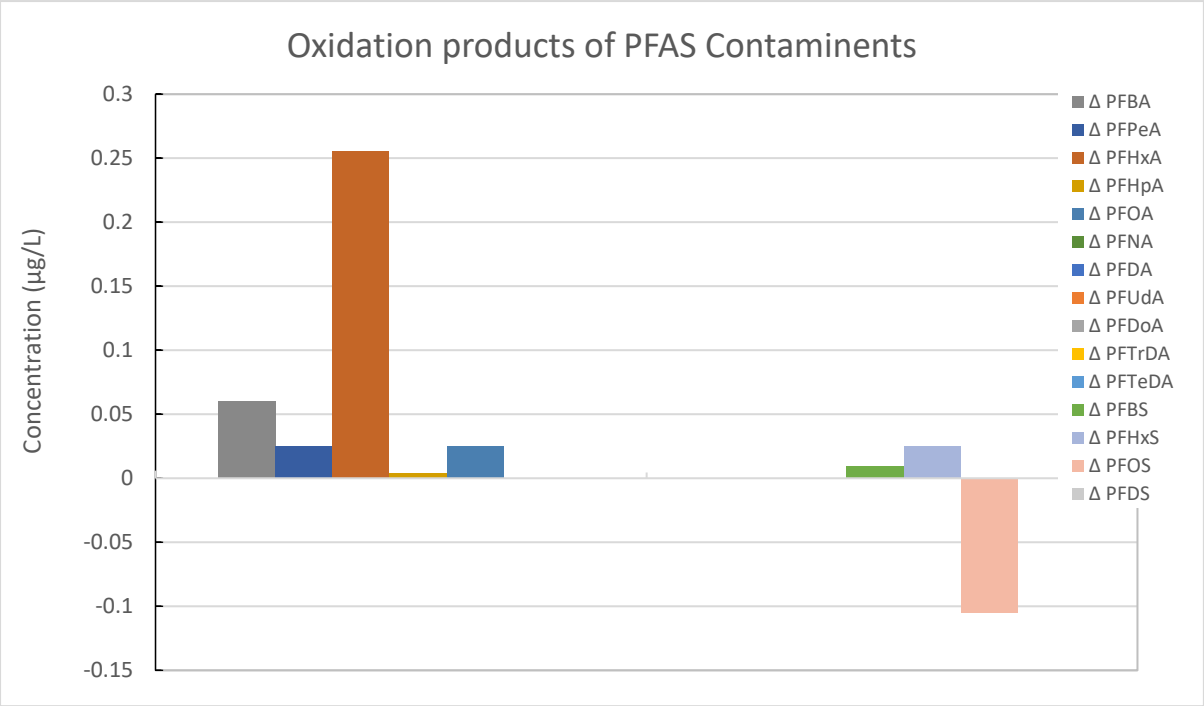


Figure FNR 10

TOPA perfluoroalkyl substances (PFAS) profile of the Cairns South Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.93 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.93 x 2836 x 0.70

= 1846.726 µg (= 0.00184673 g) of PFOS

= 0.00184673 x 100 / 1 (1% PFOS) or = 0.0024991 x 100 / 5 (5% PFOS)

= 0.185 g = 0.0369 g

= 185 mg = 37 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Cairns South Fire and Rescue station in-ground water tank is between 0.04 to 0.2 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate

Summary of Far Northern Region Results

Phase One

The Cairns Fire and Rescue station in-ground tank water results showed low levels of PFAS contamination with only the ∑(PFOS + PFHxS) (0.51 µg/L) value above the interim Australian health-based drinking water guideline, but below the recreational water guideline. However, when the current Australian health-based criteria are applied, the ∑(PFOS + PFHxS) is above the Australian health-based drinking and recreational water guidelines. The biological results (< 1 org/100mL of water for *E. coli*, >100 CFU for total coliforms, and 3 CFU for Enterococci) show the water to be equivalent to A+ recycled water for *E. coli*. The soil analyses showed Cairns station land and the adjacent nature strip had no reportable levels of PFAS contamination present. Subsequent application of the current Australian health-based criteria would result in the ∑(PFOS + PFHxS) value being above the recreational water guideline.

Phase Two

The Far Northern Region (FNR) in-ground tank water analyses showed detectable levels of PFAS contamination at both Cairns and Cairns South Fire and Rescue stations. The total PFAS concentration at Cairns South (1.45 µg/L) was ca. half that of Cairns (2.63 µg/L). The PFAS profiles of both stations show the presence of the perfluoroalkyl acids (PFAA) moieties [PFSA (major component) and PFCA], whilst Cairns also showed the presence of fluoro telomeres (PFT), (Figure FNR 11 and Figure FNR 12).

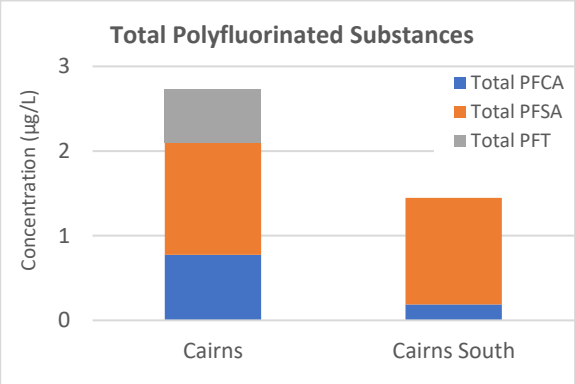


Figure FNR 11
Total PFAS contamination of water samples in Far Northern Region Fire and Rescue station in-ground tanks.

The results show neither station [Cairns (0.12 µg/L) and Cairns South (0.044 µg/L)] exceeded the Australian health-based recreational or drinking water guidelines for PFOA, but the ∑(PFOS + PFHxS) results from both stations [Cairns (1.29 µg/L) and Cairns South (1.22 µg/L)] exceeded the recreational and drinking water guidelines. The TOPA [Cairns (4.6 µg/L) and Cairns South (1.30 µg/L)] and PFOS + PFHxS for both stations exceeded the respective DES water discharge guidelines.

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

The Far Northern Region stations showed the presence of PFAS bio-transformation moieties (PFCA, PFSA, PFT). There was a different distribution of PFCA homologues between the stations with Cairns containing six homologues (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA) and Cairns South station five homologues [PFBA, PFPeA, PFHxA, PFHpA, PFOA]. A different distribution of PFSA homologues was also observed, with Cairns station containing two homologues (PFHxS, PFOS) and Cairns South station containing three homologues (PFBS, PFHxS, PFOS), (Figure FNR 12). Cairns was the only station to contain PFT with two homologues (6:2 FTS, 8:2 FTS). The potential for oxidation or biotransformation of PFAS can be highlighted by the differences (delta Δ values) between the TOPA and initial of PFAS concentrations, (Table FNR 4, Figure FNR 13).

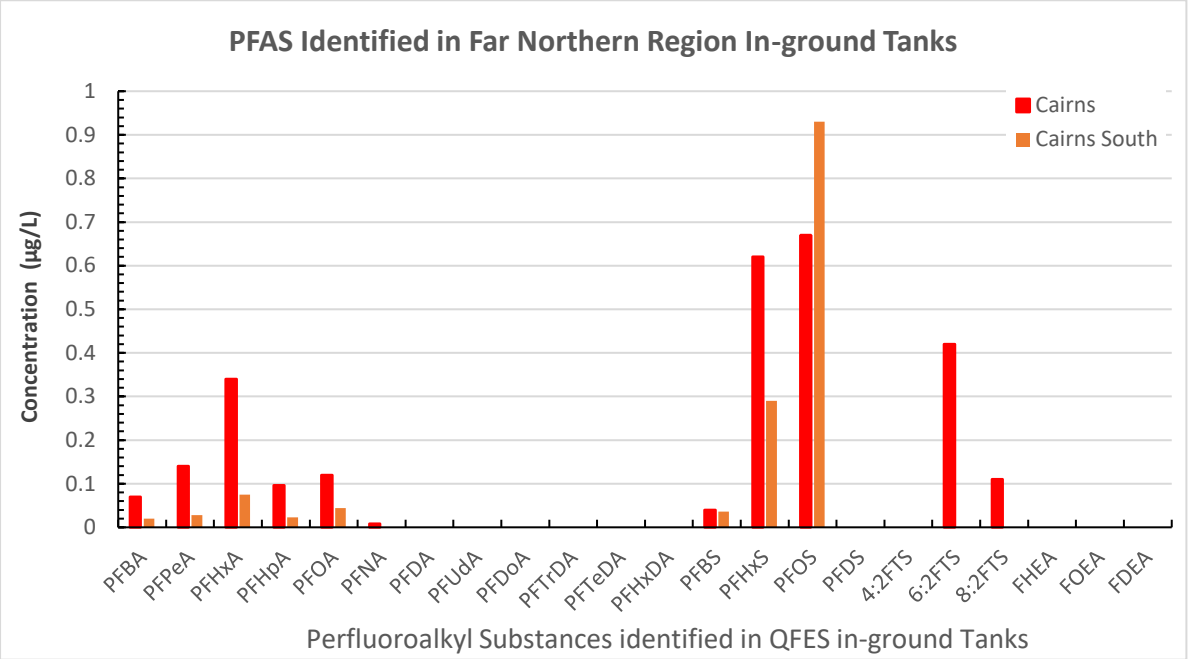


Figure FNR 12

PFAS contamination profile of water samples in Far Northern Region Fire and Rescue station in-ground tanks.

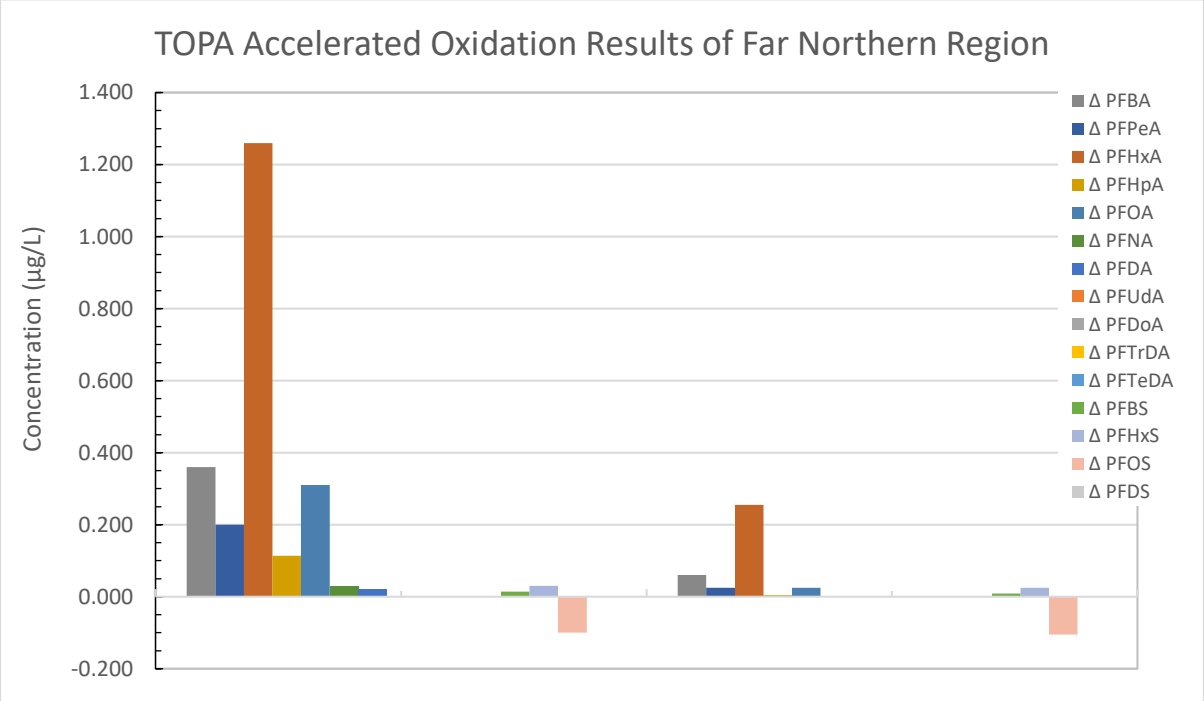


Figure FNR 13

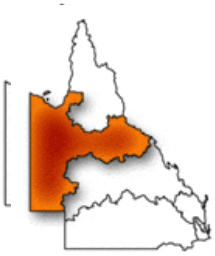
Effects of accelerated oxidation on PFAS compounds. Delta (Δ) changes reflect the actual concentration difference of starting from oxidised PFAS contaminates.

PFAS Standard Compounds	LOR	Cairns			Cairns South		
		PFAS	TOPA	Δ	PFAS	TOPA	Δ
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	0.03	(µg/L)
Perfluorobutanoic acid (PFBA)	0.01	0.07	0.43	0.36	0.02	0.08	0.060
Perfluoropentanoic acid (PFPeA)	0.007	0.14	0.34	0.20	0.028	0.053	0.025
Perfluorohexanoic acid (PFHxA)	0.005	0.34	1.6	1.26	0.075	0.33	0.26
Perfluoroheptanoic acid (PFHpA)	0.005	0.096	0.21	0.11	0.023	0.027	0.004
Perfluorooctanoic acid (PFOA)	0.007	0.12	0.43	0.31	0.044	0.069	0.025
Perfluorononanoic acid (PFNA)	0.007	0.008	0.038	0.03	< LOR	< LOR	< LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	0.02	0.02	< LOR	< LOR	< LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	< LOR	< LOR	< LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	< LOR	< LOR	< LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	< LOR	< LOR	< LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	< LOR	< LOR	< LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR			< LOR		
Perfluorobutanesulfonic acid (PFBS)	0.005	0.04	0.054	0.014	0.036	0.038	0.002
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.62	0.65	0.030	0.29	0.29	0
Perfluorooctanesulfonic acid (PFOS)	0.005	0.67	0.57	-0.100	0.93	0.83	-0.10
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	< LOR	< LOR	< LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR			< LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	0.42			< LOR		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	0.11			< LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR			< LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR			< LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR			< LOR		
Total PFAS		**2.63**			**1.45**		
TOPA (incl C_4-C_{10} Sulfonic acids)			**4.3**			**1.8**	

Table FNR 4

PFAS contaminant assay of water in Far Northern Region in-ground water tanks. All station town water samples tested less than level of reporting (<LOR).

Investigation of Potential PFAS and Microbiological Contamination of QFES Northern Region Fire and Rescue Stations with In-ground Water Tanks



The Queensland Fire and Emergency Services (QFES) Northern Region is one of the most demographically and geographically diverse regions within the Queensland Fire & Emergency Services. The region spans from Ingham to the Gulf of Carpentaria, the length of the Queensland/Northern Territory border to Birdsville and to Bowen in the south, encompassing an area of 600,000 km^2.

Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. This capability is provided by a mix of 445 employees, ranging from full-time and auxiliary firefighters, emergency management officers, community safety officers and technical rescue.

QFES Emergency Management supports Local Government areas within the region to meet the Queensland Disaster Management legislative arrangements.

Rural Fire Service (RFS) regional operations is co-located with the F&R Northern Region but led by the RFS Assistant Commissioner. RFS Northern Region operates 186 brigades, staffed by approximately 14 regional QFES personnel, 4056 Volunteer Firefighters, and 44 Volunteer Community Educators.

State Emergency Service (SES) regional operations is co-located with the F&R Northern Region but led by the SES Assistant Commissioner. State Emergency Service (SES) regional operations operates with 40 groups, staffed by approximately 596 volunteers, and they are supported by 12 SES staff in Townsville and Mount Isa offices.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, perfluoroalkyl substances (PFAS) contamination at QFES NR stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected and analysed for PFAS contamination. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
    - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
    - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS contamination. Water samples were collected from four stations. The following criteria were adopted and used for Phase Two of the study:

- The Australian health-based water quality guidelines for
    - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
    - ∑(PFOS + PFHxS): recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all Fire and Rescue stations within Northern Region Fire and Rescue Stations that contained in-ground water tanks. Townsville station was sampled and analysed in Phase One investigations and based on these results not re-sampled in Phase Two. Three stations were identified (Mt Isa, Home Hill, and Forrest Beach) for Phase Two investigations, with a fourth station (Ayr) identified by the region and added to the list during the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Four water samples, two from the in-ground water tank and two from an adjacent town water tap and two soil samples, one from the station front yard and one from adjacent nature strip outside the station were collected from the Townsville Fire and Rescue station. The water samples were analysed for PFAS and biological contamination.

Phase Two investigations

Eight water samples were collected from the Mt Isa in-ground tank - four from the in-ground water tank, two from a town water tap, one rinsate from the sample probe, and a travel blank, for PFAS and TOPA analyses.

Six water samples were collected from Forrest Beach station - two from the in-ground water tank, two from a town water tap, one rinsate from the sample probe, and a travel blank, for PFAS and TOPA analyses.

Five water samples were collected each from the Home Hill and Ayr stations - two from the in-ground water tank, two from a town water tap, and one rinsate from the sample probe for PFAS and TOPA analyses.

Forrest Beach Fire and Rescue Station

Forrest Beach Fire and Rescue station is a single storey, one engine bay station housing a fire-fighting appliance and staffed by on-call auxiliary fire-fighters. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (2000 mm diameter x 3700 mm deep, capacity of 11620 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover to prevent water ingress. Water samples were collected from the in-ground tank that was 90% full at the time of sampling.

Figure NR 1

Forrest Beach Fire and Rescue station and surrounding suburban setting.

Forrest Beach Results

Forrest Beach Fire and Rescue station was one of the five identified in Northern Region containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Six water samples were collected from Forrest Beach station - two from the in-ground water tank, two from a town water tap, one rinsate from the sample probe, and a travel blank, were analysed for PFAS contamination. The results are shown in Table NR 1 below.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		<LOR	<LOR				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	<LOR		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	<LOR		
TOPA (incl C_4-C_{10} Sulfonic acids)	**<LOR**			**< LOR**	**<LOR**		

Table NR 1

Water sample analyses from Forrest Beach Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NR 1) showed no reportable PFAS in the water sampled and as such all results were below the Australian health-based guidelines for both drinking and recreational water, and DES environmental discharge values, (Table NR 1).

Calculation of PFOS concentrate

No calculation of the amount of QFES foam[119] concentrate typically used prior to 2003 (3M Light Water AFFF) could be performed since no reportable PFAS was present in the water in-ground tank.

Townsville Fire and Rescue Station

Townsville Fire and Rescue station is an older style station built prior to 1970. It is the major station in the Townsville area, with four engine bays housing one operational support unit, one rescue unit, one firefighting appliance, one aerial appliance, and one hazmat support unit. The station is crewed by six firefighters in the standard QFES 10/14 shift system. The station also houses the regional fire communication centre and BA HazMat unit. The station in-ground water tank is of concrete construction (1500 mm diameter and 6000 mm deep, capacity of 10 600 L) adjacent to a multi-storey tower is used for pump testing and water drafting activities. The in-ground tank is covered by a steel plate cover to prevent water ingress. This tank was 85% full at the time of sampling, and has been used for activities at the station including drafting water and appliance pump performance checks.

Figure NR 2

Townsville Fire and Rescue station location and surrounding suburban setting.

Townsville Results

Townsville Fire and Rescue station was one of the five identified in Northern Region sites containing an in-ground water tank. This study investigated for PFAS contamination at Townsville Fire and Rescue station by collecting and analysing water and soil samples from the site.

Phase One investigation

Two water samples from the in-ground tank and two from an adjacent town water tap were collected for PFAS and biological analyses. One soil sample from behind the station tower and one from the adjacent nature strip outside the station were also collected for PFAS analysis, (Table NR 1).

Phase Two investigation

This station was not involved in Phase Two tests.

Analyte Name	PFAS Analyses						Biological Analyses	
	Water (µg/L)			Soil (mg/kg)			Water Samples (CFU/100ml)	
	LOR	Tap	Tank	LOR	Street	Station	Tank	Tap
Biological Test								
E. coli							<1	<1
Coliforms							<1	31
Enterococci							<1	<1
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.01	0.005	<LOR	<LOR		
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.008	0.001	<LOR	<LOR		
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	0.007	<LOR	0.038		
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	0.01	<LOR	<LOR		
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR					
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.006	0.001	<LOR	<LOR		
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.042	0.001	< LOR	<LOR		
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.041	0.001	<LOR	0.005		
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	0.002	< LOR	<LOR		
1H,1H,2H,2H-Perfluorohexanesulfonic acid	0.005	<LOR	<LOR	0.002	< LOR	<LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid	0.01	<LOR	<LOR					
1H,1H,2H,2H-Perfluorodecanesulfonic acid	0.02	<LOR	<LOR	0.005	<LOR	<LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2			0.002	<LOR	<LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR	0.02	<LOR	<LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR	0.02	<LOR	<LOR		
Total PFAS		**<LOR**	**0.11***	**0.008**	**<LOR**	**0.043**		

* Total PFAS for this sample did not include a measurement for Perfluorohexyl ethanoic acid (FHEA).

Table NR 2

Water sample analyses from Townsville Fire and Rescue station in-ground tank and town water.

The Phase One in-ground tank water analysis (Table FNR 1) shows the total PFAS (0.11 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages shows the highest contribution from the PFSA (sulfonates) moiety. The PFCA (carboxylic acid) makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NR 3). The in-ground tank water analysis shows that PFOA (< LOR µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, ∑(PFOS + PFHxS) (0.083 µg/L) was above the drinking water guideline and below the recreational water guideline. Consideration of the Queensland Government environmental water discharge criteria show both the PFOA and ∑(PFOS + PFHxS) were below the discharge criteria, (Figure NR 4).

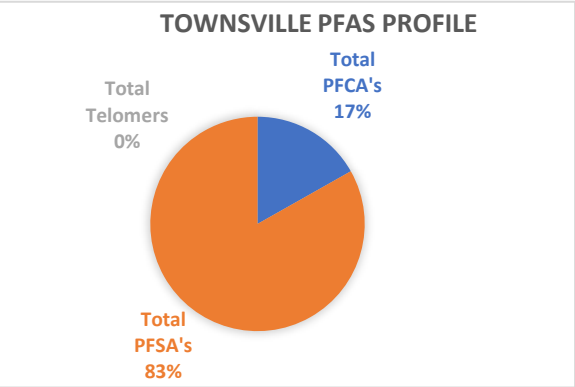


Figure NR 3

PFAS molar profile of the Townsville in-ground tank.

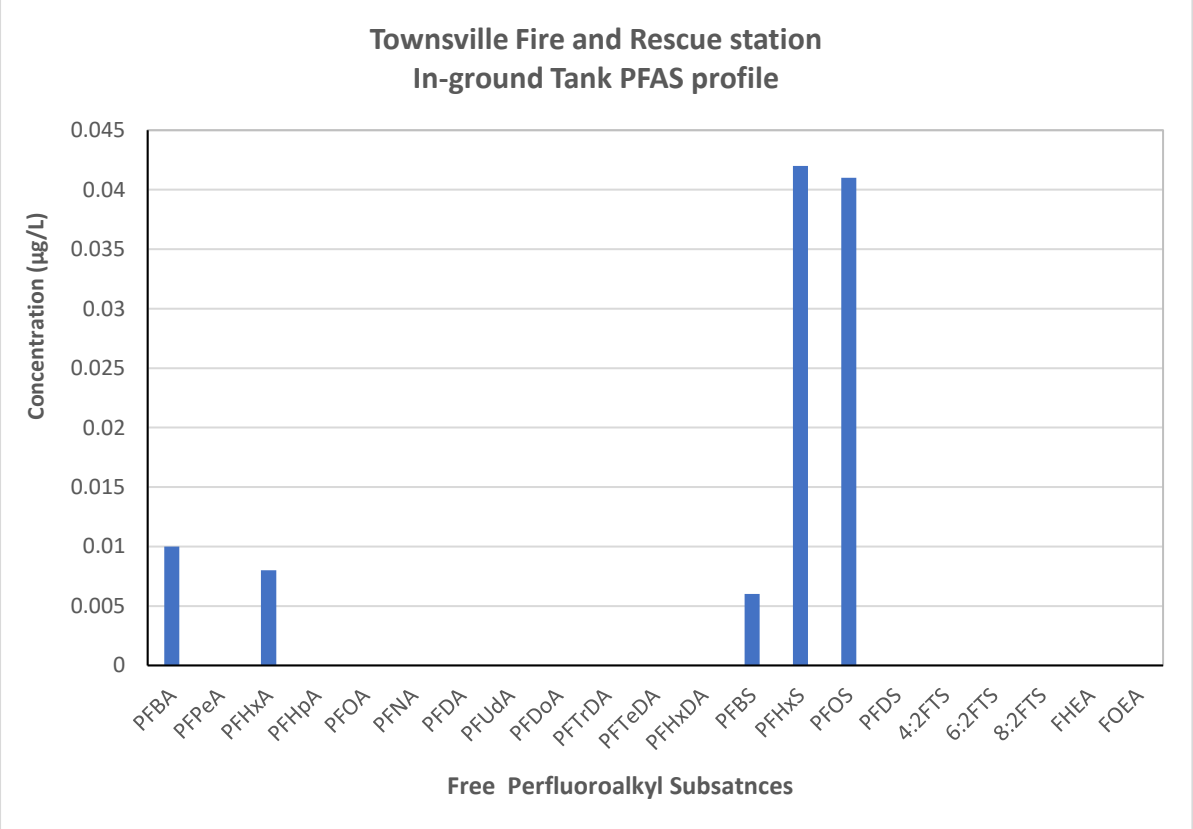


Figure NR 4

Perfluoroalkyl substances (PFAS) profile of the Townsville Fire and Rescue station in-ground tank.

The biological results (< 1 org/100mL of water for *E. coli*, < 1 org/100mL for total coliforms, and < 1 org/100mL for Enterococci) show the water is equivalent to A+ recycled water for *E. coli*. The soil analyses for the station land (total PFAS 0.043 mg/kg) showed very low levels of PFAS present. The PFOA (<LOR mg/kg) was below reportable concentrations and the ∑(PFOS + PFHxS) (0.005 mg/kg)] was at the limit of reporting, therefore below the DES ERA60: Material used in Capping and NEMP human health-based soil criteria for industrial/commercial land.

The total PFAS analysis shows that PFAS precursors [PFCA (0.018 µg/L from PFBA, PFHxA) and PFSA (0.089 µg/L from PFBS, PFHxS, PFOS)] were present and may oxidise or biotransform into PFAS of concern over time, (Table NR 2, Figure NR 4).

Calculation of PFOS concentrate

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.041 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.041 x 10600 x 0.85
= 369.41 µg (= 0.00036914 g) of PFOS

= 0.00036941 x 100 / 1 (1% PFOS)	or	= 0.00036941 x 100 / 5 (5% PFOS)
= 0.037 g		= 0.0074 g
= 37 mg		= 7.4 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Townsville Fire and Rescue station in-ground water tank is between 0.007 to 0.04 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate

Ayr Fire and Rescue Station

Ayr Fire and Rescue station is a two-storey station with three engine bays, housing two fire-fighting appliances. It is staffed by four firefighters in the QFES continuous day shift roster system in addition to auxiliary firefighters. All training activities are conducted on a large open space concreted yard. A concrete in-ground water tank (900 mm diameter x 2300 mm deep, capacity of 1460 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel grated plate to prevent water ingress. Water samples were collected from the in-ground tank that was 90% full at the time of sampling.

Figure NR 5

Ayr Fire and Rescue station location and surrounding suburban setting.

Ayr Results

Ayr Fire and Rescue station is one of the five identified Northern Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Ayr Fire and Rescue station - two from in-ground water tank, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table NR 3).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.02	<LOR	0.31	0.29	16
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.024	<LOR	0.33	0.31	14
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.05	<LOR	0.42	0.37	8.4
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.012	<LOR	0.17	0.16	14
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.031	<LOR	0.17	0.14	5.5
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	0.066	0.066	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	0.05	0.05	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	0.03	0.03	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	< LOR	< LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.01	0.06	<LOR	0.07	0.01	1.2
Perfluorooctanesulfonic acid (PFOS)	0.005	0.012	0.061	<LOR	0.072	0.011	1.2
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.01				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	0.6				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	0.11				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**0.022**	**0.98**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	1.5		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.14		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.3**			**< LOR**	**1.64**		

Table NR 3

Water sample analyses from Ayr Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NR 3) shows the total PFAS (0.98 µg/L) is comprised of the three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages shows the highest contribution from the PFCA (carboxylates) moiety. The PFSA and PFT make-up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NR 6). The in-ground tank water analysis shows that PFOA (0.031 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS (0.12 µg/L) was above the drinking water and below the recreational water guidelines, (Figure NR 7).

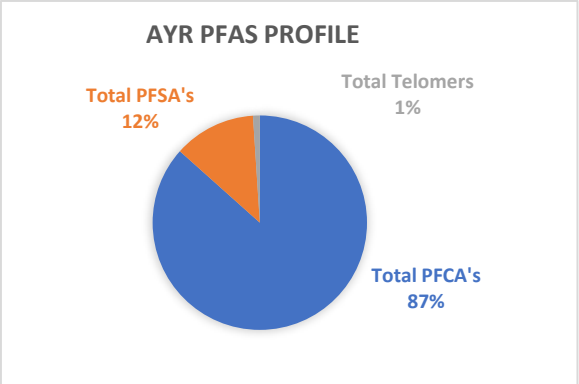


Figure NR 6
PFAS molar profile of the Ayr in-ground tank.

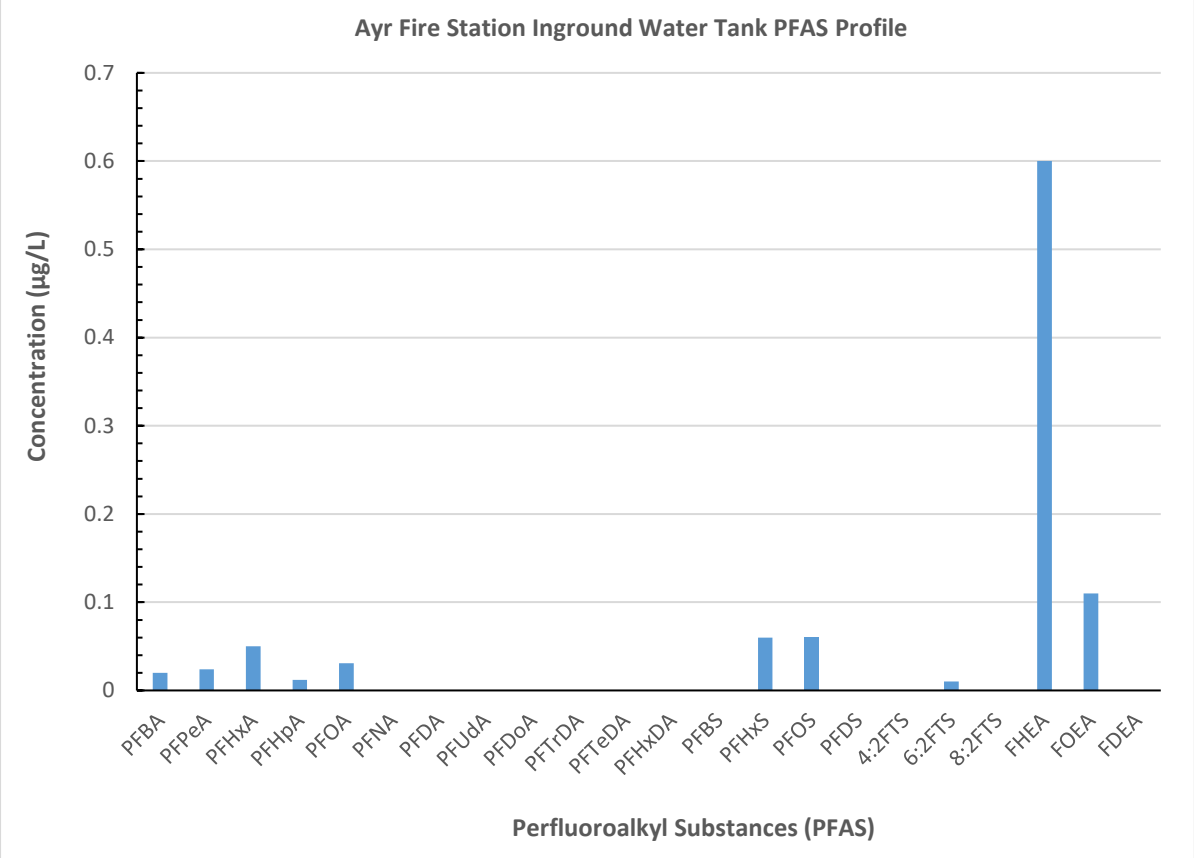


Figure NR 7
Perfluoroalkyl substances (PFAS) profile of the Ayr Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA ∑(PFOS + PFHxS were below the discharge values, but the TOPA (1.64 µg/L) was above the discharge value. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.137 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, FHEA, FOEA, PFSA (0.121 µg/L from PFHxS and PFOS) and PFT ((0.01 µg/L from 6:2 FTS)] that may oxidise or biotransform over time, (Table NR 3, Figure NR 8).

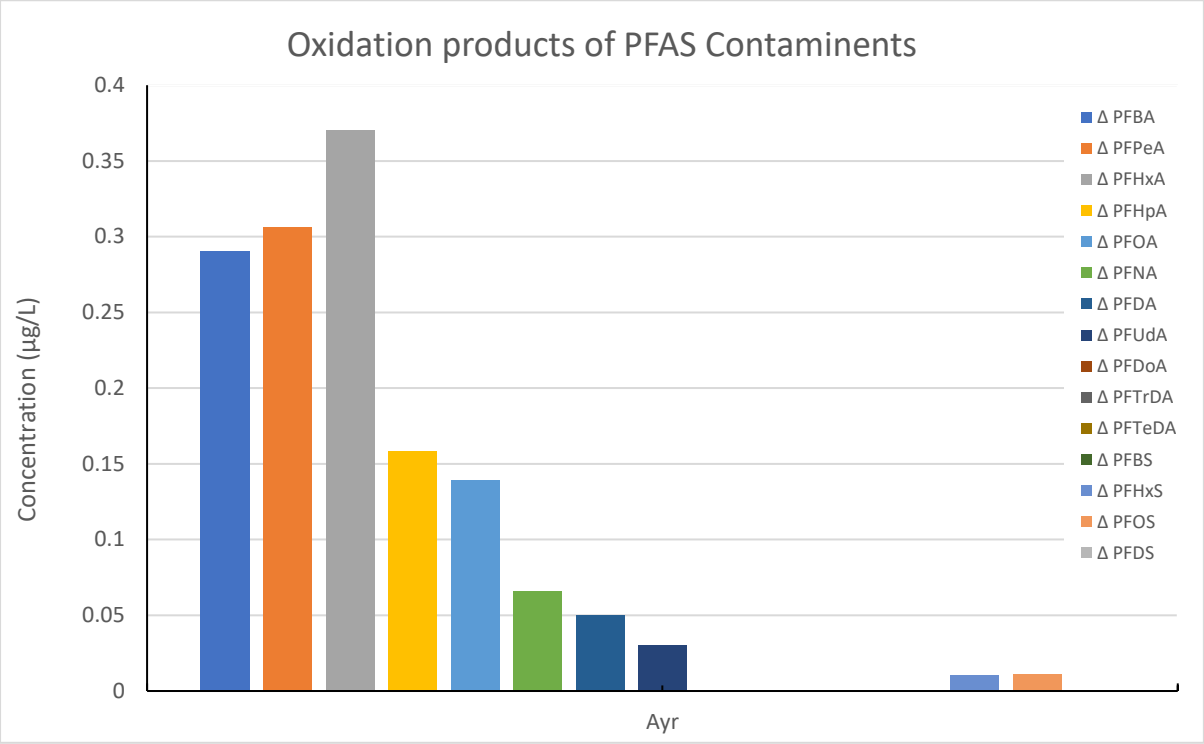


Figure NR 8

TOPA perfluoroalkyl substances (PFAS) profile of the Ayr Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.061 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.061 x 1460 x 0.91
= 81.0446 µg (= 0.0000810446 g) of PFOS
= 0.0000810446 x 100 /1 (1% PFOS) = 0.081 g = 81 mg
or
= 0.000810446 x 100 / 5 (5% PFOS) = 0.001625 g = 1.6 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Ayr Fire and Rescue station in-ground water tank is between 0.002 to 0.08 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate

Home Hill Fire and Rescue Station

Home Hill Fire and Rescue station is a single storey, four engine bay joint emergency services facility, housing one fire-fighting appliance. It is staffed by on-call auxiliary fire-fighters. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (900 mm diameter x 2400 mm deep, capacity of 1530 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel cover to prevent water ingress. Water samples were collected from the in-ground tank that was 70% full at the time of sampling.

Figure NR 9

Home Hill Fire and Rescue station location and surrounding suburban setting.

Home Hill Results

Home Hill Fire and Rescue station was one of the five identified Northern Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Home Hill Fire and Rescue station, two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table NR 4).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.008	<LOR	0.023	0.015	2.9
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	< LOR	<LOR	<LOR	LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	< LOR	<LOR	<LOR	LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.011	<LOR	0.012	0.001	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.086	<LOR	0.088	0.002	1.0
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	< LOR	<LOR	< LOR	< LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	< LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	< LOR				
Total PFAS		**<LOR**	**0.105**				
TOPA C_4-C_{14} Carboxylic acids				<LOR	0.023		
TOPA C_4-C_{10} Sulfonic acids				<LOR	0.10		
Total TOPA (incl C_4-C_{10} Sulfonic acids)	**0.02**			**< LOR**	**0.123**		

Table NR 4

Water sample analyses from Home Hill Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NR 4) shows the total PFAS (0.105 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulphonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NR 10).

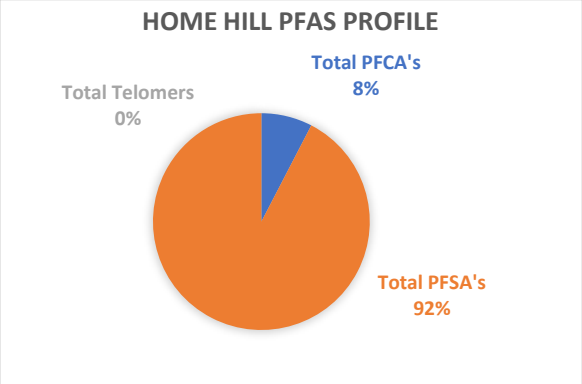


Figure NR 10
PFAS molar profile of the Home Hill in-ground tank.

The in-ground tank water analysis shows that PFOA (< LOR µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) (0.097 µg/L) was above the drinking water guidelines, but below the recreational water guidelines, (Figure NR 11).

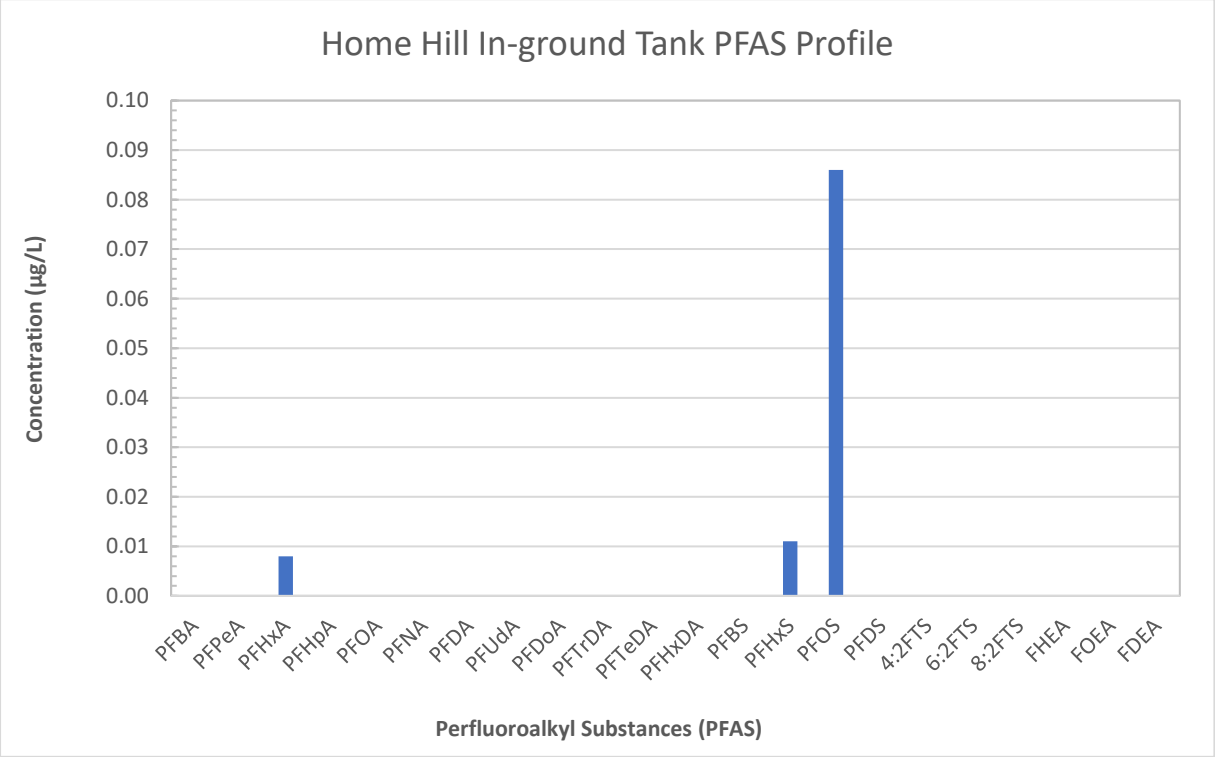


Figure NR 11
Perfluoroalkyl substances (PFAS) profile of the Home Hill Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.123 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.008 µg/L from PFHxA) and PFSA (0.097 µg/L from PFHxS and PFOS)] that may oxidise or biotransform over time, (Table NR 4, Figure NR 12).

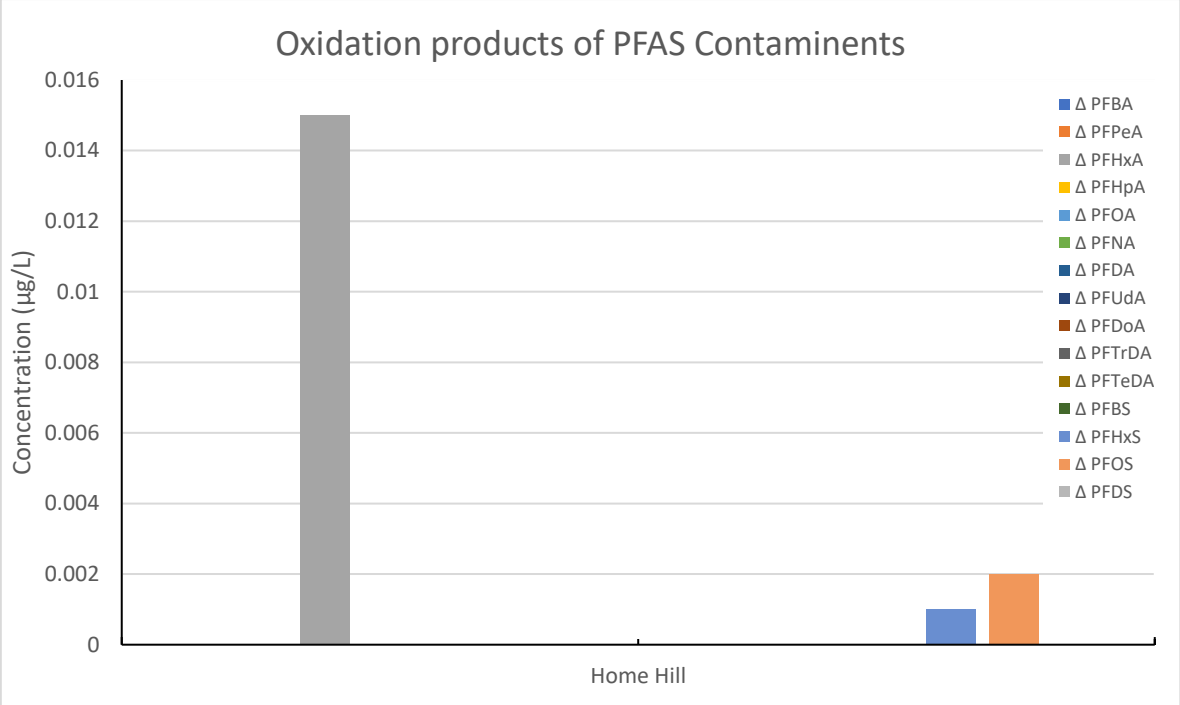


Figure NR 12

TOPA perfluoroalkyl substances (PFAS) profile of the Home Hill Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.086 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

The mass of PFOS can then be used as a basis to estimate the amount of foam concentrate present as 3M light water using the following relationship.

Mass AFFF (m_{AFFF}) = concentration PFOS (C_{PFOS}) x Volume of tank water (V_{tank}) x percent full (as fraction)

m_{AFFF} = 0.086 x 1500 x 0.70

= 90.3 µg (= 0.0000903 g) of PFOS

= 0.0000903 x 100 /1 (based on 1% PFOS) or = 0.0000903 x 100 / 5 (based on 5% PFOS)

= 0.009 g = 0.0018 g

= 9 mg = 1.8 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Home Hill Fire and Rescue Station in-ground water tank is between 0.002 to 0.009 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Mt Isa Fire and Rescue station

Mt Isa Fire and Rescue station is a two-storey station with four engine bays, housing four five-fighting and one specialist support appliances. It is staffed by four firefighters in the standard QFES 10/14 shift system. A concrete in-ground water tank (1050 mm diameter and 4500 mm deep and a capacity of 3890-L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water was collected from the in-ground that was 96% full at the time of sampling.

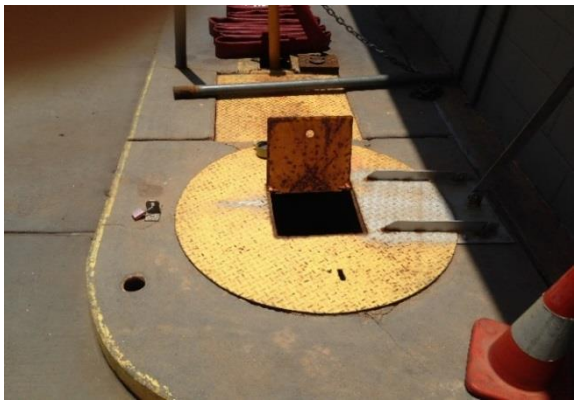


Figure NR 13

Mt Isa Fire and Rescue station location and surrounding suburban setting.

Mt Isa Results

Mt Isa Fire and Rescue station was one of the five identified Northern Region sites containing an in-ground water tank. This study investigated for PFAS contamination within the in-ground tank.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Eight water samples were collected from the Mt Isa Fire and Rescue Station -four in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank for PFAS and TOPA analyses, (Table NR 5).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		Gamma value
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	<LOR	<LOR	0.008	0.008	<LOR
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.01	<LOR	0.009	-0.001	0.89
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.014	<LOR	0.011	-0.003	0.79
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	< LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.024**				
TOPA C_4-C_{14} Carboxylic acids				<LOR	0.008		
TOPA C_4-C_{10} Sulfonic acids				<LOR	0.02		
Total TOPA (incl C_4-C_{10} Sulfonic acids)	**0.02**			**< LOR**	**0.028**		

Table NR 5

Water sample analyses from Mt Isa Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NR 5) shows the total PFAS (2.63 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NR 14).

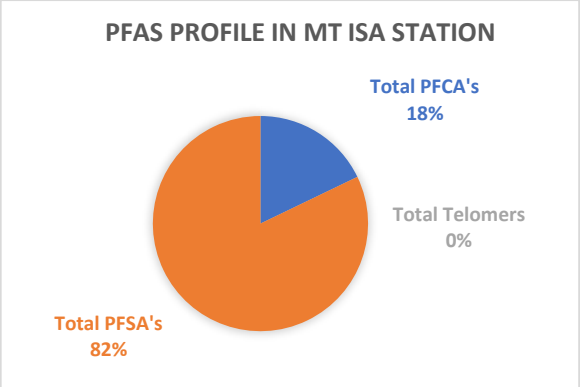


Figure NR 14

PFAS molar profile of the Mt Isa in-ground tank.

The in-ground tank water analysis shows that PFOA (< LOR) and ∑(PFOS + PFHxS) (0.024 µg/L) were below the Australian health-based guidelines for both drinking and recreational water, (Figure NR 15).

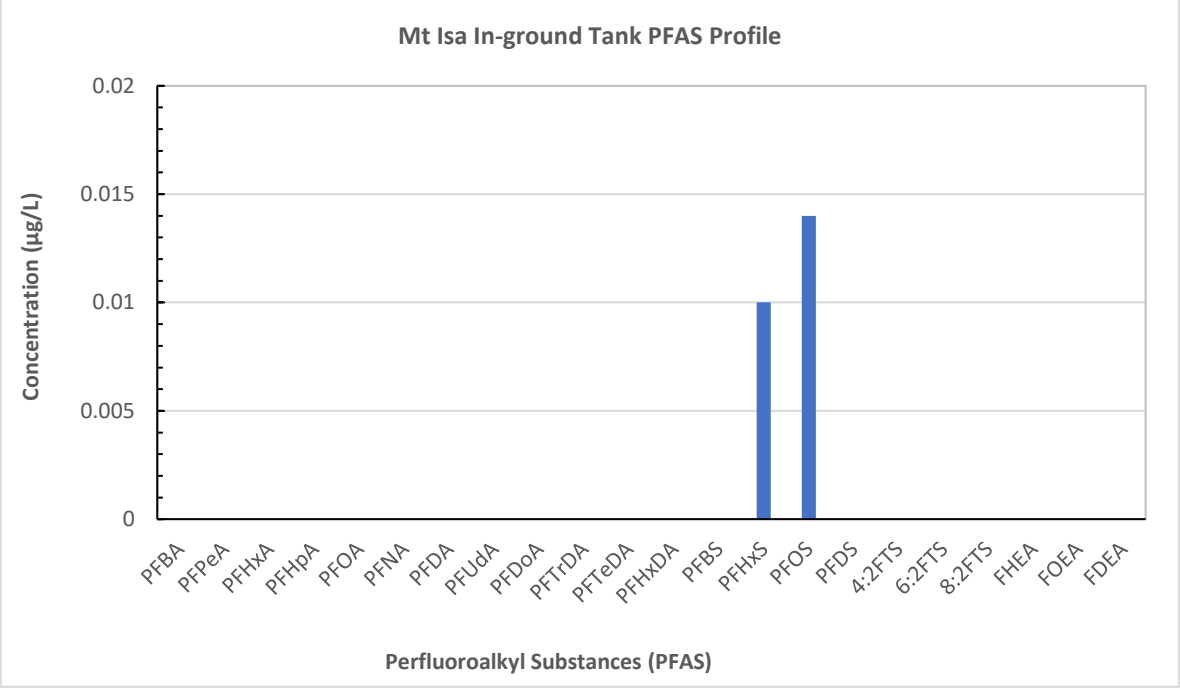


Figure NR 15

Perfluoroalkyl substances (PFAS) profile of the Mt Isa Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.028 µg/L) were all significantly below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.008 µg/L from PFHxA) and PFSA (0.020 µg/L from PFHxS, PFOS)] that may oxidise or biotransform over time, (Table NR 5, Figure NR 16).

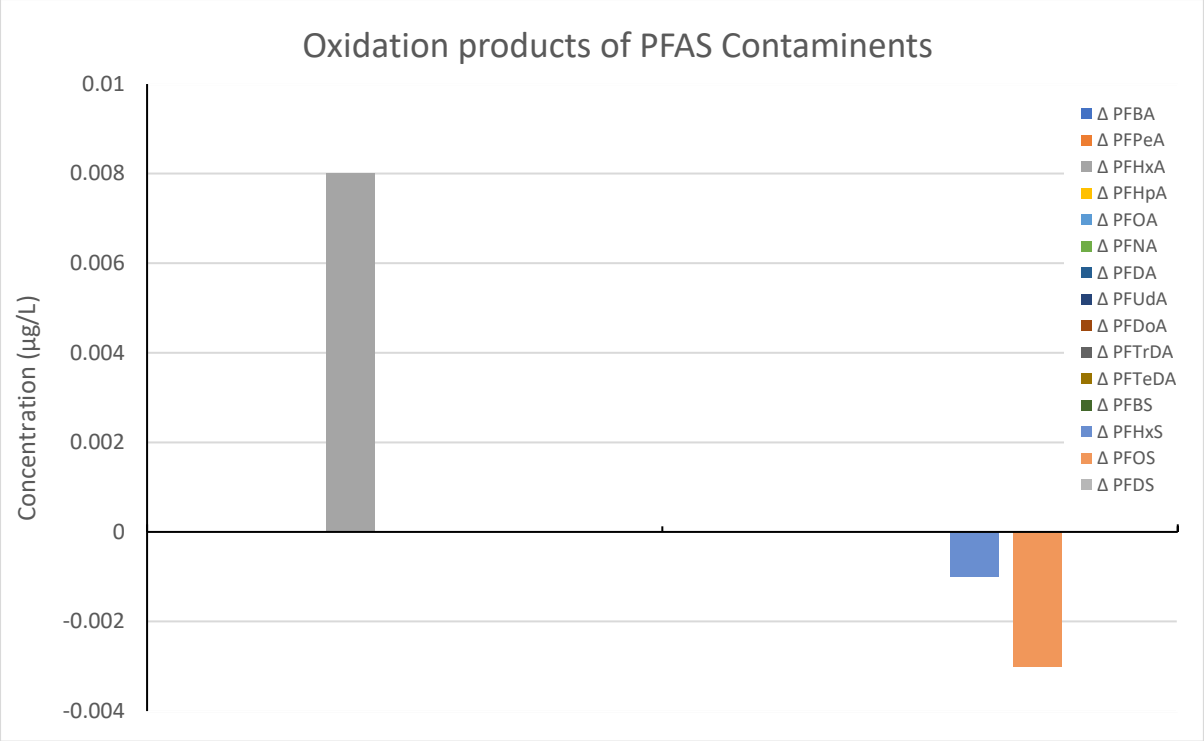


Figure NR 16

TOPA perfluoroalkyl substances (PFAS) profile of the Mt Isa Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.014 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.014 x 4000 x 0.95

= 53.2 µg (= 0.0000532 g) of PFOS

= 0.0000532 x 100 / 1 (based on 1% PFOS) or = 0.0024991 x 100 / 50 (based on 5% PFOS)

= 0.0053 g = 0.0011 g

= 5.3 mg = 1.1 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Mt Isa Fire and Rescue station in-ground water tank is between 0.001 to 0.005 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate

Summary of Northern Region Results

Phase One Investigation

The Townsville Fire and Rescue station in-ground tank water results showed low levels of PFAS contamination below the interim drinking and recreational water guidelines. However, when the current Australian health-based criteria are applied, the ∑(PFOS + PFHxS) (0.083 µg/L) value is above the interim Australian health-based drinking water guideline. The biological results (< 1 org/100mL of water for *E. coli*, < 1 org/100mL for total coliforms, and org/100mL for Enterococci) show the water equivalent to A+ recycled water for *E. coli*. The soil analyses for the station land and the nature strip showed very low levels of PFAS present, PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) 0.005 mg/kg)], and hence below the DES ERA60: Material used in Capping criteria and NEMP human health-based soil criteria for industrial/commercial land.

Phase Two Investigation

The Northern Region (NR) in-ground tank water analyses showed PFAS contamination in all Fire and Rescue station in-ground tanks [(Mt Isa, 0.024 µg/L), (Townsville, 0.11 µg/L), (Home Hill, 0.11 µg/L) (Ayr, 0.98 µg/L)], except Forrest Beach (< LOR). The PFAS profiles for all stations except Ayr show the presence of two PFAA moieties [PFCA and PFSA]. Ayr was the only station where the PFT moiety was detected. Similarly, PFSA was the predominant contaminant in all in-ground tanks, except Ayr where PFCA moiety was the predominant species. The highest total PFAS was observed in Ayr, (Figure NR 17). The PFCA and PFSA moieties are consistent with older style AFFF firefighting foams, while the PFCA and PFT are consistent with newer style AFFF firefighting foams

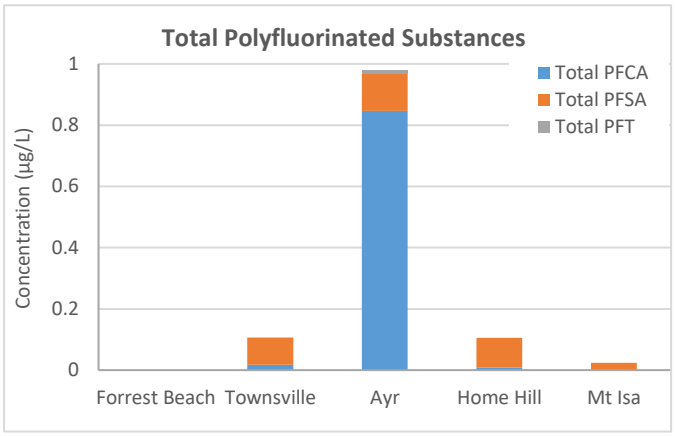


Figure NR 17

PFAS contamination of Northern Region in-ground tank water.

The Northern Region analyses show small concentrations ranges for PFOA (<LOR – 0.031 µg/L), ∑(PFOS + PFHxS) (<LOR – 0.12 µg/L) and TOPA (< LOR – 1.6 µg/L) and that that no station exceeded the Australian Health-based recreational and drinking water guidelines for PFOA. The ∑(PFOS + PFHxS) results show Forrest Beach (< LOR µg/L) was below the Australian Health-based recreational and drinking water guidelines, Townsville (0.121 µg/L) and Home Hill (0.083 µg/L) both exceeded the drinking water guideline and Ayr (0.98 µg/L) exceeded both the recreational and drinking water guidelines. The TOPA result showed that no station, except Ayr (1.6 µg/L), exceeded the Queensland Government environmental water discharge criteria. TOPA was not measured for Townsville, (Table NR 6).

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS forms PFOA. One method of measuring these changes is TOPA, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

Northern Region in-ground tank waters showed a different distribution of PFAS moieties across the stations. The PFCA homologues differences show Mt Isa contained one homologue (PFHxA), Townsville contained two homologues (PFBA, PFHxA) and Ayr contained five homologues (PFBA, PFPeA, PFHxA, PFHpA, PFOA). Home Hill and Forrest Beach contained no PFCA homologues. All stations except, Townsville and Forrest Beach, contained two PFSA homologues (PFHxS, PFOS). Townsville contained three (PFBS, PFHxS, PFOS) and Forrest Beach contained no PFSA homologues. Ayr was the only station to contain any PFT with one homologue (6:2 FTS), (Figure NR 18). The potential for PFAS oxidation or biotransformation can be highlighted by delta (Δ) values which are the differences between TOPA and initial PFAS concentrations, (Table NR 6, Figure NR 19).

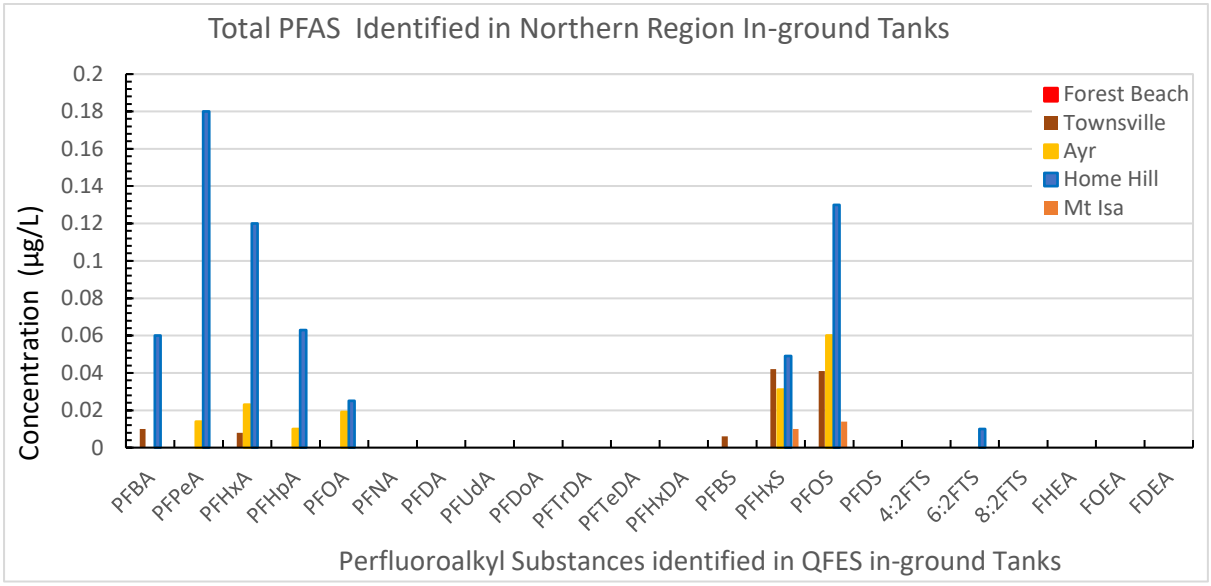


Figure NR 18

PFAS contamination profile of Northern Region Fire and Rescue station in-ground water tanks.

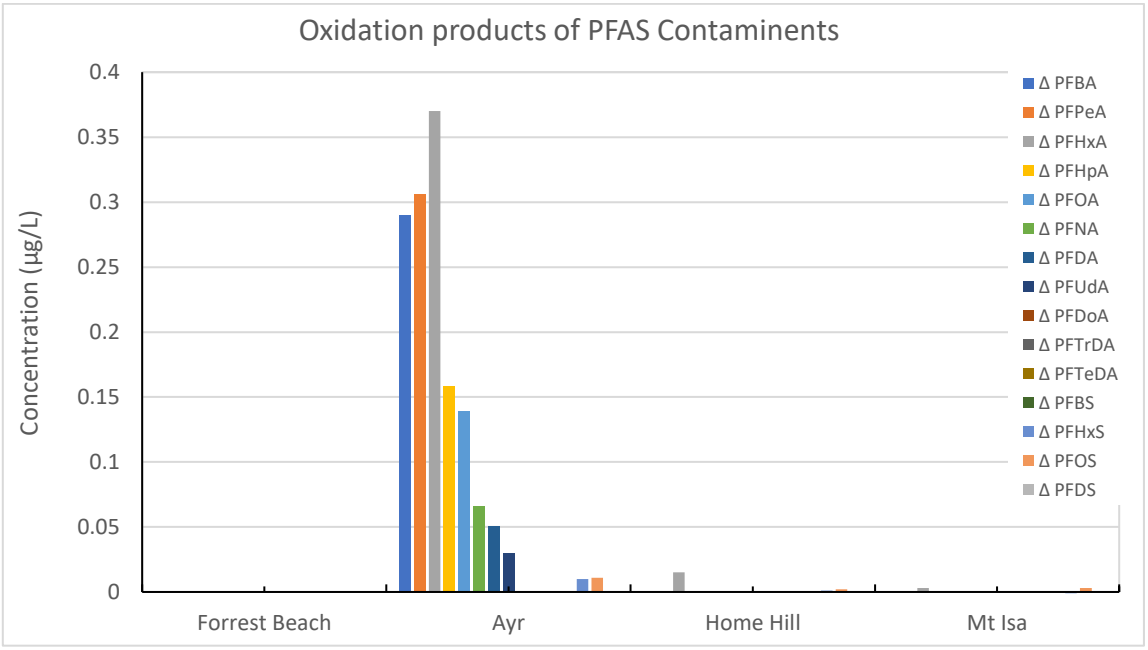


Figure NR 19

Accelerated oxidation on PFAS compounds reflected by the difference between TOPA and PFAS.

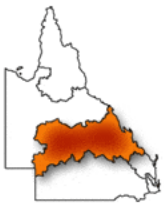
PFAS Standard Compounds	LOR	Forrest Beach			Townsville			Ayr			Home Hill			Mt Isa		
		PFAS	TOPA	Delta	PFAS	Soil	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(mg/k		(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Perfluorobutanoic acid (PFBA)	0.01	< LOR	< LOR	< LOR	0.01	< LOR		0.02	0.31	0.29	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	< LOR	< LOR	< LOR	< LOR	< LOR		0.024	0.33	0.31	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	< LOR	< LOR	< LOR	0.008	< LOR		0.05	0.42	0.37	0.008	0.023	0.015	<LOR	0.008	0.008
Perfluoroheptanoic acid (PFHpA)	0.005	< LOR	< LOR	< LOR	< LOR	< LOR		0.012	0.17	0.16	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	< LOR	< LOR	< LOR	< LOR	< LOR		0.031	0.17	0.14	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	0.066	0.066	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	0.05	0.05	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	0.03	0.03	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	< LOR	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	< LOR	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	< LOR	< LOR	< LOR	< LOR	<LOR		< LOR	< LOR	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	< LOR			< LOR			< LOR			< LOR			<LOR		
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	< LOR	< LOR	0.006	<LOR		< LOR	< LOR	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR	< LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	< LOR	< LOR	0.042	< LOR		0.06	0.07	0.010	0.011	0.012	0.001	0.01	0.009	-0.001
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	< LOR	< LOR	0.041	<LOR		0.061	0.072	0.011	0.086	0.088	0.002	0.014	0.011	-0.003
Perfluorodecanesulfonic acid (PFDS)	0.02	< LOR	< LOR	< LOR	< LOR	< LOR		< LOR	< LOR	<LOR	< LOR	< LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< LOR		< LOR	< LOR	< LOR		< LOR			< LOR			<LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	< LOR		< LOR	< LOR			0.01			< LOR			<LOR		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	< LOR		< LOR	< LOR	< LOR		< LOR			< LOR			<LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2	< LOR				< LOR		0.6			< LOR			<LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	< LOR		< LOR	< LOR	< LOR		0.11			< LOR			<LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	< LOR		< LOR	< LOR	< LOR		< LOR			< LOR			<LOR		
Total PFAS		**< LOR**			**0.11**	**< LOR**		**0.98**			**0.097**			**0.028**		
TOPA (incl C_4-C_{10} Sulfonic acids)			**< LOR**						**1.6**			**0.1**			**0.03**	

Table NR 6

PFAS contaminant assay of water in Northern Region in-ground water tanks. All station town water samples tested less than level of reporting (<LOR)

Investigation of Potential PFAS and Microbiological Contamination of QFES Central Region Fire and Rescue Stations with In-ground Water Tanks

The Queensland Fire and Emergency Services (QFES) Central Region covers a large, mainly rural area that incorporates a diverse mix of primary production, mining, mineral processing, chemicals and explosives manufacturing and export, energy production and transmission, tourism and commerce. The Region covers the Whitsunday Islands to Agnes Waters, and the Queensland/South Australian Border.



Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. This capability is provided by a mix of thirty-eight permanent, composite and auxiliary Fire and Rescue stations located throughout the Region. The region is staffed by 620 full time and auxiliary employees.

QFES Emergency Management supports the Local Government areas within the region. The QFES Emergency Management CR team work closely with all local governments to meet the Queensland Disaster Management legislative arrangements.

Rural Fire Service (RFS) regional operations is co-located with the F&R Central Region but led by the RFS Assistant Commissioner. RFS CR is staffed by approximately 8000 personnel, including regional QFES personnel, Volunteer Firefighters, and Volunteer Community Educators.

State Emergency Service (SES) regional operations is co-located with the F&R Central Region but led by the SES Assistant Commissioner. SES CR operates with 66 groups and is staffed by 14 permanent staff and approximately 1200 volunteer personnel across the region.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, of perfluoroalkyl substances (PFAS) contamination at QFES Central Region stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected and analysed for PFAS contamination. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
    - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
    - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS contamination. Water samples were collected from seven stations. The following criteria were used for Phase Two of the study:

- The Australian health-based water quality guidelines for
    - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
    - ∑(PFOS + PFHxS): recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all Central Region Fire and Rescue stations in-ground water tanks. Rockhampton and Yeppoon stations were sampled and analysed in Phase One. Seven stations (Airlie Beach, Proserpine, Mackay, Sarina, Dysart, Rockhampton and Gladstone) were sampled and analysed for Phase Two of these investigations. Moranbah station was empty at the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Two water samples were collected from Rockhampton Fire and Rescue station, one from the primary in-ground tank and one from an adjacent town water tap. Two soil samples, one from behind the station tower and one from adjacent nature strip outside the front of the station, for PFAS analysis. Two further water samples were collected, one from the in-ground tank and one from an adjacent town water tap, for biological analysis.

No water samples were collected from Yeppoon Fire and Rescue station, as no tank existed. Two soil samples, one from behind the station tower and one from adjacent nature strip outside the front of the station, were collected for PFAS analysis.

Phase Two investigations

Eight water samples were collected from the Gladstone in-ground tank - four in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank, for PFAS and TOPA analyses.

Six water samples were collected from the Sarina station - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash and a travel blank, for PFAS and TOPA analyses.

Five water samples were collected each from the Rockhampton, Mackay, Dysart, Proserpine and Airlie Beach stations - two in-ground water tank, two town water, a rinsate sample collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

Gladstone Fire and Rescue station

The Gladstone Fire and Rescue station is an older style station built prior to 1970. It is the major station in the Gladstone area, with three engine bays housing five fire appliances, one operational support unit, one rescue, two firefighting and one aerial appliance. The station is manned by six firefighters in the standard QFES 10/14 shift system. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A concrete in-ground water tank, adjacent to the tower (1560 mm diameter x 4500 mm deep and a capacity of 8630 L) is used for pump testing and water drafting training is covered by a steel plate cover, but not water proof to prevent water ingress. Water samples were collected from the in-ground tank that was 84% full at the time of sampling.

Figure CR 1

Gladstone Fire and Rescue station location and surrounding suburban setting.

Gladstone Results

Gladstone Fire and Rescue station was one of the eight identified in Central Region containing an in-ground water tank. This study investigated for PFAS contamination within the in-ground water tank.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Gladstone station - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses. The results are shown in Table CR 1 below.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	< LOR	0.5	< LOR	4.1	3.6	8.2
Perfluoropentanoic acid (PFPeA)	0.007	< LOR	2.0	< LOR	5.8	3.8	2.9
Perfluorohexanoic acid (PFHxA)	0.005	< LOR	4.9	< LOR	19	14	3.9
Perfluoroheptanoic acid (PFHpA)	0.005	< LOR	0.26	< LOR	1.3	1.0	5.0
Perfluorooctanoic acid (PFOA)	0.007	< LOR	1.4	< LOR	2.0	0.60	1.4
Perfluorononanoic acid (PFNA)	0.007	< LOR	0.96	< LOR	0.94	-0.02	0.98
Perfluorodecanoic acid (PFDA)	0.01	< LOR	0.06	< LOR	0.1	0.040	1.7
Perfluoroundecanoic acid (PFUdA)	0.01	< LOR	0.38	< LOR	0.53	0.15	1.40
Perfluorododecanoic acid (PFDoA)	0.02	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	< LOR	< LOR	< LOR	< LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	< LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	1.5	< LOR	1.3	-0.20	0.87
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	7.9	< LOR	8.7	0.80	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	34	< LOR	34	0	1
Perfluorodecanesulfonic acid (PFDS)	0.02	< LOR	0.02	< LOR	0.06	0.04	3.00
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	< LOR	6.9				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	< LOR	0.23				
Perfluorohexyl ethanoic acid (FHEA)	0.2	< LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	< LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	< LOR	< LOR				
Total PFAS		**< LOR**	**61**				
TOTAL C_4-C_{14} Carboxylic acids				< LOR	34		
TOTAL C_4-C_{10} Sulfonic acids				< LOR	44		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.010**			**<LOR**	**78**		

Table CR 1

Water sample analyses from Gladstone Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 1) shows the total PFAS (61 µg/L) is comprised of the three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFT (telomer) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure CR 2).

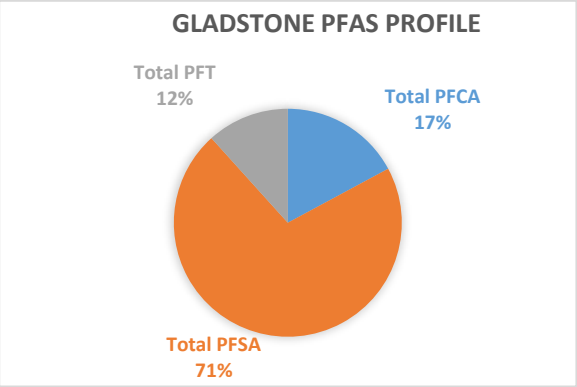


Figure CR 2

PFAS molar profile of the Gladstone in-ground tank.

The in-ground tank water analysis shows that PFOA (1.4 µg/L) was above the Australian health-based drinking water guideline, but below the recreational

water guideline. However, the ∑(PFOS + PFHxS) (41.9 µg/L) was above both drinking and recreational water guidelines, (Figure CR 3).

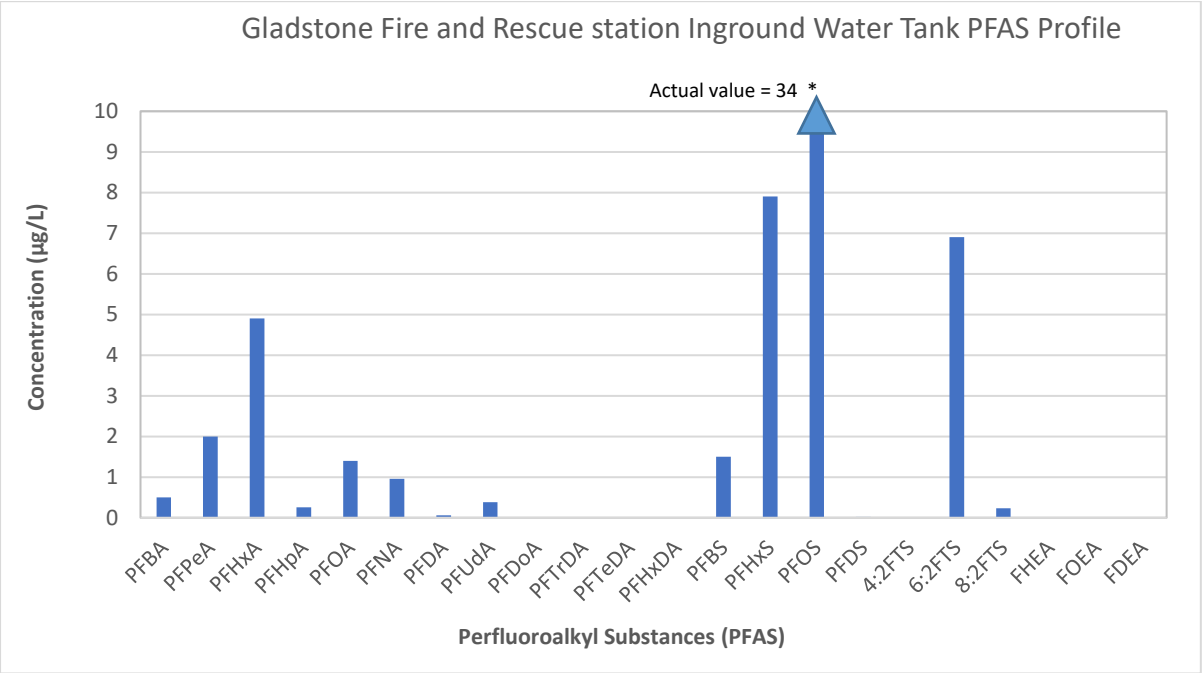


Figure CR 3

Perfluoroalkyl substances (PFAS) profile of the Gladstone Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show the PFOA, ∑(PFOS + PFHxS) and TOPA (78 µg/L) were all significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (10.5 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA), PFSA (43.4 µg/L from PFBS, PFHxS, PFOS, PFDS) and PFT (7.13 µg/L from 6:2FTS, 8:2FTS)] that may oxidise or biotransform over time, (Table CR 1, Figure CR 4).

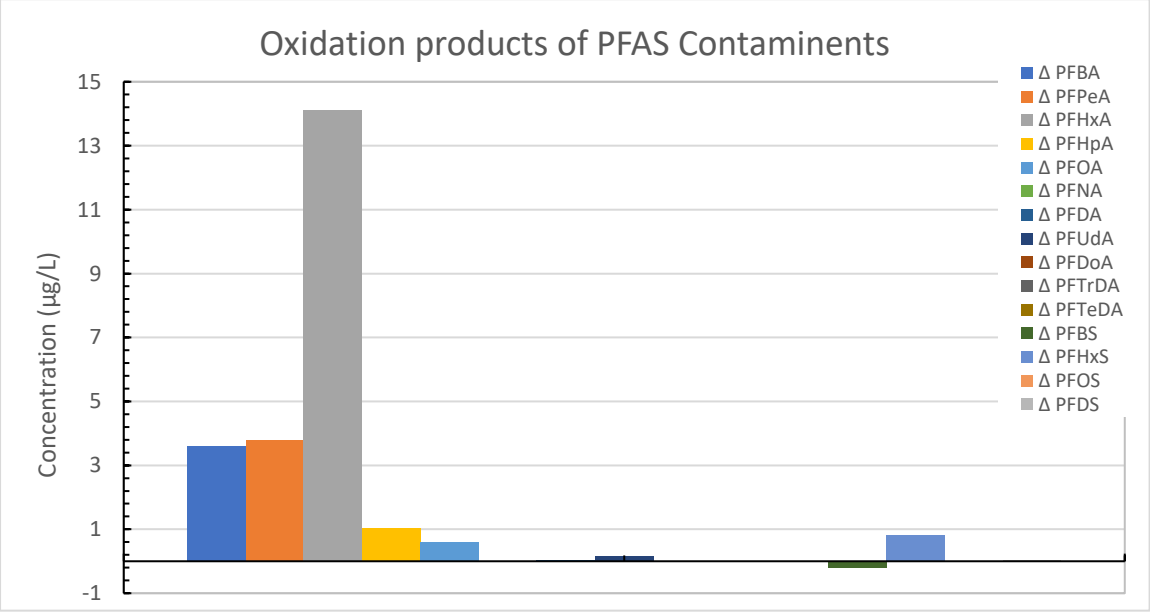


Figure CR 4

TOPA perfluoroalkyl substances (PFAS) profile of the Gladstone station in-ground tank.

The Gladstone water sample shows the two PFSA homologues, PFOS and PFHxS, are the major PFAS contaminants. The other main PFAS contaminants are the PFAA and the FTS, mainly PFOA, 6:2 FTS and small amounts of 8:2 FTS, which indicate that newer style foams have been present.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (34 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 34 x 8630 x 0.84

= 246472.8 µg (= 0. 2464728 g) of PFOS

= 0.2464728 x 100 / 1 (1% PFOS) = 25 g = 25 000 mg

or

= 0.2464728 x 100 / 5 (5% PFOS) = 4.9 g = 4900 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Gladstone Fire and Rescue station in-ground water tank is between 5 to 25 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Yeppoon Fire and Rescue station

The Yeppoon Fire and Rescue station is a newer style station built after 2000. It is the only station in the Yeppoon area, with three engine bays housing three fire-fighting, one rescue and one aerial appliance. The station is crewed by one permanent station officer and auxiliary firefighters. All training activities are conducted on a large open space to the rear and at the side of the station. No in-ground water tank exists on the site.

Figure CR 5

Yeppoon Fire and Rescue station location and surrounding suburban setting.

Yeppoon Results

Phase One investigation

Yeppoon Fire and Rescue station had no in-ground tank at the time of sampling. However, two soil samples, one adjacent to the training area and one from adjacent nature strip outside the station were collected for PFAS analysis. The analyses show the PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) (2.312 mg/kg)] were below the DES ERA60 material used in Capping: PFOA criteria and the NEMP soil criteria applied to human health exposure guidelines for industrial or commercial land.

Analyte Name	PFAS Sample Analyses						Biological Analyses	
	Water (μg/L)			Soil (mg/kg)			Water Samples (CFU/100ml)	
	LOR	Tap	Tank	LOR	Street	Yard	Tank	Tap
Biological Test								
E. coli								
Coliforms								
Enterococci								
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)				0.005	<LOR	<LOR		
Perfluoropentanoic acid (PFPeA)				0.002	<LOR	<LOR		
Perfluorohexanoic acid (PFHxA)				0.001	<LOR	0.001		
Perfluoroheptanoic acid (PFHpA)				0.001	<LOR	<LOR		
Perfluorooctanoic acid (PFOA)				0.002	<LOR	<LOR		
Perfluorononanoic acid (PFNA)				0.001	<LOR	<LOR		
Perfluorodecanoic acid (PFDA)				0.001	<LOR	<LOR		
Perfluoroundecanoic acid (PFUDA)				0.002	<LOR	<LOR		
Perfluorododecanoic acid (PFDoA)				0.002	<LOR	<LOR		
Perfluorotridecanoic acid (PFTrDA)				0.007	<LOR	<LOR		
Perfluorotetradecanoic acid (PFTeDA)				0.01	<LOR	<LOR		
Perfluorohexadecanoic acid				Not Reported				
Perfluorooctadecanoic acid								
Perfluorobutanesulfonic acid (PFBS)				0.001	< LOR	<LOR		
Perfluorohexanesulfonic acid (PFHxS)				0.001	< LOR	0.012		
Perfluorooctanesulfonic acid (PFOS)				0.001	< LOR	2.3		
Perfluorodecanesulfonic acid (PFDS)				0.002	< LOR	0.017		
2-perfluorohexyl ethanoic acid (FHEA)				0.002	< LOR	< LOR		
2-Perfluoroocty ethanoic acid (FOEA)				0.02	< LOR	< LOR		
2-Perfluorodecyl ethanoic acid (FDEA)				0.02	< LOR	< LOR		
4:2 Fluorotelomer sulfonic acid (4:2 FTS)				0.002	< LOR	< LOR		
6:2 fluorotelomer sulfonate (6:2 FTS)				Not Reported				
8:2 Fluorotelomer sulfonic acid (8:2 FTS)				0.005	<LOR	<LOR		
Total PFAS					**< LOR**	**2.33**		

Table CR 2

Phase One water and soil sample analyses from Yeppoon Fire and Rescue station.

Rockhampton Fire and Rescue station

The Rockhampton Fire and Rescue station is an older style station built prior to 1970. It is the major station in the Rockhampton area, with three engine bays housing three fire-fighting, one rescue and one aerial appliance. The station is crewed by six firefighters in the standard QFES 10/14 shift system. A fire communications centre, above the engine bays, is staffed by three officers who are also impacted by the engine room activities. The area office and BA-HazMat complex are co-located on-site, and all training activities are conducted on a large open space to the rear and at the side of the station, and/or in a multistorey training tower. Water samples were collected from a concrete lined rectangular tank (8200 mm long x 1000 mm wide x 2000 mm deep) and a concrete in-ground water tank (1800 mm diameter and 7050 mm deep) with a padlocked steel plate cap. The former tank has a water capacity of 14850 L and was 90% full at the time of sampling. The latter tank has a water capacity of 17940 L and was 96.5% full at the time of sampling. These tanks have been used in the past for activities at the station including drafting water and appliance pump performance checks.

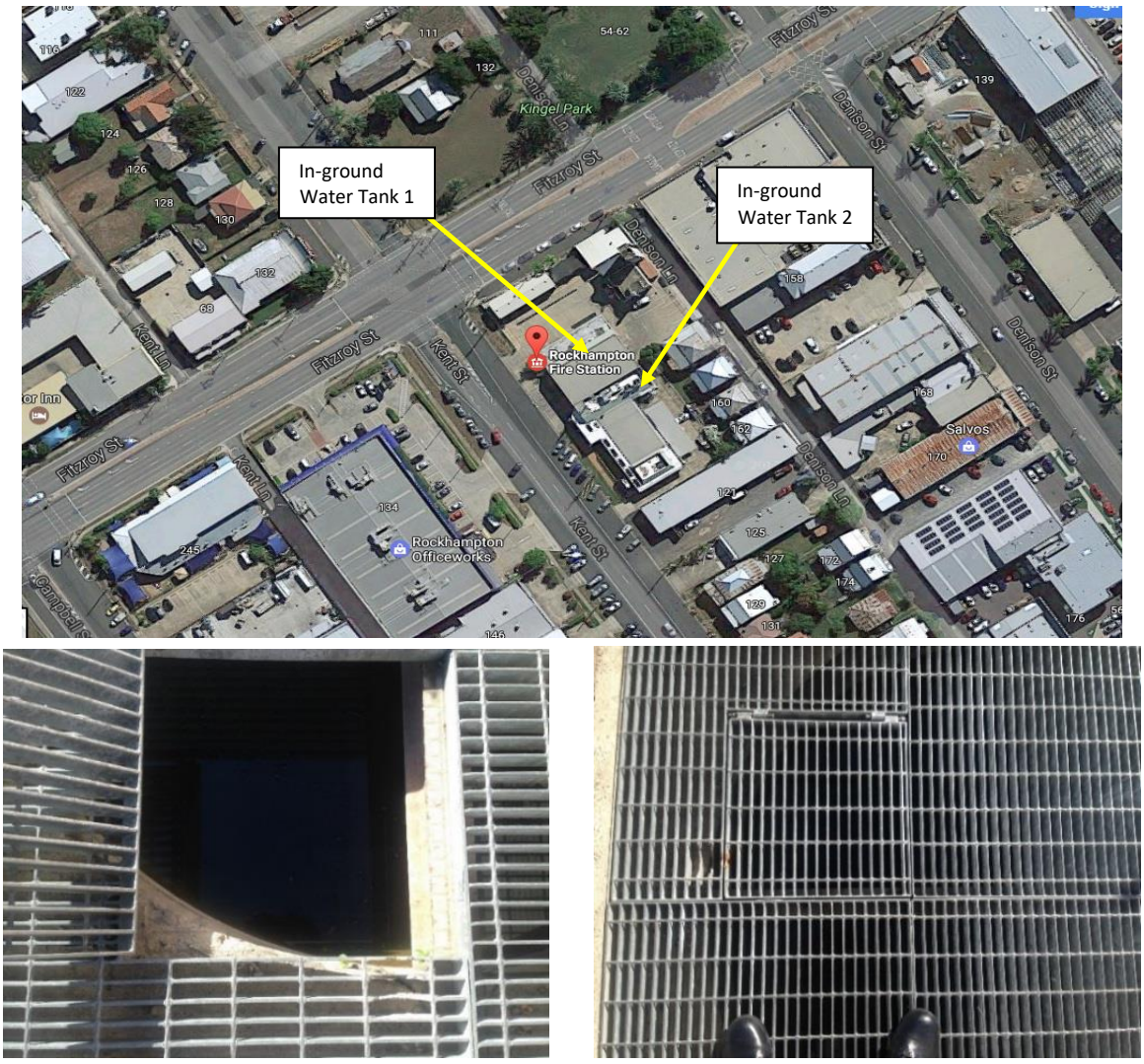


Figure CR 6

Rockhampton Fire and Rescue station location and surrounding suburban setting.

Rockhampton Results

Rockhampton Fire and Rescue station was one of the eight identified in Central Region containing an in-ground water tank. Rockhampton station had two in-ground tanks, a newer water collection tank (#1) and an older disused tank (#2). This study investigated for PFAS contamination within the in-ground water tanks.

Phase One investigation

Four water samples were collected for PFAS and biological analyses, two from the in-ground tank 1 and two from an adjacent town water tap. Two soil samples were collected for PFAS analysis, one within the station confines and one from the nature strip outside the station. The results are shown in Table CR 3 below.

Analyte Name	PFAS Sample Analyses						Biological Analyses	
	Water (µg/L)			Soil (mg/kg)			water (CFU/100ml)	
	LOR	Tap	Tank	LOR	Street	Yard	Tank	Tap
Biological Test								
E. coli							<1	<1
Confirmed coliforms							2500	<1
Enterococci							not reported	
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.02	0.005	<LOR	<LOR		
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.008	0.002	<LOR	<LOR		
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.029	0.001	<LOR	<LOR		
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.036	0.002	<LOR	<LOR		
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	0.001	<LOR	<LOR		
Perfluoroundecanoic acid (PFUDA)	0.01	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	0.002	<LOR	<LOR		
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	0.007	<LOR	<LOR		
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	0.01	<LOR	<LOR		
Perfluorohexadecanoic acid	0.05	<LOR	<LOR	Not Reported				
Perfluorooctadecanoic acid	Not Reported							
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	0.009	0.001	< LOR	<LOR		
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	0.092	0.001	0.008	0.003		
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	0.11	0.001	< LOR	0.015		
Perfluorodecanesulfonic acid (PFDS)	0.005	< LOR	<LOR	0.002	< LOR	< LOR		
2-perfluorohexyl ethanoic acid (FHEA)	Not Reported			0.002	< LOR	< LOR		
2-Perfluoroocty ethanoic acid (FOEA)	0.05	< LOR	<LOR	0.02	< LOR	< LOR		
2-Perfluorodecyl ethanoic acid (FDEA)	0.05	< LOR	<LOR	0.02	< LOR	< LOR		
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	0.005	< LOR	<LOR	0.002	< LOR	< LOR		
6:2 fluorotelomer sulfonate (6:2 FTS)	0.01	< LOR	<LOR	Not Reported				
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	0.02	<LOR	<LOR	0.005	<LOR	<LOR		
Total PFAS	0.04	<LOR	0.304	0.002	0.008	0.018		

Table CR 3

Phase One water and soil sample analyses from Rockhampton Fire and Rescue station.

The Phase One in-ground tank water analysis (Table CR 3) shows the total PFAS (0.304 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages shows the highest contribution from the PFSA (sulfonates) moiety which comprises of 70% of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 7). The in-ground tank water analysis shows that PFOA (0.036 µg/L) and ∑(PFOS + PFHxS) (0.202 µg/L) were below the interim Australian health-based guidelines for both drinking and recreational water. Similarly, PFOA and ∑(PFOS + PFHxS) were below the Queensland Government environmental water discharge criteria, (Figure CR 8).

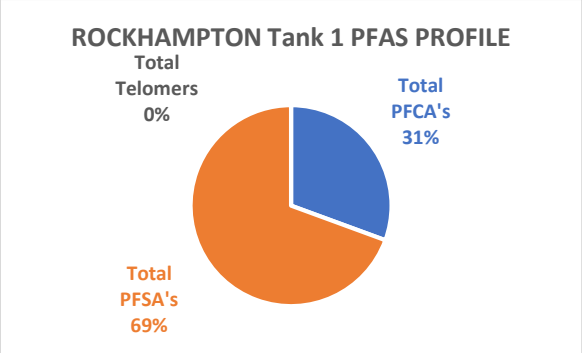


Figure CR 7
PFAS molar profile of the Rockhampton in-ground tank #1.

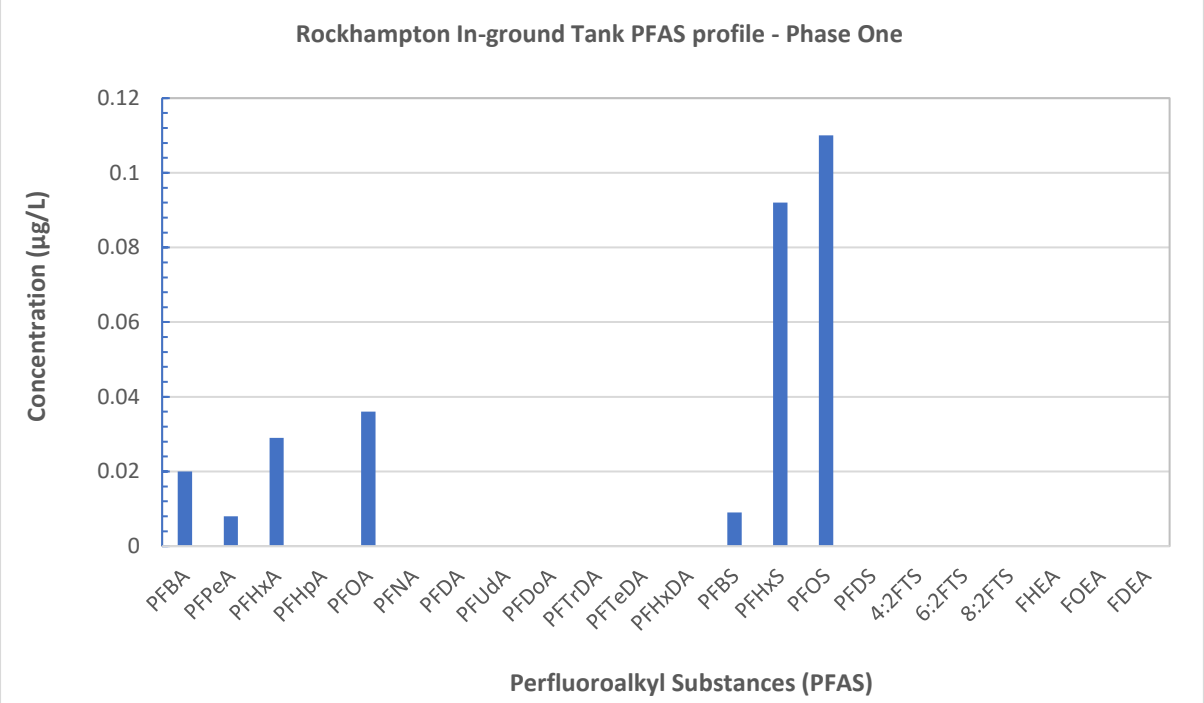


Figure CR 8
Perfluoroalkyl substances (PFAS) profile of the Rockhampton Fire and Rescue station in-ground tank.

The biological results (< 1 org/100mL of water for *E. coli*, 2500 CFU for total coliforms) show water is equivalent to A+ recycled water for *E. coli*. The soil analyses showed no reportable levels of PFAS (<LOR) , but trace contamination of ∑(PFOS + PFHxS) (0.018 mg/kg) on the station site. This is significantly below the DES soil contamination and NEMP human health criteria for soil.

Phase Two investigation

Six water samples were collected for PFAS and TOPA analyses - two in-ground water tank samples, two town water samples, one sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank. The results for the four in-ground and tap samples are shown in Table CR 4.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	< LOR	0.01	<LOR	0.05	0.040	5.0
Perfluoropentanoic acid (PFPeA)	0.007	< LOR	0.023	<LOR	0.015	-0.008	0.65
Perfluorohexanoic acid (PFHxA)	0.005	< LOR	0.021	<LOR	0.1	0.079	4.8
Perfluoroheptanoic acid (PFHpA)	0.005	< LOR	0.013	<LOR	0.013	0	1
Perfluorooctanoic acid (PFOA)	0.007	< LOR	0.019	<LOR	0.051	0.032	2.7
Perfluorononanoic acid (PFNA)	0.007	< LOR	0.01	<LOR	0.02	0.010	2.0
Perfluorodecanoic acid (PFDA)	0.01	< LOR	0.01	<LOR	0.02	0.010	2.0
Perfluoroundecanoic acid (PFUdA)	0.01	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	< LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	0.006	<LOR	0.007	0.001	1.2
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	0.024	<LOR	0.027	0.003	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	0.099	<LOR	0.17	0.071	1.7
Perfluorodecanesulfonic acid (PFDS)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	< LOR	< LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	< LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	< LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	< LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	< LOR	< LOR				
Total PFAS		**<LOR**	**0.24**				
TOPA C_4-C_{14} Carboxylic acids				<LOR	0.27		
TOPA C_4-C_{10} Sulfonic acids				<LOR	0.20		
Total TOPA	**0.17**			<LOR	**0.47**		

Table CR 4

Water analyses from Rockhampton Fire and Rescue station in-ground tank 2 and town water.

The Phase Two in-ground tank water analysis (Table CR 4) shows the total PFAS (0.24 µg/L) is comprised of the two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages shows the highest contribution from the PFSA (sulfonates) moiety comprising 70% of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 9).

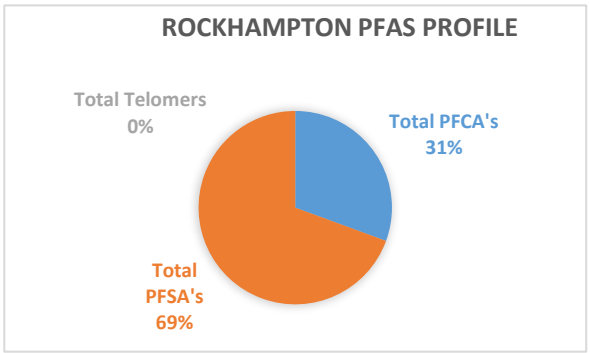


Figure CR 9

PFAS molar profile of the Rockhampton in-ground tank #2.

The in-ground tank water analysis shows that PFOA (0.019 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.123 µg/L) was below the recreational water guideline, but above both drinking water guideline, (Figure CR 10).

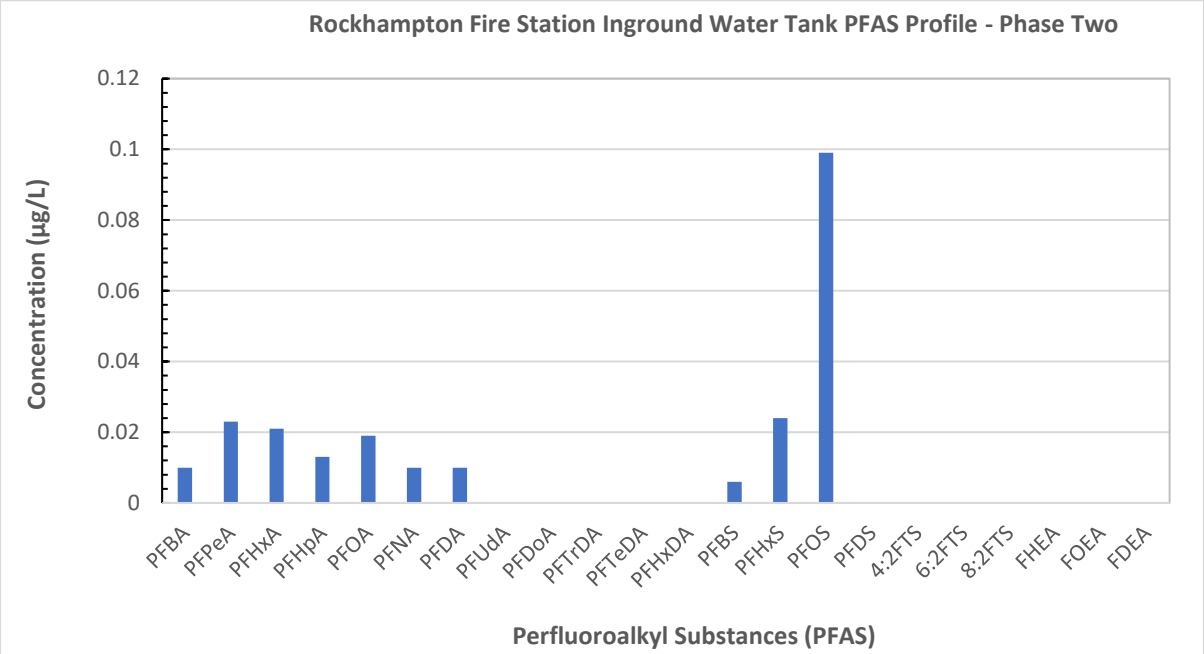


Figure CR 10

Perfluoroalkyl substances (PFAS) profile of water from the Rockhampton station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.47 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.27 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA) and PFSA (0.204 µg/L from PFHxS, PFOS, PFDS)] that may oxidise or biotransform over time, (Table CR 4, Figure CR 11).

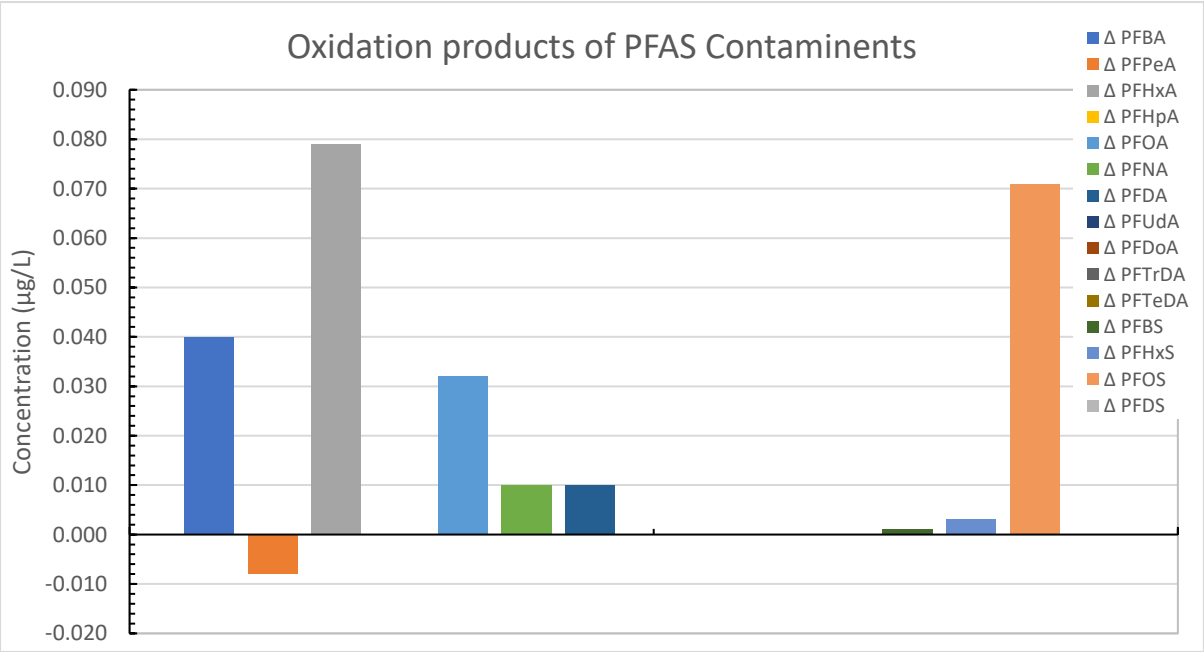


Figure CR 11

TOPA perfluoroalkyl substances (PFAS) profile of the Rockhampton Fire and Rescue station in-ground tank 2.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (tank 1 = 0.11 µg/L; tank2 = 0.099 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

In-ground tank 1

m_{AFFF} = 0.11 x 15000 x 0.90
= 1485 µg (= 0.001485 g) of PFOS
= 0.001485 x 100 / 1 (1% PFOS) or = 0.001485 x 100 / 5 (5% PFOS)
= 0.149 g = 0.0297
= 149 mg = 29.7 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Rockhampton Fire and Rescue station in-ground water tank is between 0.03 to 0.2 g.

In-ground tank 2

m_{AFFF} = 0.099 x 17940 x 0.965
= 1713.9041 µg (= 0.001713041 g) of PFOS
= 0.001713041 x 100 / 1 (1% PFOS) or = 0.001713041 X 100 / 5 (5% PFOS)
= 0.171 g = 0.0343 g
= 171 mg = 34.3 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Rockhampton Fire and Rescue station in-ground water tank is between 0.03 to 0.2 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Sarina Fire and Rescue station

Sarina Fire and Rescue station is an older style two storey station built prior to 1970. It has a two engine bays housing one fire appliance and training rooms above them. The station is crewed by auxiliary firefighters and was only involved in Phase Two of the QFES water sampling. The station adjoins a state school and residential houses around it. The water samples were collected from a concrete in-ground water tank (1230 mm diameter and 1100 mm deep capacity of 1310 L) used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 24.6 % full at the time of sampling.

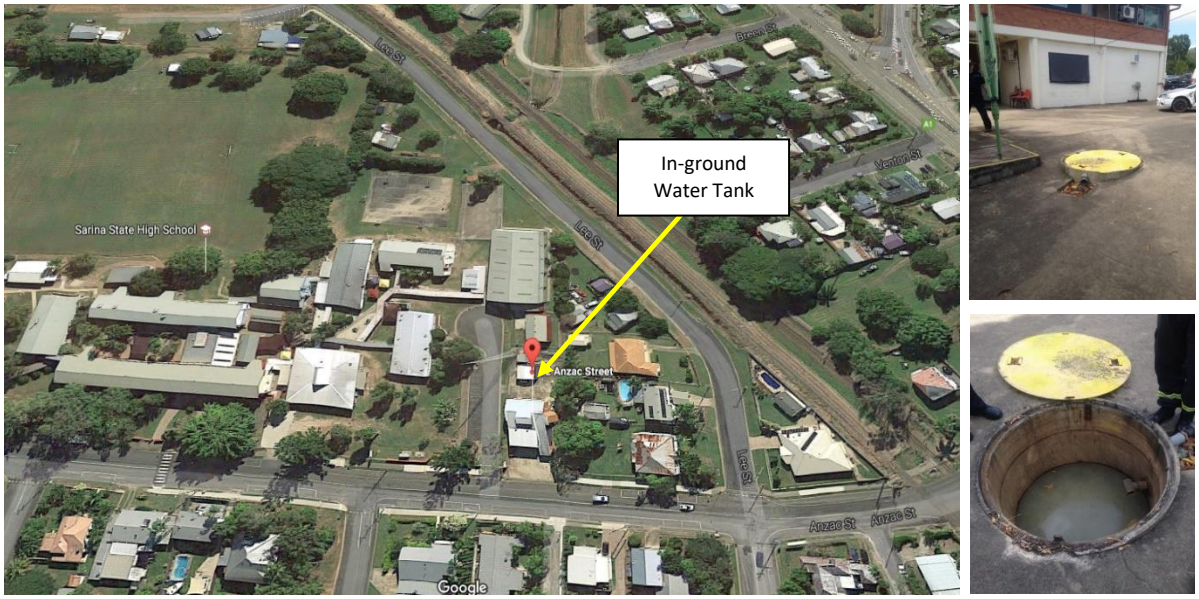


Figure CR 12
Sarina Fire and Rescue station in-ground water tank and surrounding suburban setting.

Sarina Results

Sarina Fire and Rescue station was one of the eight identified in Central Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Sarina in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table CR 5).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	<LOR	<LOR	0.014	0.014	<L
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.01	<LOR	0.011	0.001	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.015	<LOR	0.025	0.010	1.7
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.025**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.01		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.04		
TOPA (incl C_4-C_{10} Sulfonic acids)				**<LOR**	**0.05**		

Table CR 5

Water sample analyses from Sarina Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 5) shows the total PFAS (0.025 µg/L) is comprised entirely of one PFAA moiety (PFSA). The PFSA is representative of the older style fluorinated foams, (Figure CR 13). The in-ground tank water analysis shows that PFOA (<LOR µg/L) and ∑(PFOS + PFHxS) level (0.025 µg/L) were both below the Australian health-based guidelines for both drinking and recreational water, (Figure CR 14).

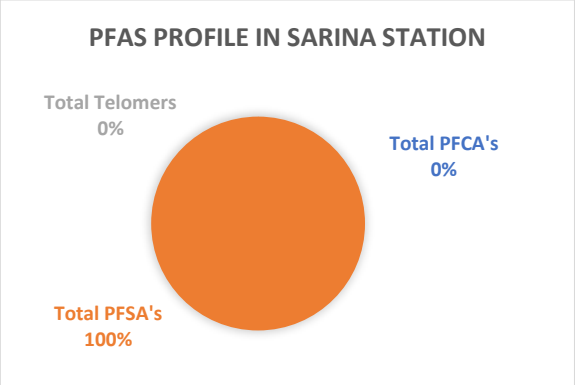


Figure CR 13

PFAS molar profile of the Sarina in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show that PFOA, ∑(PFOS + PFHxS) and TOPA (0.04 µg/L) were all significantly below the discharge criteria. The TOPA

analysis showed the presence of PFAS precursors [PFCA (0.014 µg/L from PFHxA), PFSA (0.036 µg/L from PFHxS, PFOS)] that may oxidise or biotransform over time, (Table CR 5, Figure CR 15).

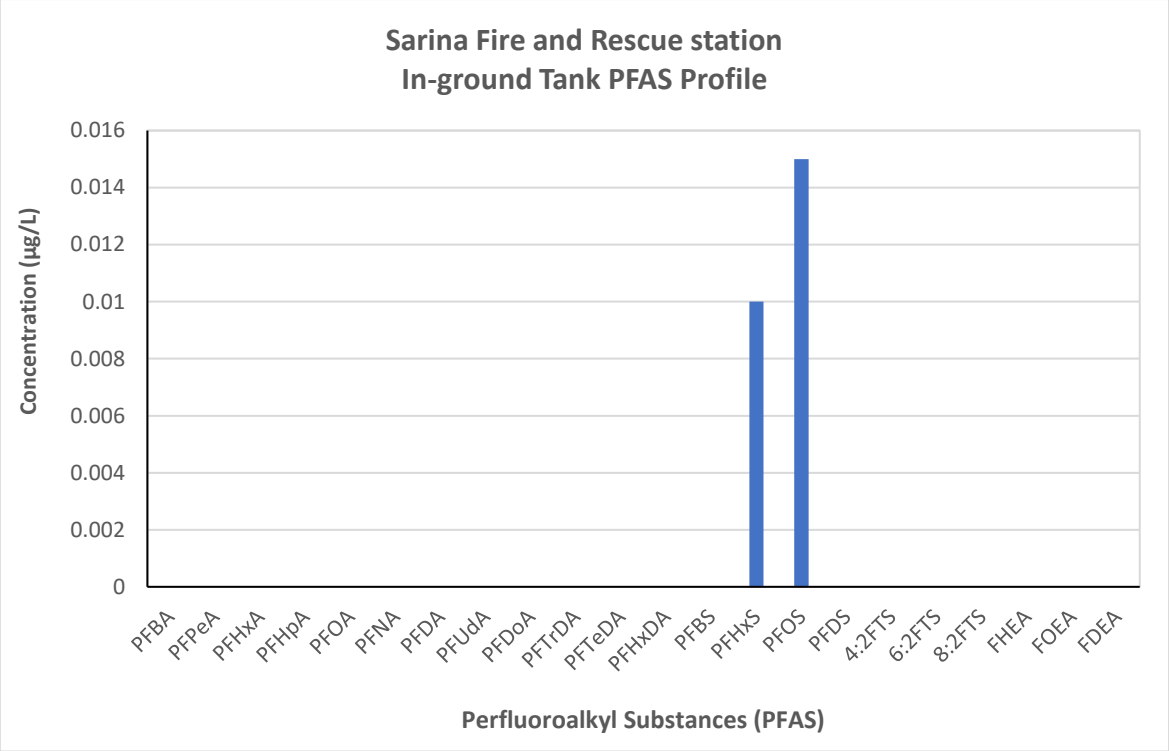


Figure CR 14

Perfluoroalkyl substances (PFAS) profile of water from the Sarina station in-ground tank.

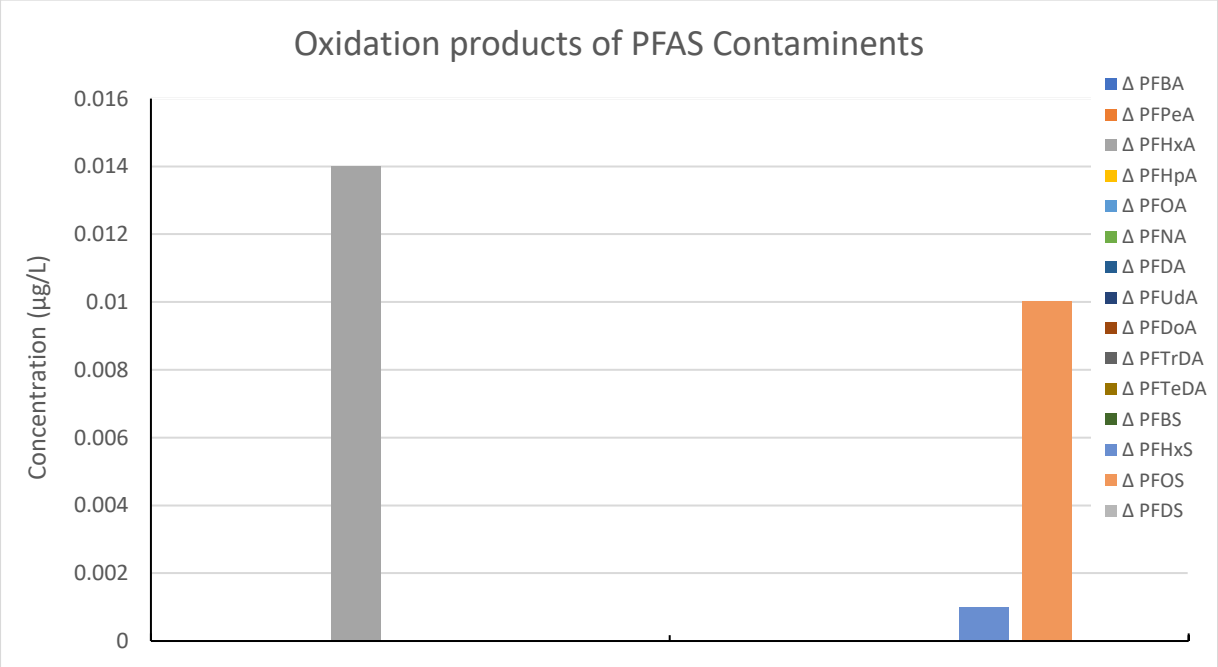


Figure CR 15

TOPA perfluoroalkyl substances (PFAS) profile of the Sarina Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.015 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.015 x 1310 x 0.246

= 4.8339 µg (= 0.0000903 g) of PFOS

= 0.0000048339 x 100 / 1 (1% PFOS) or = 0.0000048339 X 100 / 5 (5% PFOS)

= 0.000483 g = 0.00009668 g

= 0.48 mg = 0.1 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Sarina Fire and Rescue station in-ground water tank is between 0.00001 to 0.0005 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Dysart Fire and Rescue station

Dysart Fire and Rescue station is an older style station built prior to 1970. It has a small engine bay with side attached rooms houses one fire-fighting appliance. The station is crewed by auxiliary firefighters and was only involved in Phase Two of the QFES water sampling. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1070 mm diameter x 4500 mm deep, capacity of 4040 L) at the rear of the yard is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 33.3% full at the time of sampling.

Figure CR 16

Dysart Fire and Rescue station location and surrounding suburban setting.

Dysart Results

Dysart Fire and Rescue station was one of the eight identified in Central Region stations containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Dysart Fire and Rescue station - two in-ground tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table CR 6).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	0.01	0.01	0
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.011	<LOR	0.015	0.004	1.4
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.008	<LOR	0.041	0.033	5.2
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.006	<LOR	0.006	0	1
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	<LOR	0.011	0.004	1.6
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.005	<LOR	0.006	0.001	1.2
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.009	<LOR	0.012	0.003	1.3
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.066	<LOR	0.12	0.054	1.8
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.11**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.082		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.14		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.064**			**<LOR**	**0.22**		

Table CR 6

Water sample analyses from Dysart Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 6) shows the total PFAS (0.11 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights

the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 17). The in-ground tank water analysis shows that PFOA (<LOR µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.075 µg/L) was below the recreational water guideline and marginally above the drinking water guideline, (Figure CR 18).

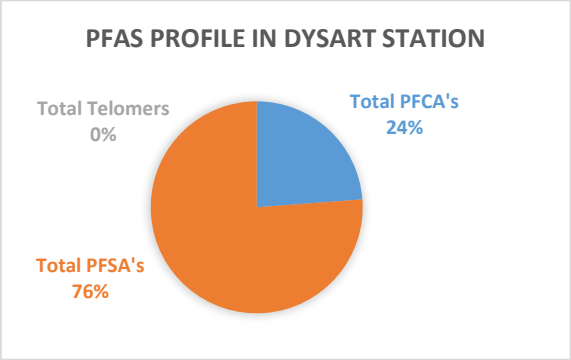


Figure CR 17

PFAS molar profile of the Dysart in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.14 µg/L) were all significantly below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.083 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA), PFSA (0.14 µg/L from PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table CR 6, Figure CR 19).

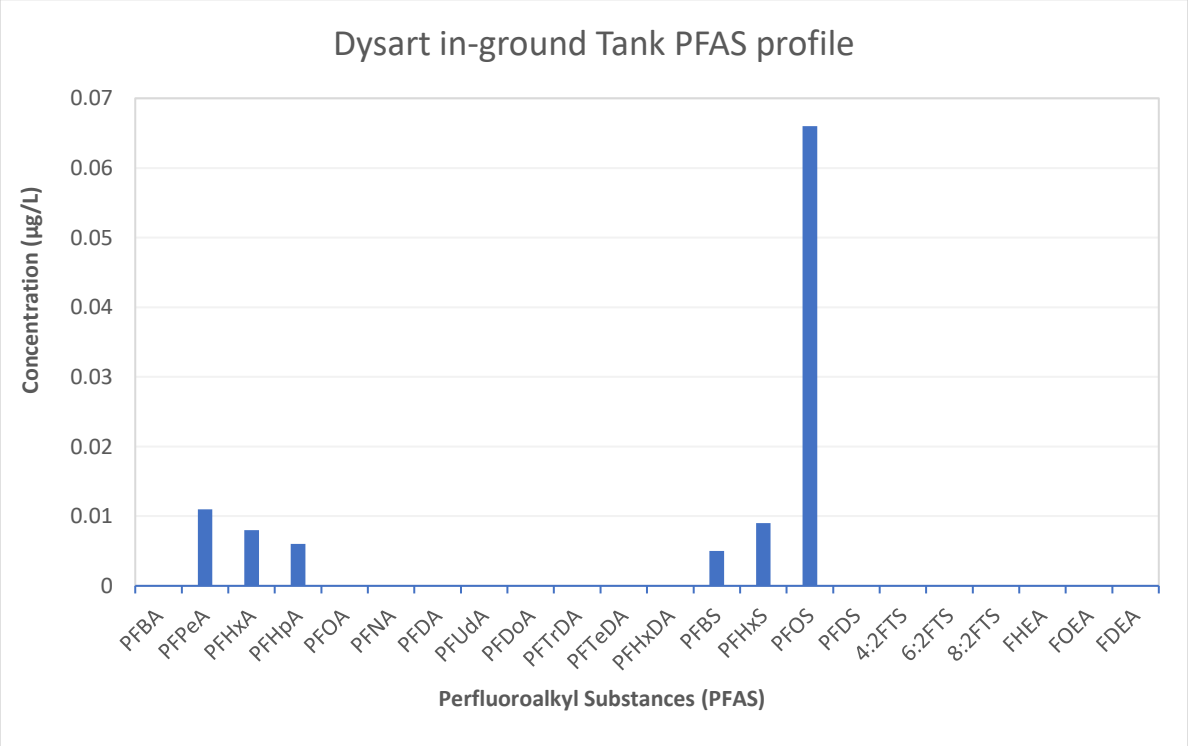


Figure CR 18

Perfluoroalkyl substances (PFAS) profile of water from the Dysart station in-ground tank.

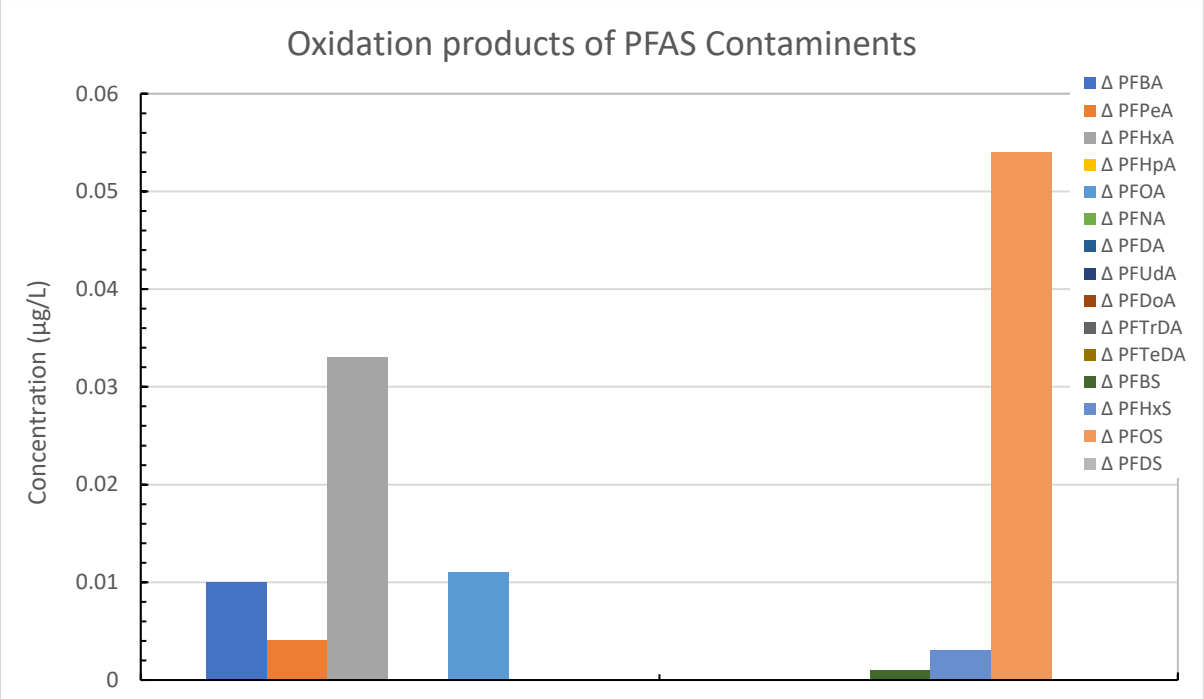


Figure CR 19

TOPA perfluoroalkyl substances (PFAS) profile of the Dysart Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.066 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.066 x 4040 x 0.333

= 88.8791 µg (= 0.00008888 g) of PFOS

= 0.00008888 x 1 / 100 (1% PFOS) or = 0.00008888 X 5 / 100 (5% PFOS)

= 0.00889 g = 0.0018 g

= 8.9 mg = 1.8 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Dysart Fire and Rescue station in-ground water tank is between 0.002 to 0.009 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Moranbah Fire and Rescue station

The Moranbah Fire and Rescue station is an older style auxiliary station built prior to 1970. It has a small engine bay with side attached rooms housing one fire-fighting appliance. The station is crewed by auxiliary firefighters. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A small concrete in-ground water tank (1270mm in diameter and 600mm deep, capacity of 760 L) that is kept empty and only filled for training is located behind the station. It contained a large drain in the centre that allows crews to fill and empty.

Figure CR 20

Moranbah Fire and Rescue station location and surrounding suburban setting.

Moranbah Results

Moranbah Fire and Rescue station was one of the eight identified Central Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

The in-ground tank at Moranbah was empty at the time of sampling. No samples were collected for analysis as the tank was typically empty and filled for training when required.

Mackay Fire and Rescue station

Mackay Fire and Rescue station is an older style station built prior to 1970. It one of two stations in the Mackay area, with three engine bays housing two fire-fighting, one rescue and one special appliance. The station is crewed by six firefighters in the standard QFES 10/14 shift system. The BA-HazMat complex is co-located on-site and all training activities are conducted off-site. A concrete in-ground water tank (1800 mm diameter x 3400 mm deep, capacity of 8650 L), located inside the engine bay and used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover to prevent water ingress. Water was collected on one occasions from the in-ground tank that was 13.5% full at the time of sampling.

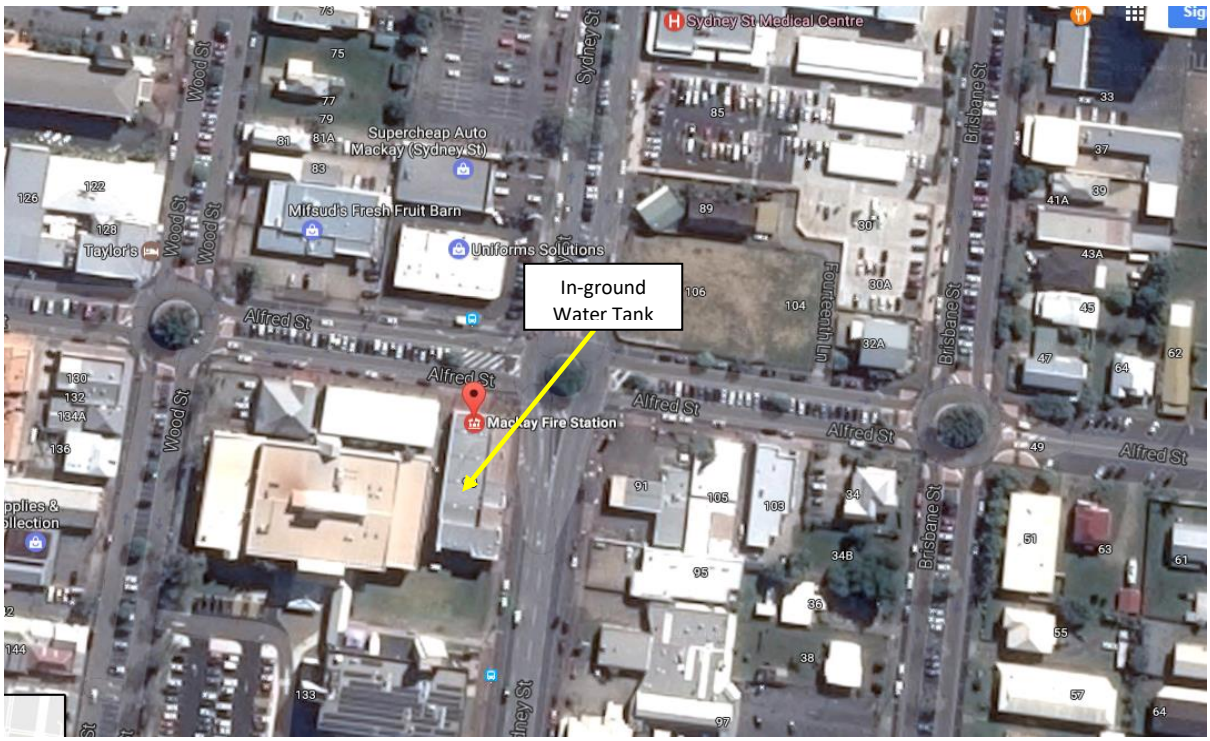


Figure CR 21

Mackay Fire and Rescue station location and surrounding suburban setting.

Mackay Results

Mackay Fire and Rescue station was one of the eight identified in Central Region stations containing sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Mackay stations - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table CR 7 below).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	< LOR	0.18	<LOR	0.76	0.58	4.2
Perfluoropentanoic acid (PFPeA)	0.007	< LOR	0.41	<LOR	0.34	-0.070	0.83
Perfluorohexanoic acid (PFHxA)	0.005	< LOR	1.1	<LOR	2	0.90	1.8
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.28	<LOR	0.17	-0.11	0.61
Perfluorooctanoic acid (PFOA)	0.007	< LOR	0.4	<LOR	0.49	0.090	1.2
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.1	<LOR	0.11	0.010	1.1
Perfluorodecanoic acid (PFDA)	0.01	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	< LOR	0.02	<LOR	0.02	0	1
Perfluorododecanoic acid (PFDoA)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	< LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	0.37	<LOR	0.32	-0.050	0.87
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	3.6	<LOR	2.9	-0.700	0.81
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	6.7	<LOR	5.1	-1.600	0.76
Perfluorodecanesulfonic acid (PFDS)	0.02	< LOR	< LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	< LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	< LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	< LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**13**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	3.9		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	8.2		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.076**			<LOR	**12**		

Table CR 7

Water sample analyses from Mackay Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 7) shows the total PFAS (13.2 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 22).

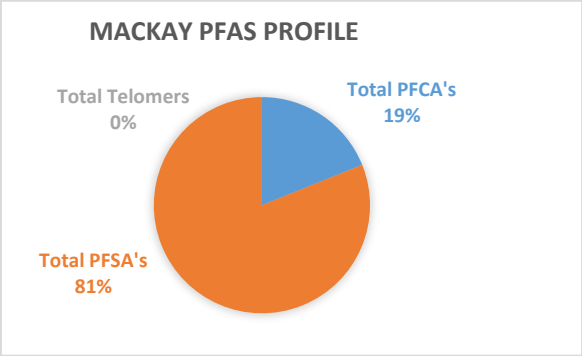


Figure CR 22
PFAS molar profile of the Mackay in-ground tank.

The in-ground tank water analysis shows that PFOA (0.4 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) (10.3 µg/L) was significantly above both drinking and recreational water guidelines, (Figure CR 23).

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (12.1 µg/L) were both significantly above their respective discharge values.

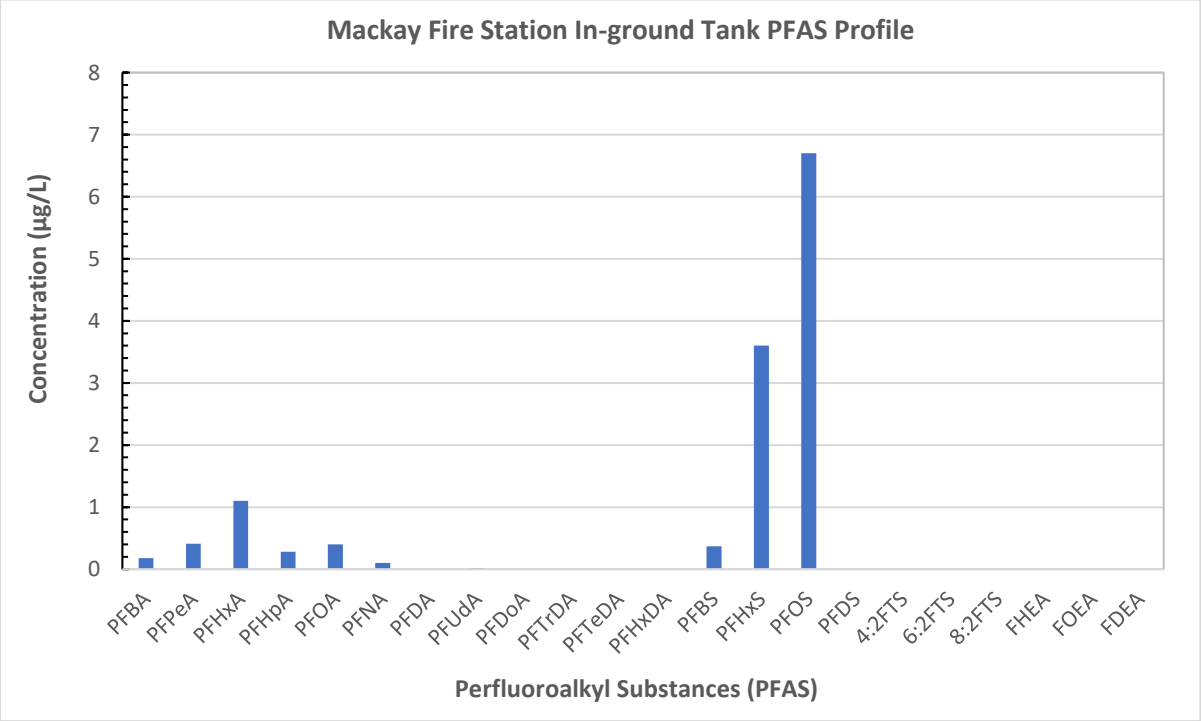


Figure CR 23
Perfluoroalkyl substances (PFAS) profile of water for Mackay Fire and Rescue station in-ground tank.

The Queensland environmental water discharge PFAS trigger homologues, PFOA and ∑(PFOS + PFHxS), were both present in the analyses. The PFOA, ∑(PFOS + PFHxS). and TOPA (12.1 µg/L) are all significantly higher than their trigger values. The TOPA analysis showed the presence of PFAS precursors [PFCA (3.89 µg/L from (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFUdA) and PFSA (8.32 µg/L from (PFHxS, PFOS, PFDS)] that may oxidise or biotransform over time, (Table CR 7, Figure CR 24).

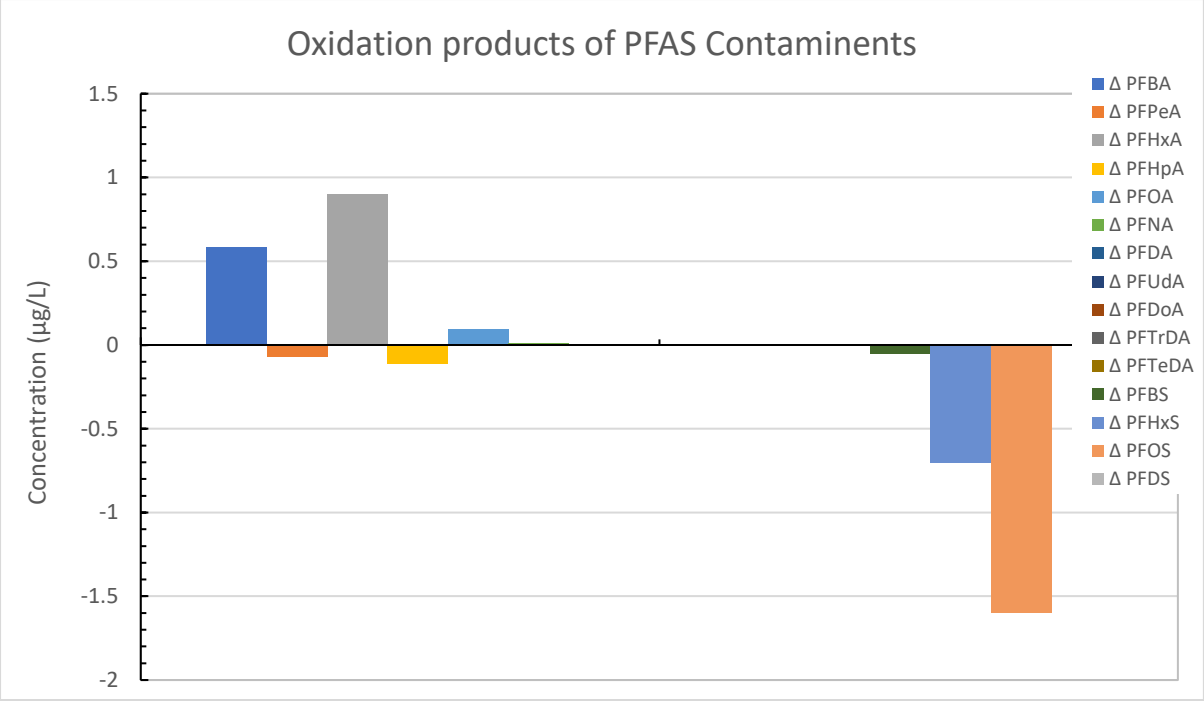


Figure CR 24

TOPA perfluoroalkyl substances (PFAS) profile of the Mackay Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (6.7 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 6.7 x 8650 x 0.1353

= 7843.076 µg (= 0.007843076 g) of PFOS

= 0.007843076 x 100 / 1 (1% PFOS) or = 0.007843076 X 100 / 5 (5% PFOS)

= 0.784 g = 0.157 g

= 784 mg = 157 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Mackay Fire and Rescue station in-ground water tank is between 0.2 to 0.8 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Proserpine Fire and Rescue station

The Proserpine Fire and Rescue station is an older style station built prior to 1970. It has a small engine bay with side attached rooms and houses one fire-fighting appliance. The station is crewed by auxiliary firefighters and was only involved in Phase Two of the QFES water sampling. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1060 mm diameter x 3840 mm deep, capacity of 3390 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover that partially prevents water ingress. Water was collected on one occasion from the in-ground tank that was 10.4% full at the time of sampling.

Figure CR 25

Proserpine Fire and Rescue station location and surrounding suburban setting.

Proserpine Results

Proserpine Fire and Rescue station was one of the eight identified in Central Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Proserpine station - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table CR 8).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.01	<LOR	0.12	0.11	12
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.011	<LOR	< LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.063	<LOR	0.89	0.83	14
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.011	<LOR	< LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.011	<LOR	0.076	0.065	6.9
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.008	<LOR	0.011	0.003	1.4
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	0.02	<LOR	0.03	0.01	1.5
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.021	<LOR	0.032	0.011	1.5
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.49	<LOR	0.59	0.1	1.2
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.41	<LOR	0.46	0.05	1.1
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**1.1**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	1.1		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	1.1		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.066**			**<LOR**	**2.2**		

Table CR 8

Water sample analyses from Proserpine Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 8) shows the total PFAS (1.1 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 26).

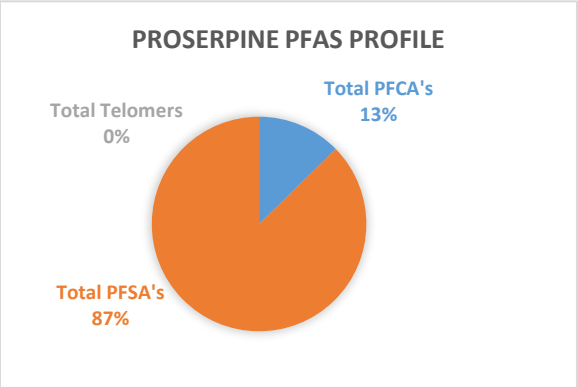


Figure CR 26
PFAS molar profile of the Proserpine in-ground tank.

The in-ground tank water analysis shows that PFOA (0.011 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.90 µg/L) was above both the drinking water and the recreational water guidelines, (Figure CR 27).

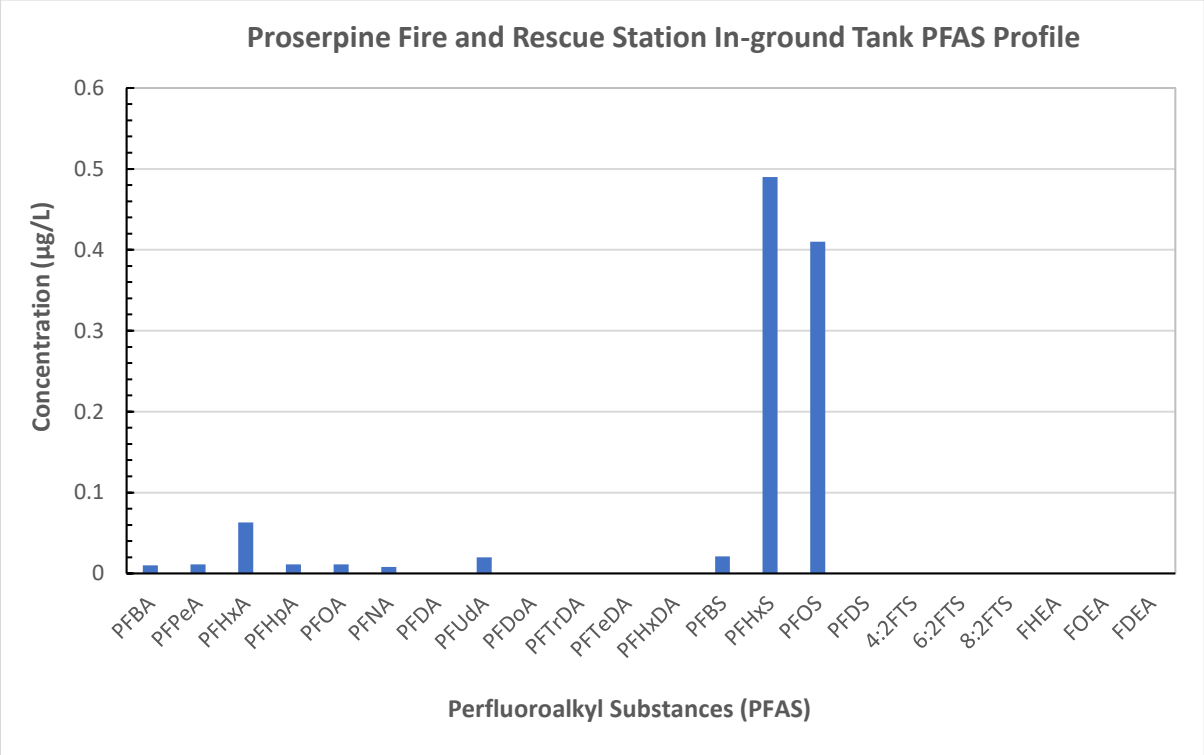


Figure CR 27
Perfluoroalkyl substances (PFAS) in the Proserpine Fire and Rescue station in-ground tank water.

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (2.2 µg/L) were both above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.134 µg/L from (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFUdA) and PFSA (0.921 µg/L from (PFHxS, PFOS, PFBS)] that may oxidise or biotransform over time, (Table CR 8, Figure CR 28).

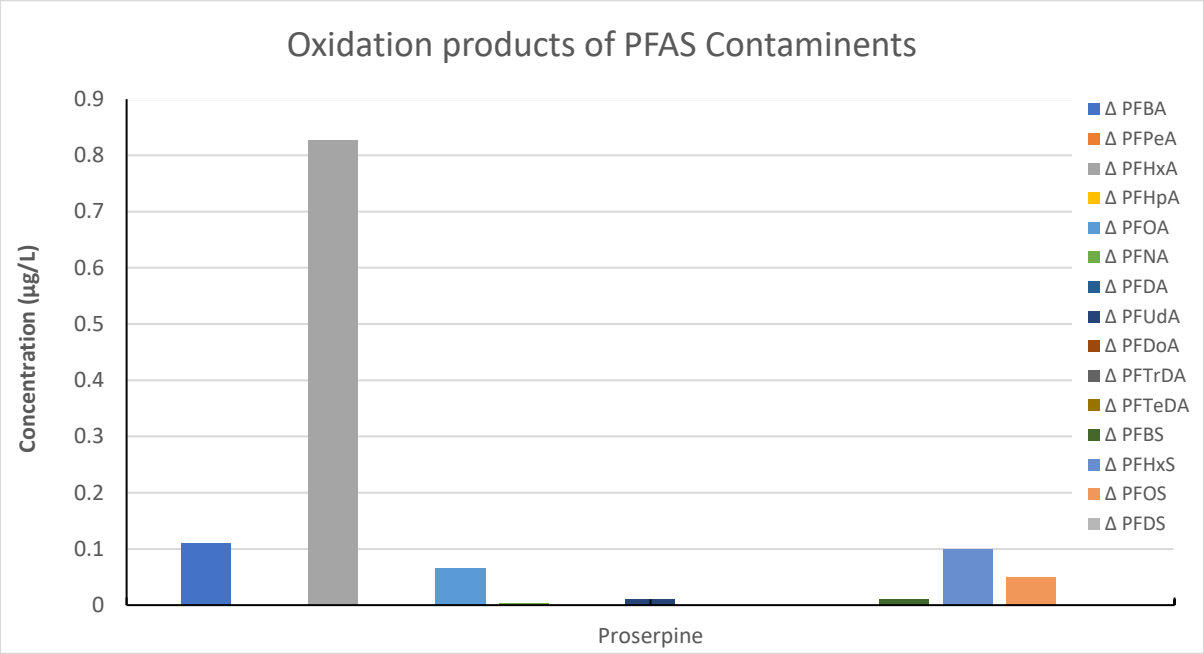


Figure CR 28

TOPA perfluoroalkyl substances (PFAS) profile of the Proserpine Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.41 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.41 x 3390 x 0.1042

= 144.82758 µg (= 0.00014482758 g) of PFOS

= 0.00014482758 x 100 / 1 (1% PFOS) = 0.0145 g = 14.5 mg

or

= 0.00014482758 X 100 / 5 (5% PFOS) = 0.0029 g = 2.9 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Proserpine Fire and Rescue station in-ground water tank is between 0.003 to 0.02 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Airlie Beach Fire and Rescue station

The Airlie Beach Fire and Rescue station is a new style station with two engine bays housing two fire-fighting appliances. The station is crewed by four permanent firefighters operating a standard 10/14 shift. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1600 x 1000 x 1800 mm with a capacity of 2830 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate that does not prevent water ingress. Water was collected on one occasion from the in-ground that was 75% full at the time of sampling.

Figure CR 29

Airlie Beach Fire and Rescue station location and surrounding suburban setting

Airlie Beach Results

Airlie Beach Fire and Rescue station was one of the eight identified in Central Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Airlie Beach station, two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table CR 9).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.01	<LOR	0.02	0.01	2.0
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.008	<LOR	0.014	0.006	1.8
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.006	<LOR	0.006	0	1.0
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.033	<LOR	0.03	-0.003	0.91
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.064	<LOR	0.063	-0.001	0.98
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.12**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.034		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.093		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.03**			**<LOR**	**0.13**		

Table CR 9

Water sample analyses from Airlie Beach Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table CR 9) shows the total PFAS (0.12 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure CR 30).

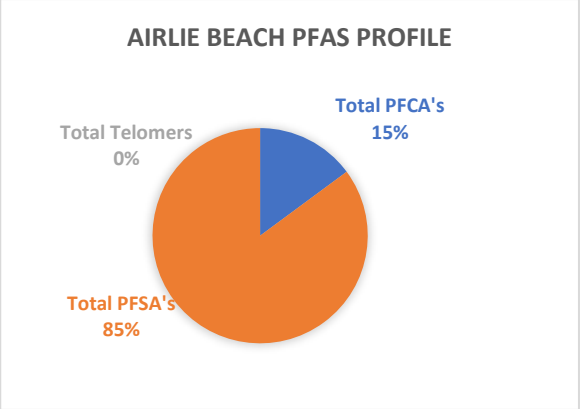


Figure CR 30

PFAS molar profile of the Airlie Beach in-ground tank.

The in-ground tank water analysis shows that PFOA (<LOR µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.097 µg/L) was below the recreational water guideline, but above both drinking water guideline, (Figure CR 31).

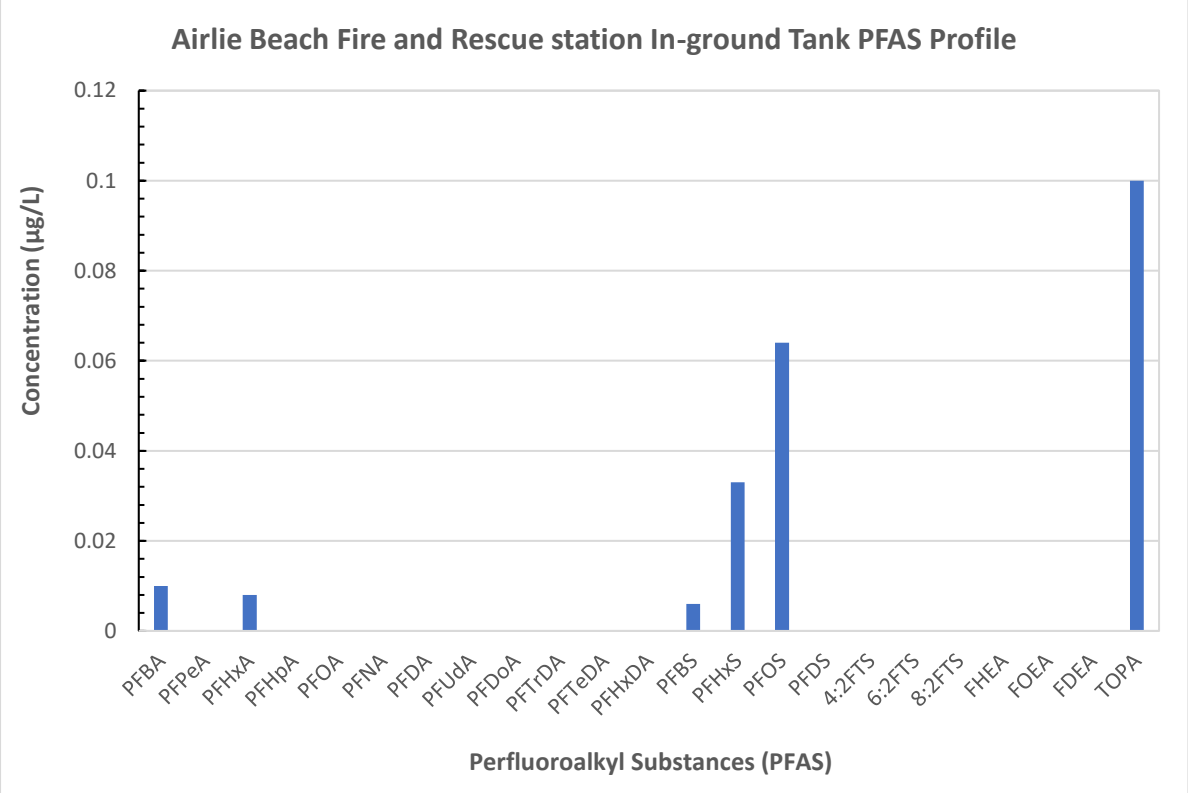


Figure CR 31

Perfluoroalkyl substances (PFAS) in the Airlie Beach Fire and Rescue station in-ground tank water.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.1 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.018 µg/L from (PFBA, PFHxA) and PFSA (0.103 µg/L from (PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table CR 9, Figure

CR 32). However, the very low PFAS concentrations together with the TOPA analysis show that negligible oxidation or biotransformation should occur over time.

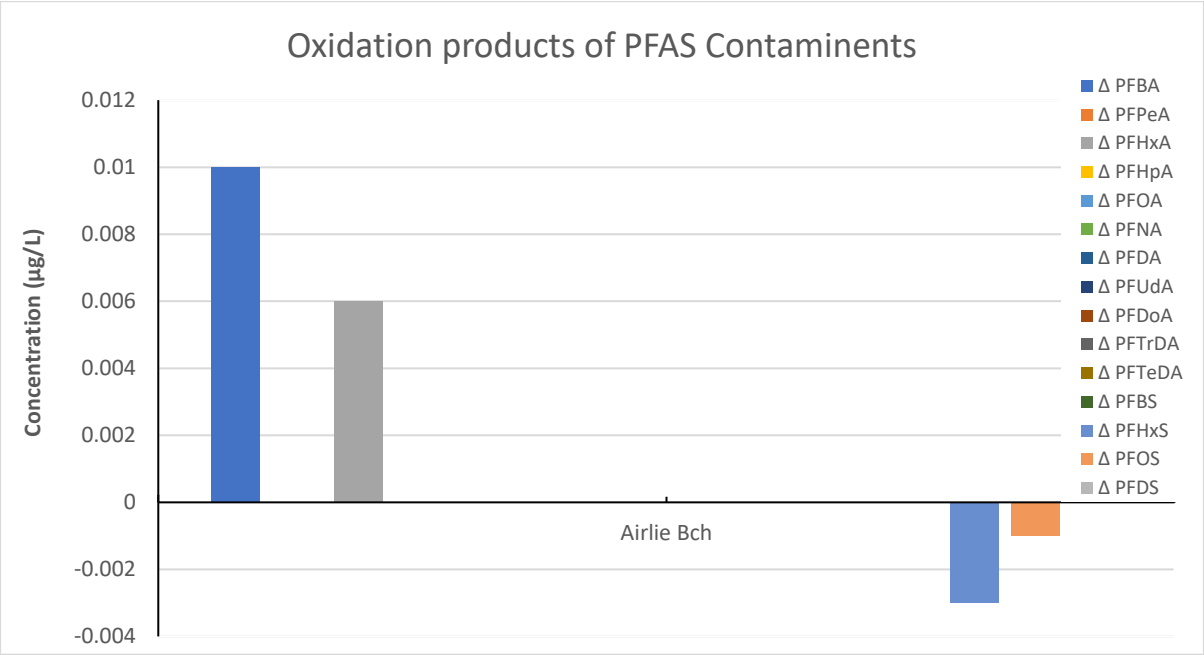


Figure CR 32

TOPA perfluoroalkyl substances (PFAS) profile of the Airlie Beach Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.064 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.064 x 2830 x 0.75
= 135.84 µg (= 0.000135.84 g) of PFOS

= 0.000135.84 x 100 / 1 (1% PFOS)	or	= 0.00013584 x 100 / 5 (5% PFOS)
= 0.0136 g		= 0.00272 g
= 13.6 mg		= 2.7 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Airlie Beach Fire and Rescue station in-ground water tank is between 0.003 to 0.02 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Summary of Central Region Results

Phase One

Rockhampton and Yeppoon were the Central Region Fire and Rescue Fire and Rescue stations selected for Phase One investigations. Water samples were collected from Rockhampton in-ground tank 1. The Rockhampton Fire and Rescue station in-ground tank 1 water results showed low levels of PFAS contamination below the interim Australian health-based drinking and recreational water guidelines. Subsequent application of the current Australian health-based criteria results in the ∑(PFOS + PFHxS) (0.20 µg/L) exceeding the drinking water guideline. The biological results (< 1 CFU/100mL of water for *E. coli*, and 2500 CFU/100mL for total coliforms show the water equivalent to A+ recycled water for *E. coli*.

The soil analyses showed detectable levels of PFAS at Rockhampton [station, (PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) 0.018 mg/kg); nature strip [(PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) 0.008 mg/kg)] and Yeppoon [station PFOA (<LOR), ∑(PFOS + PFHxS) (2.312 mg/kg); nature strip [(PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) 0.008 mg/kg)]. All CR soil results were below the DES land contamination levels and the NEMP health-based criteria for industrial/commercial land.

Phase Two

The Central Region (CR) water analyses showed detectable levels of PFAS contamination at all Fire and Rescue station in-ground tanks (Gladstone, Rockhampton (in-ground tank 2), Dysart, Sarina, Mackay, Proserpine and Airlie Beach). The total PFAS concentration at Gladstone (61 µg/L), Rockhampton tank 1 (0.30 µg/L) and tank 2 (0.24 µg/L), Sarina (0.025 µg/L), Mackay (13 µg/L), Dysart (0.11 µg/L), Proserpine (1.1 µg/L), and Airlie Beach (0.12 µg/L)] show low contamination levels except for Gladstone and Mackay, (Table CR 10, Figure CR 33).

The PFAS profiles of all stations, except Gladstone, show the presence of two PFAA moieties [PFCA and PFSA (major component)]. Gladstone is the only station to also contain the PFT moiety, (Figure FNR 11 and Figure FNR 12).

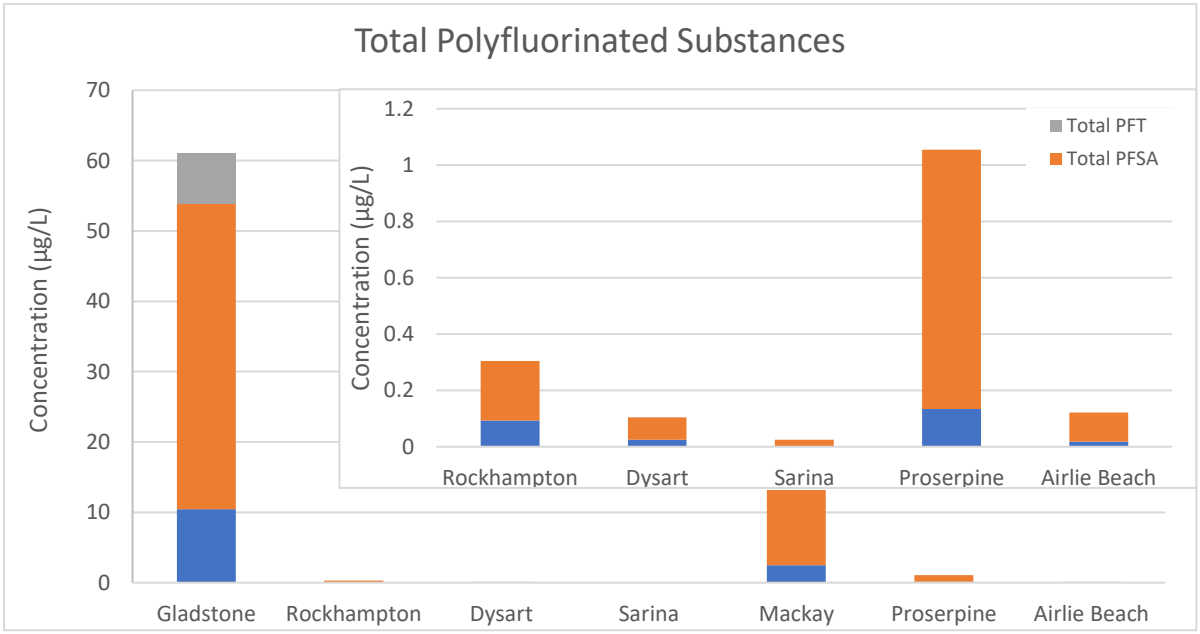


Figure CR 33

Total (PFAS) contamination of in-ground tank water in Central Region Fire and Rescue stations.

The Central Region analyses show a narrow concentration range for PFOA (<LOR – 1.4 µg/L), but wide concentrations ranges for both PFOS + PFHxS (0.025 – 42 µg/L) and TOPA (<LOR – 78 µg/L). No station in-ground tank water, except Gladstone (1.4 µg/L), exceeded the Australian Health-based drinking and recreational water guidelines for PFOA. Conversely, all stations except Sarina (0.025 µg/L) exceeded the Australian Health-based drinking water guideline for PFOS + PFHxS. Three stations, Gladstone (42 µg/L), Mackay (10 µg/L), and Proserpine (1.1 µg/L) also exceeded the recreational water guideline for PFOS + PFHxS. The results show three station in-ground tanks, Gladstone (78 µg/L), Mackay (12 µg/L) and Proserpine (2.2 µg/L) exceeded the DES water discharge guidelines for TOPA ∑(PFOS + PFHxS). Gladstone was the only station to exceed the DES water discharge guideline for PFOA.

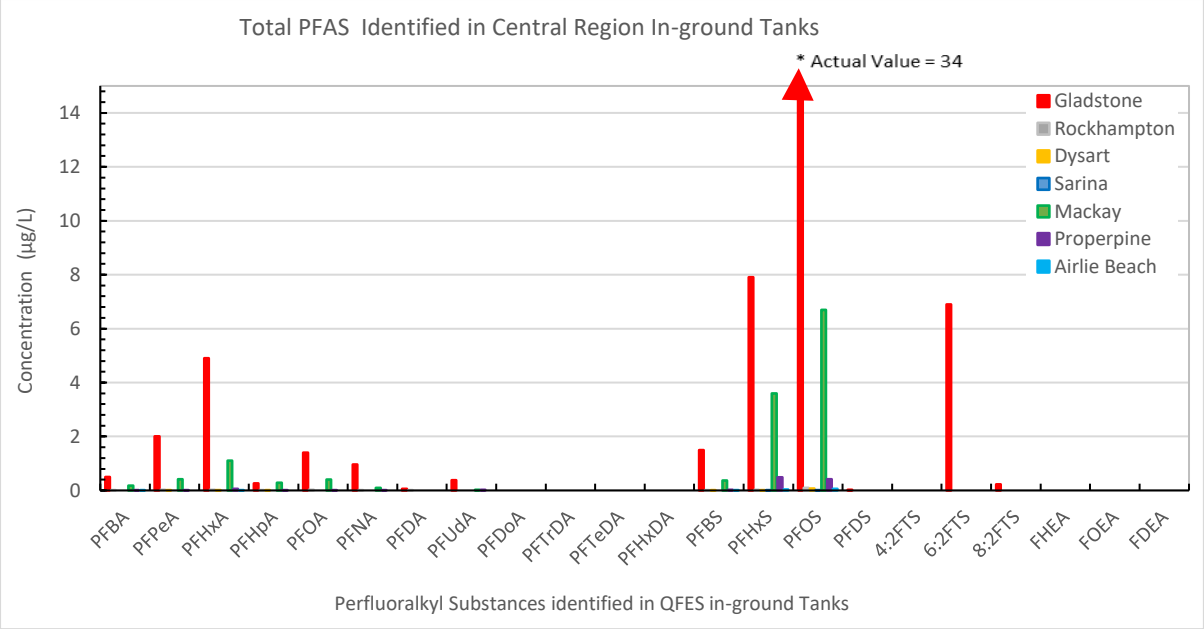


Figure CR 34

PFAS contamination profile of Central Region Fire and Rescue station in-ground tank waters.

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103] These chagess can be further enhanced by the differences (delta Δ values) in concentration between the TOPA PFAS and initial PFAS concentrations, (Table CR 10, Figure CR 33).

The Central Region delta results showed the presence of three PFAA moieties (PFCA, PFSA, PFT), with increases in eight PFCA homologues [Perfluorobutanoic acid (PFBA), Perfluoropentanoic acid (PFPeA), Perfluorohexanoic acid (PFHxA), Perfluoroheptanoic acid (PFHpA), Perfluorooctanoic acid (PFOA), Perfluorononanoic acid (PFNA), Perfluorodecanoic acid (PFDA), Perfluoroundecanoic acid (PFUdA)] and two PFSA homologues [Perfluorohexanesulfonic acid (PFHxS), Perfluorodecanesulfonic acid (PFDS)].

The Gladstone in-ground tank was the only to contain all three moieties and showed the highest level of PFAS speciation with eight PFCA homologues (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA,

PFUdA) and four PFSA homologues (PFBS, PFHxS, PFOS, PFDS), and two PFT homologues (6:2 FTS, 8:2 FTS). It also showed the greatest increases in PFAA delta values from seven PFCA (PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFDA, PFUdA) and two PFSA (PFHxS, PFDS) values. PFOS, has remained unchanged. However, only three of these PFAA homologues with (PFBA, PFHxA, PFOA), showed significant changes across all stations. All stations except Sarina, show the presence of the PFCA and PFSA moieties. Sarina only contained the two PFSA homologues (PFHxS, PFOS).

PFHxA was the only homologue to show any significant change across all stations, while PFBA showed increases in all stations, except Dysart and Sarina, and PFOA showed increases in all stations, except Sarina and Airlie Beach. The results show that although Gladstone has the greatest concentration of foam present, the greatest amount of potential future oxidation was at Proserpine station. The three major PFCA compounds (PFBA, PFHxA, PFOA) are consistent with the biotransformation of PFAS foam products, (Table CR 3 and Figure CR 33).

All other station tanks contained the PFAA moieties (PFCA and PFSA), but with slightly different speciation of homologues. Rockhampton tank 1 [(PFBA, PFPeA, PFHxA, PFOA) + (PFBS, PFHxS, PFOS)] and tank 2 [(PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA) + (PFBS, PFHxS, PFOS)] were similar to Mackay and Proserpine which had the same profiles [(PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFUdA) + (PFBS, PFHxS, PFOS)]. The Dysart in-ground tank contained [(PFPeA, PFHxA, PFHpA) + PFSA (PFBS, PFHxS, PFOS)] and the Airlie Beach contained [(PFBA, PFHxA) + (PFBS, PFHxS, PFOS)].

These results show all Central Region stations except Gladstone have only used the PFOS base foams used by QFES prior to 2003. Gladstone results show that newer type foams, typical of those used in fire extinguisher solutions, have been used at the site.

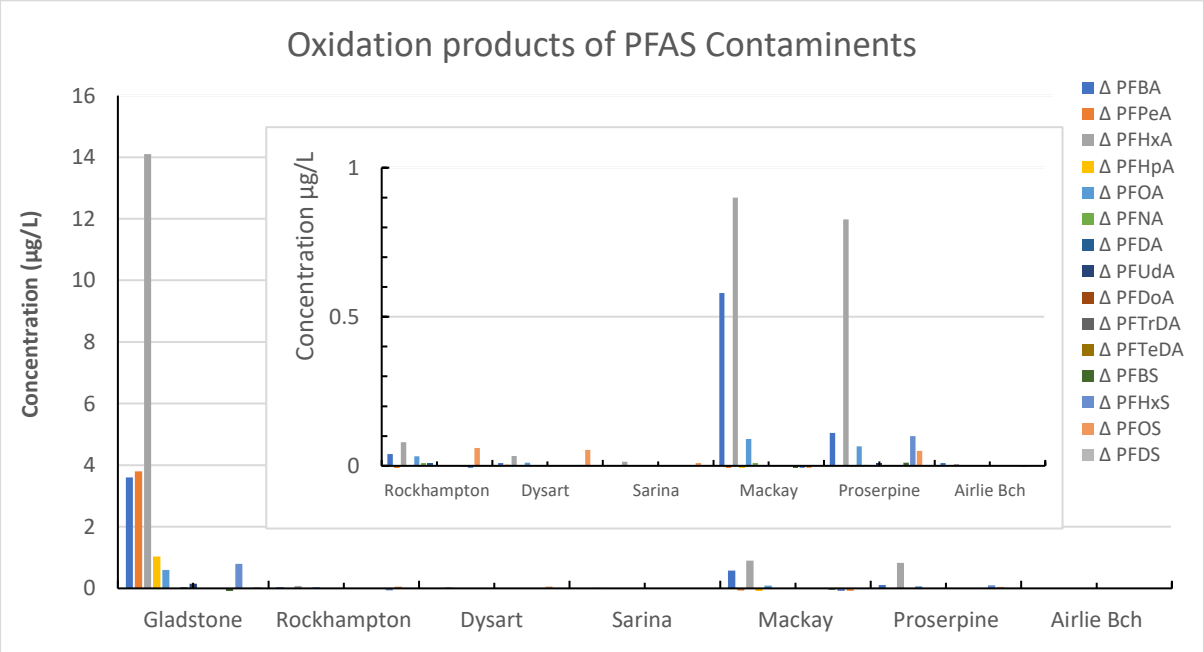


Figure CR 35

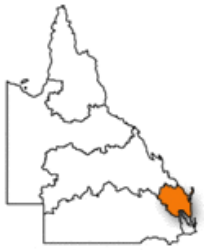
Effects of accelerated oxidation on PFAS compounds. Delta (Δ) changes reflect the actual concentration difference of starting from oxidised PFAS contaminates.

PFAS Compounds	LOR	Gladstone			Rockhampton				Sarina			Dysart			Mackay			Proserpine			Airlie Beach		
		PFAS	TOPA	Delta	PFAS T 1	PFAS T 2	TOPA T 2	Delta T 2	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta
	µg/L	µg/L			µg/L				µg/L			µg/L			µg/L			µg/L			µg/L		
Perfluorobutanoic acid (PFBA)	0.01	0.50	4.1	3.6	0.02	0.01	0.05	0.04	<LOR	<LOR	<LOR	<LOR	0.01	0.01	0.18	0.76	0.58	0.01	0.12	0.11	0.01	0.02	0.01
Perfluoropentanoic acid (PFPeA)	0.007	2.0	5.8	3.8	0.01	0.02	0.02	-0.01	<LOR	<LOR	<LOR	0.01	0.02	0.00	0.41	0.34	-0.07	0.01	<LOR	-0.01	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	4.9	19	14	0.03	0.02	0.10	0.08	<LOR	0.01	1.0	0.01	0.04	0.03	1.1	2.00	0.90	0.06	0.89	0.83	0.01	0.01	0.01
Perfluoroheptanoic acid (PFHpA)	0.005	0.26	1.3	1.04	<LOR	0.01	0.01	0.00	<LOR	<LOR	<LOR	0.01	0.01	0.00	0.28	0.17	-0.11	0.01	<LOR	-0.01	<LOR	<LOR	<LOR
Perfluorooctanoic acid (PFOA)	0.007	1.4	2.0	0.60	0.04	0.02	0.05	0.03	<LOR	<LOR	<LOR	<LOR	0.01	0.01	0.40	0.49	0.09	0.01	0.08	0.08	<LOR	<LOR	<LOR
Perfluorononanoic acid (PFNA)	0.007	0.96	0.94	-0.02	<LOR	0.01	0.02	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	0.10	0.11	0.01	0.01	0.01	0.01	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	0.06	0.10	0.04	<LOR	0.01	0.02	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	0.38	0.53	0.15	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	0.02	0.02	0.00	0.02	0.03	0.03	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR		-0.20	<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorobutanesulfonic acid (PFBS)	0.005	1.5	1.3	0.80	0.01	0.01	0.01	0.0	<LOR	<LOR	<LOR	0.01	0.01	0.0	0.37	0.32	-0.05	0.02	0.03	0.01	0.01	0.01	0.0
Perfluorohexanesulfonic acid (PFHxS)	0.005	7.9	8.7	0.00	0.09	0.02	0.03	0.0	0.01	0.01	0.0	0.01	0.01	0.0	3.6	2.9	-0.70	0.49	0.59	0.10	0.03	0.03	0.0
Perfluorooctanesulfonic acid (PFOS)	0.005	34	34	0.04	0.11	0.10	0.17	0.07	0.02	0.03	0.01	0.07	0.12	0.05	6.7	5.1	-1.6	0.41	0.46	0.05	0.06	0.06	0.0
Perfluorodecanesulfonic acid (PFDS)	0.02	0.02	0.06	-0.20	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR		23	<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	6.9		0.0	<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	0.23		23	<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR				<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR			<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR			<LOR	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Total PFAS		**61**			**0.30**	**0.24**			**0.03**			**0.11**			**13**			**1.1**			**0.12**		
Total TOPA (incl C_4-C_{10} Sulfonic acids)	0.13		**78**				**0.50**			**<LOR**			**<LOR**			**12**			**2.2**			**<LOR**	

Table CR 10

Total PFAS contaminant assay of water in Central Region in-ground water tanks. All station town water samples tested less than level of reporting (<LOR).

Investigation of Potential PFAS and Microbiological Contamination of QFES North Coast Region Fire and Rescue Stations with In-ground Water Tanks



The Queensland Fire and Emergency Services (QFES) North Coast Region covers the coastal areas of Bundaberg, Hervey Bay and the Sunshine Coast and inland to the North and South Burnett. Hervey Bay and the Sunshine Coast are among the fastest growing urban areas in Australia and attract significant numbers of tourists throughout the year. The Region is divided into two Zones, Wide-Bay Burnett and Sunshine Coast.

Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. This capability is provided by a mix of 46 Urban Fire and Rescue stations located throughout the Region. The region is staffed by 700 full time employees.

QFES Emergency Management supports the Local Government areas within the region. The QFES Emergency Management NCR team has a total of five staff who work closely with all local governments to meet the Queensland Disaster Management legislative arrangements.

Rural Fire Service (RFS) regional operations is co-located with the F&R Region, but led by the RFS Assistant Commissioner. RFS North Coast operates with 280 brigades, and is staffed by approximately 6300 personnel, including regional QFES personnel, Volunteer Firefighters, and Volunteer Community Educators.

State Emergency Service (SES) regional operations is co-located with the F&R Region but led by the SES Assistant Commissioner. SES NCR operates with 48 groups, and is staffed by approximately 1,000 personnel, including regional QFES personnel and volunteers.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, of perfluoroalkyl substances (PFAS) contamination at QFES FNR stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected

and analysed for PFAS contamination. No North Coast Region station was investigated in Phase One testing. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
  - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
  - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS contamination. Water samples were collected from four stations. The following criteria were adopted and used for Phase Two of the study:

- The Australian health-based water quality guidelines for
  - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
  - ∑PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all North Coast Region Fire and Rescue stations that contained in-ground water tanks. No stations were involved in Phase One investigations. Four stations (Bundaberg, Maryborough, Noosa Heads and Caloundra) were identified for Phase Two of these tests. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

No North Coast Region stations were used for Phase One tests.

Phase Two investigations

The Bundaberg in-ground tank water was clear and clean looking with no obvious foaming. Six water samples were collected, two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank, for PFAS and TOPA analyses.

The Maryborough and Noosa Heads in-ground tanks waters were clear and clean looking with no obvious foaming. Five water samples were collected from each, two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

The Caloundra in-ground tank water was clear and clean looking with no obvious foaming. Seven water samples were collected four in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

Bundaberg Fire and Rescue station

Bundaberg Fire and Rescue station is an old-style station with three engine bays housing two F & R fire-fighting and appliances, and other bays housing RFS equipment. The station is crewed by permanent firefighters in the standard QFES 10/14 shift system. The area office, RFS office are all co-located on-site. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A concrete in-ground water tank (1200 x 1300 mm and 7400 mm deep), capacity of 11540 L) adjacent to the tower is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate cover to prevent water ingress. Water was collected on one occasions from the in-ground tank that was 98.4% full at the time of sampling.

Figure NCR 1

Bundaberg Fire and Rescue station location and surrounding suburban setting.

Bundaberg Results

Bundaberg Fire and Rescue station was one of the four identified in North Coast Region containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

Bundaberg station was not involved in Phase One testing.

Phase Two investigation

Six water samples were collected from the Bundaberg in-ground tank - two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses and a travel blank. The results are shown in Table NCR 3 below.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.06	<LOR	0.11	0.050	1.8
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.18	<LOR	0.2	0.020	1.1
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.12	<LOR	0.23	0.11	1.9
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.063	<LOR	0.071	0.008	1.1
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.025	<LOR	0.042	0.017	1.7
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.049	<LOR	0.054	0.005	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.13	<LOR	0.13	0	1.0
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.01				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.64**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.7		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.19		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.89**		

Table NCR 1

Water sample analyses from Bundaberg Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NCR 1) shows the total PFAS (0.64 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFCA (carboxylic acid) moiety is the highest contribution of the PFAS contamination. The PFSA (sulfonate) and PFT (telomer) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure NCR 2).

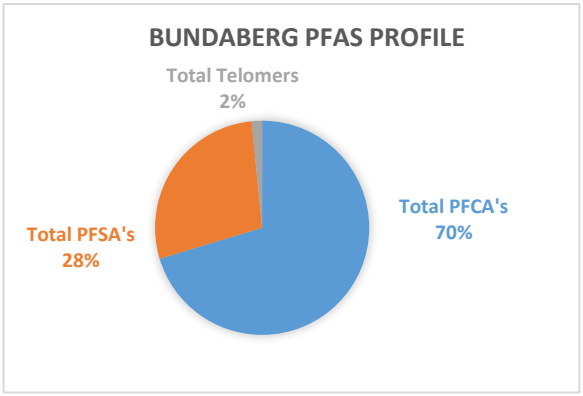


Figure NCR 2

PFAS molar profile of the Bundaberg in-ground tank.

The in-ground tank water analysis shows that PFOA (0.025 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.18 µg/L) was below the recreational water guidelines, but above the drinking water guideline, (Figure NCR 3).

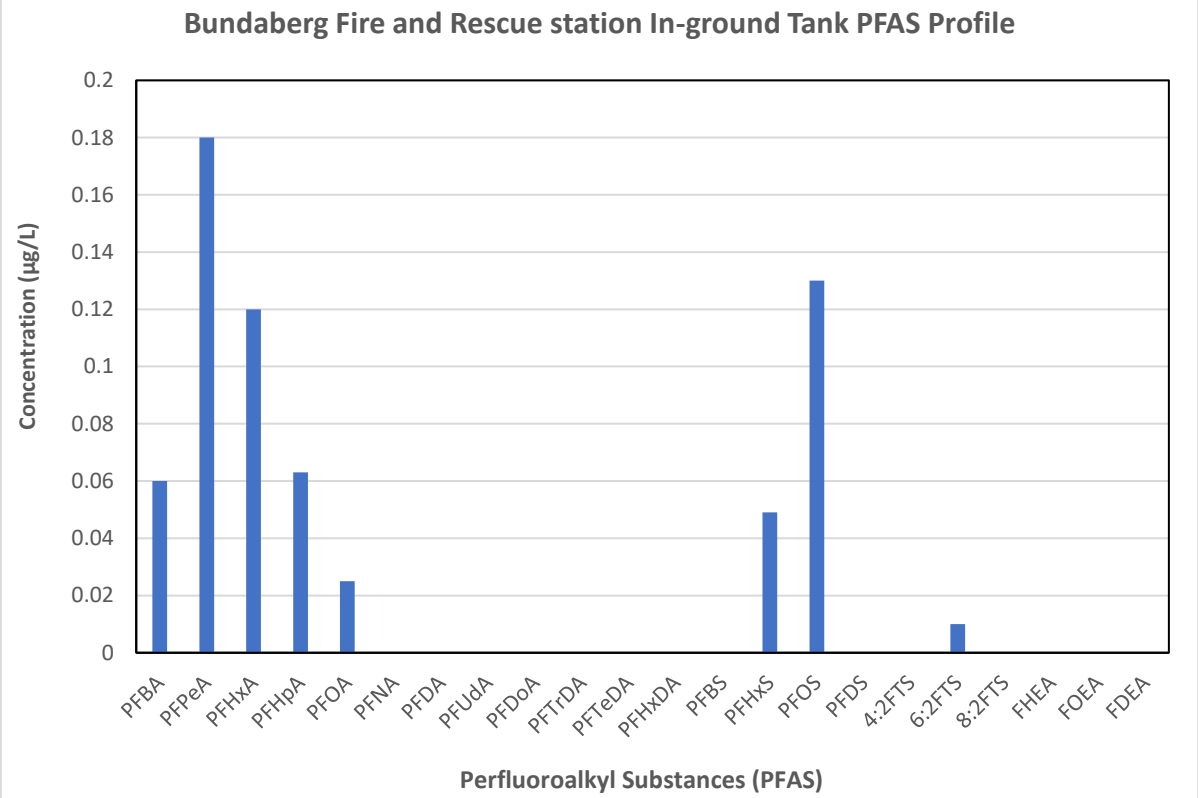


Figure NCR 3

Perfluoroalkyl substances profile of the Bundaberg Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.89 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.45 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA), PFSA (0.18 µg/L from PFHxS, PFOS) and PFT (0.01 µg/L from 6:2 FTS)] that may oxidise or biotransform over time, (Table NCR 1, Figure NCR 4).

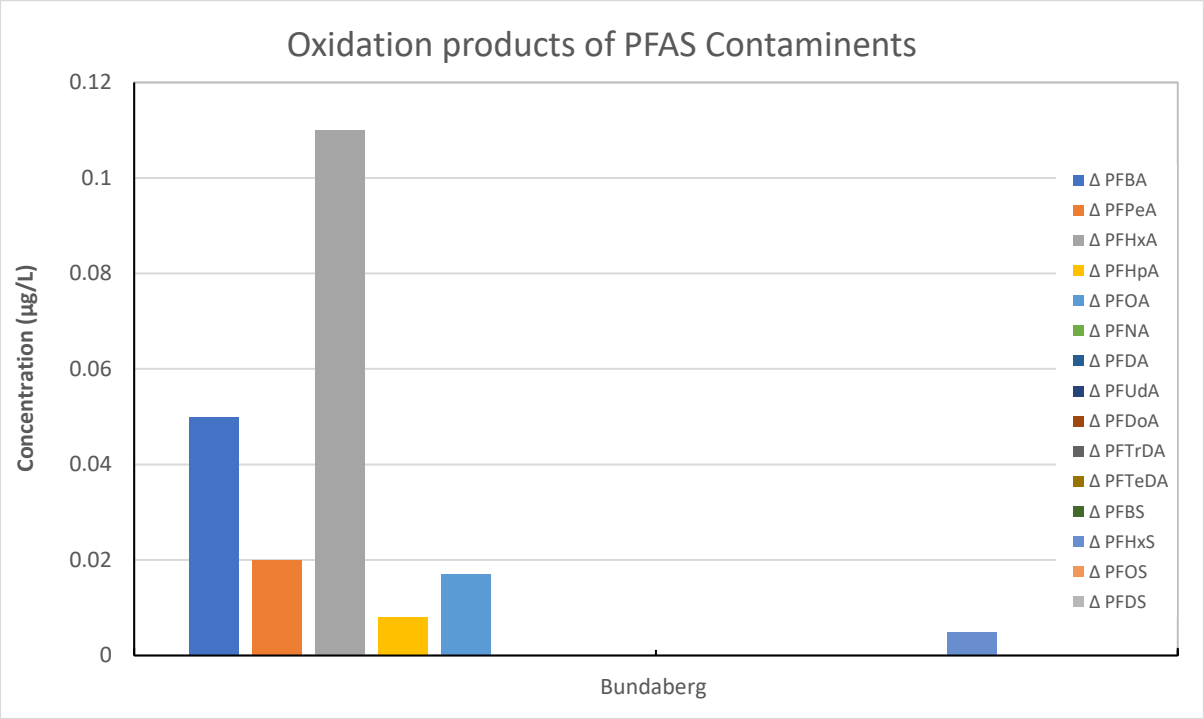


Figure NCR 4

TOPA perfluoroalkyl substances (PFAS) profile of the Bundaberg Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.13 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.13 x 11540 x 0.98

= 1470.706 µg (= 0.001470706 g) of PFOS

= 0.001470706 x 100 / 1 (1% PFOS) or = 0.001470706 x 100 / 5 (5% PFOS)

= 0.147 g = 0.0294 g

= 147 mg = 29.4 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Bundaberg Fire and Rescue station in-ground water tank is between 0.03 to 0.2 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Maryborough Fire and Rescue station

Maryborough Fire and Rescue station is an older style station with two engine bays housing one fire-fighting and appliance, and rear shed housing a special appliance. The station is crewed by four in the standard QFES 10/14 shift system. The regional and area office, BA-HazMat complex, training and emergency management centre are all co-located on-site. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A concrete in-ground water (1200 mm diameter and 5100 mm deep, capacity of 5800 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 100% full at the time of sampling.

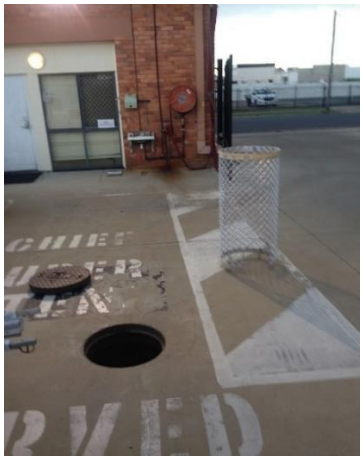


Figure NCR 5

Maryborough Fire and Rescue station location and surrounding suburban setting.

Maryborough Results

Maryborough Fire and Rescue station was one of the four identified in North Coast Region containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One testing.

Phase Two investigation

Five water samples were collected from the Maryborough in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table NCR 2).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	0.03	0.03	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.014	<LOR	0.026	0.012	1.9
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.023	<LOR	0.1	0.077	4.4
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.01	<LOR	0.017	0.007	1.7
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.019	<LOR	0.033	0.004	0.014
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.031	<LOR	0.039	0.008	1.3
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.06	<LOR	0.072	0.012	1.2
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.16**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.21		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.11		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.31**		

Table NCR 2

Water sample analyses from Maryborough Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NCR 2) shows the total PFAS (0.016 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NCR 6).

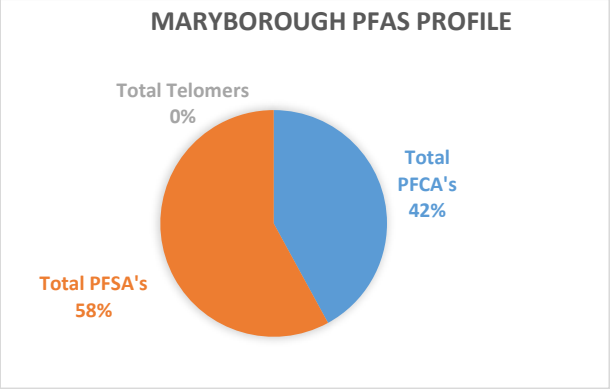


Figure NCR 6

PFAS molar profile of the Maryborough in-ground tank.

The in-ground tank water analysis shows that PFOA (0.019 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.091 µg/L) was below the recreational water guideline and above the drinking water guideline, (Figure NCR 7).

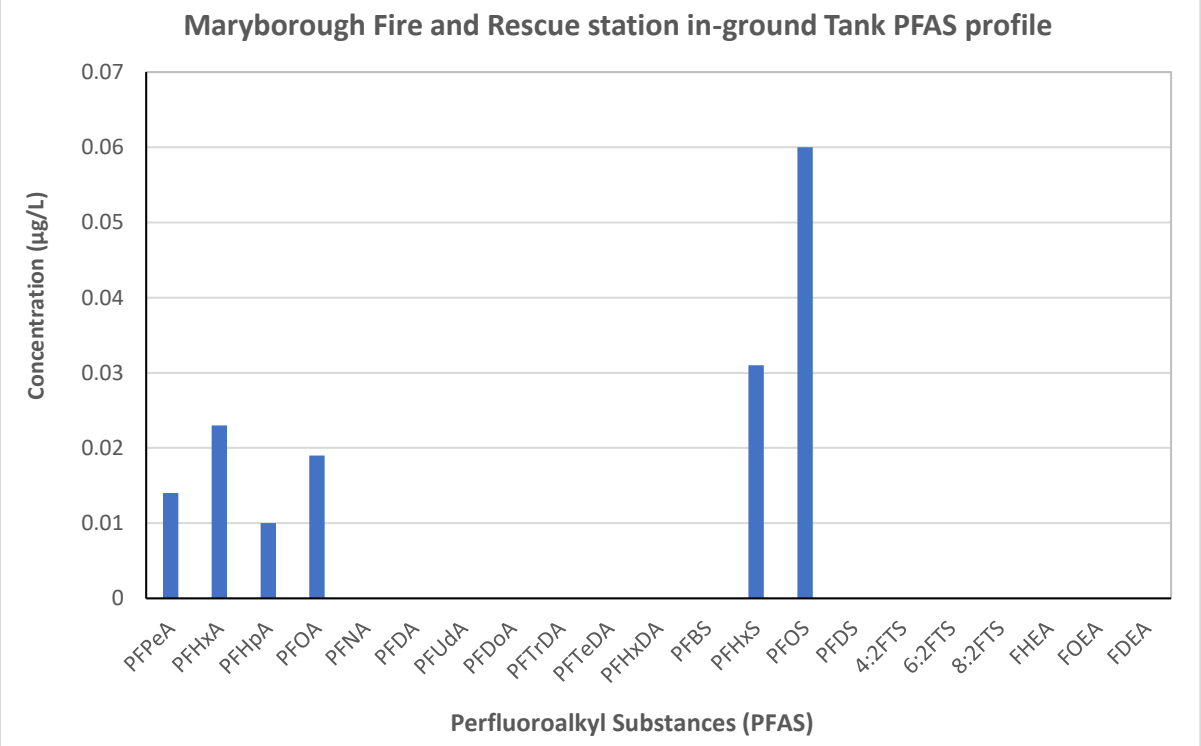


Figure NCR 7

Perfluoroalkyl substances (PFAS) profile of the Maryborough Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.31 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.066 µg/L from PFPeA, PFHxA, PFHpA, PFOA) and PFSA (0.091 µg/L from PFHxS, PFOS)] that may oxidise or biotransform over time, (Table NCR 2, Figure NCR 8).

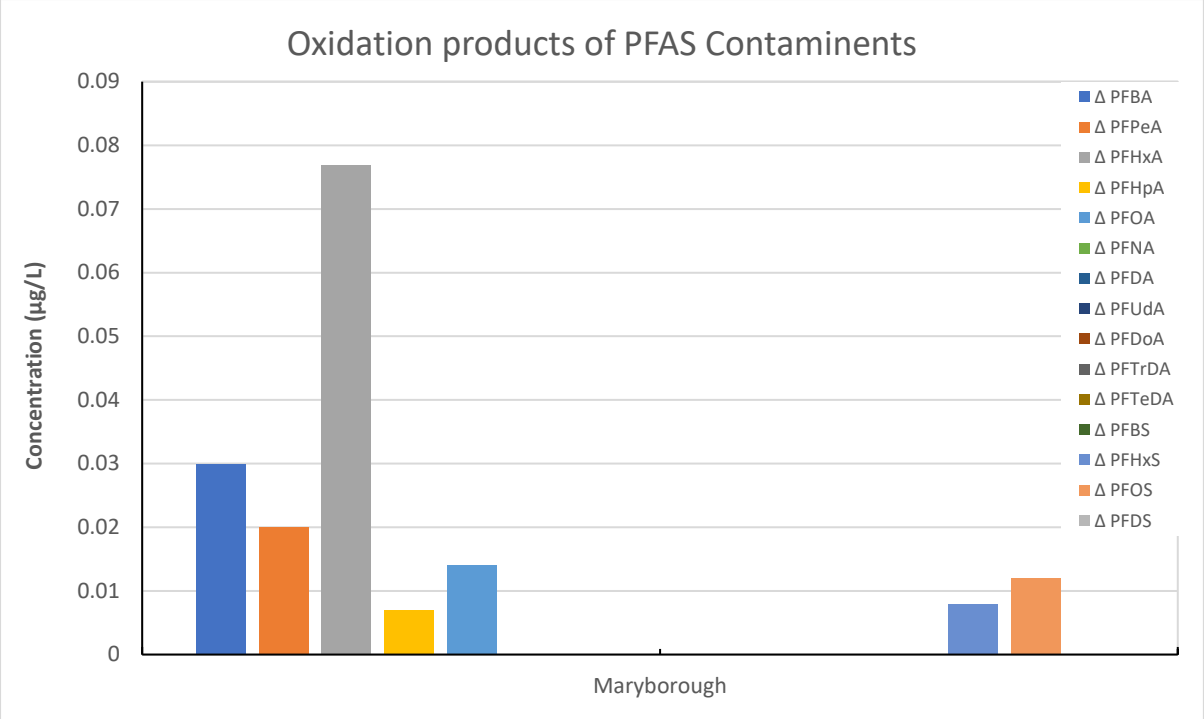


Figure NCR 8

TOPA perfluoroalkyl substances (PFAS) profile of the Maryborough Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.06 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.06 x 5800 x 1.00

= 348 µg (= 0.000348 g) of PFOS

= 0.000348 x 100 / 1 (1% PFOS) = 0.0348 g = 34.8 mg

or

= 0.000348 X 100 / 5 (5% PFOS) = 0.00696 g = 7.0 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Maryborough Fire and Rescue station in-ground water tank is between 0.007 to 0.04 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Noosa Heads Fire and Rescue station

Noosa Heads Fire and Rescue station is a new style station with two engine bays housing one fire-fighting and appliance. The station is crewed by four permanent firefighters in the standard QFES 10/14 shift system. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1050 mm diameter and 4900 mm deep, capacity of 4240 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 100% full at the time of sampling.

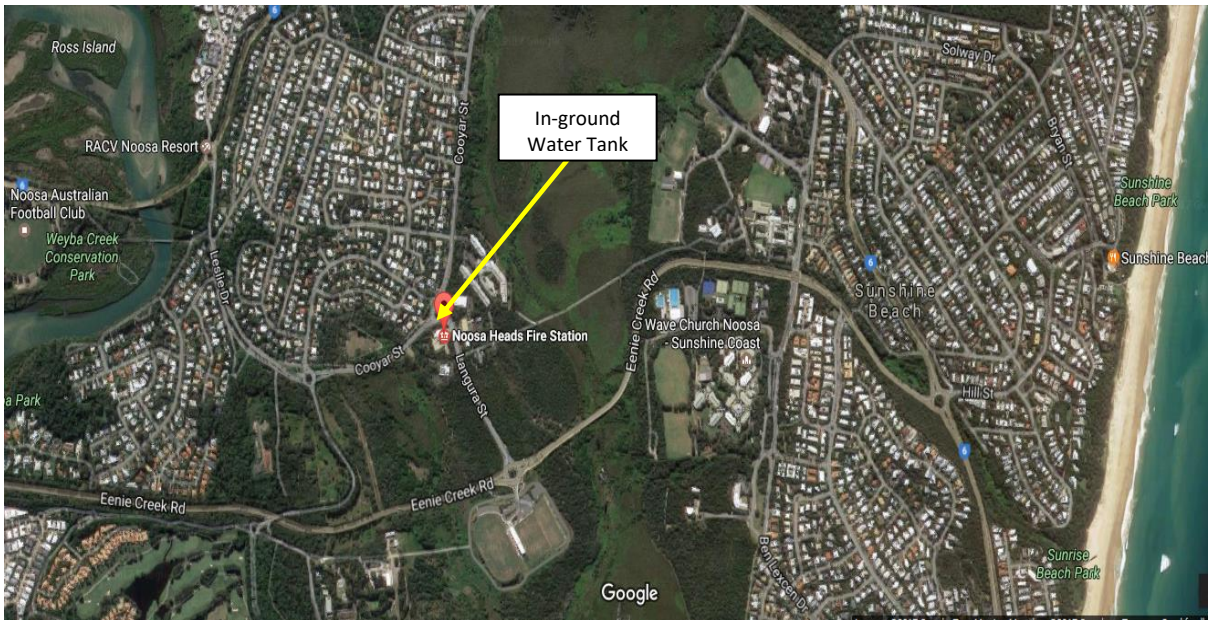


Figure NCR 9

Noosa Heads Fire and Rescue station location and surrounding suburban setting.

Noosa Heads Results

Noosa Heads Fire and Rescue station was one of the four identified in North Coast Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Noosa Heads in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses. The results are shown in Table NCR 3 below.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	0.04	0.04	0
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.018	<LOR	0.16	0.14	8.9
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.005	<LOR	0.006	0.001	1.2
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.011	<LOR	0.03	0.019	2.7
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	0.007	0.007	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.034	<LOR	0.049	0.015	1.4
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.23	<LOR	0.25	0.020	1.1
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.30**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.2		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.3		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.5**		

Table NCR 3

Water sample analyses from Noosa Heads Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NCR 3) shows the total PFAS (0.030 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NCR 10).

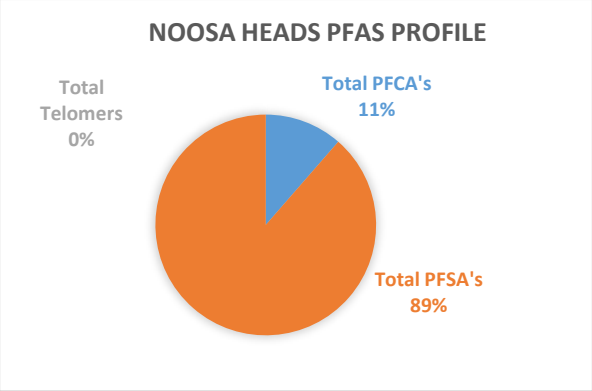


Figure NCR 10
PFAS molar profile of the Noosa Heads in-ground tank.

The in-ground tank water analysis shows that PFOA (0.011 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.26 µg/L) was below the recreational water guideline and above the drinking water guideline, (Figure NCR 11).

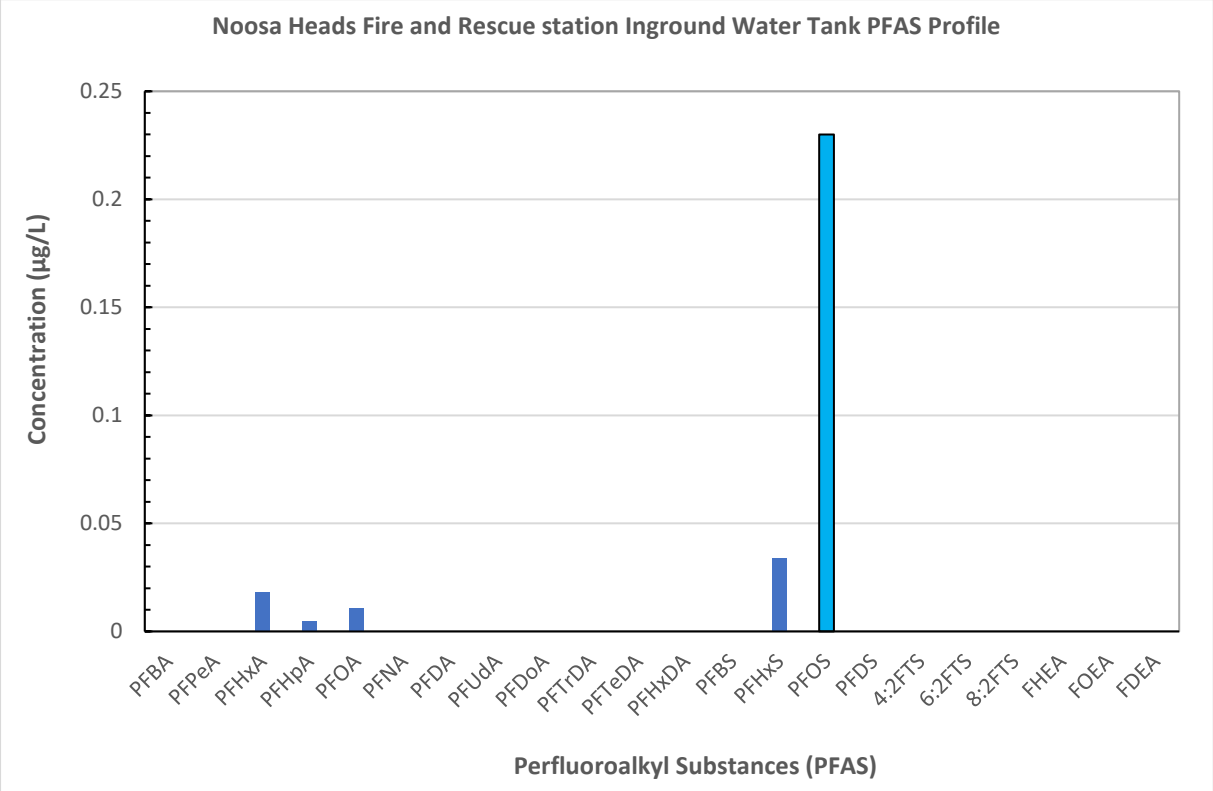


Figure NCR 11
Perfluoroalkyl substances (PFAS) profile of the Noosa Heads Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (5 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.034 µg/L from (PFHxA, PFHpA, PFOA) and PFSA (0.26 µg/L from (PFHxS, PFOS)] that may oxidise or biotransform over time, (Table NCR 3, Figure NCR 12).

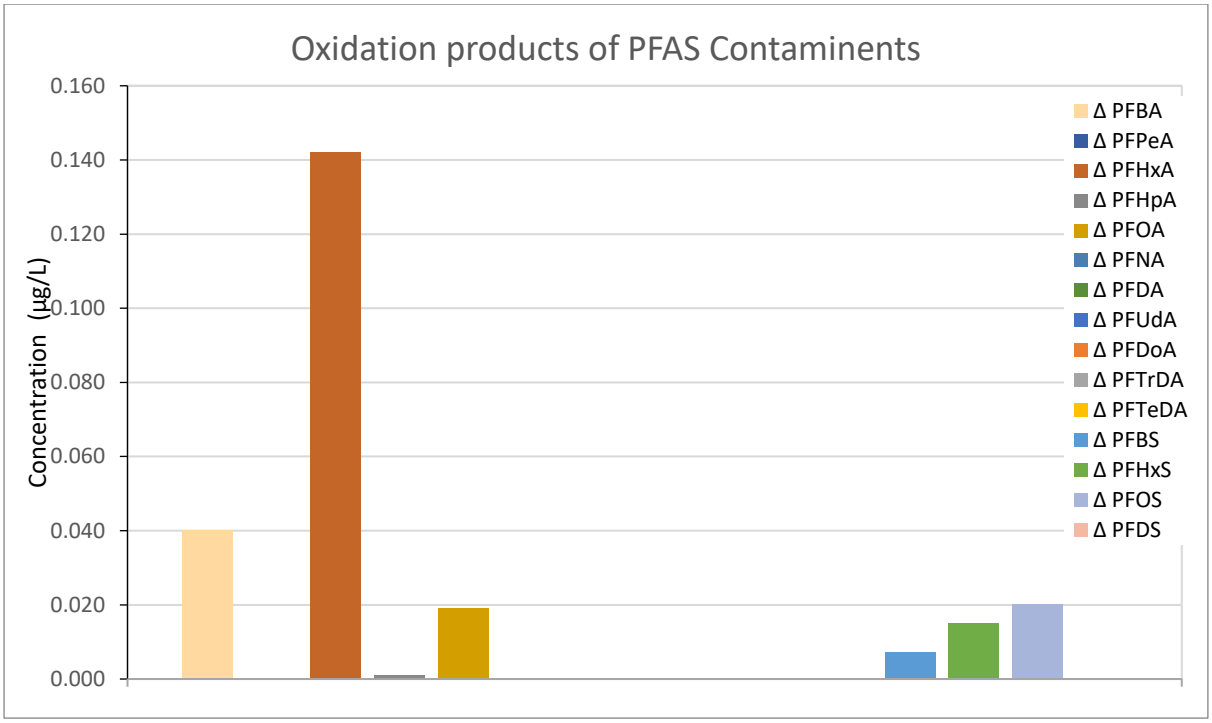


Figure NCR 12

TOPA perfluoroalkyl substances (PFAS) profile of the Noosa Heads Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.23 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.23 x 4240 x 1.00

= 975.2 µg (= 0.0009752 g) of PFOS

= 0.0009752 x 100 / 1 (1% PFOS) = 0.09752 g = 97.5 mg

or

= 0.0009752 x 100 / 5 (5% PFOS) = 0.0195 g = 19.5 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Noosa Heads Fire and Rescue station in-ground water tank is between 0.02 to 0.1 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Caloundra Fire and Rescue station

Caloundra Fire and Rescue station is an older style station with two engine bays housing two fire-fighting and one special appliance. The station is crewed by four permanent firefighters in the standard QFES 10/14 shift system. The area office, BA-HazMat complex, training and emergency management centre, and RFS officers are all co-located on-site. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1840 mm diameter and 2100 mm deep, capacity of 5580 L) is used for pump testing and water drafting training. The in-ground tank is covered by a concrete cover to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 68.6% full at the time of sampling.

Figure NCR 13

Caloundra Fire and Rescue station location and surrounding suburban setting.

Caloundra Results

Caloundra Fire and Rescue station was one of the four identified in North Coast Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Caloundra in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table NCR 4).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	0.03	0.03	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.008	<LOR	0.022	0.014	2.8
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.026	<LOR	0.15	0.12	5.8
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.006	<LOR	0.008	0.002	1.3
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.013	<LOR	0.022	0.009	1.7
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.017	<LOR	0.018	0.001	1.1
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.16	<LOR	0.17	0.010	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.32	<LOR	0.33	0.010	1.0
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	< LOR	<LOR	< LOR	< LOR	< LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	< LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	< LOR				
Total PFAS		**<LOR**	**0.55**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.23		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.52		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.75**		

Table NCR 4

Water sample analyses from Caloundra Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table NCR 4) shows the total PFAS (0.55 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure NCR 14).

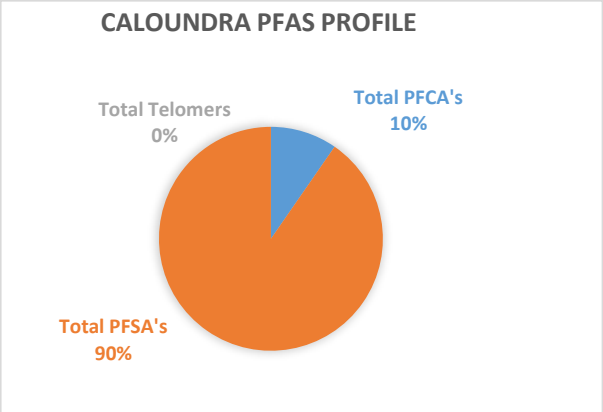


Figure NCR 14

PFAS molar profile of the Caloundra in-ground tank.

The in-ground tank water analysis shows that PFOA (0.013 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.48 µg/L) was below the recreational water guideline and above the drinking water guideline, (Figure NCR 15).

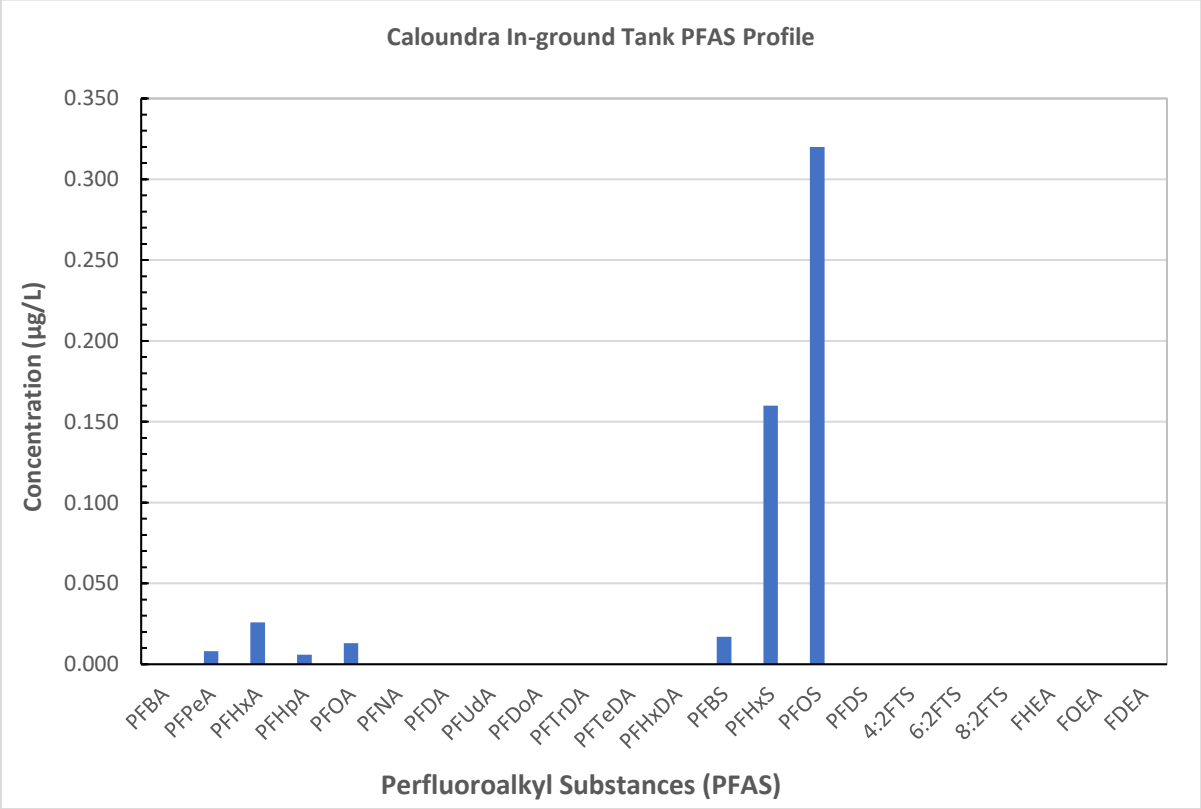


Figure NCR 15

Perfluoroalkyl substances (PFAS) profile of the Caloundra Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA and TOPA (0.71 µg/L) were both below their respective discharge values, but the ∑(PFOS + PFHxS) was above the discharge criteria. The TOPA analysis showed the presence of PFAS precursors [PFCA [0.053 µg/L from (PFPeA, PFHxA, PFHpA, PFOA) and PFSA [0.50 µg/L from (PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table FNR 2, Figure NCR 16).

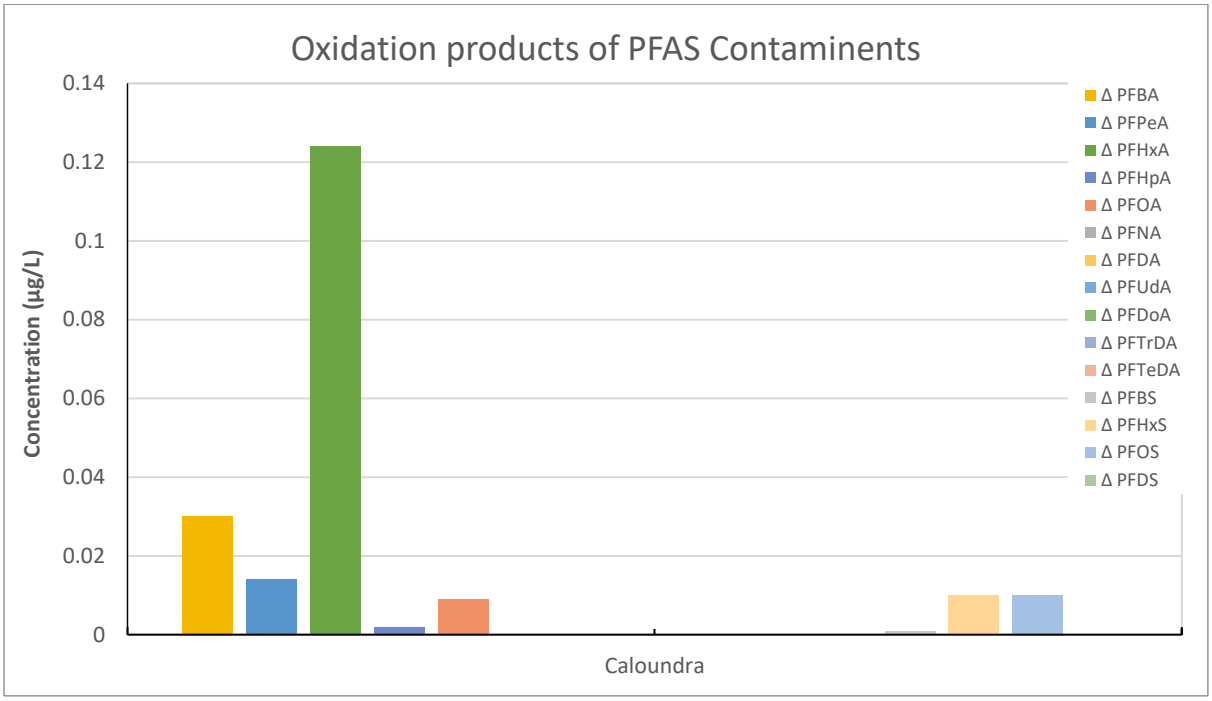


Figure NCR 16

TOPA perfluoroalkyl substances (PFAS) profile of the Caloundra Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.32 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Applying these relationships

m_{AFFF} = 0.32 x 5600 x 0.69

= 1236.48 µg (= 0.00123648 g) of PFOS

= 0.00123648 x 100 / 1 (1% PFOS)	or	= 0.00123648 x 100 / 5 (5% PFOS)
= 0.1237 g		= 0.0247 g
= 123.7 mg		= 24.7 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Caloundra Fire and Rescue station in-ground water tank is between 0.03 to 0.1 g.

Summary of North Coast Region Results

Phase One

No North Coast Region stations were involved in Phase One testing.

Phase Two

The North Coast Region (NCR) in-ground tank water analyses showed detectable levels of PFAS contamination in all Stations [(Bundaberg, 0.64 µg/L), (Maryborough, 0.16 µg/L), (Noosa Heads, 0.30 µg/L) (Caloundra, 0.55 µg/L)]. The PFAS profiles for NCR show two PFAS moieties [perfluoroalkyl carboxylic acid (PFCA), perfluorsulfonic acid (PFSA)] are present in all stations. In Bundaberg, minor traces of a third moiety [perfluoroalkyl telomers (PFT)] were also present. The PFSA moiety (sulfonates) is the predominant moiety for all stations, except Bundaberg where the PFCA moiety is the predominant species. The highest total PFAS for the region was observed in Bundaberg, (Figure NCR 17).

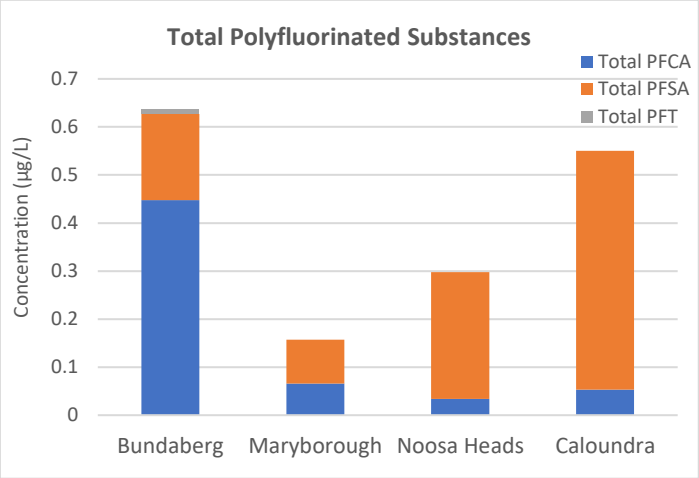


Figure NCR 17

Total (PFAS) contamination of water samples in North Coast Region Fire and Rescue station in-ground tanks.

The PFAS moiety ranges PFOA (0.011 – 0.031 µg/L), PFOS + PFHxS (0.091 – 0.48 µg/L) and TOPA (0.31 – 0.89 µg/L), show that no station exceeded the Australian Health-based recreational and drinking water guidelines for PFOA. The ∑(PFOS + PFHxS) results show that no station exceeded the Australian Health-based recreational water guideline, but that all stations were above the and drinking water guideline. The PFOA and TOPA results show that no station exceeded the Queensland Government environmental water discharge criteria. No station, except Caloundra, exceeded PFOS + PFHxS environmental discharge guideline., (Table NCR 18).

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

The North Coast delta results showed the presence of the three PFAA moieties (PFCA, PFSA, PFT), with increases in five of the twelve PFCA homologues (PFB), PFPeA, PFHxA, PFHpA, PFOA) and three of the four PFSA homologues (PFBS, PFHxS, PFOS). There were increases in all homologue concentrations across all stations, except Noosa Heads where the PFPeA was unchanged. All stations contained PFHxS and PFOS, except Caloundra which also contained PFBS. However, PFHxS was the only homologue to increase across all stations, while PFOS was detected in all stations, but no increases observed. Bundaberg was the only station to contain any of the PFT homologues with the presence of 6:2 FTS, albeit it at the LOR, (Figure NCR 18).

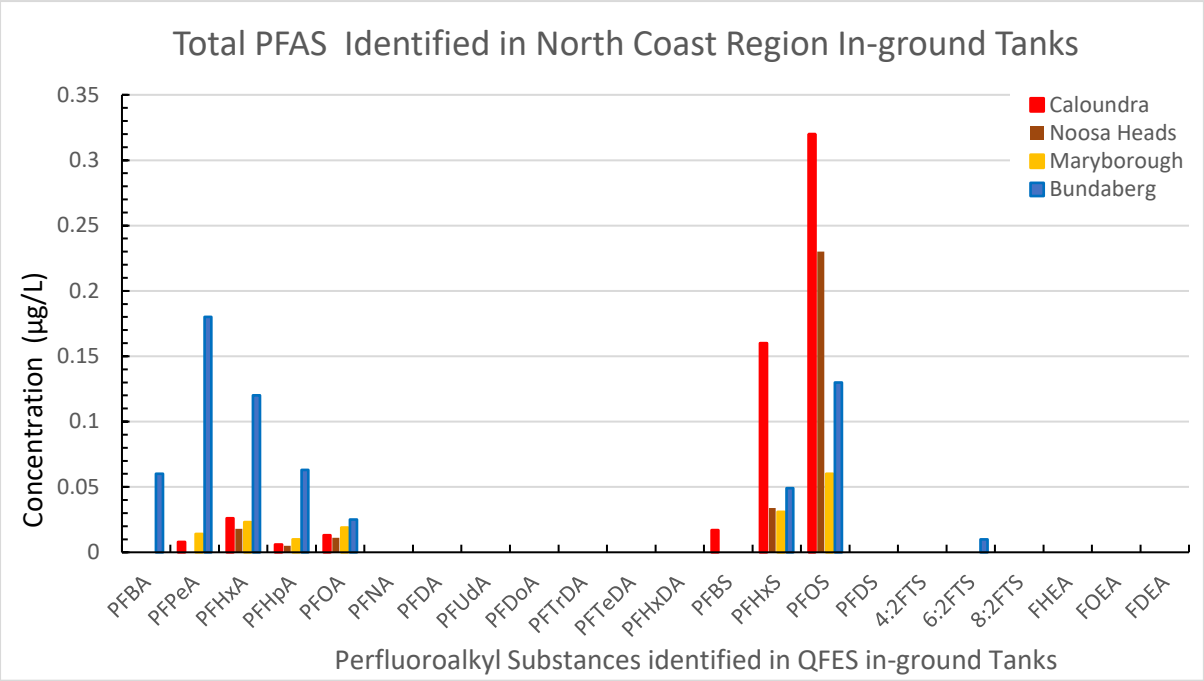


Figure NCR 18

PFAS contamination of water samples in North Coast Region Fire and Rescue station in-ground tanks.

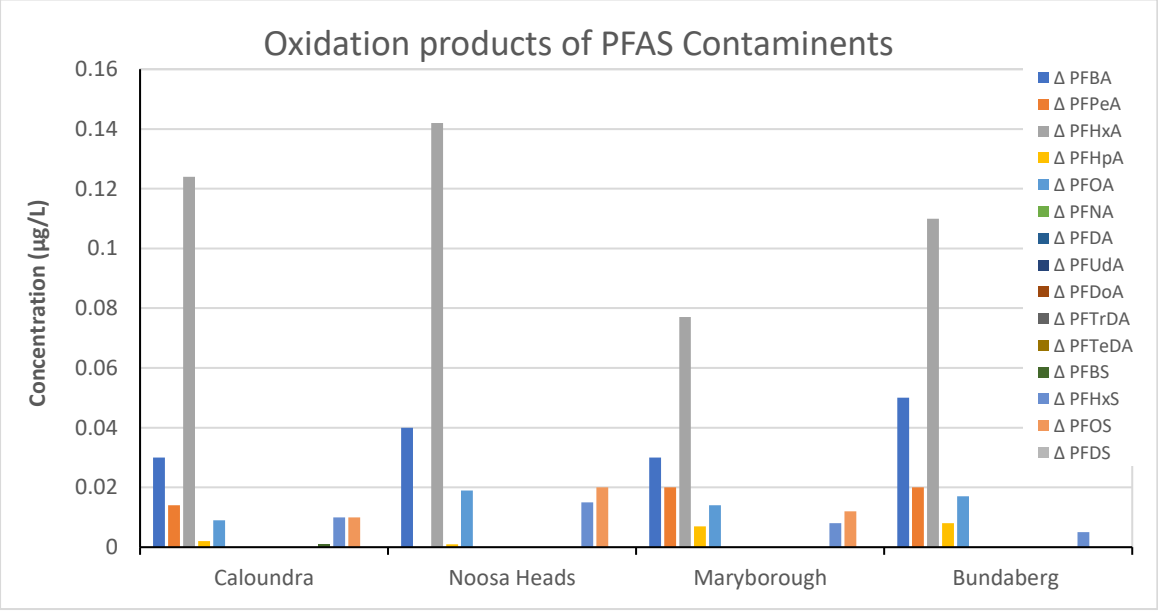


Figure NCR 19

Effects of accelerated oxidation on PFAS compounds. Delta (Δ) changes reflect the actual concentration difference of starting from oxidised PFAS contaminates.

PFAS Standard Compounds		Caloundra			Noosa Heads			Maryborough			Bundaberg		
	LOR	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.03	0.03	<LOR	0.04	0.040	< LOR	0.03	0.030	0.06	0.11	0.050
Perfluoropentanoic acid (PFPeA)	0.007	0.008	0.022	0.014	<LOR	<LOR	<LOR	0.014	0.026	0.012	0.18	0.2	0.020
Perfluorohexanoic acid (PFHxA)	0.005	0.026	0.15	0.124	0.018	0.16	0.142	0.023	0.1	0.077	0.12	0.23	0.110
Perfluoroheptanoic acid (PFHpA)	0.005	0.006	0.008	0.002	0.005	0.006	0.001	0.01	0.017	0.007	0.063	0.071	0.008
Perfluorooctanoic acid (PFOA)	0.007	0.013	0.022	0.009	0.011	0.03	0.019	0.019	0.033	0.014	0.025	0.042	0.017
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR			<LOR			<LOR			< LOR		
Perfluorobutanesulfonic acid (PFBS)	0.005	0.017	0.018	0.001	<LOR	0.007	0.007	<LOR	< LOR	< LOR	< LOR	< LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.16	0.17	0.01	0.034	0.049	0.015	0.031	0.039	0.008	0.049	0.054	0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	0.32	0.33	0.01	0.23	0.25	0.020	0.06	0.072	0.012	0.13	0.13	0.00
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR			<LOR			<LOR			<LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR			<LOR			<LOR			0.01		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR			<LOR			<LOR			<LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR			<LOR			<LOR			<LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR			<LOR			<LOR			<LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR			<LOR			<LOR			<LOR		
Total PFAS		**0.55**			**0.30**			**0.16**			**0.64**		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**		**0.75**			**0.55**			**0.31**			**0.89**	

Table NCR 5

PFAS contaminant assay of water in North Coast Region in-ground water tanks. All station town water samples tested less than level of reporting (<LOR).

Investigation of Potential PFAS and Microbiological Contamination of QFES Brisbane Region Fire and Rescue Stations with In-ground Water Tanks

The Queensland Fire and Emergency Services (QFES) Brisbane Region covers the local government areas of Somerset Regional Council (part), Moreton Bay Regional Council, Brisbane City Council, and Redlands City Council, with a total population of approximately 1.8 million people.

Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. This capability is provided by a mix of 38 urban Fire and Rescue stations located throughout the Region. The region is staffed by 880 full time employees.

QFES Emergency Management supports the Local Government areas within the region to meet the Queensland Disaster Management legislative arrangements.

Rural Fire Service (RFS) regional operations is co-located with the F&R Brisbane Region and operates with 30 brigades. It is staffed by regional QFES personnel, Volunteer Firefighters, and Volunteer Community Educators.

State Emergency Service (SES) regional operations is co-located with the F&R Brisbane Region and operates with 22 groups.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, perfluoroalkyl substances (PFAS) contamination at QFES FNR stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. The following criteria were adopted and used for Phase One of the study: No soil samples were collected from the all concrete site.

- The interim Australian health-based water quality guidelines for
  - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
  - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from in-ground water tanks and corresponding town supplies for PFAS contamination. Water samples were collected from six stations. The following criteria were adopted and used for Phase Two of the study:

- The Australian health-based water quality guidelines for
  - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
  - ∑PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all Brisbane Region Fire and Rescue stations that contained in-ground water tanks. Enoggera station was sampled and analysed in Phase One of the investigation and re-sampled in Phase Two based on the results from Phase One tests. Seven stations (Arana Hills, Enoggera, Windsor, Roma Street, Kemp Place, Annerley and Cleveland) were identified for Phase Two of these investigations, but no samples were collected from Cleveland because the tank was identified as a stormwater drain only and was empty at the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Two water samples were collected from the Enoggera Fire and Rescue station - one from the in-ground tank and one from an adjacent town water tap, for PFAS analysis. Two further water samples were collected, one from the in-ground tank and one from an adjacent town water tap, for biological analysis.

Phase Two investigations

Eight water samples were collected from the Arana Hills Fire and Rescue station in-ground tank - four in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank, for PFAS and TOPA analyses.

Six water samples were collected each from the Enoggera and Windsor Fire and Rescue station in-ground tanks - two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyse, and a travel blank, for PFAS and TOPA analyses.

Five water samples were collected each from the Arana Hills, Roma Street, Kemp Place and Annerley Fire and Rescue station in-ground tanks - two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

Water samples were collected from an in-ground tank identified at Acacia Ridge Fire and Rescue station after the QFES investigations. Samples were subsequently collected and analysed by the regulated waste contractor prior to emptying the tank and transport.

Arana Hills Fire and Rescue station

Arana Hills Fire and Rescue station is a newer style building built after 2000. It is a standard two engine bay, one appliance station that is located on a major road within a residential area. The station is crewed by four firefighters in the standard QFES 10/14 shift system. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (800 mm diameter x 2200 mm deep, capacity of 1100 L), at the rear of the yard is used for pump testing and drafting training. The in-ground tank is covered by a steel plate cover that does not prevent water ingress. Water samples were collected on two occasions from the in-ground tank that was 50% full each time of sampling.

Figure BR1

Arana Hills Fire and Rescue station and surrounding suburban setting.

Arana Hills Results

Arana Hills Fire and Rescue station was one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

Five water samples were collected from the Arana Hills in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table BR 1).

Perfluoroalkyl Substances (PFAS)	LOR		PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Tap[1]	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	0.15	<LOR	0.32	0.17	2.1
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	0.4	<LOR	0.15	-0.25	0.38
Perfluorohexanoic acid (PFHxA)	0.005	0.018	<LOR	0.23	<LOR	0.36	0.13	1.6
Perfluoroheptanoic acid (PFHpA)	0.005	0.006	<LOR	0.22	<LOR	0.12	-0.1	0.55
Perfluorooctanoic acid (PFOA)	0.007	<LOR	<LOR	0.042	<LOR	0.073	0.031	1.7
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	0.047	<LOR	0.076	0.029	1.6
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	0.027	<LOR	0.024	-0.003	0.89
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	<LOR	0.065	<LOR	0.076	0.011	1.2
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	<LOR	0.059	<LOR	0.087	0.028	1.5
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	< LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	0.97	<LOR	0.57				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR	< LOR				
Total PFAS	0.57	**0.99**	**<LOR**	**1.81**				
TOTAL C_4-C_{14} Carboxylic acids					<LOR	1.1		
TOTAL C_4-C_{10} Sulfonic acids					<LOR	0.19		
TOPA (incl C_4-C_{10} Sulfonic acids)					**<LOR**	**1.3**		

1. Tap water sample repeated after minor contamination of original sample.

Table BR 1

Water sample analyses from Arana Hills Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table BR 1) shows the total PFAS (1.81 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFCA (carboxylic acid) moiety is the highest contribution of the PFAS contamination. The PFSA (sulfonates) and PFT (telomer) moieties make-up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure BR 2). The in-ground tank water analysis shows that PFOA (<LOR µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) (0.092 µg/L) was below the recreational water guideline and above the drinking water guideline, (Figure BR 3).

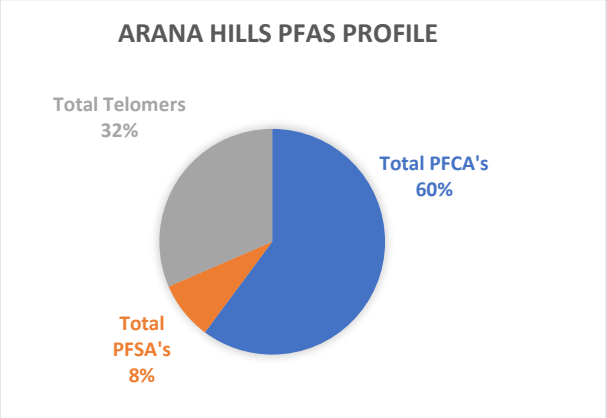


Figure BR 2

PFAS molar profile of the Arana Hills in-ground tank.

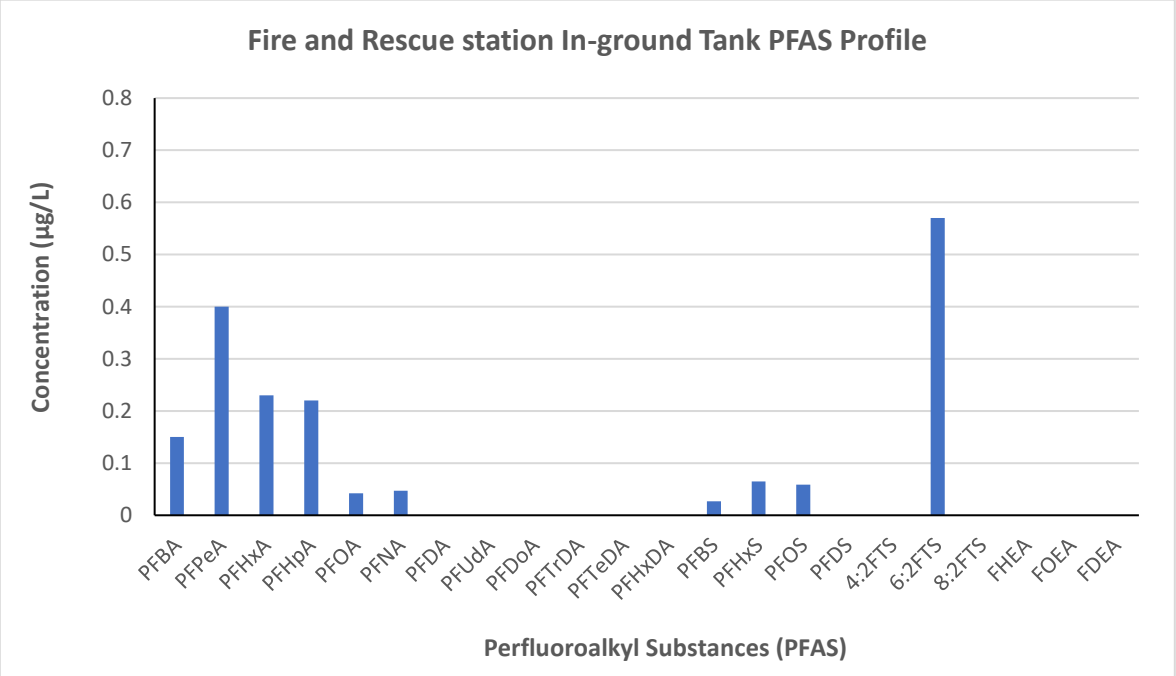


Figure BR 3

Perfluoroalkyl substances (PFAS) profile of the Arana Hills Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA and ∑(PFOS + PFHxS) were below their respective discharge criteria. The TOPA (1.59 µg/L) was the environmental discharge value. The TOPA analysis showed the presence of PFAS [PFCA (1.1 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (0.15 µg/L from PFBS, PFHxS, PFOS) and PFT (0.57 µg/L from 6:2 FTS)] that may oxidise or biotransform over time, (Table BR 1, Figure BR 4).

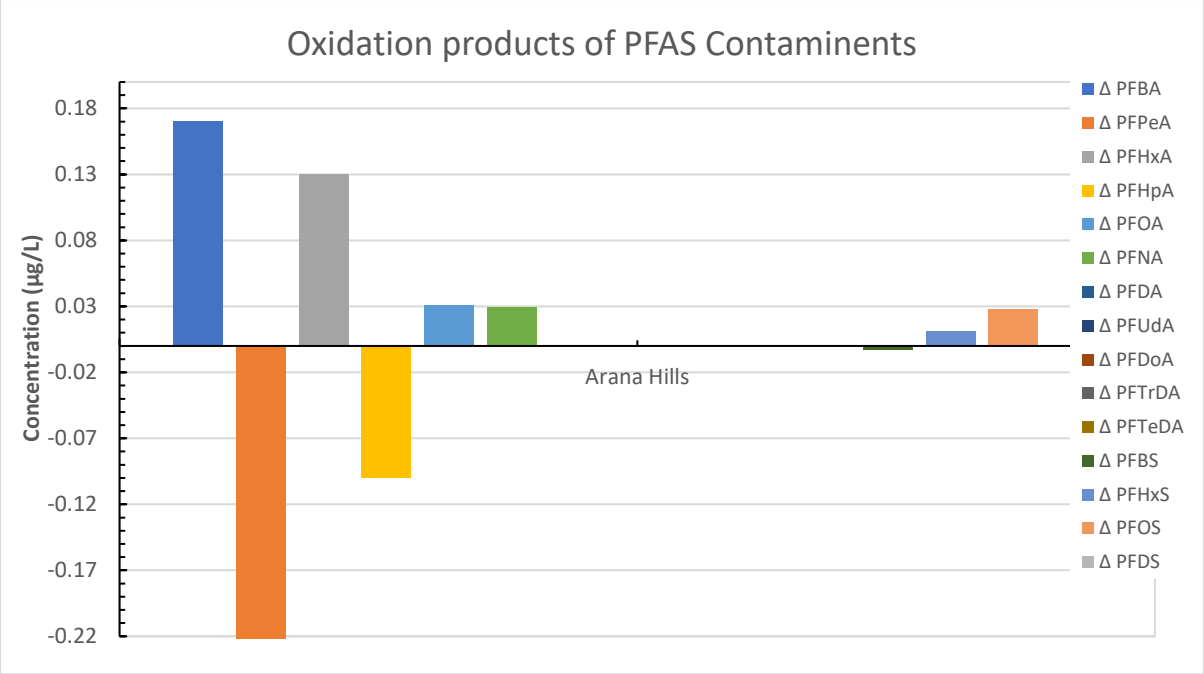


Figure BR 4

TOPA perfluoroalkyl substances (PFAS) profile of the Arana Hills Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.059 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.059 x 1100 x 0.50

= 32.45 µg (= 0.00003245 g) of PFOS

= 0.00003245 x 100 / 1 (1% PFOS) = 0.00325 g = 3.3 mg

or

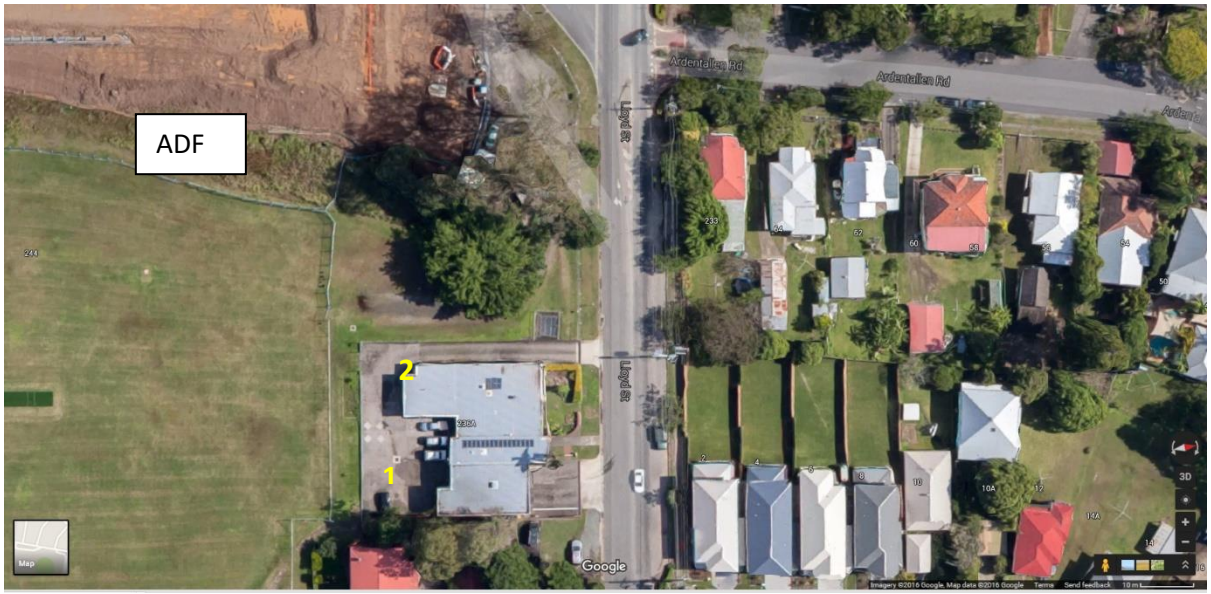
= 0.0003245 X 100 / 5 (5% PFOS) = 0.00065 g = 0.65 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Arana Hills Fire and Rescue station in-ground water tank is between 0.0007 to 0.003 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Enoggera Fire and Rescue station

Enoggera Fire and Rescue station is an older style building built prior to 1990. It is a standard two engine bay, one appliance station that is located on a major road within a residential area. The station is crewed by four firefighters in the standard QFES 10/14 shift system. All training activities are conducted on a large open space at the rear of the station. A concrete in-ground water tank (1500 mm diameter x 9200 mm deep, capacity of 16260 L), at the rear of the yard is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water samples were collected on two occasions from the in-ground tank that was 70% full each time of sampling.



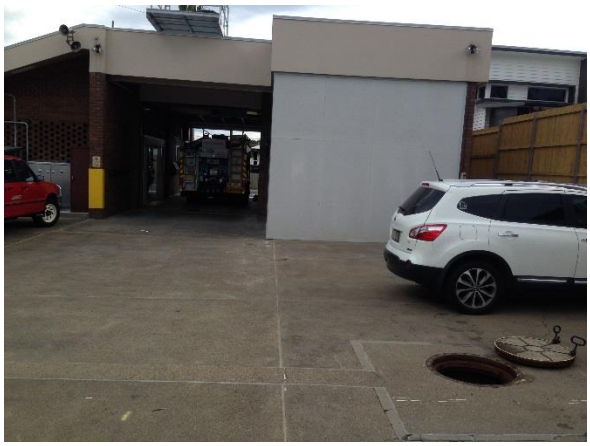


Figure BR 5

Enoggera Fire and Rescue station location and surrounding suburban setting.

Enoggera Results

Enoggera Fire and Rescue station is one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated for PFAS contamination by collecting and analysing water samples from the site.

Phase One investigation

Two water samples were collected from the Enoggera Fire and Rescue station, one from the in-ground tank and one from an adjacent town water tap. No soil samples were collected. Two further water samples were collected, one from the in-ground tank and one from an adjacent town water tap, for biological analysis. The tank and tap water results are shown in Table BR 2.

Analyte Name	PFAS Sample Analyses						Biological Analyses	
	Water (µg/L)				Soil (mg/kg)		Water Samples (CFU/100ml)	
	LOR	Tap	Tank surface	Tank 5 m	Street	Yard	Tank	Tap
Biological Test								
E. coli							0	
Coliforms							280	
Enterococci							21	
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)	0.005	<LOR	0.42	0.39				
Perfluoropentanoic acid (PFPeA)	0.005	<LOR	0.84	0.66				
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	1.1	1.2				
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.44	0.42				
Perfluorooctanoic acid (PFOA)	0.005	<LOR	0.37	0.33				
Perfluorononanoic acid (PFNA)	0.005	<LOR	0.28	0.25				
Perfluorodecanoic acid (PFDA)	0.005	<LOR	0.005	0.005				
Perfluoroundecanoic acid (PFUDA)	0.005	<LOR	0.016	0.014				
Perfluorododecanoic acid (PFDoA)	0.005	<LOR	<LOR	<LOR				
Perfluorotridecanoic acid (PFTrDA)	Not reported							
Perfluorotetradecanoic acid (PFTeDA)	Not reported							
Perfluorohexadecanoic acid	0.005	<LOR	<LOR	<LOR				
Perfluorooctadecanoic acid	0.01	<LOR	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	0.31	0.29				
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	4.9	6.3				
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	5.9	4.2				
Perfluorodecanesulfonic acid (PFDS)	0.005	< LOR	<LOR	<LOR				
2-perfluorohexyl ethanoic acid (FHEA)	Not Reported							
2-Perfluoroocty ethanoic acid (FOEA)	Not Reported							
2-Perfluorodecyl ethanoic acid (FDEA)	Not Reported							
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	0..005	<LOR	<LOR	<LOR				
6:2 fluorotelomer sulfonate (6:2 FTS)	0.01	<LOR	0.099	0.086				
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	0.02	<LOR	<LOR	<LOR				
Total PFAS		**<LOR**	**15**	**14**				

Table BR 2

Phase One water and soil sample analyses from Enoggera Fire and Rescue station

The Phase One in-ground tank water analysis (Table BR 2) shows the total PFAS (14.7 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages shows the highest contribution from the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFT (telomer) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure BR 6).

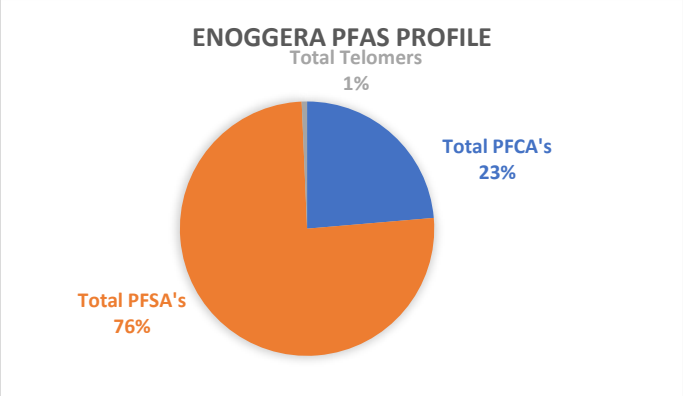


Figure BR 6

Phase 1 PFAS molar profile of the Enoggera in-ground tank.

The in-ground tank water analysis shows that PFOA (0.37 µg/L) was below the interim Australian health-based guidelines for both drinking and recreational water, but the ∑(PFOS + PFHxS) (10.8 µg/L) was considerably above the interim drinking and recreational water guidelines, (Figure BR 7). Similarly, PFOA is below the Queensland Government environmental water discharge criteria , but and ∑(PFOS + PFHxS) is above the environmental discharge guideline, (Figure NR 4). The biological results (< 1 org/100mL of water for *E. coli*, 280 CFU for total coliforms, and 21 CFU for Enterococci) show the water was equivalent to class A+ recycled water for *E. coli*.

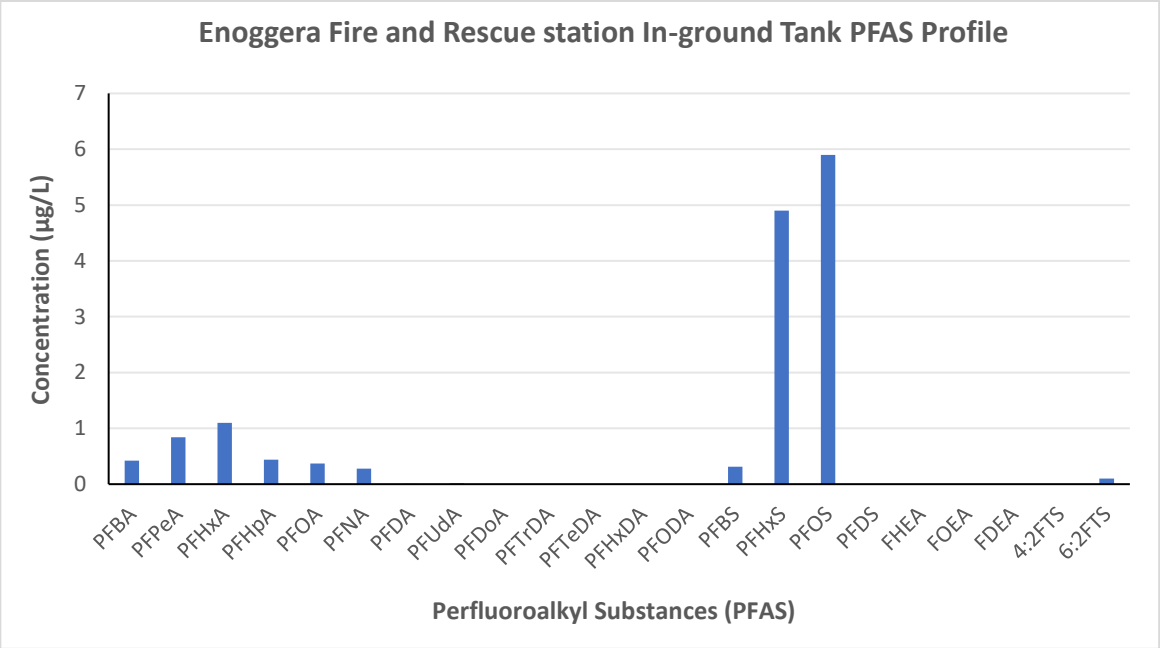


Figure BR 7

Perfluoroalkyl substances (PFAS) profile of the Enoggera Fire and Rescue station in-ground tank.

Phase Two investigation

Six water samples were collected from the Enoggera in-ground tank - two in-ground water tank samples, two town water samples, one sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank for PFAS and TOPA analyses. The tank and tap water results are shown in Table BR 3.

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.2	<LOR	0.41	0.21	2.1
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.62	<LOR	0.78	0.16	1.3
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	1.1	<LOR	2	0.9	1.8
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.24	<LOR	0.24	0	1
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.18	<LOR	0.2	0.02	1.1
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.12	<LOR	0.11	-0.01	0.92
Perfluorodecanoic acid (PFDA)	0.01	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.18	<LOR	0.19	0.01	1.1
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	3.3	<LOR	3.6	0.3	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	2.4	<LOR	2.7	0.3	1.1
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	< LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	< LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.06				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	< LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	< LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	< LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	< LOR				
Total PFAS	**0.57**	**<LOR**	**8.4**				
TOTAL C_4-C_{14} Carboxylic acids				< LOR	3.7		
TOTAL C_4-C_{10} Sulfonic acids				< LOR	6.5		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**10**		

Table BR 3

Water sample analyses from Enoggera Fire and Rescue station in-ground tank and town water.
Note: The tap sample was repeated due to minor contamination in the initial sample.

The Phase Two in-ground tank water analysis (Table BR 3) shows the total PFAS (8.4 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFT (telomer) moieties make up the remaining PFAS contamination.

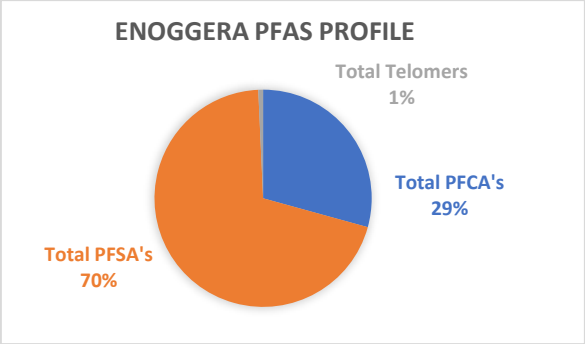


Figure BR 8

PFAS molar profile of the Enoggera in-ground tank.

The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure BR 8). The in-ground tank water analysis shows that PFOA (0.18 µg/L) was below the Australian health-

based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (5.7 µg/L) was above both drinking and recreational water guidelines, (Figure BR 9).

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (10.2 µg/L) were both significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (2.4 µg/L from PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (6.0 µg/L from PFBS, PFHxS, PFOS) and PFT (0.06 µg/L from 6:2FTS)] that may oxidise or biotransform over time, (Table BR 3, Figure BR 10).

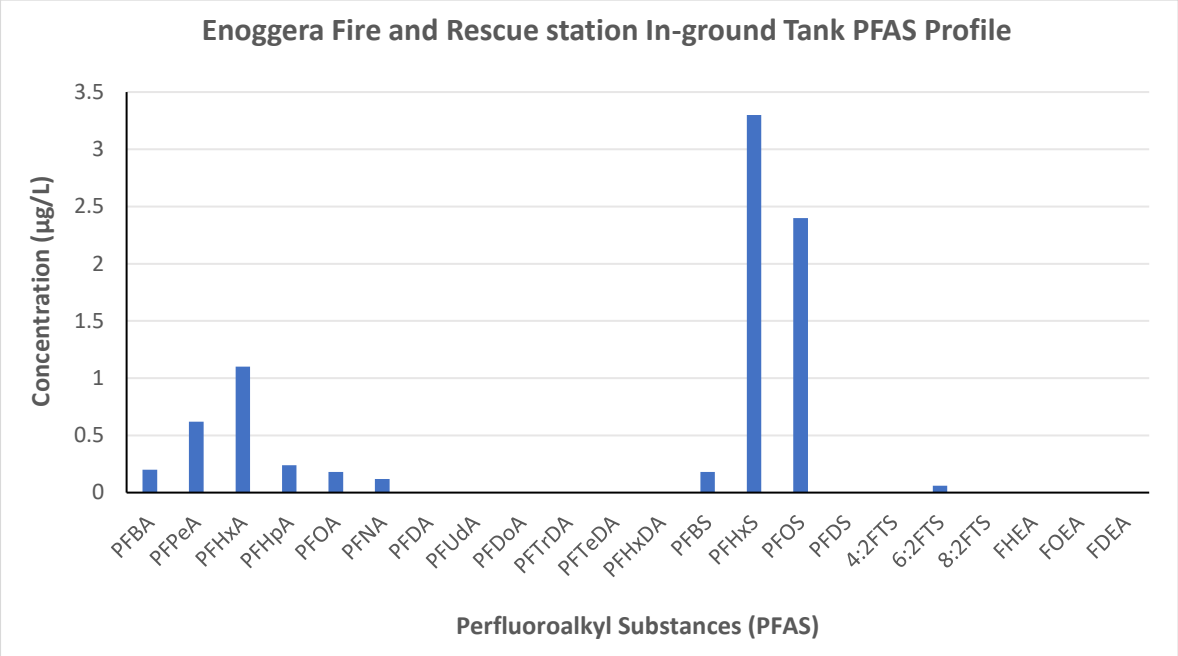


Figure Br 9

Perfluoroalkyl substances (PFAS) profile of the Enoggera Fire and Rescue station in-ground tank.

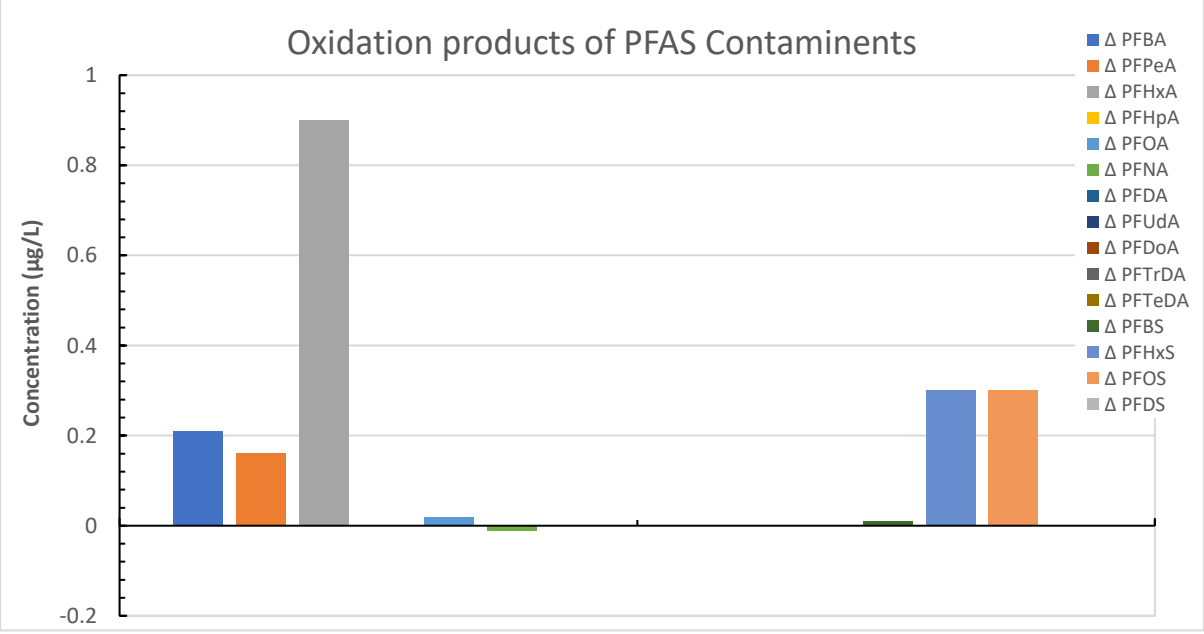


Figure BR 10

TOPA perfluoroalkyl substances (PFAS) profile of the Enoggera Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (2.4 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 2.4 x 16260 x 0.70

= 27 316.8 µg (= 0.0273168 g) of PFOS

= 0.0273168 x 100 / 1 (1% PFOS) or = 0.027316 x 100 / 5 (5% PFOS)

= 2.73 g = 0.546 g

= 2732 mg = 546 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Enoggera Fire and Rescue station in-ground water tank is between 0.6 to 3.0 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Windsor Fire and Rescue station

Windsor Fire and Rescue station is an older style building with two engine bays built prior to 1990. It is located on a major road within a residential area. The station houses one appliance and is crewed by four firefighters in the standard QFES 10/14 shift system. A regional training office is co-located on-site. All training activities are conducted on an open space at the rear of the station or inside classrooms located at the bottom of the station. A concrete in-ground water tank (1500 mm diameter x 5200 mm deep, capacity of 9200 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water samples were collected on one occasion from the in-ground tank that was 27% full at the time of sampling.

Figure BR 11

Windsor Fire and Rescue station and surrounding suburban setting.

Windsor Results

Windsor Fire and Rescue station is one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigations

No samples were collected at Windsor station in Phase One trials.

Phase Two investigation

Six water samples were collected from the Windsor station - two in-ground tanks, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyse, and a travel blank, for PFAS and TOPA analyses, (Table BR 4).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap[1]	Sample 1	Tap	Sample 2		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.04	<LOR	0.15	0.11	3.8
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.13	<LOR	0.15	0.02	1.2
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.058	<LOR	0.15	0.092	2.6
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.062	<LOR	0.045	-0.017	0.73
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.022	<LOR	0.048	0.026	2.2
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.015	<LOR	0.021	0.006	1.4
Perfluorodecanoic acid (PFDA)	0.01	<LOR	< LOR	<LOR	0.02	0.02	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	0.03	<LOR	0.03	0	1
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	< LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.006	<LOR	<LOR	-0.006	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.025	<LOR	0.025	0	1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.036	<LOR	0.049	0.013	1.4
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**0.424**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.614		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.074		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.69**		

1. Tap water sample repeated after minor contamination of original sample.

Table BR 4

Water sample analyses from Windsor Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table BR 4) shows the total PFAS (0.42 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFCA (carboxylic acid) moiety is the highest contribution of the PFAS contamination. The PFSA (sulfonates) moiety makes up the remaining PFAS contamination in similar amounts. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure BR 13).

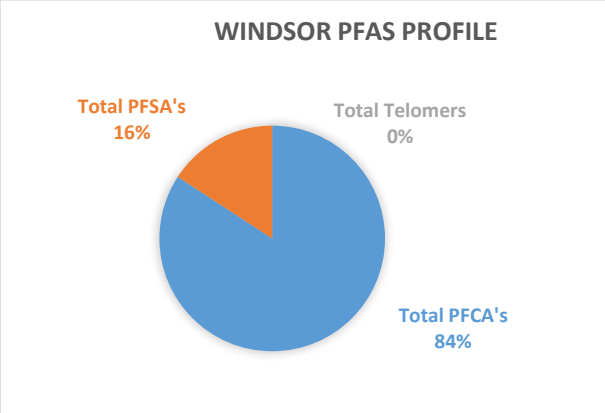


Figure BR 13
PFAS molar profile of the Windsor in-ground tank.

The in-ground tank water analysis shows that PFOA (0.022 µg/L) and ∑(PFOS + PFHxS) (0.061 µg/L) were both below the Australian health-based guidelines for both drinking and recreational water, (Figure BR 14).

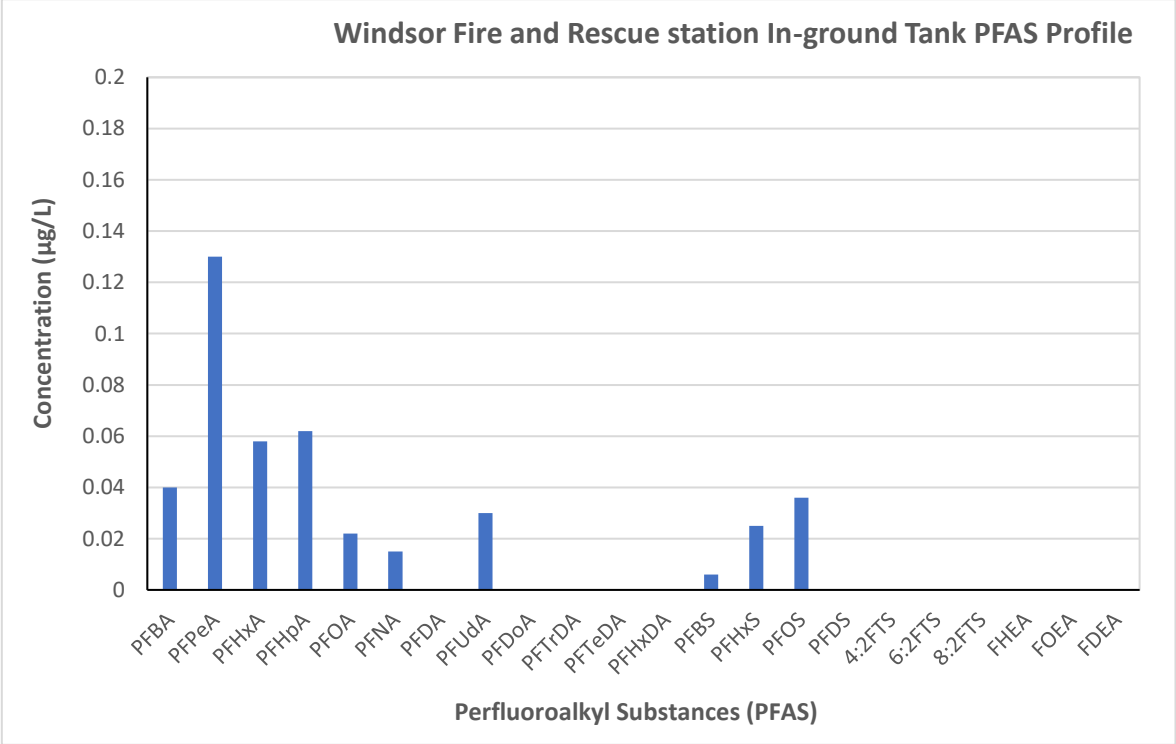


Figure BR 14
Perfluoroalkyl substances (PFAS) profile of the Windsor Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.69 µg/L) were all below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.36 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFUdA) and PFSA (0.067 µg/L from PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table BR 4, Figure BR 14).

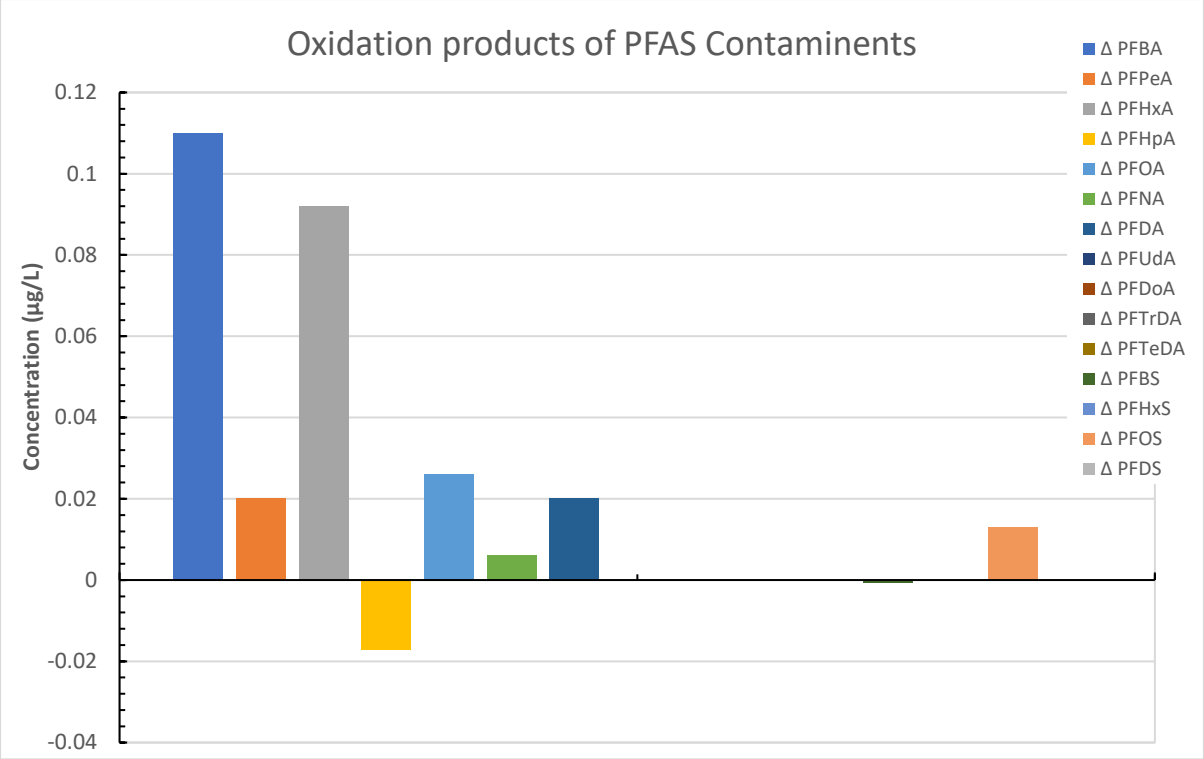


Figure BR 15

TOPA perfluoroalkyl substances (PFAS) profile of the Windsor Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.036 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.036 x 9200 x 0.27
= 89.424 µg (= 0.000089424 g) of PFOS

= 0.000089424 x 100 / 1 (1% PFOS)	or	= 0.0000894 x 100 / 5 (5% PFOS)
= 0.00894 g		= 0.001788 g
= 8.9 mg		= 1.8 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Windsor Fire and Rescue station in-ground water tank is between 0.002 to 0.009 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Roma Street Fire and Rescue station

Roma Street Fire and Rescue station is one of the two major Fire and Rescue stations located in the Brisbane CBD. It is a brick, four-storey building built after 2000. The station houses two two-fighting appliances, an aerial appliance, a foam tender and a technical rescue unit. It is crewed by ten firefighters in the standard QFES 10/14 shift system. A QAS station, an area office and training office are co-located on-site. All training activities are conducted on off station or in-side the engine bays of the station. A concrete in-ground water tank (2000 mm diameter x 9550 mm deep, capacity of 30000 L), located in the engine bay area is used for pump testing and water drafting training. The in-ground tank is covered by a concrete cover to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 94% full at the time of sampling.

Figure BR 16

Roma Street Fire and Rescue station and surrounding suburban setting.

Roma Street Results

Roma Street Fire and Rescue station is one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigations

No Phase One samples were collected from this station.

Phase Two investigations

Five water samples were collected from the Roma Street station - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses (Table BR 5).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	< LOR	<LOR	< LOR	0.01	0.01	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	< LOR	0.009	< LOR	<LOR	-0.009	<LOR
Perfluorohexanoic acid (PFHxA)	0.005	< LOR	0.008	< LOR	0.013	0.005	1.6
Perfluoroheptanoic acid (PFHpA)	0.005	< LOR	0.006	< LOR	<LOR	-0.006	<LOR
Perfluorooctanoic acid (PFOA)	0.007	< LOR	<LOR	< LOR	0.009	0.009	<LOR
Perfluorononanoic acid (PFNA)	0.007	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	< LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorooctanesulfonic acid (PFOS)	0.005	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
Perfluorodecanesulfonic acid (PFDS)	0.02	< LOR	<LOR	< LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	< LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	< LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	< LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	< LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	< LOR	<LOR				
Total PFAS		**<LOR**	**0.023**				
TOTAL C_4-C_{14} Carboxylic acids				< LOR	0.032		
TOTAL C_4-C_{10} Sulfonic acids				< LOR	< LOR		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.032**		

Table BR 5

Water sample analyses from Roma Street Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table BR 5) shows the total PFAS (0.023 µg/L) is comprised of one PFAA moiety, PFCA. The PFCA is representative of both older style and newer style fluorinated foams, (Figure BR 17). The in-ground tank water analysis shows that PFOA (<LOR µg/L) and ∑(PFOS + PFHxS) (<LOR µg/L) were below the Australian health-based guidelines for both drinking and recreational water, (Figure BR 18).

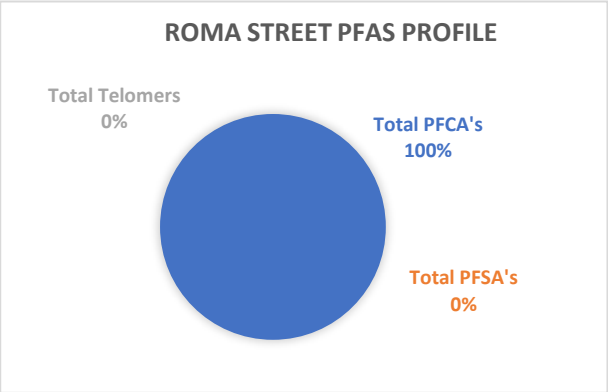


Figure BR 17

PFAS molar profile of the Roma Street in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.032 µg/L) were all significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (3.07 µg/L from PFPeA, PFHxA, PFHpA)] that may oxidise or biotransform over time, (Table BR 5, Figure BR 19).

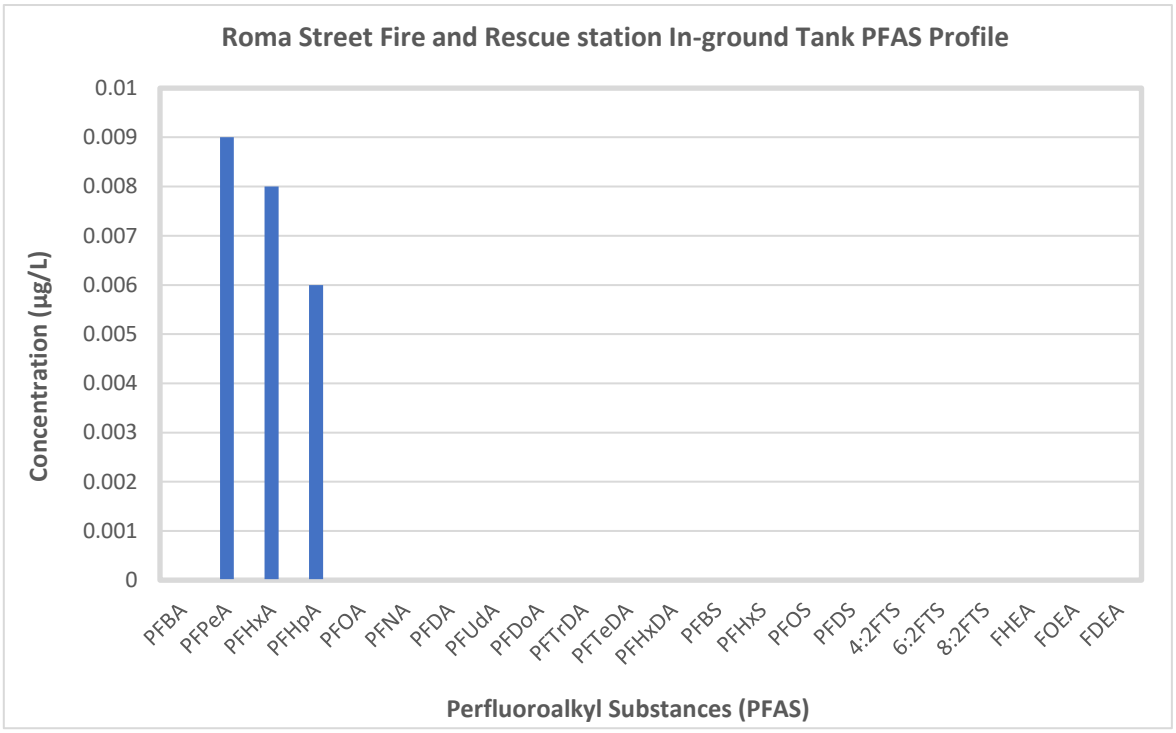


Figure BR 18

Perfluoroalkyl substances (PFAS) profile of the Roma Street Fire and Rescue station in-ground tank.

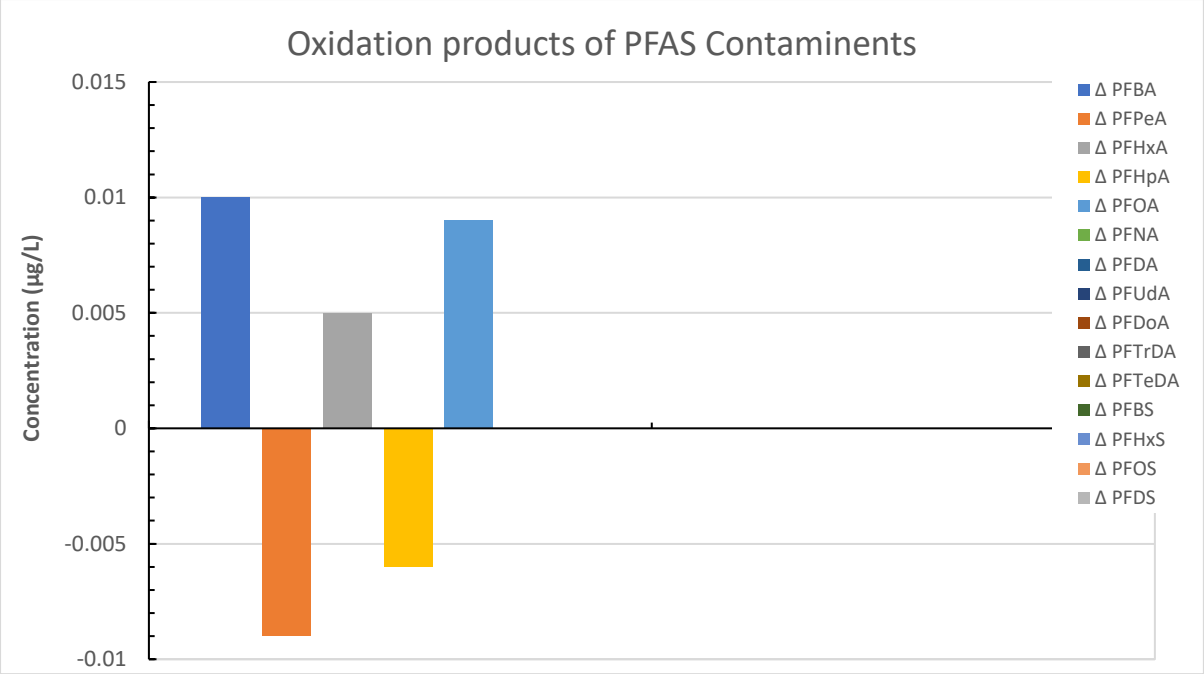


Figure BR 19

TOPA perfluoroalkyl substances (PFAS) profile of the Roma street Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (<LOR µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

Thus, no significant AFFF was detected within the Roma Street in-ground water tank.

Kemp Place Fire and Rescue station

Kemp Place Fire and Rescue station is one of the two major Fire and Rescue stations located in the Brisbane CBD. It is an older style brick, three-storey station built prior to 1980. It is a five-engine bay station and is located on a major road within a residential/commercial area. The station houses two fire appliances, one ladder appliance and one command appliance. It is crewed by ten firefighters in the standard QFES 10/14 shift system. An area office, training office, equipment office and community safety office are co-located on-site. All training activities are conducted on an open space at the rear of the station. A concrete in-ground water tank (1800 mm diameter x 9500 mm deep, capacity = 24200 L), is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water samples were collected from the in-ground tank which was 89% full at the time of sampling.

Figure BR 20

Kemp Place Fire and Rescue station and surrounding suburban setting.

Note: A feeder tank attached to the main tank was located at the time of emptying, making a total of 37100L.

Kemp Place Results

Kemp Place Fire and Rescue station is one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigations

No Phase One samples were collected from this station.

Phase Two investigations

Five water samples were collected from the Kemp Place in-ground tank, two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table BR 6).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample 1	Tap	Sample 2		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.05	<LOR	0.15	0.100	3
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.18	<LOR	0.09	-0.090	0.50
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.14	<LOR	0.53	0.390	3.8
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.12	<LOR	0.065	-0.055	0.54
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.052	<LOR	0.12	0.068	2.3
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.039	<LOR	0.049	0.010	1.3
Perfluorodecanoic acid (PFDA)	0.01	<LOR	0.02	<LOR	0.03	0.01	1.5
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	0.05	<LOR	0.07	0.02	1.4
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.025	<LOR	0.021	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.16	<LOR	0.2	0.040	1.3
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.35	<LOR	0.46	0.110	1.3
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		**<LOR**	**1.2**				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	1.1		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.68		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**1.8**		

Table BR 6

Water sample analyses from Kemp Place Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table FNR 2) shows the total PFAS (1.193 µg/L) is comprised of the two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights approximately equal proportions of the moieties, with the PFCA (carboxylic acid) moiety contributing slightly more to the PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure BR 21). The in-ground tank water analysis shows that PFOA (0.052 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. The ∑(PFOS + PFHxS) (0.51 µg/L) was below the recreational water guideline and above the drinking water guideline, (Figure BR 22).

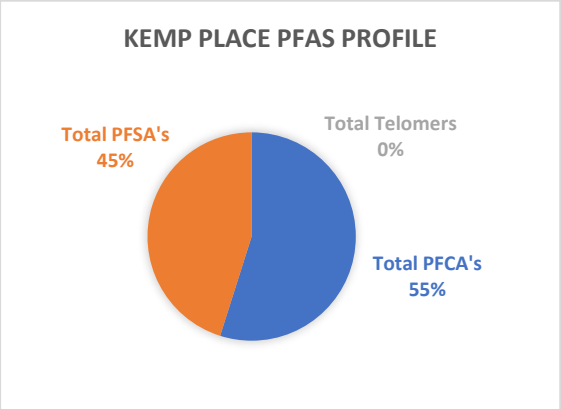


Figure BR 21

PFAS molar profile of the Kemp Place in-ground tank.

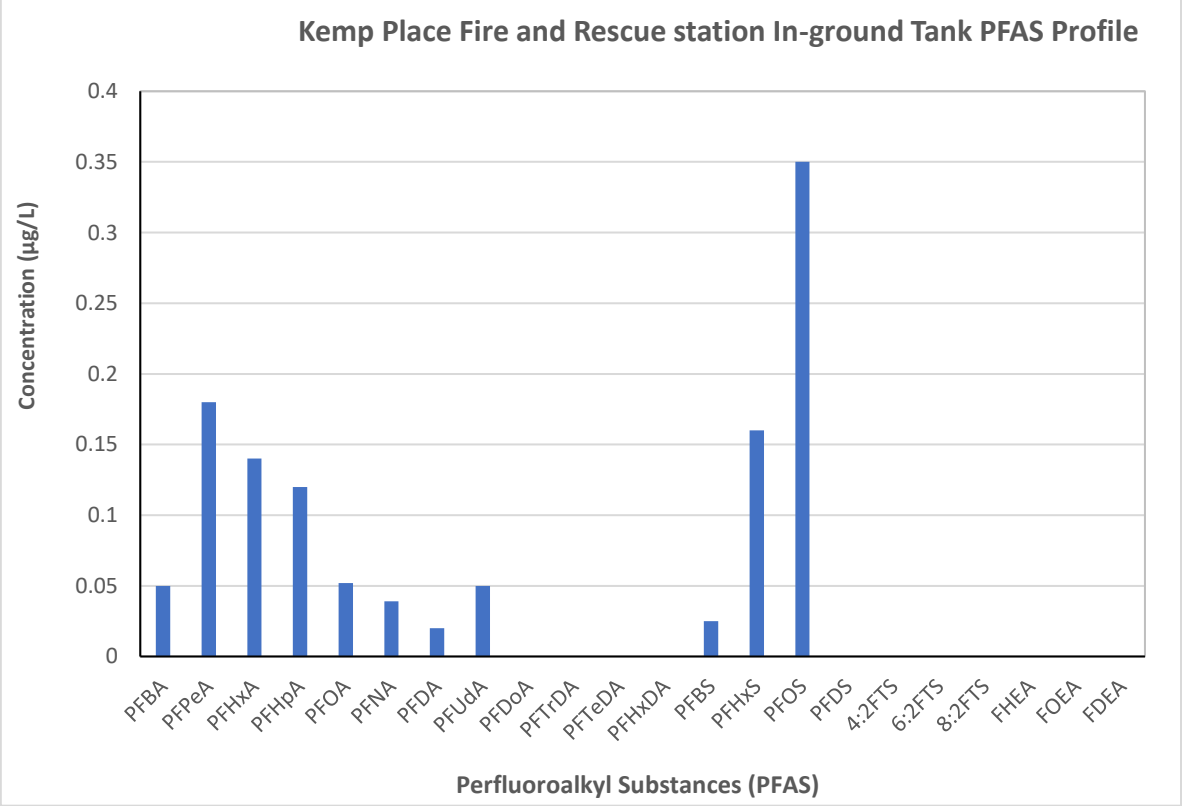


Figure BR 22

Perfluoroalkyl substances (PFAS) profile of the Kemp Place Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria, but the ∑(PFOS + PFHxS) and TOPA (1.78 µg/L) were both above their respective discharge values. The TOPA analysis showed the presence of the PFAS precursors [PFCA (0.68 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA) and PFSA (0.54 µg/L from PFHxS, PFOS, PFBS)] that may oxidise or biotransformation over time, (Table BR 6, Figure BR 23).

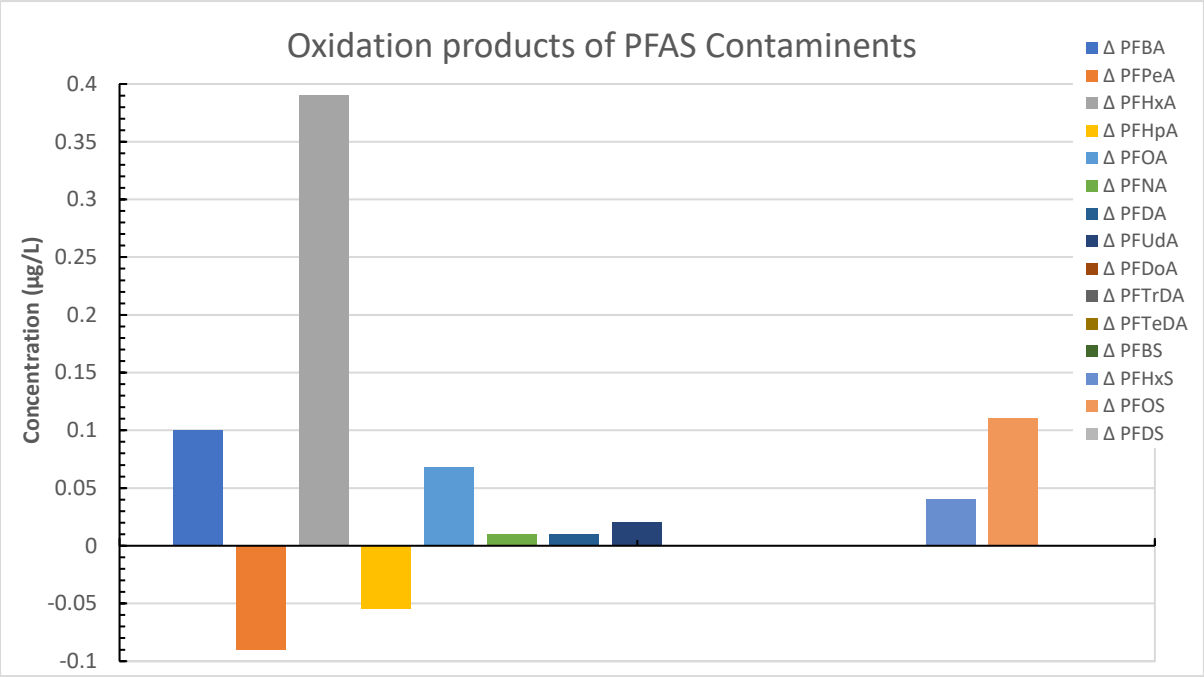


Figure BR 23

TOPA perfluoroalkyl substances (PFAS) profile of the Kemp Place Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.35 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.35 x 24200 x 0.85

= 7199.5 µg (= 0.0071995 g) of PFOS

= 0.0071995 x 100 / 1 (1% PFOS) = 0.720 g = 720 mg

or

= 0.0071995 X 100 / 5 (5% PFOS) = 0.144 g = 144 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Kemp Place Fire and Rescue station in-ground water tank is between 0.2 to 0.7 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Annerley Fire and Rescue station

Annerley Fire and Rescue station is an older style, one story brick station with two engine bays that houses two appliances and is crewed by four firefighters in the standard QFES 10/14 shift system. A large storage shed is located at the right-side rear of the station yard. It is surrounded by a commercial/residential mixed area. All training activities are conducted on an open space at the rear of the station, and it is the location of the Brisbane Region foam cache. A concrete in-ground water tank (2000 mm diameter x 9000 mm deep, capacity of 28300 L) located at the rear left of the station yard is used for pump testing and water drafting training. The in-ground tank is covered by a concrete cover to prevent water ingress. Water was collected on one occasion from the in-ground tank that was 100% full at the time of sampling. A second tap water sample was collected and analysed due to possible cross contamination.

Figure BR 24

Annerley Fire and Rescue station and surrounding suburban setting.

Annerley Results

Annerley Fire and Rescue station is one of the six identified in Brisbane Region sites containing an in-ground water tank. This study investigated the in-ground tank water for the presence of PFAS contamination.

Phase One investigations

No Phase One samples were collected from this station.

Phase Two investigations

Five water samples were collected from the Annerley in-ground tank - two in-ground water tank samples, two town water samples, and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses, (Table BR 7).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap[1]	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	<LOR	0.03	0.03	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.021	<LOR	0.05	0.029	2.4
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.022	<LOR	0.092	0.070	4.2
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.02	<LOR	0.028	0.008	1.4
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.01	<LOR	0.053	0.043	5.3
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.011	<LOR	0.023	0.012	2.1
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	0.01	0.01	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	0.01	<LOR	0.02	0.010	2
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	0.06	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.017	<LOR	0.026	0.009	1.5
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.033	<LOR	0.045	0.012	1.4
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.57				
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				
Total PFAS		<LOR	0.77				
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.3		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.07		
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19			<LOR	0.37		

1. Tap water sample repeated after minor contamination of original sample.

Table BR 7

Water sample analyses from Annerley Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table FNR 2) shows the total PFAS (0.77 µg/L) is comprised of three PFAA moieties (PFCA, PFSA and PFT). Comparison of the molar percentages highlights the PFT (telomer) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) and PFSA (sulfonates) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure BR 25).

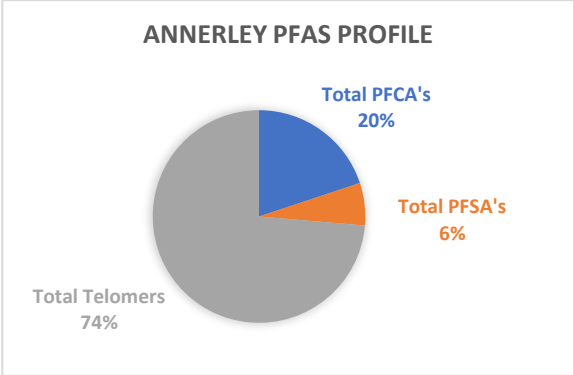


Figure BR 25

PFAS molar profile of the Annerley in-ground tank.

The in-ground tank water analysis shows that PFOA (0.01 µg/L) and ∑(PFOS + PFHxS) (0.05 µg/L) were both below the Australian health-based guidelines for drinking and recreational water, (Figure BR 26).

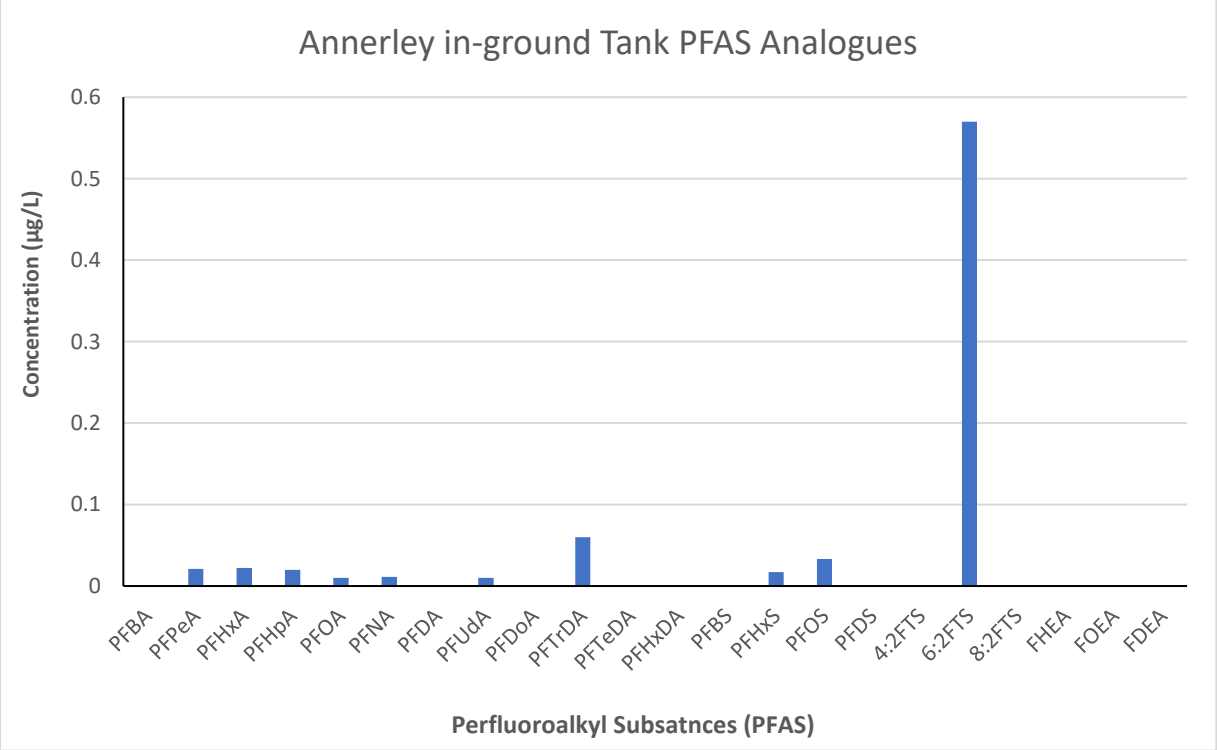


Figure BR 26

Perfluoroalkyl substances (PFAS) profile of the Annerley Fire and Rescue station in-ground tank.

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.37 µg/L) were all significantly above their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.154 µg/L from PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFUdA, PFTrDA), PFSA (0.05 µg/L from PFHxS, PFOS) and PFT (0.57 µg/L from 6:2FTS)] that may oxidise or biotransform over time, (Table BR 7, Figure BR 27).

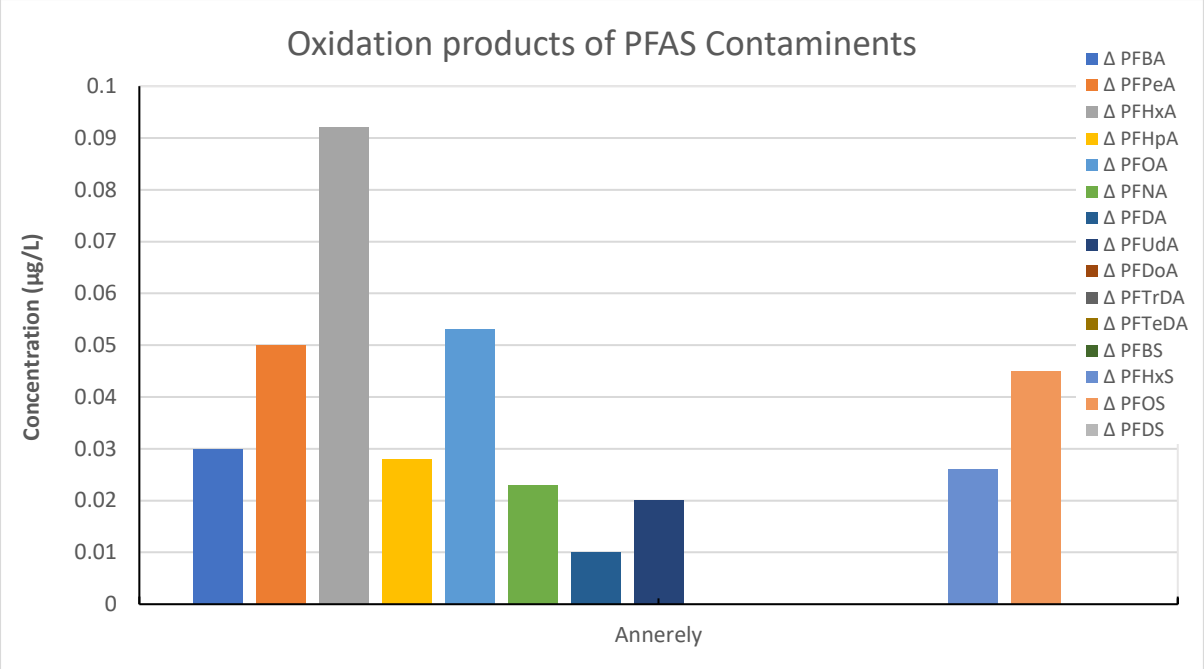


Figure BR 27

TOPA perfluoroalkyl substances (PFAS) profile of the Annerley Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.033 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.033 x 28300 x 1.00
= 933.9 µg (= 0.0009339 g) of PFOS

= 0.0009339 x 100 / 1 (1% PFOS)	or	= 0.0009339 X 100 / 5 (5% PFOS)
= 0.0934 g		= 0.0187 g
= 93.4 mg		= 18.7 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Annerely Fire and Rescue station in-ground water tank is between 0.02 to 0.09 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Summary of Brisbane Region Results

Phase One Investigation

Enoggera Fire and Rescue station in-ground tank water showed significant levels of PFAS (15 µg/L) contamination. The PFOA (0.4 µg/L) was below the interim Australian health-based water quality guidelines for drinking and recreational water. The ∑(PFOS + PFHxS) (11 µg/L) was significantly above both interim guideline values. Both PFOA and ∑(PFOS + PFHxS) were above the Queensland Government environmental water discharge criteria . The biological results [< 0 mpn/100mL of water (*E. coli*), 280 mpn/100mL (total coliforms), and 21 cfu/100 mL (enterococci)] show the water is equivalent to A+ recycled water for *E. coli*. No soil analyses were performed.

Phase Two Investigation

The Brisbane Region in-ground tank water analyses show detectable levels of PFAS contamination at all sampled sites. The total PFAS concentration at Enoggera (8.4 µg/L) was significantly higher than all other stations, with Arana Hills (1.8 µg/L) and Kemp Place (1.2 µg/L) the next highest values. All other stations showed very low levels (<1.0 µg/L) of total PFAS, (Table BR 8).

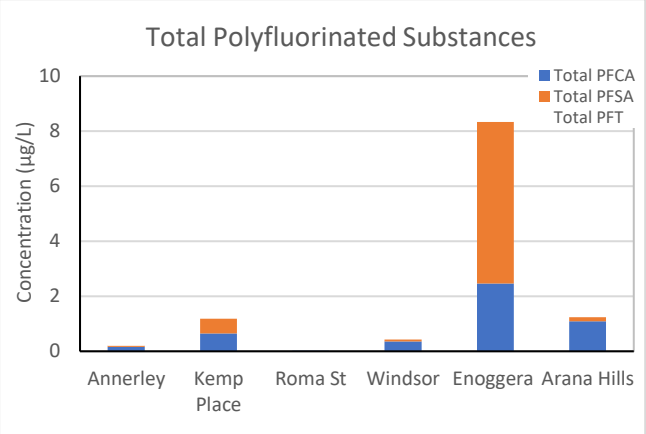


Figure BR 28

PFAS molar profile of the Annerley in-ground tank.

The PFAS profiles of the Brisbane Region differed between stations. Roma Street contained only PFCA moiety, while Kemp Place and Windsor contained only the PFCA and PFSA moieties. Kemp Place had an approximately equal amount of both moieties, while Windsor had primarily PFCA (84%). The remaining three stations Enoggera, Arana Hills and Annerley show the presence of all three PFAA moieties (PFCA, PFSA and PFT). Enoggera had the highest concentration of PFSA (70%), while Annerley showed the highest concentration of PFT (74%), (Table BR 8, Figure BR 28).

The PFOA (0.01 – 0.18 µg/L), PFOS + PFHxS (0.05 – 5.7 µg/L) and TOPA (<LOR – 10.1 µg/L) ranges show no station exceeded the Australian health-based drinking water or recreational water guidelines for PFOA or the recreational water guidelines for ∑(PFOS + PFHxS). However, Enoggera (5.7 µg/L), Kemp Place (0.51 µg/L) and Arana Hills (0.12 µg/L)] exceeded the drinking water guideline for ∑(PFOS + PFHxS). Similarly, no station exceeded the Queensland Government environmental water discharge criteria for PFOA. Enoggera was the only station to exceed the ∑(PFOS + PFHxS) discharge limit. The TOPA results show Enoggera (10.1 µg/L), Kemp Place (1.78 µg/L) and Arana Hills (1.59 µg/L) all exceeded the Queensland Government environmental water discharge criteria.

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

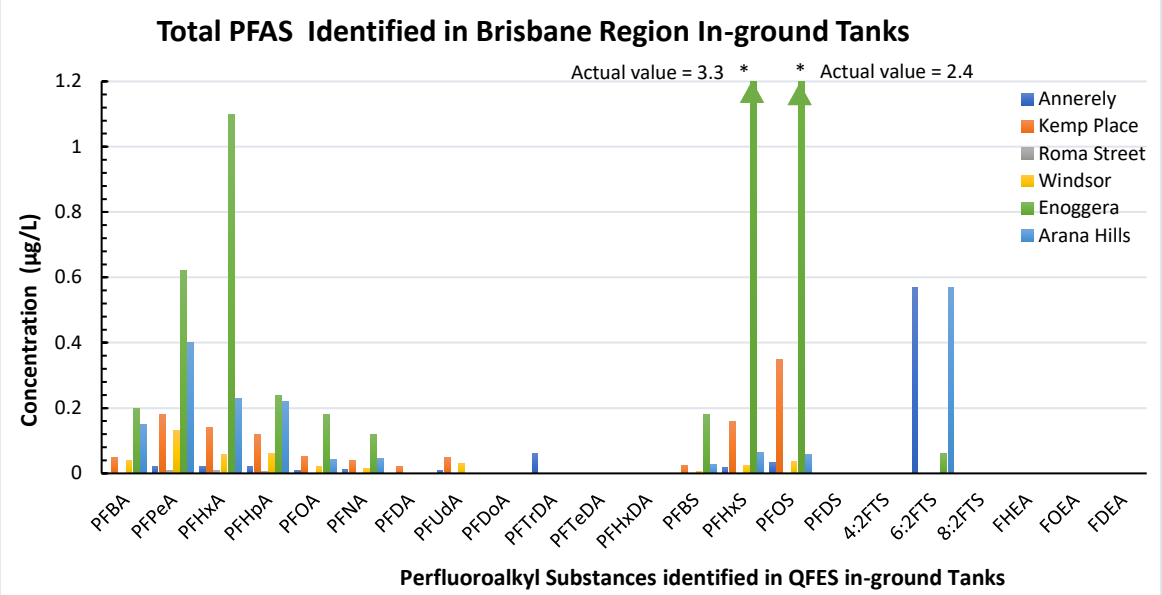


Figure BR 29

PFAS contamination profile of water in Brisbane Region Fire and Rescue station in-ground tanks.

The Brisbane Region in-ground tank waters showed the presence of the three moieties (PFCA, PFSA, PFT), with three homologues (PFBA, PFHxA, PFOA) detected across all stations. Increases were observed in eight PFCA homologues [PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA, PFDA, PFUdA] and two PFSA homologues [PFHxS, PFDS]. Enoggera showed the greatest changes in four PFCA (PFBA, PFPeA, PFHxA, PFOA) and three PFSA (PFDS, PFHxS, PFOS) homologues. PFNA showed increases in all stations, except Roma Street, which showed negligible increases in all homologues except PFHxA and PFOA, (Table BR 8 and Figure BR 30).

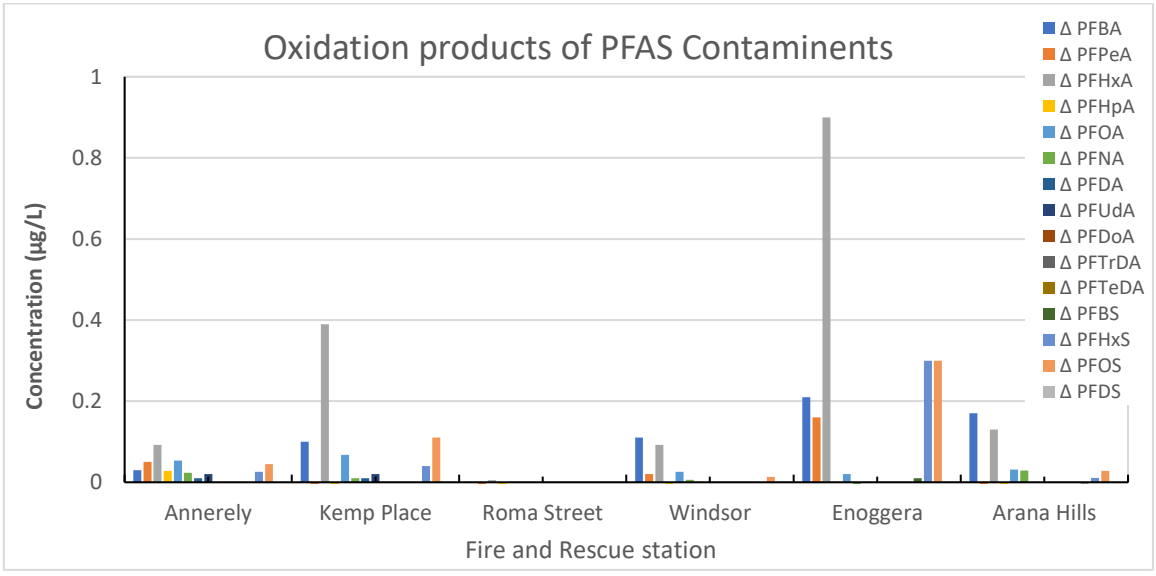


Figure BR 30

Accelerated oxidation on PFAS compounds reflected by the difference between PFAS and TOPA.

PFAS Standard Compounds	LOR	Annerley			Kemp Place			Roma Street			Windsor			Enoggera			Arana Hills		
		PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta	PFAS	TOPA	Delta
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.03	0.03	0.05	0.15	0.10	<LOR	0.01	0.01	0.04	0.15	0.11	0.2	0.41	0.21	0.15	0.32	0.17
Perfluoropentanoic acid (PFPeA)	0.007	0.021	0.05	0.05	0.18	0.089	-0.09	0.009	<LOR	-0.009	0.13	0.15	0.02	0.62	0.78	0.16	0.4	0.15	-0.25
Perfluorohexanoic acid (PFHxA)	0.005	0.022	0.092	0.092	0.14	0.53	0.39	0.008	0.013	0.005	0.058	0.15	0.092	1.1	2	0.9	0.23	0.36	0.13
Perfluoroheptanoic acid (PFHpA)	0.005	0.02	0.028	0.028	0.12	0.065	-0.06	0.006	<LOR	-0.006	0.062	0.045	-0.017	0.24	0.24	0	0.22	0.12	-0.1
Perfluorooctanoic acid (PFOA)	0.007	0.01	0.053	0.053	0.052	0.12	0.068	<LOR	0.009	0.009	0.022	0.048	0.026	0.18	0.2	0.02	0.042	0.073	0.031
Perfluorononanoic acid (PFNA)	0.007	0.011	0.023	0.023	0.039	0.049	0.01	<LOR	<LOR	<LOR	0.015	0.021	0.006	0.12	0.11	-0.01	0.047	0.076	0.029
Perfluorodecanoic acid (PFDA)	0.01	<LOR	0.01	0.01	0.02	0.03	0.010	<LOR	<LOR	<LOR	<LOR	0.02	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	0.01	0.02	0.02	0.05	0.07	0.020	<LOR	<LOR	<LOR	0.03	0.03	0	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	0.06	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	< LO	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	< LOR	<LOR	0.025	0.021	<LOR	<LOR	<LOR	<LOR	0.006	<LOR	-0.006	0.18	0.19	0.01	0.027	0.024	-0.003
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.017	0.026	0.026	0.16	0.2	0.040	<LOR	<LOR	<LOR	0.025	0.025	0	3.3	3.6	0.3	0.065	0.076	0.011
Perfluorooctanesulfonic acid (PFOS)	0.005	0.033	0.045	0.045	0.35	0.46	0.110	<LOR	<LOR	<LOR	0.036	0.049	0.013	2.4	2.7	0.3	0.059	0.087	0.028
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	0.57			<LOR			<LOR			<LOR			0.06			0.57		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR			<LOR			<LOR			<LOR			<LOR			<LOR		
Total PFAS		**0.77**			**1.2**			**0.023**			**0.424**			**8.4**			**1.8**		
Total PFOS (PFOS + PFHxS)	0.01	0.05			0.51			<LOR			0.061			5.7			0.124		
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19		**0.37**			**1.8**			**0.032**			**0.67**			**10**			**1.6**	

Table BR 8

Total PFAS contaminant assay of water in Brisbane Region in-ground water tanks. All station town water tap samples, except Annerley, Windsor and Arana Hills, tested less than level of reporting (<LOR). Tap samples at all three stations were retested, which resulted in a testing <LOR.

Investigation of Potential PFAS Contamination of QFES South Eastern Region Fire and Rescue Stations with In-ground Water Tanks

The Queensland Fire and Emergency Services (QFES) South Eastern Region contains some of the fastest developing urban/rural communities, population and land use growth areas in Queensland. This includes local Government Areas and major cities of the Gold Coast, Logan and Ipswich, and the Scenic Rim, Lockyer Valley and Somerset Regional Councils.

Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. South East regional operations oversees 35 Fire and Rescue Stations and is staffed by approximately 487 permanent fire officers, 240 auxiliary firefighters, and technical and administrative staff.

Rural Fire Service (RFS) regional operations is co-located with the F&R South Eastern Region but led by the RFS Assistant Commissioner. The SER RFS operates with 85 brigades, staffed by approximately 3500 volunteers, including regional QFES personnel, Volunteer Firefighters, Volunteer Community Educators.

State Emergency Service (SES) is co-located with the F&R South Eastern Region but led by the SES Assistant Commissioner. SES SER operates regional operations regional operations operates with 25 groups, staffed by approximately 922 members.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, of perfluoroalkyl substances (PFAS) contamination at QFES Fire and Rescue stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected and analysed for PFAS contamination. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
    - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);

  - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS contamination against updated criteria. The following criteria were adopted for Phase Two of the study:

- The Australian health-based water quality guidelines for
  - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
  - ∑PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from Southport Fire and Rescue station, which was the only station to contain an in-ground water tank. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Two water samples were collected for PFAS analyses from the Southport Fire and Rescue station - one from the in-ground water tank and one from an adjacent town water tap. Two soil samples were collected for PFAS analysis, one from the Southport Fire and Rescue station yard and one from the adjacent median strip (outside the station confines).

Phase Two investigations

No Phase Two studies were conducted in South East Region.

Southport Fire and Rescue station

Southport Fire and Rescue station is an older style building built prior to 1970. It is one of two major stations in the Gold Coast area and is located on a major road within a residential area. The station houses two appliances and support vehicles and is crewed by six firefighters in the standard QFES 10/14 shift system. The area office, BA-HazMat complex, fire communications, professional development unit and regional logistics workshops are all co-located on-site. All training activities are conducted on a large open space at the rear of the station and/or in a multistorey training tower. A concrete in-ground water tank (2000 mm x 2000 mm x 5500 mm deep, capacity of 22000 L), adjacent to the tower is used for pump testing and water drafting training. The in-ground tank is covered by a steel plate to prevent water ingress. Water samples were collected on one occasion from the in-ground tank that was 91% full at the time of sampling.

Figure SER 1

Southport Fire and Rescue station and surrounding suburban setting.

Southport Results

Southport Fire and Rescue station is the only South Eastern Region containing an in-ground water tank. This study investigated for PFAS contamination by collecting and analysing water and soil samples from the site.

Phase One investigations

Two water samples were collected from the Southport Fire and Rescue station - one from the in-ground tank and one from an adjacent town water tap. Two soil samples, one from behind the station tower and one from adjacent nature strip outside the station, were collected for PFAS analysis, Table SER 1).

The Phase One in-ground tank water analysis (Table SER 1) shows the total PFAS (0.242 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages shows the highest contribution from the PFCA (carboxylic acid) moiety. The PFSA (sulfonates) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure SER 2).

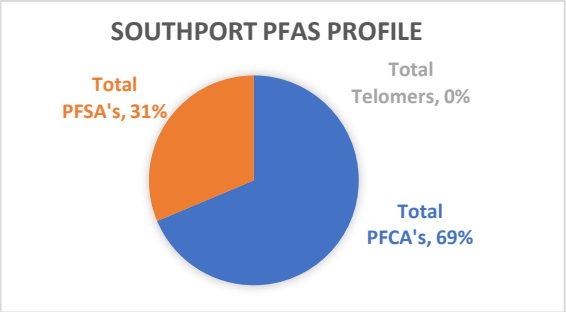


Figure SER 2

PFAS molar profile of South Port in-ground tank.

The in-ground tank water analysis shows that PFOA (0.012 µg/L) and ∑(PFOS + PFHxS) (0.163 µg/L) were below the interim Australian health-based guidelines for both drinking and recreational water. However, when the current Australian health-based criteria are applied, the ∑(PFOS + PFHxS) (0.163 µg/L) is above the drinking water guideline but below the recreational water guideline, (Figure SER 3). Consideration of the Queensland Government environmental water discharge criteria show PFOA, and ∑(PFOS + PFHxS) were both below their respective discharge values, (Table SER 1, Figure SER 3).

Perfluoroalkyl Substances (PFAS)	PFAS Sample Analyses					
	Water (µg/L)			Soil (mg/kg)		
	LOR	Tap	Sample	LOR	Street	Yard
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.013	0.005	0.007	<LOR
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.02	0.002	0.009	0.11
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.026	0.001	0.005	0.12
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.008	0.001	0.001	0.005
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.012	0.002	<LOR	0.005
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	0.001	0.002	0.004
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	0.001	<LOR	0.002
Perfluoroundecanoic acid (PFUDA)	0.01	<LOR	<LOR	0.002	<LOR	0.004
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	0.002	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	0.007	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	0.01	<LOR	<LOR
Perfluorohexadecanoic acid	0.05	<LOR	<LOR	Not Reported		
Perfluorooctadecanoic acid	Not Reported					
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	0.001	<LOR	<LOR
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.043	0.001	0.003	0.008
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.12	0.001	0.064	0.037
Perfluorodecanesulfonic acid (PFDS)	0.005	<LOR	<LOR	0.002	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR	0.002	<LOR	<LOR
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR	Not Reported		
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR	0.005	<LOR	<LOR
2-perfluorohexyl ethanoic acid (FHEA)				0.002	< LOR	<LOR
2-Perfluoroocty ethanoic acid (FOEA)	0.05	<LOR	<LOR	0.02	<LOR	<LOR
2-Perfluorodecyl ethanoic acid (FDEA)	0.05	<LOR	<LOR	0.02	<LOR	<LOR
Total PFAS	**0.36**	**<LOR**	**0.242**	**0.09**	**0.091**	**0.296**

Table SER 1

Water sample analyses from Southport Fire and Rescue station in-ground tank and town water.

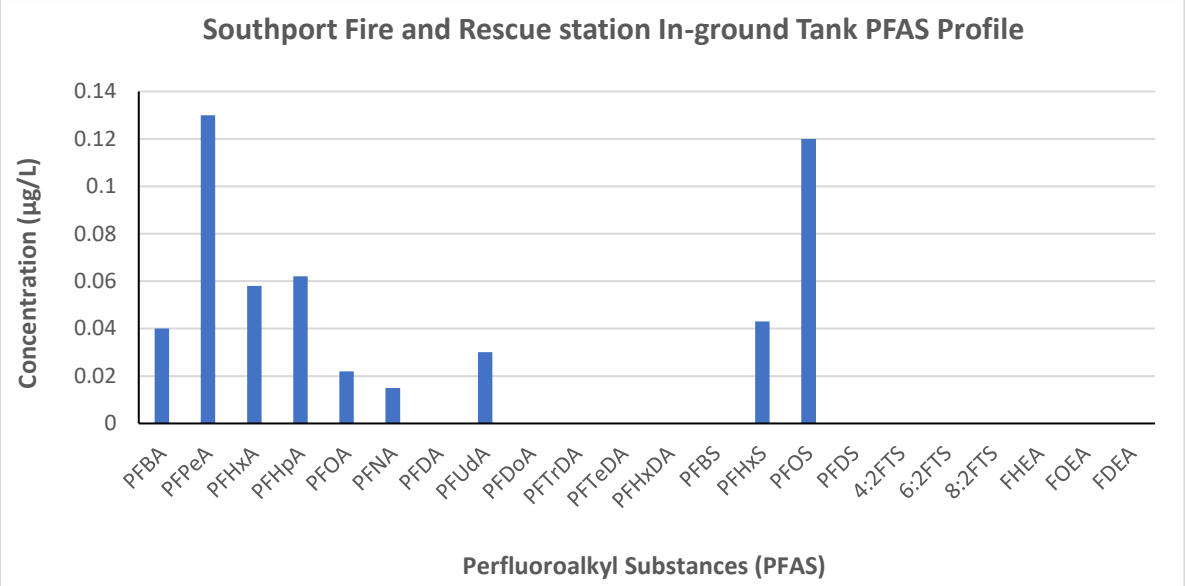


Figure SER 3

Perfluoroalkyl substances (PFAS) profile of the Southport Fire and Rescue station in-ground tank.

The PFOA (0.005 mg/kg) and ∑(PFOS + PFHxS) (0.045 mg/kg) results from soil analysis are below the DES ERA60: Material used in Capping and NEMP human health-based soil criteria for industrial/commercial land. The soil analyses showed a total PFAS (0.30 mg/kg) with PFAS precursors [PFCA (0.079 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA), PFSA (0.163 µg/L from PFBS, PFHxS, PFOS) and PFT (0.025 µg/L from 6:2 FTS, 8:2 FTS)] that may oxidise or biotransform over time, (Table SER 1, Figure SER 3).

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.12 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.12 x 22000 x 0.91

= 2402.4 µg (= 0.0024024 g) of PFOS

= 0.0024024 x 100 / 1 (1% PFOS) = 0.240 g = 240 mg

or

= 0.0024024 x 100 / 5 (5% PFOS) = 0.0481 g = 48.1 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Southport Fire and Rescue station in-ground water tank is between 0.05 to 0.2g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Summary of South Eastern Region Results

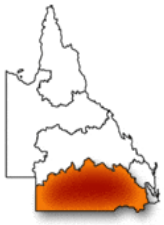
Phase One Investigation

Southport Fire and Rescue station was selected for Phase One investigations as it was a large urban station and it was the only station in the region to contain an in-ground water tank.

The South Eastern Region in-ground tank water analyses showed detectable levels of PFAS (0.24 µg/L) which comprised of two PFAA moieties (PFCA, and PFSA). The PFOA (0.012 µg/L) was below the Australian health guidelines for drinking and recreational water. However, the ∑(PFOS + PFHxS) (0.16 µg/L) was above the Australian health guidelines for drinking water, but below the recreational water guidelines, (Figure SER 3). The PFOA and ∑(PFOS + PFHxS) results for Southport in-ground water tank were less than the Queensland Government environmental water discharge criteria.

The Phase One soil analyses show that both PFOA 0.005 mg/kg) and ∑(PFOS + PFHxS) (0.045 mg/kg)] were below the DES ERA60 Waste Disposal Model for Capping materials [PFOA (16 mg/kg) and PFOS (6 mg/kg)] and NEMP[124] health exposure guidelines for industrial or commercial land use (PFOA = 50 mg/kg and ∑ (PFOS + PFHxS) = 20 mg/kg).

Investigation of Potential PFAS and Microbiological Contamination of QFES South Western Region Fire and Rescue stations with In-ground Water Tanks



The Queensland Fire and Emergency Services South Western Region runs from Toowoomba in the east, west to the South Australian border and south to the New South Wales border. The region's major city is Toowoomba with most of the population concentrated in the eastern part of the region, with the western areas more sparsely populated.

Fire and Rescue (F&R) provides Fire, Rescue, Hazmat, Community Safety and Special Operations capability to the entire Region. South West regional operations oversees 40 Fire and Rescue Stations and is staffed by approximately 580 permanent fire officers, 240 auxiliary firefighters, and technical and administrative staff.

Rural Fire Service (RFS) regional operations is co-located with the F&R South Western Region but led by the RFS Assistant Commissioner. RFS SWR operates with 350 brigades, staffed by approximately 3500 volunteers, including regional QFES personnel, Volunteer Firefighters, Volunteer Community Educators and covers a geographically large area of approximately 400,000 square kilometres.

State Emergency Service (SES) is co-located with the F&R South Western Region but led by the SES Assistant Commissioner. SES SWR regional operations has six fulltime and three-part time staff in both Toowoomba and Roma who oversee 41 groups, staffed by approximately 922 members, including regional QFES personnel, local council officers and SES Volunteers.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, perfluoroalkyl substances (PFAS) contamination at QFES FNR stations with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected and analysed for PFAS contamination. The following criteria were adopted and used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
    - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);

  - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and corresponding town supplies for PFAS. Water samples were collected from one station. The following criteria were adopted and used for Phase Two of the study:

- The Australian health-based water quality guidelines for
  - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
  - ∑PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: ∑(PFOS + PFHxS) (0.3 µg/L), PFOA (0.3 µg/L), TOPA(including C4-C8 sulfonates) (1 µg/L).

In-ground Tank Sampling

This study involved collecting water samples from all South Western Region Fire and Rescue stations that contained in-ground water tanks. Oakey Fire and Rescue station was sampled and analysed in Phase One of the investigation. No water samples were collected as no tank was present at the station. Soil samples were collected and analysed for PFAS contamination. Three stations (Charleville, Anzac Avenue, Crows Nest) were identified for Phase Two of these investigations, but samples were only collected from Charleville. No samples were collected from Crows Nest as no tank was present at the station. No samples were collected from Anzac Avenue as the tank was empty at the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

Two soil samples were collected from the Oakey Fire and Rescue station, one from the station yard and one from outside the station confines were collected for PFAS analysis.

Phase Two investigations

Six water samples were collected from the Charleville in-ground tank - two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash, and a travel blank, for PFAS and TOPA analyses.

Charleville Fire and Rescue station

Charleville Fire and Rescue station is an older style building built prior to 1940. It is located on a major road within a residential area. The station houses two appliances and support vehicles and is crewed by auxiliary firefighters. The area office and regional logistics stores are all co-located on-site. Training activities are conducted at the rear of the station. A concrete in-ground water tank, (3000 x 1070 mm x 1600 mm deep, with a capacity of 5136 L) is used for pump testing and water drafting training. The in-ground tank is covered by a steel grate that does not prevent water ingress. Water was collected on one occasion from the in-ground tank that was 50% full at the time of sampling.

Figure SWR 1
Charleville Fire and Rescue and surrounding suburban setting.

Charleville Results

Charleville Fire and Rescue station is one of the two identified in South Western Region sites containing an in-ground water tank. This study investigated for PFAS contamination by collecting and analysing water samples from the site.

Phase One investigations

No Phase One samples were collected from this station.

Phase Two investigations

Seven water samples were collected from the Charleville station - two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses and a travel blank, (SWR 1).

Perfluoroalkyl Substances (PFAS)	LOR	PFAS		TOPA		Delta	TOPA/PFAS Ratio
		Tap	Sample	Tap	Sample		
	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	(µg/L)	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.02	<LOR	0.01	-0.01	0.5
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	<LOR	<LOR	0.01	0.01	0
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.011	<LOR	0.033	0.022	3
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.006	<LOR	0.011	0.005	1.8
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.01	<LOR	0.015	0.005	1.5
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	<LOR	<LOR	0.008	0.008	0
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.023	<LOR	0.04	0.017	1.7
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.029	<LOR	0.04	0.011	1.4
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR	<LOR			
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR	<LOR			
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR	<LOR			
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR	<LOR			
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR	<LOR			
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR	<LOR			
Total PFAS		**<LOR**	**0.099**	**<LOR**			
TOTAL C_4-C_{14} Carboxylic acids				<LOR	0.079		
TOTAL C_4-C_{10} Sulfonic acids				<LOR	0.088		
TOPA (incl C_4-C_{10} Sulfonic acids)	**0.19**			**<LOR**	**0.17**		

Table SWR 1

Water sample analyses from Charleville Fire and Rescue station in-ground tank and town water.

The Phase Two in-ground tank water analysis (Table SWR 1) shows the total PFAS (0.099 µg/L) is comprised of two PFAA moieties (PFCA and PFSA). Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination. The PFCA (carboxylic acid) moiety makes up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, (Figure SWR 2).

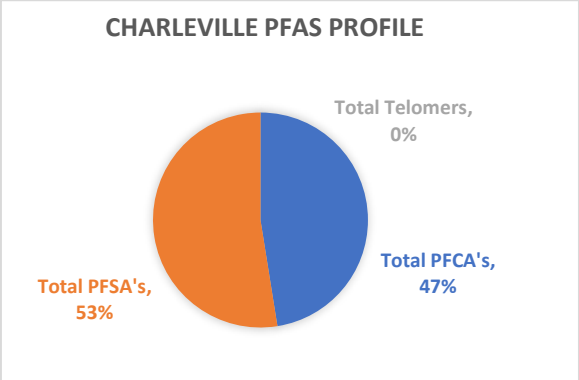


Figure SWR 2
PFAS molar profile of the Charleville in-ground tank.

The in-ground tank water analysis shows that PFOA (0.01 µg/L) and ∑(PFOS + PFHxS) (0.052 µg/L) were both below the Australian health-based guidelines for both drinking and recreational water, (Figure SWR 3).

Consideration of the Queensland Government environmental water discharge criteria show PFOA, ∑(PFOS + PFHxS) and TOPA (0.017 µg/L) were all significantly below their respective discharge values. The TOPA analysis showed the presence of PFAS precursors [PFCA (0.079 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA) and PFSA (0.088 µg/L from PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table SWR 1, Figure SWR 4).

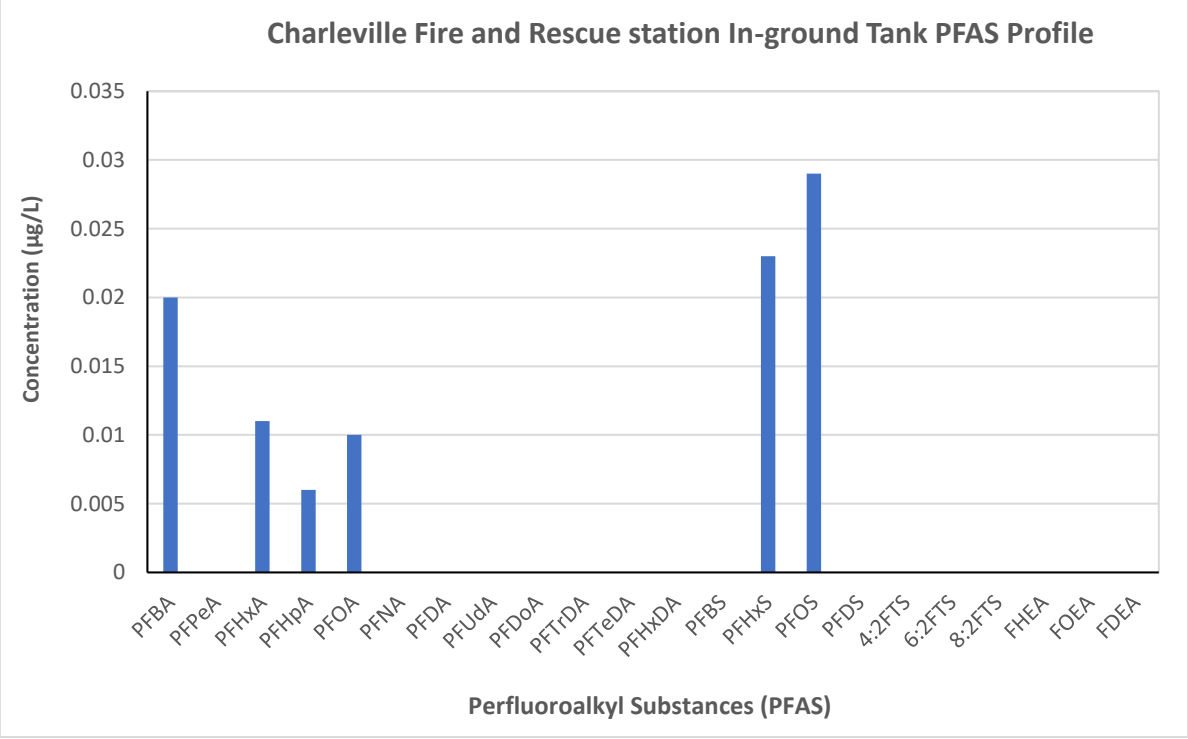


Figure SWR 3
Perfluoroalkyl substances (PFAS) profile of the Charleville Fire and Rescue station in-ground tank.

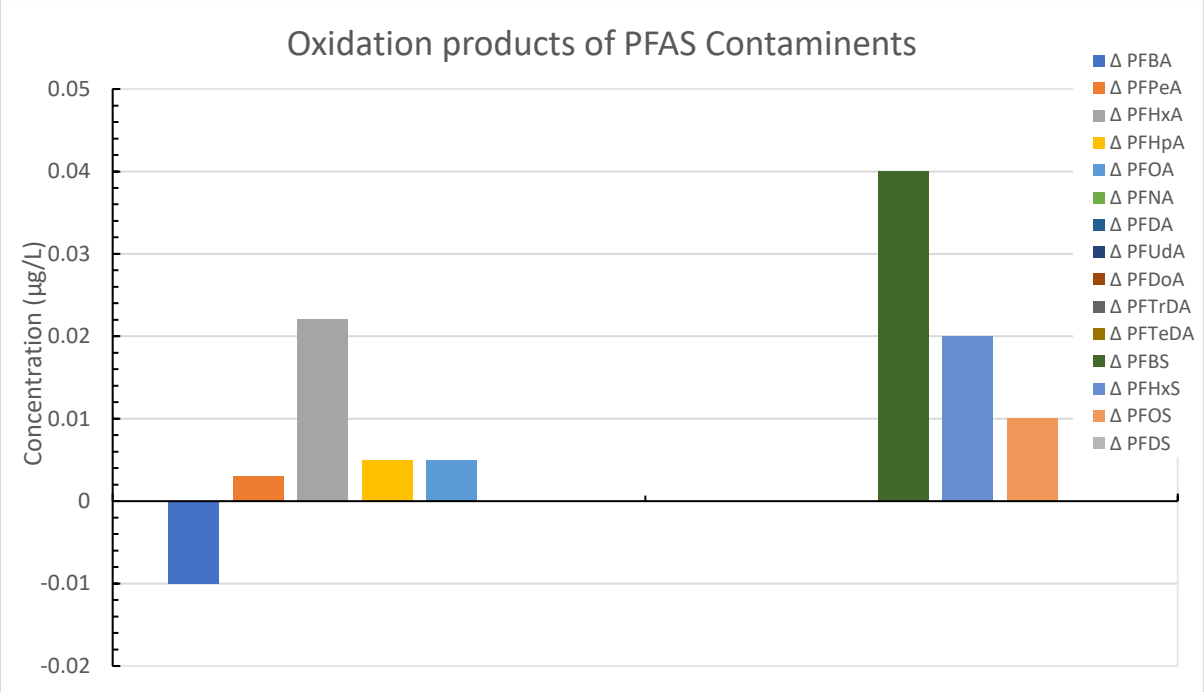


Figure SWR 4

TOPA perfluoroalkyl substances (PFAS) profile of the Charleville Fire and Rescue station in-ground tank.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS (0.029 µg/L) concentration in the in-ground tank water. The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (mAFFF) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

m_{AFFF} = 0.029 x 5136 x 0.50
= 74.472 µg (= 0.000074472 g) of PFOS

= 0.000074472 x 100 / 1 (1% PFOS)	or	= 0.000074472 x 100 / 5 (5% PFOS)
= 0.00745 g		= 0.00149 g
= 7.5 mg		= 1.5 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the Charleville Fire and Rescue station in-ground water tank is between 0.002 to 0.008 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Oakey Fire and Rescue station

Oakey Fire and Rescue station is a new station built in 2017 on the same site of the previous site where the soil samples were collected. It is located on a major road within a commercial/residential area. The station houses two appliances and support vehicles and is crewed by auxiliary firefighters. No in-ground water tank has ever existed at the site. Soil samples were collected from the station for PFAS analysis

Figure SWR 5

Oakey Fire and Rescue station location of the in-ground water tank and surrounding suburban setting.

Oakey Results

Oakey Fire and Rescue station is one of the four South Western Region sites that were checked for an in-ground water tank. This study investigated for PFAS contamination by collecting and analysing water samples from the site.

Phase One investigations

Oakey Fire and Rescue station had no in-ground tank at the time of sampling. However, two soil samples, one adjacent to the training area and one from adjacent nature strip outside the station were collected for PFAS analysis.

Phase Two investigations

No Phase Two samples were collected from this station.

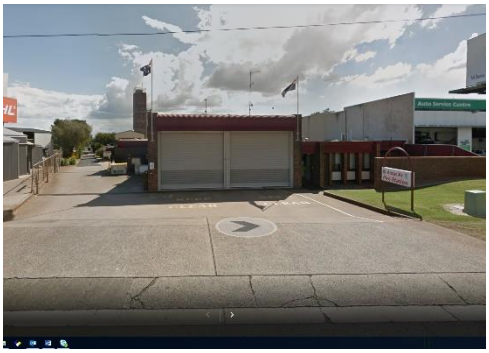
Analyte Name	PFAS Sample Analyses						Biological Analyses	
	Water (μg/L)			Soil (mg/kg)			Water Samples (CFU/100ml)	
	LOR	Tap	Tank	LOR	Street	Yard	Tank	Tap
Biological Test								
E. coli								
Coliforms								
Enterococci								
PFAS Chemical Test								
Perfluorobutanoic acid (PFBA)				0.005	<LOR	<LOR		
Perfluoropentanoic acid (PFPeA)				0.002	<LOR	<LOR		
Perfluorohexanoic acid (PFHxA)				0.001	<LOR	<LOR		
Perfluoroheptanoic acid (PFHpA)				0.001	<LOR	<LOR		
Perfluorooctanoic acid (PFOA)				0.002	<LOR	<LOR		
Perfluorononanoic acid (PFNA)				0.001	<LOR	<LOR		
Perfluorodecanoic acid (PFDA)				0.001	<LOR	<LOR		
Perfluoroundecanoic acid (PFUDA)				0.002	<LOR	<LOR		
Perfluorododecanoic acid (PFDoA)				0.002	<LOR	<LOR		
Perfluorotridecanoic acid (PFTrDA)				0.007	<LOR	<LOR		
Perfluorotetradecanoic acid (PFTeDA)				0.01	<LOR	<LOR		
Perfluorohexadecanoic acid				Not Reported				
Perfluorooctadecanoic acid								
Perfluorobutanesulfonic acid (PFBS)				0.001	<LOR	<LOR		
Perfluorohexanesulfonic acid (PFHxS)				0.001	<LOR	<LOR		
Perfluorooctanesulfonic acid (PFOS)				0.001	0.003	0.010		
Perfluorodecanesulfonic acid (PFDS)				0.002	<LOR	<LOR		
2-perfluorohexyl ethanoic acid (FHEA)				0.002	< LOR	< LOR	<LOR	<LOR
2-Perfluoroocty ethanoic acid (FOEA)				0.02	<LOR	<LOR		
2-Perfluorodecyl ethanoic acid (FDEA)				0.02	<LOR	<LOR		
4:2 Fluorotelomer sulfonic acid (4:2 FTS)				0.002	<LOR	<LOR		
6:2 fluorotelomer sulfonate (6:2 FTS)				Not Reported				
8:2 Fluorotelomer sulfonic acid (8:2 FTS)				0.005	<LOR	<LOR		
Total PFAS					**0.003**	**0.010**		

Table SWR 2

Phase One water and soil sample analyses from Oakey Fire and Rescue station.

The soil analyses show the PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) (0.010 mg/kg)] were below the DES ERA60 Waste Disposal Model Operating Conditions for material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg). These two values are also below the soil criteria applied to human health exposure guidelines for industrial or commercial land use (PFOA = 50 mg/kg and ∑ (PFOS + PFHxS) = 20 mg/kg) published in the Australian *PFAS National Environmental Management Plan NEMP,*[124] Table SWR 2.

Toowoomba (Anzac Avenue) Fire and Rescue station



The Anzac Avenue Fire and Rescue station is an older style Permanent station built prior to 1970. It has two engine bays with side attached rooms housing one fire-fighting appliance. The station is crewed by permanent firefighters. Co-located at the rear of the station is the training facility where BA-Hazmat operate, a station tower and smoke room. Located at the rear of the training station car park is a large concrete in-ground tank (2300 x 12400 x 5800 mm; capacity 165400 L) that was empty at the time of checking. The tank had three entry point with 64 mm coupling threads in each. The tank had not been used for 8 – 10 years and was visually very dry.

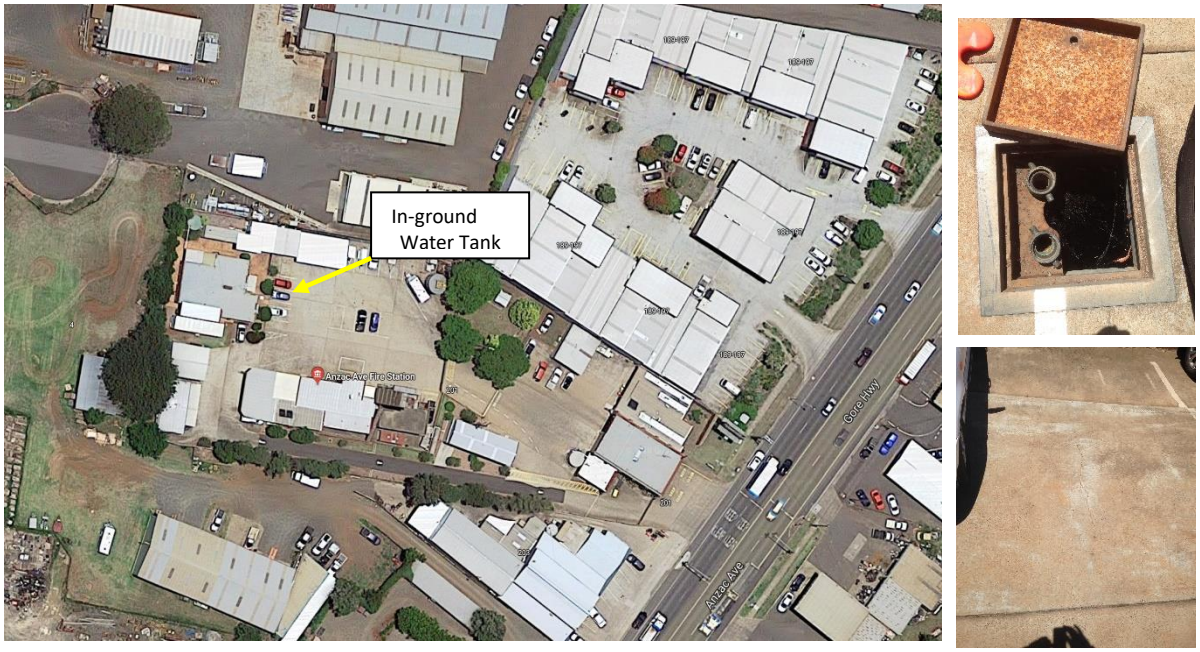


Figure SWR 6

Anzac Avenue Fire and Rescue station and surrounding suburban setting.

Toowoomba (Anzac Avenue) Results

Anzac Avenue Fire and Rescue station is one of the four South Western Region sites that were checked for an in-ground water tank. This study investigated for PFAS contamination by collecting and analysing water samples from the site.

Phase One investigations

No Phase One samples were collected from this station.

Phase Two investigations

Anzac Avenue Fire and Rescue station had an in-ground tank that was empty and dry at the time of sampling. No water had been put into the tank for several years.

Crows Nest Fire and Rescue station

The Crows Fire and Rescue station is an older style station built prior to 1970. It has a small engine bay with side attached rooms housing one fire-fighting appliance. The station is crewed by auxiliary firefighters. This station had never had an in-ground water tank.

Figure SWR 7

Moranbah Fire and Rescue station location of the in-ground water tanks and surrounding suburban setting.

Crows Nest Results

Crows Nest Fire and Rescue station was one of four identified South Western Region sites suspected of containing an in-ground water tank.

Phase One investigation

This station was not involved in Phase One tests.

Phase Two investigation

There was no in-ground tank at the time of testing. No samples were collected. Advice was that there had never been an in-ground water tank.

Summary of South Western Region Results

Phase One Investigation

Oakey Fire and Rescue station was selected for Phase One investigations. However, no water samples were collected because Oakey station had no in-ground water tank. Soil samples were collected and analysed for PFAS contamination. The soil analyses show that both PFOA (<LOR mg/kg) and ∑(PFOS + PFHxS) (0.01 mg/kg)] were below the DES ERA60 Waste Disposal Model for Capping materials [PFOA (16 mg/kg) and PFOS (6 mg/kg)] and NEMP[124] health exposure guidelines for industrial or commercial land use (PFOA = 50 mg/kg and ∑ (PFOS + PFHxS) = 20 mg/kg).

Phase Two Investigation

This study involved inspecting the remaining three stations identified that may have contained an in-ground tank - Toowoomba (Anzac Avenue), Crows Nest and Charleville. However, Crows Nest had no in-ground tank, and the Anzac Avenue station in-ground water tank was empty and very dry. The only station to have an in-ground water tank in use was Charleville where water samples were collected for analysis.

The Charleville in-ground tank water analyses showed detectable levels of PFAS (0.099 µg/L) which comprised of approximately equal contributions the two PFAA moieties (PFCA, and PFSA). The PFOA (0.01 µg/L) and ∑(PFOS + PFHxS) (0.052 µg/L) were both below the Australian health guidelines for recreational and drinking water, (Figure SWR 8). Together with the TOPA (0.17 µg/) analysis, the PFOA and ∑(PFOS + PFHxS) results for the Charleville tank water were below Queensland Government environmental water discharge criteria.

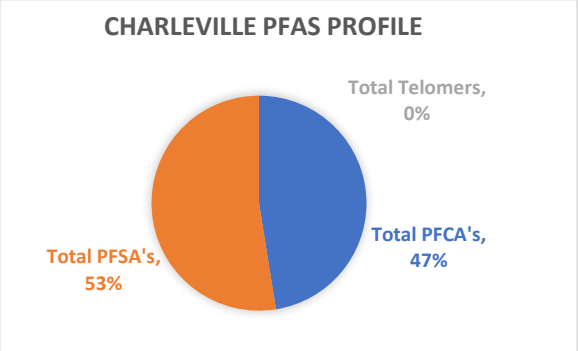


Figure SWR 8

PFAS molar profile of the Charleville in-ground tank.

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through biotransformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

The Charleville in-ground tank water showed the presence of two PFAA moieties (PFCA and PFSA). These moieties and other undetected species can be highlighted by the difference (delta Δ values) between the TOPA and the initial of PFAS concentrations, (Table SWR 3, Figure SWR 4). The Charleville delta values show increases in four PFCA homologues [PFPeA, PFHxA, PFHpA, PFOA] and a decrease in the acid (PFBA) and three PFSA homologues [PFBS, PFHxS, acid (PFOS)]. The increases in these homologues are consistent with the biotransformation of PFAS foam products, (Table SWR 3 and Figure SWR 4).

PFAS Standard Compounds	LOR	Charleville			Oakey		Anzac Avenue (TWBA)			Crows Nest		
		Water			Soil							
		PFAS	TOPA	Delta	PFAS	TOPA						
	µg/L	µg/L	µg/L	µg/L	µg/L	µg/L						
Perfluorobutanoic acid (PFBA)	0.01	0.02	0.01	0.01	Blank	station						
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.01	0.01	<LOR	<LOR						
Perfluorohexanoic acid (PFHxA)	0.005	0.011	0.033	0.033	<LOR	<LOR						
Perfluoroheptanoic acid (PFHpA)	0.005	0.006	0.011	0.011	<LOR	<LOR						
Perfluorooctanoic acid (PFOA)	0.007	0.01	0.015	0.015	<LOR	<LOR						
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR						
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR			<LOR	<LOR						
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.008	0.008	<LOR	<LOR						
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.023	0.04	0.04	<LOR	<LOR						
Perfluorooctanesulfonic acid (PFOS)	0.005	0.029	0.04	0.04	0.003	0.010						
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR						
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR			<LOR	<LOR						
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR			<LOR	<LOR						
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR			<LOR	<LOR						
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR			<LOR	<LOR						
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR			<LOR	<LOR						
Perfluorodectyl ethanoic acid (FDEA)	0.01	<LOR			<LOR	<LOR						
Total PFAS		**0.099**			**0.003**	**0.010**						
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19		**0.17**			**1.8**						

Table SWR 3

Total PFAS contaminant assay of water in South Western region in-ground water tanks and soil. All station town water samples tested less than level of reporting (<LOR).

Investigation of Potential PFAS Contamination of the Queensland Combined Emergency Services Academy

The Queensland Combined Emergency Services Academy (QCESA), located at Whyte Island Brisbane, is a purpose-built training, management and learning complex offering a range of specialised education and training facilities for emergency services personnel. QCESA supports the education and training of staff and volunteers through state-based program management teams, builds community resilience through programs and resources and develops workplace/organisational emergency management capabilities for the Queensland Fire and Emergency Services (QFES). QCESA provides both classroom and practical based training for emergency response agencies including:

- Fire and Rescue;
- Rural Fire Service;
- State Emergency Service;
- Queensland Ambulance Service; and
- Other agencies such as Queensland Police Service or industry groups.

PFAS Investigations and Contamination Criteria

In 2016 the Queensland Department of Environmental and Science (DES) released guidelines for the storage, use, disposal and subsequent remediation of contamination by fire-fighting foams containing fluorinated components. The QFES Research and Scientific Branch (RSB) has undertaken a testing regime to determine the level and extent, if any, perfluoroalkyl substances (PFAS) contamination at QFES sites with existing in-ground water tanks. The AFFF (Aqueous Film Forming Foam) project was undertaken in two phases.

Phase One of the investigation focused on water samples from in-ground tanks and adjacent town water supply collected and analysed for the presence of PFAS and biological contamination. Soil samples from the station yard and a site adjacent to, but off the station confines were also collected and analysed for PFAS contamination. The following criteria were used for Phase One of the study:

- The interim Australian health-based water quality guidelines for
    - PFOA: recreational water (50 µg/L); and drinking water (5 µg/L);
    - ∑(PFOS + PFHxS): recreational water (5 µg/L); and drinking water (0.5 µg/L);
- DES ERA60: Material used in Capping: PFOA (16 mg/kg) and PFOS (6 mg/kg); and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

Phase Two of the investigation involved sampling and analysing water from all in-ground water tanks and town supplies for PFAS contamination. The following criteria were set for Phase Two of the study and applied to the results:

- The Australian health-based water quality guidelines for
    - PFOA: recreational water (5.6 µg/L); and drinking water (0.56 µg/L);
    - ∑ PFOS + PFHxS: recreational water (0.7 µg/L); and drinking water (0.07 µg/L); and
- The DES interim water release guidelines: PFOS (0.3 µg/L), PFOA are (0.3 µg/L) and TOPA including C_4-C_8 sulfonates (1 µg/L). The alternative ∑PFOS+PFHxS (0.3 µg/L) measure has also been applied.

In-ground Tank Sampling

This study involved collecting water samples from eight in-ground water tanks located on the main campus of QCESA. No samples were collected for one in-ground tank that was empty at the time of sampling. No visible foaming was present in the in-ground tank water, or after agitation of the collected sample.

Phase One investigations

No Phase One investigations were conducted at QCESA.

Phase Two investigations

No samples were collected from the empty in-ground water tank SS6.

Twelve water samples were collected for PFAS and TOPA analyses, three each from the in-ground water tanks (SS1), (SS2), (SS5) and (WW2) - two in-ground tank water samples and a sample of rinsate collected from the sample probe pre-use cleaning wash.

Four water samples were collected from the in-ground tank (SS4) -two in-ground water tank samples, a sample of rinsate collected from the sample probe pre-use cleaning wash and a deionised water (rinsate) sample for PFAS and TOPA analyses.

Five water samples were collected from the in-ground tank (WW1) - four in-ground water tank samples (duplicate set for quality control) and a sample of rinsate collected from the sample probe pre-use cleaning wash for PFAS and TOPA analyses.

Twelve water samples were collected, six each from the in-ground tanks (SS3) and (WW3) - two in-ground water tank samples, two town water samples, a sample of rinsate collected from the sample probe pre-use cleaning wash and a travel blank for PFAS and TOPA analyses.

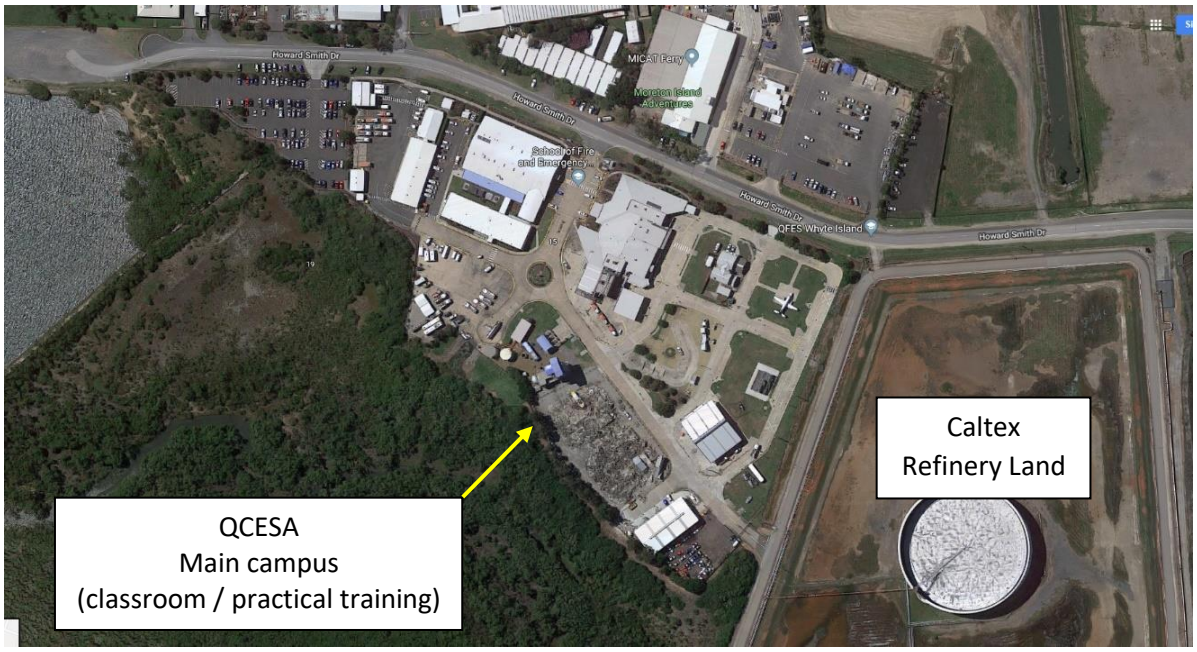
Combined Emergency Services Academy

The Combined Fire and Emergency Services Academy (QCESA) was built and has operated since 2001 and is the emergency services site for all class room and practical based training. Co-located on the site is the Queensland Ambulance Service training, Queensland Fire and Emergency Services (QFES) training and administration staff and a hot fire campus. Nine concrete in-ground water tanks are used for pump testing and water drafting training. The in-ground tanks are covered by steel plates to prevent the ingress of surface water. They are interconnected and fed by a recirculating water system, managed on-site. Water was collected on one occasion from eight of the in-ground tanks. The locations and sizes of the QCESA in-ground water tanks are shown in Table QC 1 and Figure QC 1.

	WW1	WW2	WW3	SS1	SS2	SS3	SS4	SS5	SS6
Diameter (mm)	2500	2500	2500	3200	3200	3200	3200	3200	3200
Depth (mm)	5700	6200	6400	4800	5200	5200	5400	5200	5200
Volume (L)	27980	30440	31420	38850	41800	41800	43430	41800	41800
% full at time of sampling	90	75	75	50	25	63	85	50	0

Table QC 1

QCESA in-ground tank sizes and water capacities



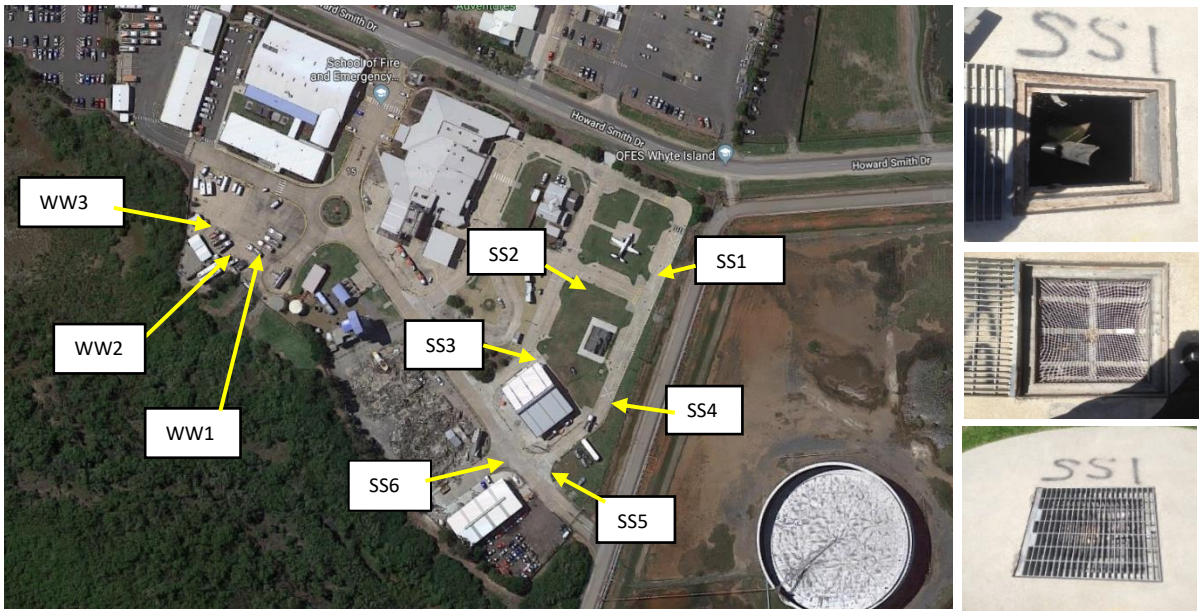


Figure QC 1

Combined Emergency Services Academy in-ground water tank locations.

QCESA Results

QCESA is the QFES training academy site containing nine in-ground water tanks. This study investigated for in-ground tank water PFAS contamination by collecting and analysing water samples from the site.

Phase Two investigation

Thirty-three water samples were collected from eight QCESA in-ground water tanks for PFAS and TOPA analyses; eighteen in-ground water tank samples, four town water samples, eight sample of rinsate collected from the sample probe pre-use cleaning wash, a rinse water blank, and two travel blanks.

The QCESA in-ground tanks are located in two groups on the training campus. The first group includes the three in-ground tanks WW1, WW2 and WW3. These were originally built for water drafting training and were being used for pump testing on fire appliances. The results for the three WW in-ground tanks and tap samples are shown in Table QC 2.

The Phase Two in-ground tank water analysis (Table QC 2) shows the total PFAS range for the WW in-ground tanks (1.4 – 1.7 µg/L) is comprised predominately of two PFAA moieties (PFCA and PFSA). The exception is WW1 where PFT is observed albeit at the level of reporting. Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of PFAS contamination in all three in-ground tanks. The PFT (telomer) and/or PFCA (carboxylic acid) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure QC 2).

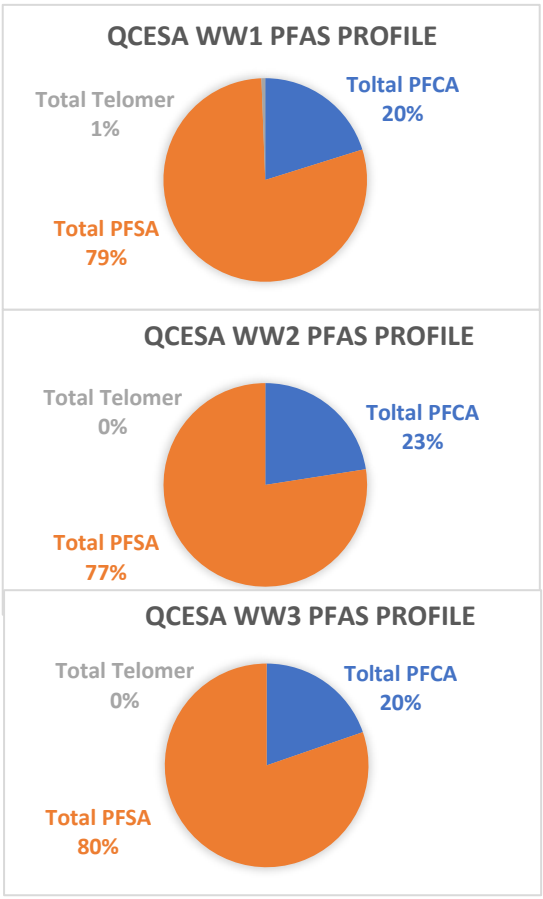


Figure QC 2
PFAS molar profile of the QCESA WW In-ground tanks.

The WW in-ground tank water analyses show PFOA (0.039 - 0.058 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) (1.08 – 1.32 µg/L) wwas above both drinking and recreational water guidelines, (Figure QC 3).

Consideration of the Queensland Government environmental water discharge criteria shows PFOA was below the discharge criteria, but ∑(PFOS + PFHxS) and TOPA (1.8 – 2.1 µg/L) were both significantly above their respective discharge values.

The WW in-ground tank water analyses showed the PFAS precursors in WW1 [PFCA (0.34 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA), PFSA (1.32 µg/L from PFBS, PFHxS, PFOS) and PFT (0.01 µg/L from 6:2 FTS)], WW2 [PFCA (0.33 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA) and PFSA (1.12 µg/L from PFBS, PFHxS, PFOS)] and WW3 [PFCA (0.33 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA) and PFSA (1.36 µg/L from PFBS, PFHxS, PFOS)] that may oxidise or biotransform over time, (Table QC 2, Figure QC 4).

PFAS Standard Compounds	LOR	Tap	QCESA WW1				QCESA WW2				QCESA WW3			
			PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS
	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.04	0.08	0.04	2.0	0.04	0.08	0.04	2.0	0.04	0.08	0.04	2
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.058	0.076	0.018	1.3	0.057	0.058	0.001	1.0	0.065	0.076	0.011	1.2
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.13	0.41	0.28	3.2	0.14	0.39	0.25	2.8	0.13	0.43	0.3	3.3
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.049	0.038	-0.01	0.78	0.049	0.033	-0.02	0.67	0.054	0.041	-0.01	0.76
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.058	0.055	-0.003	0.95	0.039	0.065	0.026	1.7	0.045	0.056	0.011	1.2
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				<LOR				<LOR			
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.036	0.034	-0.002	0.94	0.037	0.032	-0.01	0.85	0.041	0.033	-0.01	0.81
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.38	0.41	0.03	1.1	0.37	0.42	0.05	1.1	0.4	0.49	0.09	1.2
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.9	0.9	0	1.0	0.71	0.78	0.07	1.1	0.92	0.87	-0.05	0.95
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				<LOR				<LOR			
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.01				<LOR				<LOR			
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				<LOR				<LOR			
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				<LOR				<LOR			
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				<LOR				<LOR			
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				<LOR				<LOR			
Total PFAS		**<LOR**	**1.66**				**1.44**				**1.70**			
TOTAL C_4-C_{14} Carboxylic acids				0.7				0.6				0.7		
TOTAL C_4-C_{10} Sulfonic acids				1.3				1.2				1.4		
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19			**2.0**				**1.8**				**2.1**		

Table QC 2

Water sample analyses from QCESA WW1, WW2, WW3 in-ground tanks and town water.

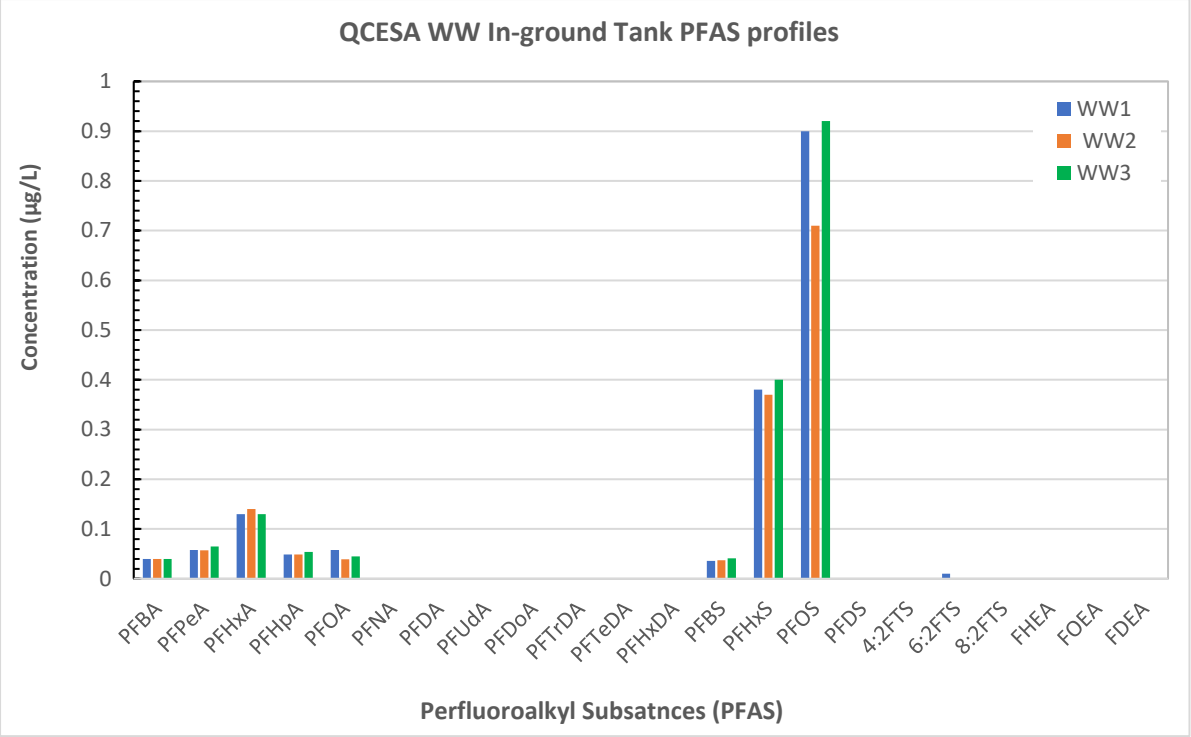


Figure QC 3

Perfluoroalkyl substances (PFAS) profile of the QCESA WW in-ground tanks.

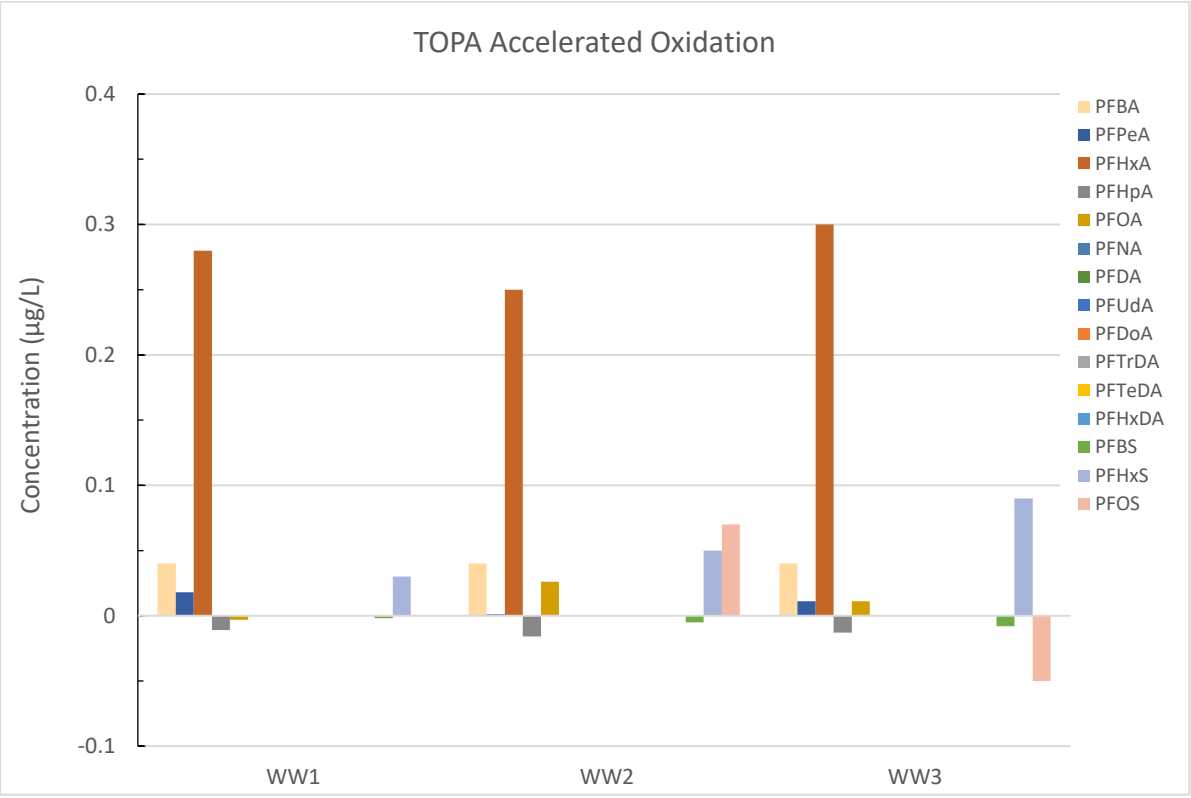


Figure QC 4

TOPA perfluoroalkyl substances (PFAS) profile of the QCESA in-ground tanks WW1, WW2, WW3.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS concentrations in the water from in-ground tanks WW1 (0.9 µg/L), WW2 (0.71 µg/L) and WW3 (0.92 µg/L). The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (m_{AFFF}) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

WW 1: m_{AFFF} = 0.9 x 27980x 0.9
= 22663.8 µg (= 0.0226638 g) of PFOS
= 0. 0226638 x 100 / 1 (1% PFOS) or = 0.00024991 x 100 / 5 (5% PFOS)
= 2.27 g = 0.453 g
= 2270 mg = 453 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA WW1 in-ground water tank is between 0.5 to 22 g.

WW 2: m_{AFFF} = 0.71 x 30440 0.75
= 16209.3 µg (= 0.0162093 g) of PFOS
= 0. 0162093 x 100 / 1 (1% PFOS) or = 0.0162093 x 100 / 5 (5% PFOS)
= 1.62 g = 0.324 g
= 1620 mg = 324 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA WW2 in-ground water tank is between 0.3 to 2 g.

WW 3: m_{AFFF} = 0.92 x 31420 0.75
= 21679.8 µg (= 0.0216798 g) of PFOS
= 0. 0216798 x 100 / 1 (1% PFOS) or = 0.021678 x 100 / 5 (5% PFOS)
= 2.17 g = 0.434 g
= 2168 mg = 434 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA WW3 in-ground water tank is between 0.4 to 2 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

The second cluster of QCESA in-ground tanks are located in and around the road crash rescue site and adjacent to the Hazmat training site. The second group incudes the six in-ground tanks SS1 to SS6, built for water drafting training and currently used for water capture on the site. The results for the five SS in-ground tanks containing water and tap samples are shown in Tables QCESA 3 - 4.

PFAS Standard Compounds	LOR	Tap	QCESA SS1				QCESA SS2				QCESA SS3			
			PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS
	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	0.05	0.12	0.070	2.4	0.06	0.15	0.090	2.5	0.07	0.14	0.07	2.0
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.1	0.14	0.040	1.4	0.14	0.17	0.030	1.2	0.11	0.038	-0.072	0.35
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.26	1	0.740	3.9	0.26	1.4	1.140	5.4	0.26	1.3	1.04	5.0
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.071	0.068	-0.003	1.0	0.088	0.076	-0.012	0.86	0.076	0.027	-0.049	0.36
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.074	0.1	0.026	1.4	0.083	0.11	0.027	1.3	0.091	0.086	-0.005	0.95
Perfluorononanoic acid (PFNA)	0.007	<LOR	0.012	0.01	-0.002	0.83	0.015	0.014	-0.001	0.93	0.014	0.013	-0.001	0.93
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				<LOR				<LOR			
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.069	0.062	-0.007	0.90	0.064	0.054	-0.01	0.84	0.071	0.062	-0.009	0.87
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.9	1	0.100	1.1	1.1	1.2	0.10	1.1	1	1.1	0.100	1.1
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	2	2.1	0.100	1.1	3.2	3.5	0.30	1.1	2.7	2.8	0.100	1.0
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	< LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				<LOR				<LOR			
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	0.02				0.05				0.03			
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				<LOR				<LOR			
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				<LOR				<LOR			
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				<LOR				<LOR			
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				<LOR				<LOR			
Total PFAS		**<LOR**	**3.6**				**5.1**				**4.4**			
TOTAL C_4-C_{14} Carboxylic acids				1.5				1.9				1.6		
TOTAL C_4-C_{10} Sulfonic acids				3.2				4.8				3.9		
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19			**4.7**				**6.7**				**5.5**		

Table QCESA 3

Water sample analyses from QCESA SS1, SS2, SS3 in-ground tanks and town water.

PFAS Standard Compounds	LOR	Tap	QCESA SS4				QCESA SS5				QCESA SS6			
			PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS	PFAS	TOPA	Delta	TOPA/PFAS
	µg/L	µg/L	µg/L	µg/L	µg/L		µg/L	µg/L	µg/L		µg/L	µg/L	µg/L	
Perfluorobutanoic acid (PFBA)	0.01	<LOR	<LOR	0.02	0.02	<LOR	0.04	0.05	0.07	2.4				
Perfluoropentanoic acid (PFPeA)	0.007	<LOR	0.014	0.013	-0.001	0.93	0.057	0.087	0.023	1.3				
Perfluorohexanoic acid (PFHxA)	0.005	<LOR	0.027	0.13	0.103	4.5	0.14	0.25	0.74	4.0				
Perfluoroheptanoic acid (PFHpA)	0.005	<LOR	0.014	0.008	-0.006	0.57	0.049	0.065	-0.015	0.77				
Perfluorooctanoic acid (PFOA)	0.007	<LOR	0.012	0.015	0.003	1.3	0.039	0.071	0.022	1.3				
Perfluorononanoic acid (PFNA)	0.007	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	0.01	0.002	1.2				
Perfluorodecanoic acid (PFDA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
Perfluoroundecanoic acid (PFUdA)	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
Perfluorododecanoic acid (PFDoA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
Perfluorotridecanoic acid (PFTrDA)	0.05	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
Perfluorotetradecanoic acid (PFTeDA)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
Perfluorohexadecanoic acid (PFHxDA)	0.05	<LOR	<LOR				<LOR							
Perfluorobutanesulfonic acid (PFBS)	0.005	<LOR	0.011	0.008	-0.003	0.73	0.064	0.064	-0.002	0.97				
Perfluorohexanesulfonic acid (PFHxS)	0.005	<LOR	0.1	0.12	0.020	1.2	0.91	0.91	0.090	1.1				
Perfluorooctanesulfonic acid (PFOS)	0.005	<LOR	0.24	0.25	0.010	1.0	2	2	0.00	1.0				
Perfluorodecanesulfonic acid (PFDS)	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR				
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	<LOR	<LOR				<LOR							
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.01	<LOR	<LOR				0.02							
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.02	<LOR	<LOR				<LOR							
Perfluorohexyl ethanoic acid (FHEA)	0.2	<LOR	<LOR				<LOR							
Perfluorooctyl ethanoic acid (FOEA)	0.05	<LOR	<LOR				<LOR							
Perfluorodectyl ethanoic acid (FDEA)	0.05	<LOR	<LOR				<LOR							
Total PFAS		**<LOR**	**0.42**				**3.5**							
TOTAL C_4-C_{14} Carboxylic acids				0.2				1.4						
TOTAL C_4-C_{10} Sulfonic acids				0.38				3						
TOPA (incl C_4-C_{10} Sulfonic acids)	0.19			**0.58**				**4.4**						

Table QCESA 4

Water sample analyses from QCESA SS4, SS5 in-ground tanks and town water. Tank SS6 contained no water at time of sampling

The Phase Two SS in-ground tank water analyses (Table QC 3 and Table QC 4) shows the total PFAS (0.42 – 5.1 µg/L) was comprised predominantly of the PFAA moieties (PFCA, PFSA and PFT). The exception is SS4 where PFT was not observed. Comparison of the molar percentages highlights the PFSA (sulfonates) moiety is the highest contribution of the PFAS contamination in all in-ground tanks. The PFT (telomer) and/or PFCA (carboxylic acid) moieties make up the remaining PFAS contamination. The PFSA and PFCA are representative of the older style fluorinated foams, while the PFCA and PFT indicate newer style fluorinated foams, (Figure QC 5).

The SS in-ground tank water analyses show PFOA (0.012 - 0.091 µg/L) was below the Australian health-based guidelines for both drinking and recreational water. However, the ∑(PFOS + PFHxS) range (0.34 – 4.30 µg/L) was above the drinking water guideline for all in-ground tanks. Similarly, all SS in-ground water tanks, except SS4 (0.34 µg/L), were above the recreational water guideline. In-ground tank SS4 was below the recreational water guideline, (Figure QC 6).

Consideration of the Queensland Government environmental water discharge criteria show PFOA was below the discharge criteria. The ∑(PFOS + PFHxS) and TOPA values (0.58 – 6.7 µg/L) were both significantly above their respective discharge values for all tanks except SS4. The TOPA value (0.58 µg/L) for inground water tank SS4 was below the Queensland Government environmental water discharge criteria.

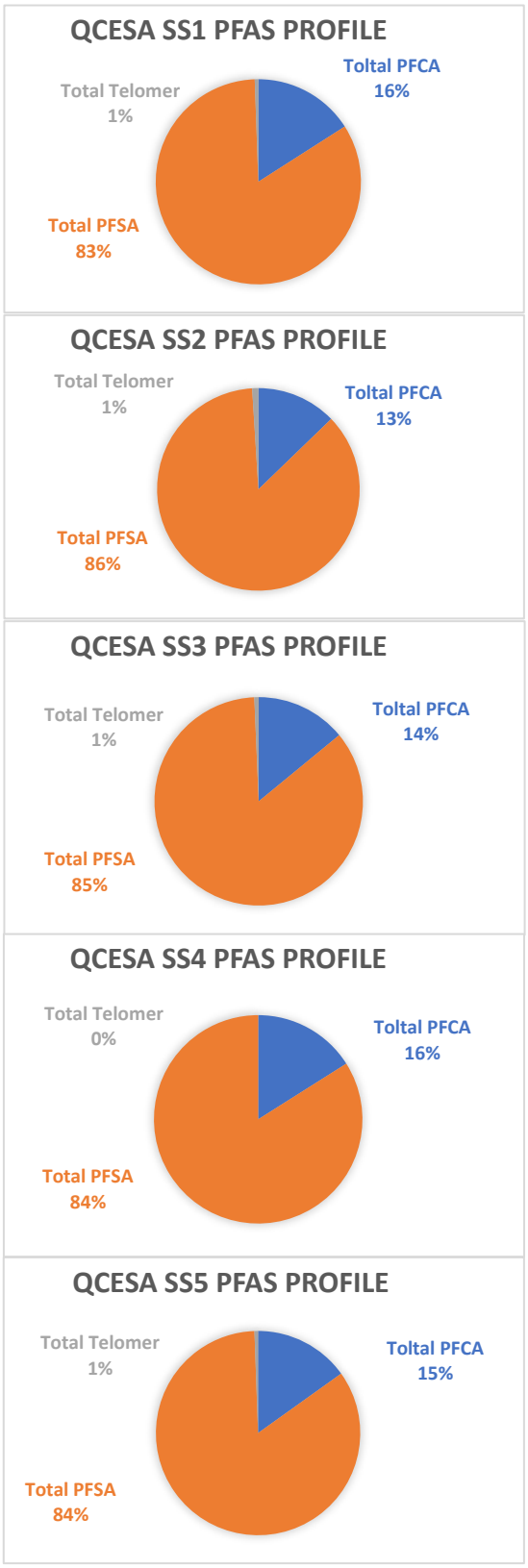


Figure QC 5
PFAS molar profile of QCESA SS In-ground tanks.

The SS in-ground water tank analyses showed the presence of PFAS precursors in SS1 [PFCA (0.57 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (2.97 µg/L from PFBS, PFHxS, PFOS) and PFT (0.02 µg/L from 6:2 FTS)], SS2 [PFCA (0.65 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (4.36 µg/L from PFBS, PFHxS, PFOS) and PFT (0.05 µg/L from 6:2 FTS)], SS3 [PFCA (0.62 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (3.77 µg/L from PFBS, PFHxS, PFOS) and PFT (0.03 µg/L from 6:2 FTS)], SS4 [PFCA (0.067 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA) and PFSA (0.35 µg/L from PFBS, PFHxS, PFOS)] and SS5 [PFCA (0.53 µg/L from PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA), PFSA (3.77 µg/L from PFBS,

PFHxS, PFOS) and PFT (0.02 µg/L from 6:2 FTS)] that may oxidise or biotransform over time, (Table QC 3 and Table QC 4, Figure QC 7).

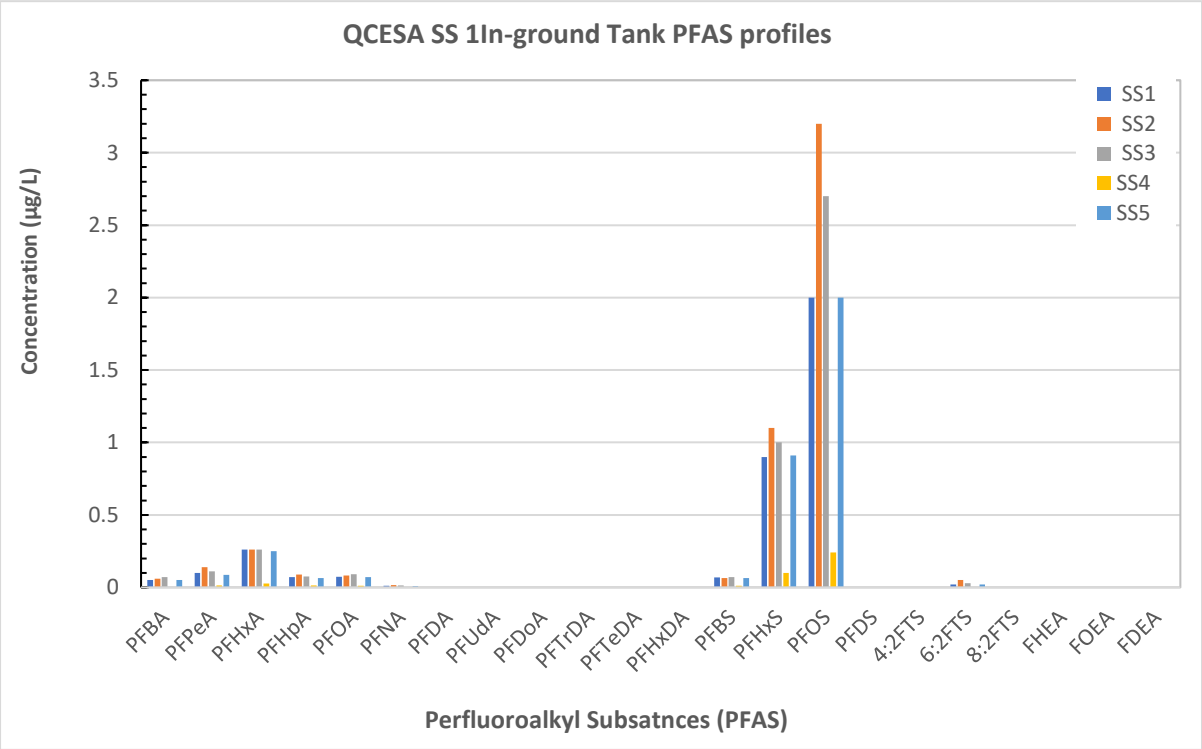


Figure QC 6

Perfluoroalkyl substances (PFAS) profile of the QCESA SS in-ground tanks.

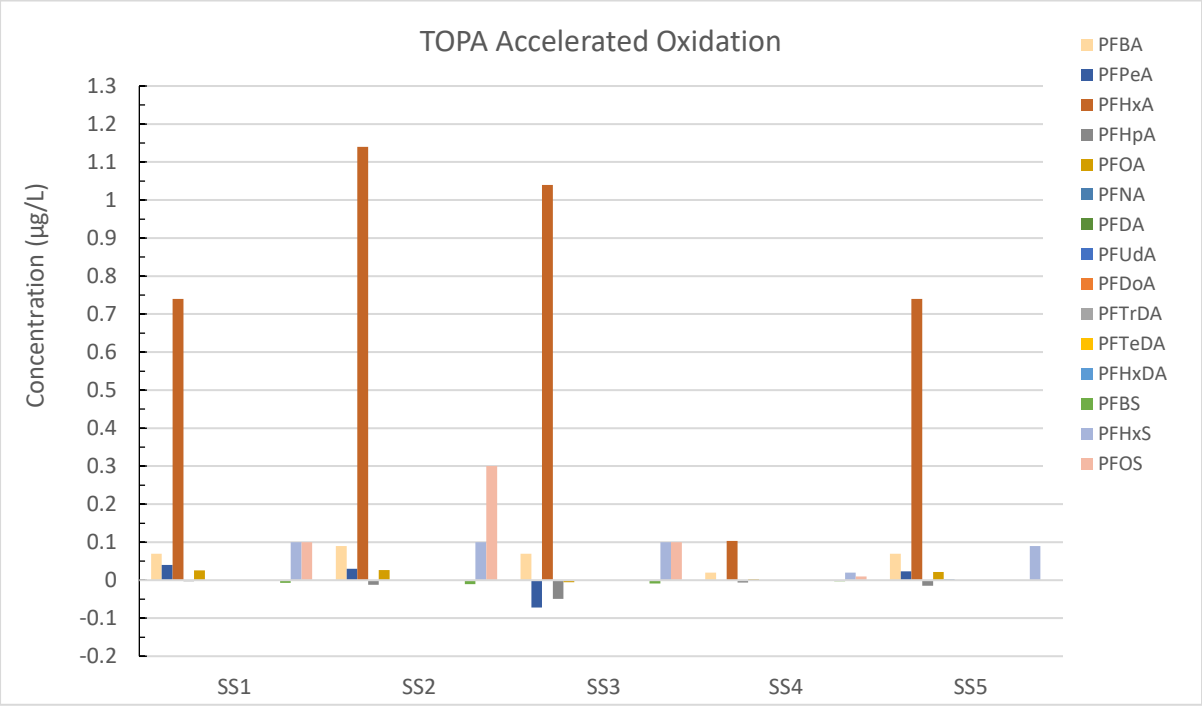


Figure QC 7

TOPA perfluoroalkyl substances (PFAS) profile of the QCESA in-ground tanks SS1, SS2, SS3, SS4 and SS5.

Calculation of PFOS concentrate within the In-ground water tank

The B class foam concentrate 3M Light Water[119] AFFF typically used by QFES prior to 2003 contained 1% to 5 % PFOS. The equivalent amount of foam concentrate within the in-ground tank water can be calculated using the measured PFOS concentrations in the in-ground tank water from SS1 (2.0 µg/L), SS2 (3.2 µg/L), SS3 (2.7 µg/L), SS4 (0.24 µg/L) and SS5 (2.0 µg/L). The total mass of PFOS foam concentrate in the in-ground tank water was calculated based on 3M Light Water AFFF foam concentrate using the following relationship.

Mass AFFF (m_{AFFF}) = concentration PFOS x Volume of tank water x percent full (as fraction) x 1/(fraction of PFOS within concentrate)

SS 1: m_{AFFF} = 2 x 38850 x 0.5
= 38850 µg (= 0.03885 g) of PFOS
= 0. 03885 x 100 / 1 (1% PFOS) or = 0.03885 x 100 / 5 (5% PFOS)
= 3.89 g = 0.777 g
= 3885 mg = 777 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA SS1 in-ground water tank is between 0.8 to 4 g.

SS 2: m_{AFFF} = 3.2 x 41800 0.25
= 33440 µg (= 0.033440 g) of PFOS
= 0. 03344 x 100 / 1 (1% PFOS) or = 0.03344 x 100 / 5 (5% PFOS)
= 3.34 g = 0.669 g
= 3344 mg = 669 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA SS2 in-ground water tank is between 0.7 to 3 g.

SS 3: m_{AFFF} = 2.7 x 41800 x 0.63
= 71101.8 µg (= 0.0711018 g) of PFOS
= 0. 071102 x 100 / 1 (1% PFOS) or = 0.021678 x 100 / 5 (5% PFOS)
= 7.11g = 1.42 g
= 7110 mg = 1422 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA SS3 in-ground water tank is between 1 to 7 g.

SS 4: m_{AFFF} = 0.24 x 43430 x 0.85
= 8859.72 µg (= 0.00885972 g) of PFOS
= 0. 0088597 x 100 / 1 (1% PFOS) or = 0.0088597 x 100 / 5 (5% PFOS)
= 0.886 g = 0.177 g
= 886 mg = 177 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA SS 4 in-ground water tank is between 0.2 to 0.9 g.

SS 5: m_{AFFF} = 2.0 x 41800 0.50

= 41800 µg (= 0.418 g) of PFOS

= 0. 0418 x 100 / 1 (1% PFOS) or = 0.021678 x 100 / 5 (5% PFOS)

= 4.18 g = 0.836 g

= 4180 mg = 836 mg

Thus, the amount of AFFF foam concentrate (as 3M Light Water) within the QCESA SS5 in-ground water tank is between 0.8 to 4 g.

Note: based on the specific gravity of the foam concentrate, the mass of concentrate is approximately equal to the volume of concentrate.

Summary of QCESA Results

The QCESA in-ground tank water analyses showed detectable levels of PFAS contamination in all eight of the sampled tanks. The total PFAS concentration in the WW in-ground tanks (average: 1.6 µg/L, range: 1.4 – 1.7 µg/L) was considerably lower than the SS in-ground tanks (average: 3.4 µg/L, range: 0.43 – 5.1 µg/L). The PFAS profiles of both in-ground tank groups show the WW in-ground tanks are contaminated predominately by the two PFAA moieties (PFCA and PFSA). The exception is WW 1 where the PFT is observed albeit at the level of reporting. Conversely, the SS in-ground tanks are predominately contaminated by the three PFAA moieties (PFCA, PFSA and PFT). The exception is SS 4 where no PFT is observed, (Figure QC 9 and Figure QC 10).

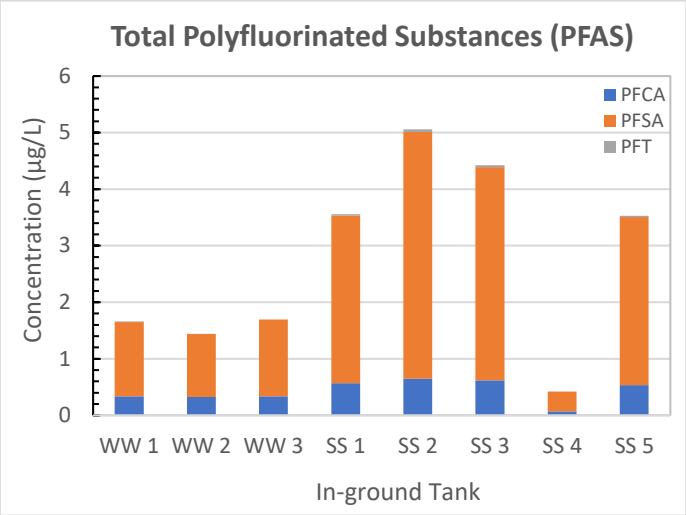


Figure QC 9
PFAS contamination of QCESA in-ground tank water.

The PFOA results show neither in-ground tank group [WW (average 0.05 µg/L, range: 0.039 – 0.058 µg/L), SS (average: 0.066 µg/L, range: 0.012 – 0.091 µg/L)] exceeded the Australian health-based recreational or drinking water guidelines. However, the ∑(PFOS + PFHxS) results from both in-ground tank groups [WW (average 1.2 µg/L, range: 1.44 – 1.70 µg/L), SS (average: 2.8 µg/L, range: 0.34 – 4.30 µg/L)] exceeded the recreational and drinking water guidelines. The in-ground tank SS4 did not exceed the recreational water guideline, but it was interconnected with the remaining tanks in the group. The TOPA results for the in-ground tank group [WW (average 2.0 µg/L, range: 1.80 – 2.10 µg/L), SS (average: 4.4 µg/L, range: 0.58 – 6.70 µg/L)] and the PFOS + PFHxS results for both in-ground tanks group exceeded the Queensland Government environmental water discharge criteria.

Concern for PFAS bio-persistence has been reported for a number of years,[115,116,120-122] but more recently interest has centred on the environmental fate through bio-transformation or oxidation into chemicals of concern, e.g. 8:2FTS telomer forms PFOA. One method of measuring these changes is through TOPA investigations, which accounts for a 73 ± 5 % conversion of the 6:2 FTS fluorotelomer (22% PFBA, 27% PFPeA, 22% PFHxA, 2% PFHpA), and 95 ± 9 % conversion of the 8:2 FTS fluorotelomer (11% PFBA, 12% PFPeA, 19% PFHxA, 27% PFHpA, 21% PFOA, 3% PFNA) into PFCA of concern.[103]

The tanks in the QCESA WW in-ground tank group all contained five of the twelve PFCA homologues (PFBA, PFPeA, PFHxA, PFHpA, PFOA) and three of the four PFSA homologues (PFBS, PFHxS, PFOS). In-ground tank WW1 also contained one of the three PFT homologues (6:2 FTS). The SS in-ground tank group tanks all contained six of the twelve homologues [PFBA, PFPeA, PFHxA, PFHpA, PFOA, PFNA], three of the four PFSA homologues (PFBS, PFHxS, PFOS), and one of the three PFT homologues (6:2 FTS), (Figure QC10). The in-ground tank SS4 had the lowest contamination and no PFNA. The presence of the PFAS that may bio-transform into the chemicals of concern can be highlighted by the differences (delta Δ values) in concentration between the TOPA PFAS and initial PFAS concentrations, (Table QC 2, Table QC 3, Table QC 4, Figure QC 11).

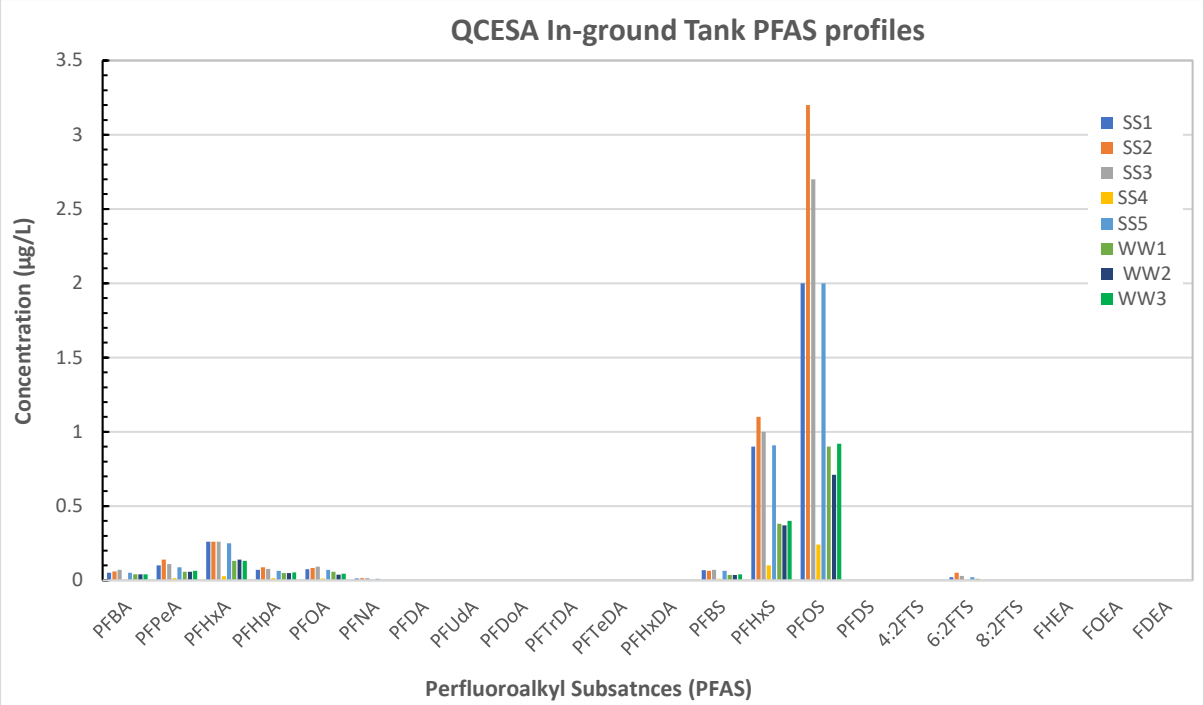


Figure QC 10

Perfluoroalkyl substances (PFAS) profile of the Queensland Combined Emergency Services Academy in-ground tanks.

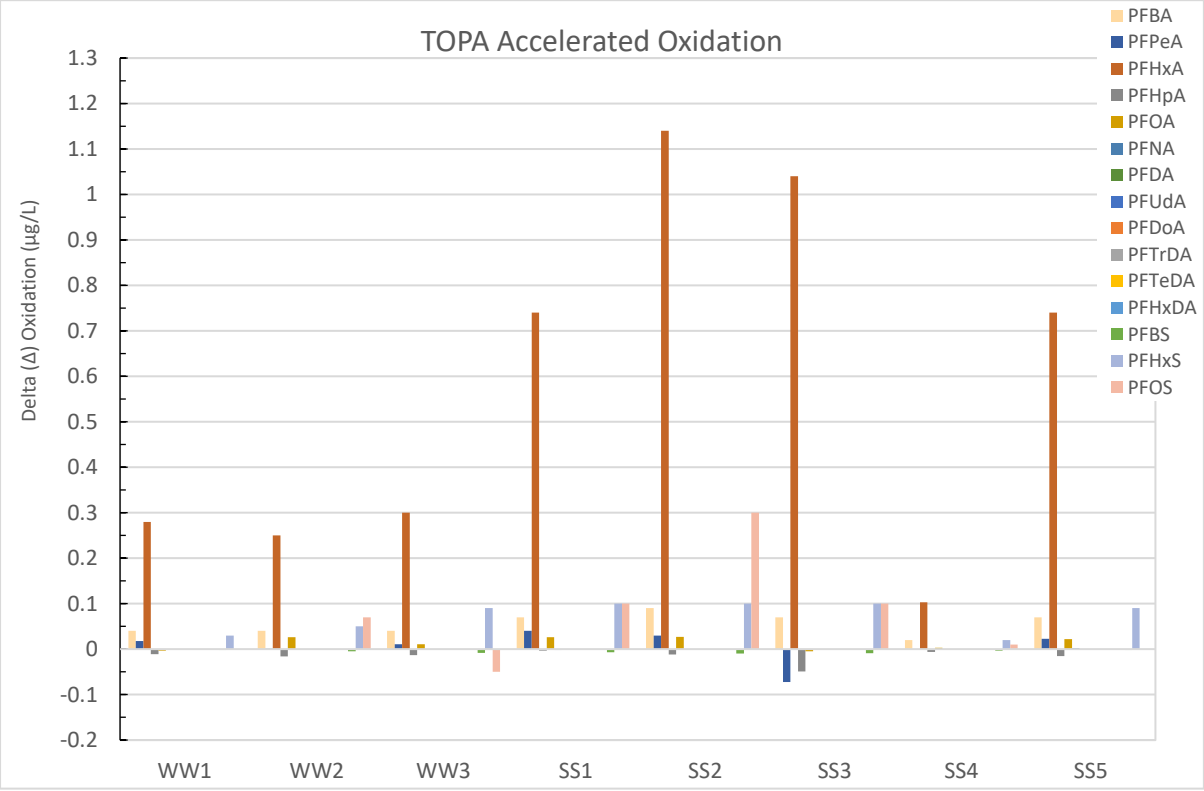


Figure QC 11

Effects of accelerated oxidation on PFAS compounds. Delta (Δ) changes reflect the actual concentration difference of starting from oxidised PFAS contaminates.

Summary of PFAS Contamination based on PFAS, PFOS (∑(PFOS + PFHxS), and TOPA (incl C4-C8 sulfonates)

This section reports the collective Fire and Rescue station and QCESA PFAS results for in-ground tank water and compares them against the established water quality guidelines. The results of interest are:

- PFOA;
- PFOS (∑(PFOS + PFHxS); and
- TOPA (incl C4-C8 sulfonates).

The established Australian health-based and environmental based water quality guidelines[107,132] are:

- PFOA: recreational water 5.6 µg/L; and drinking water 0.56 µg/L;
- PFOS as ∑ (PFOS + PFHxS): recreational water 0.7 µg/L; and drinking water 0.07 µg/L;
- DES interim water release concentrations[32,139]: PFOS as ∑ (PFOS + PFHxS) and PFOA are 0.3 µg/L; and TOPA including C4-C8 sulfonates (PFBS, PFHxS, PFOS, PFOSA, PFDcS) is 1 µg/L; and
- NEMP human health-based soil criteria for industrial/commercial land: PFOA (50 mg/kg) PFOS (20 mg/kg).

The results for all the sites tested in the table (Table 8) on the next two pages. The table is set up in three columns. They are:

- Column one is the PFOA concentration. Where the result exceeds the Australian health-based recreational water guideline it is highlighted in red. Where the result exceeds the Australian health-based drinking water quality guideline it is highlighted in orange;
- Column two is the sum of PFOS and Perfluorohexane sulfonic acid (PFHxS) concentrations. Where the result exceeds the Australian health-based recreational water guideline it is highlighted in red. Where the result exceeds the Australian health-based drinking water quality guideline it is highlighted in orange; and
- Column three is the TOPA (Total Oxidisable Precursor Assay including C4-C8 sulfonates) as described above. Where the result exceeds the Queensland Government environmental water discharge criteria it is highlighted in red. Where the PFOA or ∑(PFOS + PFHxS) concentration exceeded the Queensland Government environmental water discharge criteria the TOPA column is highlighted in yellow.

PFOA (PerFluoro-Octanoic Acid)

The PFOA results are summarised in Table 8 and graphically displayed in Figure 7. The red line in the graph represents the the Australian health-based recreational water quality guideline and the orange line the Australian health-based drinking water quality guideline. The yellow line represents the Queensland Government environmental water discharge criteria.

The results show the PFOA concentration in Gladstone Fire and Rescue station in-ground tank water exceeded the Australian health-based drinking water quality guideline, but not the recreational water quality guideline.[107,132]

Fire and Rescue station	**PFOA** (µg/L)	**PFOS** (∑(PFOS + PFHxS) (µg/L)	**TOPA** (incl C4-C8 sulfonates) (µg/L)
Gladstone	1.4	42	78
Mackay	0.49	5.1	12
Enoggera (Phase One)	0.33	11	-
Enoggera (Phase Two)	0.18	5.7	10
Proserpine	0.011	0.9	2.2
Kemp Place	0.052	0.51	1.8
Cairns (Phase One)	0.044	0.51	-
Cairns (Phase Two)	0.12	1.3	4.3
Cairns South	0.069	1.2	1.8
QCESA WW1	0.058	1.3	2.1
QCESA WW2	0.039	1.1	1.8
QCESA WW3	0.045	1.3	2.1
QCESA SS1	0.074	2.9	4.7
QCESA SS2	0.083	4.3	6.7
QCESA SS3	0.091	3.7	5.4
QCESA SS5	0.071	2.9	4.4
Ayr	0.031	0.12	1.6
Caloundra	0.013	0.48	0.74
QCESA SS4	0.012	0.34	0.58
Noosa Heads	0.011	0.26	0.5
Rockhampton Pit 1 (Phase One)	0.036	0.20	-
Bundaberg	0.025	0.18	0.89
Southport	0.12	0.16	-
Dysart	0.009	0.13	0.29
Rockhampton Pit 2 (Phase Two)	<LOR	0.12	0.50
Arana Hills	0.042	0.12	0.056
Maryborough	0.019	0.091	0.31
Airlie Beach	<LOR	0.097	0.07
Home Hill	<LOR	0.097	<LOR
Townsville	<LOR	0.083	-
Windsor	0.022	0.061	0.67
Annerley	0.01	0.050	0.37
Charleville	0.01	0.052	<LOR
Mt Isa	<LOR	0.024	<LOR
Roma St	<LOR	<LOR	<LOR
Forrest Beach	<LOR	<LOR	<LOR
Sarina	<LOR	<LOR	<LOR
QCESA SS6	-	-	-
Gordonvale	-	-	-
Moranbah	-	-	-
Atherton	-	-	-
Anzac Avenue	-	-	-
Cleveland	-	-	-
Oakey	-	-	-
Yeppoon	-	-	-
Crows Nest	-	-	-

Table 8

PFAS in-ground tank water quality summary results for PFOA, PFOS (∑(PFOS + PFHxS), and TOPA (incl C4-C8 sulfonates).

The PFOA concentration in water within the in-ground tank at all other Fire and Rescue stations and QCESA was less than the Australian health-based recreational water and drinking water guidelines.[107,132] The Gladstone Fire and Rescue station result was almost three times higher than the next highest result at Mackay Fire and Rescue station, and more than 16 times higher than the average PFOA (0.097 µg/L) across all stations and QCESA. Thus, Gladstone Fire and Rescue station was the highest priority site based on the PFOA test results. The median PFOA result (0.031 µg/L) obtained was less than the median PFOA value (0.44 µg/L) reported in leachate from landfill.[130]

PFOS (PerFluoro-Octane Sulfonate) (∑ (PFOS + PFHxS))

The ∑(PFOS + PFHxS results are summarised in Table 8 and graphically displayed in Figure 8. The red line in the graph represents the Australian health-based recreational water quality guideline.[107,132] The Australian health-based drinking water quality guideline and the Queensland Government environmental water discharge criteria are not shown.

The results show that PFOS (∑ (PFOS + PFHxS)) concentration in water within the in- ground tanks at seven Fire and Rescue stations, plus six QCESA in-ground tanks exceeded the Australian health-based recreational water guideline.[107,132] The Fire and Rescue stations were: Gladstone; Mackay; Enoggera; Proserpine; Cairns; and Cairns South. Duplicate samples were taken at Enoggera Fire and Rescue station and Cairns Fire and Rescue station and the result demonstrated a variance of approximately 2. The origin of the difference was not determined. However, there are many explanations that may account for the variance including environmental conditions, and inherent sampling and analytical errors.[135] The highest result was obtained at the Gladstone Fire and Rescue station (42 µg/L), which was more than 4 times higher the next highest result at Enoggera Fire and Rescue station. The value obtained at the Gladstone Fire and Rescue station was also more than 16 times higher than the average ∑(PFOS + PFHxS (2.6 µg/L) result for all stations and QCESA. Thus, Gladstone Fire and Rescue station is the highest priority site to manage based on ∑(PFOS + PFHxS) values. The ∑(PFOS + PFHxS values obtained at the Mackay and Enoggera Fire and Rescue stations were approximately 2 times and 4 times higher, respectively, than the average ∑(PFOS + PFHxS) result obtained. Thus, Mackay and Enoggera Fire and Rescue stations are the next highest priority sites to manage.

The results show that the PFOS (∑ (PFOS + PFHxS)) concentration in the water within the in-ground tank at thirteen Fire and Rescue stations and a sampling site at QCESA exceeded the Australian health-based drinking water guideline.[107,132] These Fire and Rescue stations were: Ayr; Caloundra; Bundaberg; Maryborough; Noosa Heads; Home Hill; Townsville; Airlie beach; Dysart; Rockhampton; Arana Hills; Kemp Place, and Southport.

The results show that PFOS (∑ (PFOS + PFHxS)) concentration in the water within the in-ground tank at all other (seven) Fire and Rescue stations and a further sampling site at QCESA were less than the Australian health-based drinking water guidelines.[107,132] These Fire and Rescue stations were: Mt Isa; Forrest Beach; Sarina; Annerley; Windsor; Roma St, and Charleville. The values reported in this study were significantly less than PFOS (∑ (PFOS + PFHxS)) groundwater values obtained in studies of Oakey Army Aviation Centre and similar sites.[85,96,133,135,143] The median PFOS (∑ (PFOS + PFHxS)) result (0.41 µg/L) was less than the median PFOS (∑ (PFOS + PFHxS)) (0.66 µg/L) value reported in leachate from landfill[130].

TOPA Including (C4-C8 sulfonates)

The TOPA (incl C4-C8 sulfonates) is a measure of (C4-C14) perfluoroalkyl acid precursors that are not measured in the standard analytical suite. They are substances that are transformed in the environment to perfluoroalkyl acids (PFAA) by natural processes.[103,115,116,123,144,145] It is another analytical approach applied to inform understanding the extent of PFC contamination arising from AFFF use within the environment.

The TOPA (incl C4-C8 sulfonates) results are summarised in Table 8 and graphically displayed in Figure 9. The red line in the graph represents the Queensland Government environmental water discharge criteria.[32,139]

The results show that the TOPA (incl C4-C8 sulfonates) concentration within the in-ground tank water at nine Fire and Rescue stations and QCESA exceeded the interim water release concentration (as per DES Environmental Management of Firefighting Foam Table 6.4.2).[32,139] These Fire and Rescue stations were: Gladstone; Mackay; Enoggera; Proserpine; Cairns; Cairns South; Ayr; Caloundra; and Kemp Place. Thus, the water within the in-ground water tanks at these sites cannot be directly discharged to the environment.

The Gladstone Fire and Rescue station TOPA result was amost 7 times higher than the next highest result at Mackay Fire and Rescue station, and more than 14 times higher than the average TOPA (5.5 µg/L) across all stations and QCESA. Thus, Gladstone Fire and Rescue station was the highest priority site to manage, followed by Mackay and Enoggera Fire and Rescue stations as the next highest priority sites.

The TOPA (incl C4-C8 sulfonates) results for in-ground water tanks at all the other Fire and Rescue stations were less than the Queensland Government environmental water discharge criteria (as per DES Environmental Management of Firefighting Foam). [32,139]

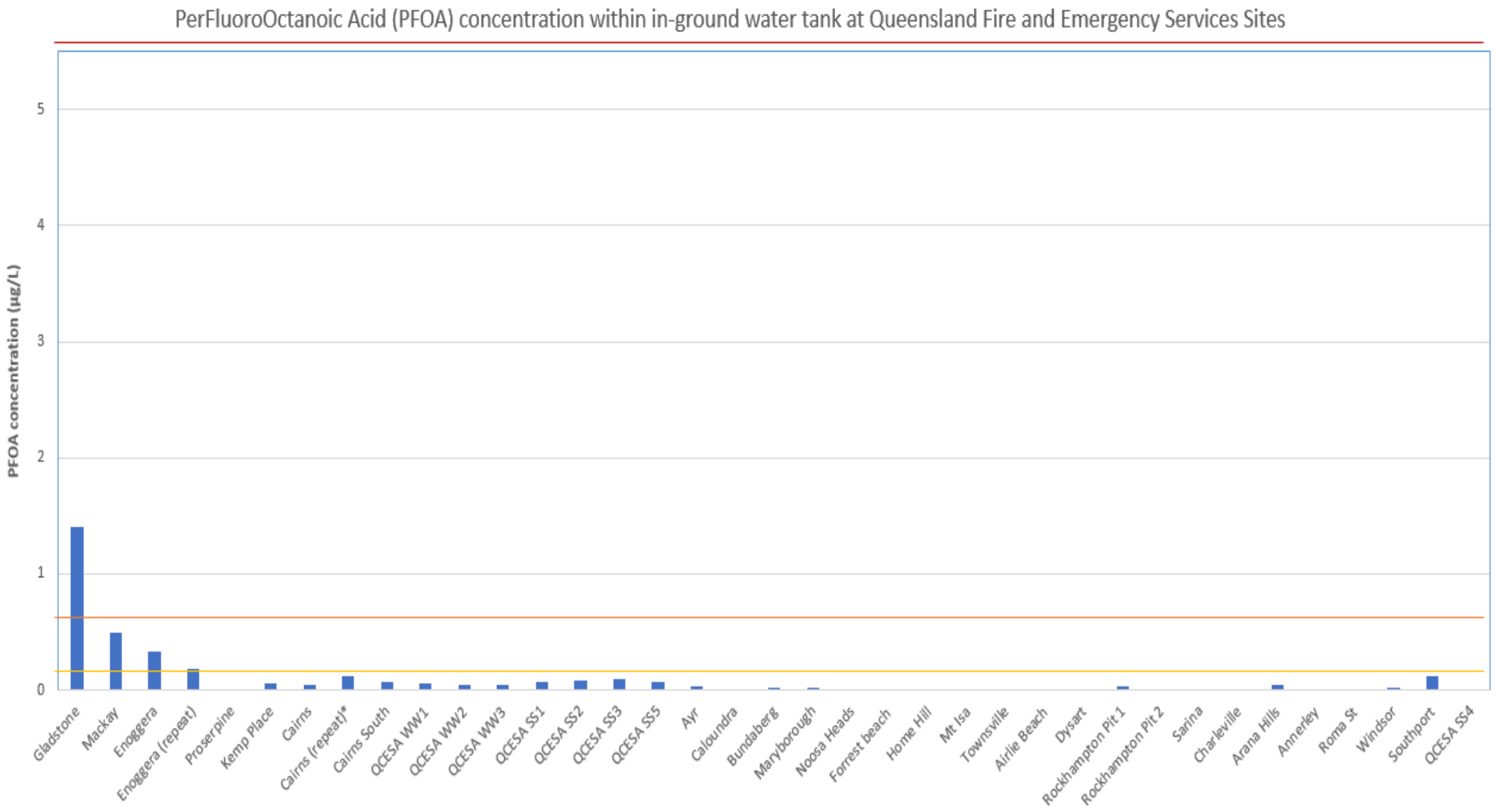


Figure 7

Perfluoro-octanoic Acid (PFOA) concentration within in-ground tank water as a function of Fire and Rescue stations and QCESA.

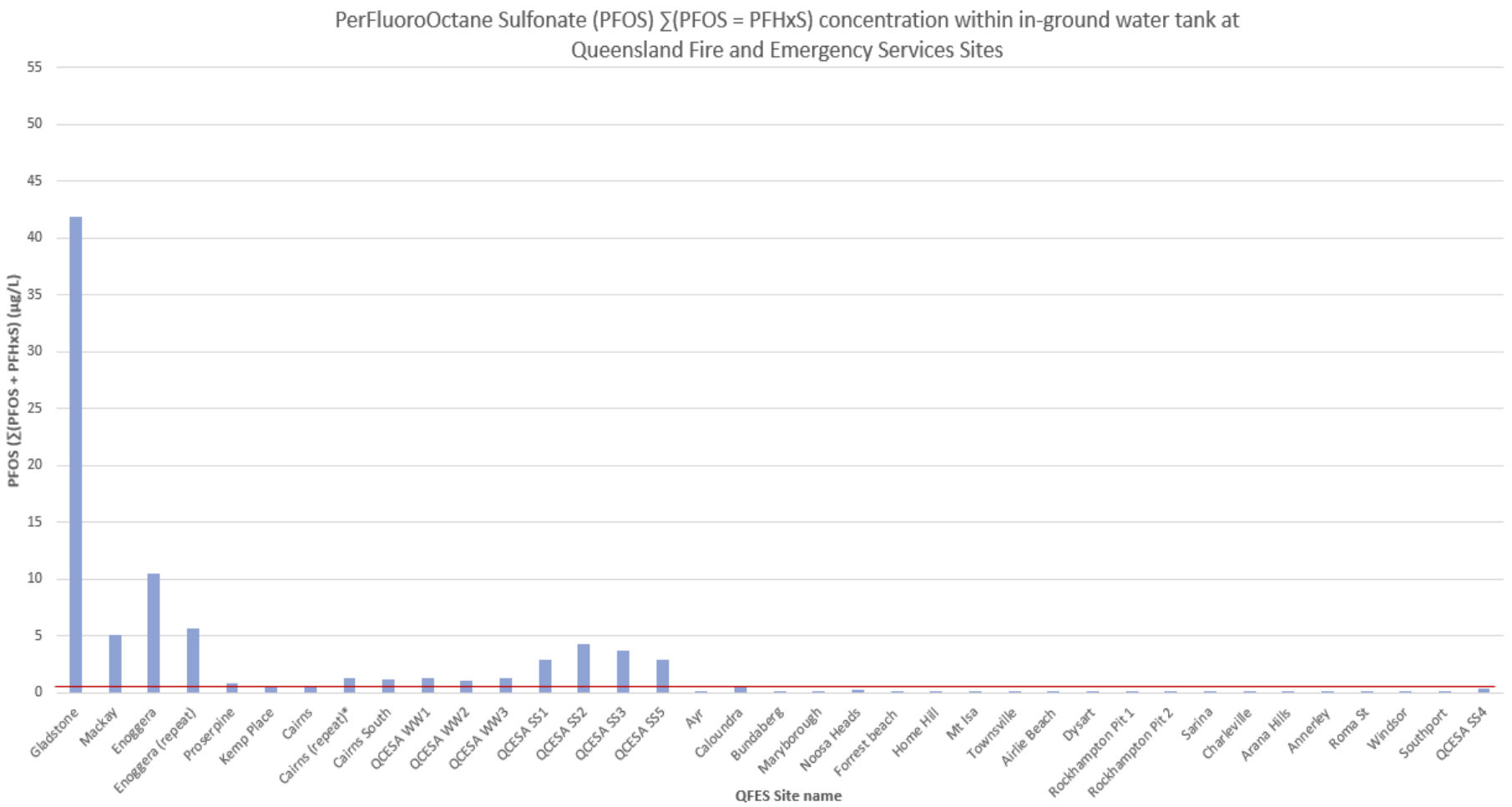


Figure 8

Perfluorooctane sulfonate (PFOS (∑(PFOS + PFHxS)) concentration within in-ground water tanks as a function of Fire and Rescue station and QCESA.

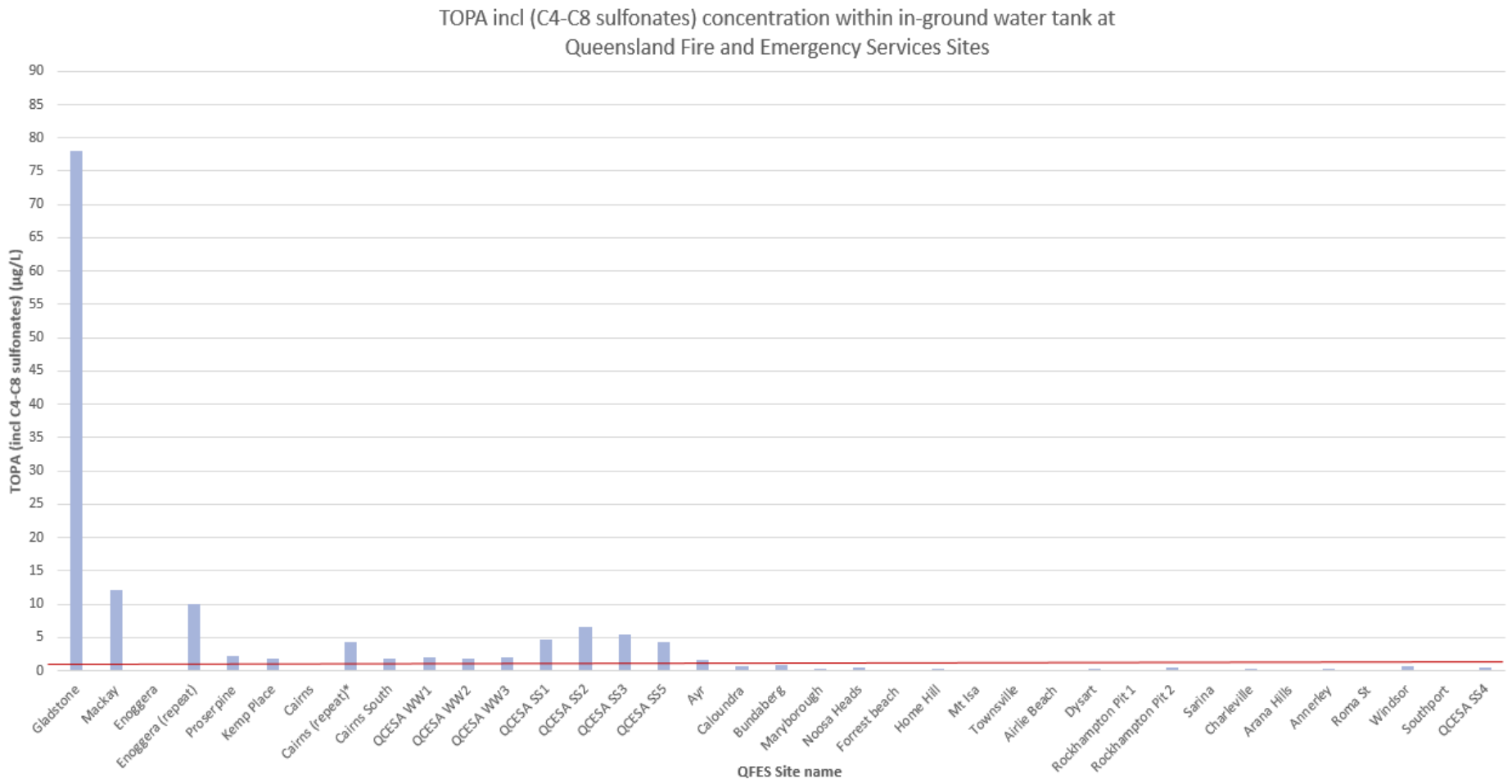


Figure 9

Total Oxidisable Precursor Assay [TOPA (incl C4-C8 sulfonates)] concentration within in-ground tank water as a function of Fire and Rescue station and QCESA.

Conclusions and Recommendations

This section is separated into three parts.

- General conclusion;
- Recommendations about Fire Stations and QCESA in the study; and
- General recommendations for QFES to consider.

General Conclusion

The concentration and distribution of perfluoroalkyl substances (PFAS) within in-ground tank and tap water was characterised at thirty Fire Stations and QCESA. The microbiological water quality and PFAS concentration and distribution within soil was characterised at seven Fire Stations. The in-ground water tanks at eight Fire Stations were not sampled since the tanks were absent or empty.

The PFAS results showed the level of contaimination at all Fire Stations was less than the the human health-based soil criteria for industrial/commercial land, and the values at which soil can be applied as cover materials for landfills.

The results of the microbiological testing of water sampled in Phase One showed that concentration of microbiological organisms met the standards for Class A water.

The concentration of PFOA in the in-ground tanks for all Fire Stations, except Gladstone, was less than the Australian health-based PFOA drinking water guideline. Gladstone Fire Station exceeded the Australian health-based PFOA drinking water guideline.

The highest PFAS water concentrations were obtained at Gladstone Fire Station. Mackay and Enoggera Fire Stations exhibited the next two highest PFAS water concentrations. The results for these three Fire Stations together with Proserpine, Cairns and Cairns South all exceeded the ∑(PFOS + PFHxS) Australian health-based recreational water guideline and the Queensland Government environmental water discharge criteria for TOPA.

The PFAS water concentrations obtained for the majority of sites tested at QCESA also exceeded the ∑(PFOS + PFHxS) Australian health-based recreational water guideline and Queensland Government environmental water discharge criteria for TOPA. QCESA has unique circumstances where the water is continuously recycled for use at the facility. During the study opportunities were identified to consider enhancing water treatment approaches at QCESA.

The PFAS water results for Kemp Place, Ayr, Caloundra, Bundaberg, Noosa Heads, Home Hill, Townsville, Airlie Beach, Arana Hills and Southport Fire Stations were all greater than the ∑(PFOS + PFHxS) Australian health-based drinking water guideline, but less than the recreational water quality guideline. The PFAS water results for Kemp Place, Ayr and Caloundra also exceeded the Queensland Government environmental water discharge criteria for TOPA and/or the ∑(PFOS + PFHxS) release value. Thus, the PFAS results for the remaining Fire Stations were less than the ∑(PFOS + PFHxS) Australian health-based drinking water guideline, (Table 8).

Recommendations about Fire Stations and QCESA in this study

The results of the investigation of PFAS contamination of in-ground tank water have shown the PFAS concentration and distribution within the majority of in-ground water tanks are less than the recreational water guideline and environmental discharge criteria applied in the study. Nonetheless, the results have been used in the development of a risk-based approach to manage the PFAS contamination within the existing in-ground water tanks. The results obtained in this study are sufficiently novel to publish in a peer reviewed journal to further inform Fire and Emergency Services internationally.

The recommendations are listed in order of priority and include further explanation where appropriate. The actions considered varied from maintaining status quo, discharging the water or treating/removing the water.

Priority One - Gladstone Fire Station

The in-ground water tank PFAS concentration was the highest obtained of all sites sampled. A reasonable explanation relates directly to using AFFF foam sourced in the past few years. This water cannot be discharged directly to the environment.

It is considered prudent, and hence recommended that the water from the in-ground water tank be removed and treated at an approved facility. It is also recommended that the in-ground water tank be filled with a suitable gravel or a similar inert material and capped with concrete (of suitable thickness and strength) to render it inoperative.

Priority Two - Mackay and Enoggera Fire Station

The in-ground water tank PFAS concentrations at Mackay Fire Station and Enoggera Fire Stations were the next highest obtained of all sites sampled. This water cannot be discharged directly to the environment.

It is considered prudent, and hence recommended that the water from the in-ground water tank be removed and treated at an approved facility. It is also recommended that the in-ground water tanks be filled with a suitable gravel or a similar material and capped with concrete (of suitable thickness and strength) to render them inoperative.

Priority Three - Queensland Emergency Services Combined Academy (QCESA)

The operating environment at QCESA incorporates unique circumstances compared with the Fire Stations sampled in this study. The water is continuously recycled for use at the facility. Excess water required during peak demands is drawn directly from town supply. Furthermore, in some instances excess water is released directly to the environment. The study identified opportunities to address more globally the water management arrangements at QCESA.

There is regular microbiological testing of the water. However, it is not clear the QCESA monitoring program is sufficiently broad to ensure that the water meets established water quality guidelines for such use, or that an adverse change in water quality would be readily detected. It is recommended that QCESA consider establishing an ongoing water monitoring program at a suitable frequency that characterises both biological and chemical constituents. This program would provide a water quality baseline and changes in water quality would be readily identified in a timely manner.

The results showed there were PFA'S present within the water and at levels that the water cannot in general be discharged directly to the environment. Removing the PFAS contaminated water is not

likely to be an adequate risk control measure since it cannot be discounted that any new water refilling the tanks is free of residual PFAS sourced from the local environment. Consequently, there is an opportunity for QCESA to review, and if appropriate, improve water purification arrangements for the recycled water including removing any PFA'S within the water. It is recommended QCESA engage an appropriate consultant to review, and if appropriate, provide a strategy to enhance the water treatment facilities on site to assure the water quality meets established guidelines. This should also include establishing a suitable and cost-effective treatment system to remove the residual PFAS detected in the water. The strategy can then be considered by the QFES as an element of the QCESA site arrangements. The strategy provides a long-term water quality management road map to ensure QCESA's water and water quality needs and likely regulatory requirements are met in the future.

Priority Four - Cairns, Proserpine, Ayr, Kemp Place and Caloundra Fire Stations

The PFAS in-ground tank water concentrations at the Cairns, Proserpine, Ayr, Kemp Place and Caloundra Fire Stations cannot be discharged directly to the environment. Based on the relative PFAS concentrations there are several approaches that can be adopted to manage this water including:

- Applying the existing arrangements (status quo);
- Removing water from the in-ground water tank for treatment at an approved facility on a risk basis; and
- Treating water in-situ to remove the PFAS contaminants.

The first option is not favoured since the concern remains and if the criteria become more stringent the perception about the adequacy of the QFES practices and ultimate treatment/disposal costs may significantly increase. The second option is a prudent approach and can be implemented using a tiered approach. The third option whilst feasible is not likely to be significantly more cost effective than the second option.

It is recommended that the second option be considered and also the in-ground water tanks be filled with a suitable gravel or a similar material and capped with concrete (of suitable thickness and strength) to render them inoperative.

Priority Five - All Other Fire Stations

The PFAS in-ground tank water concentrations at all the other Fire Stations were less than the criteria (levels of concern) applied. It is recommended the QFES consider establishing a water management program for the remaining in-ground water tanks. This may include: status quo; removal; or discharge of the water directly to the environment. If option two (removal) is selected the in-ground water tanks should be filled with a suitable gravel or a similar material and capped with concrete (of suitable thickness and strength) to render them inoperative.

General Recommendations

The QFES has approximately 242 urban Fire Stations incorporating a variety of designs and layouts. In-ground water tanks were identified at 31 Fire and Rescue Stations during this investigation. These stations have historically developed local management arrangements regarding the use and maintenance of the in-ground water tanks. These local arrangements also include capturing rainwater run-off, pump testing, and water drafting training and exercising.

There is merit for the QFES to review, and where appropriate modify QFES doctrine about foam training at Fire and Rescue stations. The review would assure QFES practices are contemporary and consistent with the DES Operational Policy Environmental Management of Firefighting foam.

There is merit for the QFES to review, and where appropriate modify QFES doctrine about pump testing and drafting practise and exercising at Fire stations or a nominated location. The review would assure the QFES practices are contemporary and meet our readiness objectives and community expectations.

It is not clear why 13% of Fire and Rescue Stations have an in-ground water tank. Consequently, there is merit to consider the purpose of the in-ground water tanks, their suitability and ultimate fate. If appropriate the arrangements regarding the use of the in-ground tanks should be modified to reflect contemporary practices, and consideration given to render the in-ground water tanks inoperative over an agreed time frame. This approach will assist standardising the design and layout across all urban and Fire and Rescue Stations.

This program provides an opportunity to implement an education program within the QFES:

- Environmental management strategy adopted and the proactive actions of the QFES;
- Communication of the findings of the AFFF investigation program within QFES and specific areas of PSBA;
- Highlight QFES policy regarding foam training, drafting and pump testing arrangements; and
- Highlight QFES policy regarding acceptance of foam and other materials at QFES Facilities.

This program also provides an opportunity to communicate to the broader community about Environmental management strategy adopted and the proactive actions of the QFES.

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Supplementary Data

Appendix A

Phase One

Laboratory analyses Data

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0051857
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 09-Sep-2016
Date Commenced	: 13-Sep-2016
Laboratory Number/s	: 16KS955 – 16KS958

Submitting Authority :

Number of Samples : 4

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : Please note that the two water samples have been reported separately.
6:2 FTS is normally not reported in soil because of blank contamination.

The LCMS screen (Liquid Chromatogrphy Mass Spectrometry) orbitrap also indicated the presence of the following compounds in sample 16KS958:
(FOSA) Perfluorooctanesulfonamide
(PFDoS) Perfluorododecanesulfonic acid
(PFHpS) Perluoroheptanesulfonic acid
(N-EtFOSA) N-ethylperfluorooctyl sulfonamide
(N-MeFOSA) N-methylperfluorooctyl sulfonamide

Perfluorotetradecanoic acid (PFTeDA) has a low recovery.

Results in this report have been authorised for release by M. du Plessis

M du Plessis

Martha du Plessis
Chemist, Organics Laboratory
13-Oct-16

16KS955-958

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Client Reference					Sample 3	Sample 4
Sample Type					Blank soil	Station yard soil
Sampling Time / Date					11:30 07-09-2016	11:30 07-09-2016
Sample Description					FNR Tap	FNR Case 4 Pit
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS957**	**16KS958**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170
michael.logan@qfes.qld.gov.au

ATTN: Attn - Michael Logan

Laboratory Reference	: SSP0051857
Client Order No.	: Bott_R
Date Received	: 09-Sep-2016
Date Commenced	: 13-Sep-2016
Laboratory Number/s	: 16KS955-16KS958

Number of Samples : 4

Method/s of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : Please note that the soil samples 16KS957 (FNR Tap), 16KS958 (FNR Case 4 Pit) will be reported separately.

The liquid chromatography mass spectrometry screen (Orbitrap) indicated the presence of the following substances in the listed samples:

16KS956 6:2 Fluorotelomer sulfonic acid (6:2 FTS) at 0.15 ug/L
16KS956 8:2 Fluorotelomer sulfonic acid (8:2 FTS) at 0.13 ug/L

16KS956 Perfluorooctanesulfonamide (FOSA),Perfluorododecanesulfonic acid (PFDoS), Perfluoroheptanesulfonic acid (PFHpS). Please note that no quantitation is available for these compounds.

Martha du Plessis
Chemist, Organic Chemistry
21-Sep-16

NATA Accredited Laboratory 41

16KS955-16KS958

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Client Reference				FNRTAP	FNRCASE4PIT
Sample Type				Water Tap	Water
Sampling Time/Date				10:30 07-Sep-2016	10:30 07-Sep-2016
Sample Description				Station Tap	Case 4 Pit
Method	Perfluorinated Compounds	Units	Reporting Limit	16KS955	16KS956
32403	Perfluorobutanoic acid	µg/L	0.005	< 0.01	**0.027**
32403	Perfluoropentanoic acid	µg/L	0.01	< 0.007	**0.08**
32403	Perfluorohexanoic acid	µg/L	0.005	< 0.005	**0.11**
32403	Perfluoroheptanoic acid	µg/L	0.005	< 0.005	**0.045**
32403	Perfluorooctanoic acid	µg/L	0.005	< 0.007	**0.065**
32403	Perfluorononanoic acid	µg/L	0.005	< 0.007	< 0.007
32403	Perfluorodecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluoroundecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluorododecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorotridecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid	µg/L	0.005	< 0.005	**0.018**
32403	Perfluorohexanesulfonic acid	µg/L	0.005	< 0.005	**0.21**
32403	Perfluorooctanesulfonic acid	µg/L	0.005	< 0.005	**0.30**
32403	Perfluorodecanesulfonic acid	µg/L	0.005	< 0.02	< 0.02

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Laboratory Services
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Certificate of Analysis

Final Report

Project No: 082001
Report ID: 19823

Attention: **Ray Bott**
Client: **Queensland Fire and Emergency Service**
Address: PO Box 280
WESTCOURT QLD 4870

Date Received: **7/09/2016 12:30pm**
Date Issued: **08-Sep-2016**

The sample(s) referred to in this report were analysed by the following method(s):

Analysis	*Method*	*Laboratory*	*NATA Accredited*
Coliforms	USEPA 1604	Cairns Regional Council Water & Waste (Accreditation # 14206)	✓
Intestinal Enterococci	TPB080	Cairns Regional Council Water & Waste (Accreditation # 14206)	✓

The result(s) in this report were authorised by:

Name	*Title*	*Qualifications*
Murray Revell	Scientist (Microbiology)	B. App. Sci., Grad. Dip.
Siobhan Barrett	Scientist (Microbiology)	B. Sc. (Hons) Medical Lab Science., M.Phil.

Principal Contact for this Report:

Dr. Francoise Pieltain
Laboratory Coordinator
Ing.Agr., Ph.D MRACI C Chem

NATA 14206 Chemical & Biological Accredited for compliance with ISO / IEC 17025.

Cairns Regional Council
Water and Waste

Client: Queensland Fire and Emergency Service

Project No: 082001
Report ID: 19823
Date Issued: 08-Sep-2016
Page 2 of 2

LRN: 422868
Tap water
Date Sampled: 07-09-2016 11:30am
Received at Lab: 07-09-2016 12:35pm

	Method	Analyte	Result	LOR	Guideline	Date Started
	Microbiology					
422870	Intestinal Enterococci		<1 CFU/100mL	<1		07-09-2016
422870	Coliforms	E. coli	<1 CFU/100mL	<1		07-09-2016
	Coliforms	Total coliforms	<1 CFU/100mL	<1		07-09-2016

LRN: 422869
Case 4 Pit
Date Sampled: 07-09-2016 11:30am
Received at Lab: 07-09-2016 12:35pm

	Method	Analyte	Result	LOR	Guideline	Date Started
	Microbiology					
422871	Intestinal Enterococci		est 3 CFU/100mL	<1		07-09-2016
	Uncertainty is increased due to the low number of colonies isolated, therefore the result above is an estimated value.					
422871	Coliforms	E. coli	<1 CFU/100mL	<1		07-09-2016
	Coliforms	Total coliforms	>100 CFU/100mL	<1		07-09-2016

Explanatory Notes for this Project

Responsibility for sampling lies with the CUSTOMER. Samples analysed as received.

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0051976
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 20-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS1029 – 16KS1032

Submitting Authority :

Number of Samples :4

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : Please note that the water samples have been reported separately.

6:2 Fluorotelomer sulfonic acid (6:2 FTS) is normally not reported because of blank contamination in soils.

Results in this report have been authorised for release by M. du Plessis

Martha du Plessis
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14-Oct-16

16KS1029-16KS1032

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Client Reference					Sample 1	Sample 2
Sample Type					soil	soil
Sampling Time / Date					16-09-2016	16-09-2016
Sample Description					NRT-BLANK	NRT-YARD
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS1029**	**16KS1030**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007	**0.038**
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	**0.004**	**0.005**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

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ATTN: Attn - Michael Logan

Laboratory Reference : SSP0061976
Client Order No. : BOTT_R
Date Received : 20-Sep-2016
Date Commenced : 27-Sep-2016
Laboratory Number's : 16KS1029-16KS1032

Number of Samples : 4

Method's of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : Please note that the soil samples 16KS1029 (NRT-Blank), 16KS1030 (NRT-Yard) will be reported separately.

The following substances were not detected at the LOR below in the listed samples:
16KS1031, 16KS1032

2-Perfluorooctyl ethanoic acid (FOEA) < 0.05 ug/L
2-Perfluorodecyl ethanoic acid (FDEA) < 0.05 ug/L
4:2 Fluorotelomer sulfonic acid (4:2 FTS) < 0.005 ug/L
6:2 Fluorotelomer sulfonic acid (6:2 FTS) < 0.01 ug/L
8:2 Fluorotelomer sulfonic acid (8:2 FTS) < 0.02 ug/L

Please note that NATA accreditation does not cover the performance of this service.

Martha du Plessis
Chemist, Organic Chemistry
05-Oct-16

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16KS1029-16KS1032

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70000-0253 Printed: 10:19 05-Oct-16 mcclpl

Client Reference					Sample 1	Sample 2
Sample Type					soil	soil
Sampling Time / Date					16-09-2016	16-09-2016
Sample Description					NRT-BLANK	NRT-YARD
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS1029**	**16KS1030**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007	**0.038**
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	**0.004**	**0.005**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170
michael.logan@qfes.qld.gov.au

ATTN: Attn - Michael Logan

Laboratory Reference	: SSP0051976
Client Order No.	: BOTT_R
Date Received	: 20-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS1029-16KS1032

Number of Samples : 4

Method/s of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : Please note that the soil samples 16KS1029 (NRT-Blank), 16KS1030 (NRT-Yard) will be repported separately.

The following substances were not detected at the LOR below in the listed samples:
16KS1031, 16KS1032

2-Perfluorooctyl ethanoic acid (FOEA) < 0.05 ug/L
2-Perfluorodecyl ethanoic acid (FDEA) < 0.05 ug/L
4:2 Fluorotelomer sulfonic acid (4:2 FTS) < 0.005 ug/L
6:2 Fluorotelomer sulfonic acid (6:2 FTS) < 0.01 ug/L
8:2 Fluorotelomer sulfonic acid (8:2 FTS) < 0.02 ug/L

Please note that NATA accreditation does not cover the performance of this service.

Martha du Plessis
Chemist, Organic Chemistry
05-Oct-16

NATA Accredited Laboratory 41

16KS1029-16KS1032

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Client Reference				NRTTAP	NRTCASE4PIT
Sample Type				Water	Water
Sampling Time/Date				??:?? 16-Sep-2016	??:?? 16-Sep-2016
Sample Description					
Method	Perfluorinated Compounds	Units	Reporting Limit	16KS1031	16KS1032
32403	Perfluorobutanoic acid	µg/L	0.005	< 0.01	**0.010**
32403	Perfluoropentanoic acid	µg/L	0.01	< 0.007	< 0.007
32403	Perfluorohexanoic acid	µg/L	0.005	< 0.005	**0.008**
32403	Perfluoroheptanoic acid	µg/L	0.005	< 0.005	< 0.005
32403	Perfluorooctanoic acid	µg/L	0.005	< 0.007	< 0.007
32403	Perfluorononanoic acid	µg/L	0.005	< 0.007	< 0.007
32403	Perfluorodecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluoroundecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluorododecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorotridecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid	µg/L	0.005	< 0.005	**0.006**
32403	Perfluorohexanesulfonic acid	µg/L	0.005	< 0.005	**0.042**
32403	Perfluorooctanesulfonic acid	µg/L	0.005	< 0.005	**0.041**
32403	Perfluorodecanesulfonic acid	µg/L	0.005	< 0.02	< 0.02

TOWNSVILLE LABORATORY SERVICES
TOWNSVILLE CITY COUNCIL
Delivery Address: Douglas Water Plant, Angus Smith Drive, Douglas, Qld 4814
Postal Address: P.O. Box 1268, Townsville, Qld 4810
Ph 07 4727 8666
e-mail labenquiries@townsville.qld.gov.au

CERTIFICATE OF ANALYSIS

Client:	Prepaid Client
Attention:	Ray Bott
Contact Number:	0417783779
Job Reference:	16-3641
Job Description:	QFES Ray Bott 16/09/16
Sample Condition:	Samples intact and within holding time requirement
Registration Date:	16/09/16
Registration Time:	10:55
Report Date:	19/09/16
Purchase Order Number:	

Peter Mockeridge
Authorised test signatory

ACCREDITED FOR TECHNICAL COMPETENCE

The Townsville Laboratory Services is accredited for compliance with ISO/IEC 17025
NATA is a signatory to the ILAC mutual recognition arrangement for the mutual recognition of the equivalence of testing and inspection reports
Test preceded with asterisk (*) are not yet part of the scope of NATA accreditation.
Results refer only to the samples as received

TOWNSVILLE CITY COUNCIL

Job Reference: 16-3641

	Sample Description: Sample Date and Time: Sample Number: Microbiology (Potable)	Units	NRT CASE 4 PIT 16/09/2016 10:15:00 16-3641-1	TAP BLANK 16/09/2016 10:15:00 16-3641-2
TM_MI10	*Total Coliform*	org/100ml	<1	31
TM_MI10	*E. coli* MPN	org/100ml	<1	<1

	Sample Description: Sample Date and Time: Sample Number: Microbiology (Environmental)	Units	NRT CASE 4 PIT 16/09/2016 10:15:00 16-3641-1	TAP BLANK 16/09/2016 10:15:00 16-3641-2
TM_MI01	*Enterococcus*	org/100ml	<1	<1

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0061950
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 16-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS1000 – 16KS1005

Submitting Authority :

Number of Samples :6

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : Please note that the water samples have been reported separately.

6:2 Fluorotelomer sulfonic acid (6:2 FTS) is normally not reported because of blank contamination in soils.

Perfluorotetradecanoic acid (PFTeDA) has a low recovery

Results in this report have been authorised for release by M. du Plessis

Martha du Plessis
Chemist, Organics Laboratory
18-Oct-16

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Client Reference					Sample 1	Sample 1	Sample 3	Sample 4
Sample Type					soil	soil	Soil	Soil
Sampling Time / Date								
Sample Description					CRY-BLANK	CRY-YARD	CRR- BLANK	CRR-YARD
Method	Perfluorinated Compounds	Guidelines	Units	Reporting Limit	16KS1000	16KS1001	16KS1002	16KS1003
33946	Perfluorobutanoic acid (PFBA)		mg/kg	0.005	< 0.005	< 0.005	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	0.001	< 0.001	0.001	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	0.001	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	0.001	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	0.001	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	0.007	< 0.007	< 0.007	< 0.007	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	0.01	< 0.01	< 0.01	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	0.001	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	0.001	< 0.001	0.012	< 0.001	0.003
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	0.001	< 0.001	2.3	0.008	0.015
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	0.002	< 0.002	0.017	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	2-Perfluorooctyl ethanoic acid (FOEA)		mg/kg	0.02	< 0.02	< 0.02	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	0.02	< 0.02	< 0.02	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	0.002	< 0.002	< 0.002	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	0.005	< 0.005	< 0.005	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170
michael.logan@qfes.qld.gov.au

ATTN: Attn - Michael Logan

Laboratory Reference : SSP0051950
Client Order No. : ADMIN
Date Received : 16-Sep-2016
Date Commenced : 19-Sep-2016
Laboratory Number/s : 16KS1000-16KS1005

Number of Samples : 6

Method/s of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : The liquid chromatography mass spectrometry screen (orbitrap) indicated the presence of the following substances below the LOR in the listed samples: 16KS1004, 16KS1005
6:2 Fluorotelomer sulfonic acid (6:2 FTS) < 0.01 ug/L

The following were not detected at the LOR below:
2-Perfluorooctyl ethanoic acid (FOEA) < 0.05 ug/L
2-Perfluorodecyl ethanoic acid (FDEA) < 0.05 ug/L
4:2 Fluorotelomer sulfonic acid (4:2 FTS) < 0.005 ug/L
8:2 Fluorotelomer sulfonic acid (8:2 FTS) < 0.02 ug/L

Please note that NATA accreditation does not cover the performance of this service

The soil samples 16KS1000 -16KS1003 will be reported separately.

DduPlessis

Martha du Plessis
Chemist, Organic Chemistry
28-Sep-16

NATA Accredited Laboratory 41

16KS1000-16KS1005

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Client Reference				CRRTAPBLANK	CRRCASE4PIT
Sample Type				Water	Water
Sampling Time/Date				00:05 14-Sep-2016	00:05 14-Sep-2016
Sample Description					
Method	Perfluorinated Compounds	Units	Reporting Limit	16KS1004	16KS1005
32403	Perfluorobutanoic acid	µg/L	0.005	< 0.01	**0.020**
32403	Perfluoropentanoic acid	µg/L	0.01	< 0.007	0.008
32403	Perfluorohexanoic acid	µg/L	0.005	< 0.005	**0.029**
32403	Perfluoroheptanoic acid	µg/L	0.005	< 0.005	< 0.005
32403	Perfluorooctanoic acid	µg/L	0.005	< 0.007	**0.036**
32403	Perfluorononanoic acid	µg/L	0.005	< 0.007	< 0.007
32403	Perfluorodecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluoroundecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluorododecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorotridecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid	µg/L	0.005	< 0.005	**0.009**
32403	Perfluorohexanesulfonic acid	µg/L	0.005	< 0.005	**0.092**
32403	Perfluorooctanesulfonic acid	µg/L	0.005	< 0.005	**0.11**
32403	Perfluorodecanesulfonic acid	µg/L	0.005	< 0.02	< 0.02

W D HOLLOWAY & ASSOCIATES PTY LTD (ABN 89107270657) T/as
BUNDABERG ANALYTICAL SERVICES

14 Enterprise Street
BUNDABERG Q 4670
Ph 07 41531440
warren.holloway@bigpond.com

Attention: Inspector Dr Ray Bott

QFES Scientific
Brisbane QLD

LABORATORY REPORT

Sample Type: Water
Date Received: 14.09.16
Date Test Commenced: 15.09.16
Report Date: 16.09.16

Lab No.	Sample Id.	Confirmed Coliforms cfu/100ml	E. coli cfu/100ml
17353	CRR Tap Water (blank)	<1	<1
17534	CRR Case 4 Pit	2,500	<1

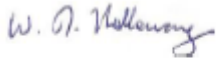
> = greater than, < = less than, cfu = colony forming units.

No E coli detected, high level of coliforms in the pit water. High levels of coliforms are often associated with soil bacteria contamination. Ideally fire fighting water should comply with the bacteria drinking water recommendations to reduce the risk of inhalation infections.

The NHMRC (June 1994, 2-14) recommendations for drinking water is there should be no Coliforms and no Thermotolerant Coliforms (E. coli) per 100 ml of water.

The level of bacteria can be reduced by the addition of Sodium Hypochlorite to the water. It is suggested that 500ml of Sodium Hypochlorite could be added to 10,000L of water.

Method
AS4276.3.1-1995,AS4276. 5-1995 & AS4276.7-1995.



Issued by: Dr W Holloway MSc PhD FRACI CChem Chief Scientist and Director

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

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24 Corporate Drive
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michael.logan@qfes.qld.gov.au

ATTN: Attn - Michael Logan

Laboratory Reference : SSP0051089
Client Order No. : Bott_R
Date Received : 14-Jul-2016
Date Commenced : 18-Jul-2016
Laboratory Number/s : 16KS687-16KS689

Number of Samples : 3

Reason for Analysis : Perfluorinated Compounds in Water

Method/s of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : The liquid chromatography mass spectrometry screen indicated the presence of the following substances in the listed samples:
16KS687 6:2 Fluorotelomer Sulfonate (FTS) at 0.099 ug/L
16KS688 6:2 Fluorotelomer Sulfonate (FTS) at 0.086 ug/L

Please note that no dilutions were done for sample 16KS687 and values above 0.48 ug/L are only approximate. Dilutions were done for sample 16KS688.

The following sulfonates are reported as the acid:
Perfluorobutanesulfonate
Perfluorohexanesulfonate
Perfluorooctanesulfonate

Martha du Plessis
Chemist, Organic Chemistry
27-Jul-16

NATA Accredited Laboratory 41

16KS687-16KS689

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Client Reference				1	2	3
Sample Type				Water Surface	Water Well	Water Town
Sampling Time/Date				15:00 08-Jul-2016	15:00 08-Jul-2016	15:00 08-Jul-2016
Sample Description				Enogerra Fire Station	Enogerra Fire Station	Enogerra Fire Station
Method	**Perfluorinated Compounds**	**Units**	**Reporting Limit**	**16KS687**	**16KS688**	**16KS689**
32403	Perfluorobutanoic acid	µg/L	0.005	**0.42**	**0.39**	< 0.005
32403	Perfluoropentanoic acid	µg/L	0.01	**0.84**	**0.66**	< 0.01
32403	Perfluorohexanoic acid	µg/L	0.005	**1.1**	**1.2**	< 0.005
32403	Perfluoroheptanoic acid	µg/L	0.005	**0.44**	**0.42**	< 0.005
32403	Perfluorooctanoic acid	µg/L	0.005	**0.37**	**0.33**	< 0.005
32403	Perfluorononanoic acid	µg/L	0.005	**0.28**	**0.25**	< 0.005
32403	Perfluorodecanoic acid	µg/L	0.005	**0.005**	**0.005**	< 0.005
32403	Perfluoroundecanoic acid	µg/L	0.005	**0.016**	**0.014**	< 0.005
32403	Perfluorododecanoic acid	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorohexadecanoic acid	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorooctadecanoic acid	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluorobutanesulfonic acid	µg/L	0.005	**0.31**	**0.29**	< 0.005
32403	Perfluorohexanesulfonic acid	µg/L	0.005	**4.9**	**6.3**	< 0.005
32403	Perfluorooctanesulfonic acid	µg/L	0.005	**5.9**	**4.2**	< 0.005
32403	Perfluorodecanesulfonic acid	µg/L	0.005	< 0.005	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)	QFES Research and Scientific Branch 24 Corporate Drive CANNON HILL QLD 4170 michael.logan@qfes.qld.gov.au ATTN: Attn - Michael Logan	Laboratory Reference : SSP0051138 Client Order No. : Reid_Damien Date Received : 18-Jul-2016 Laboratory Number/s : SS16MW11322

Number of Samples : 1

Key :

cfu	= Colony Forming Units
est	= Estimated Count
FDMEAS	= Field Measurements as provided by Submitting Authority
mg	= Milligrams
mpn	= Most Probable Number
NA	= Not Applicable
NR	= No Result
NT	= Not Tested
NTU	= Nephelometric Turbidity Units
pfu	= Plaque Forming Units
Positive	= Detected, but no count possible due to confluent growth on the plate(s)
TFOL	= Results to Follow
--	= Not Ordered

NATA Accredited Laboratory 41 Accredited for compliance with ISO/IEC 17025.

Bruce Gray
Supervising Scientist, Water Microbiology
24-Jul-16

SS16MW11322

Enquiries Bruce Gray
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Client Reference			FIRE STATION CASE 4 PIT
Sample Type			Water Well
Sampling Time/Date			09:45 18-Jul-2016
Testing Time/Date			16:40 18-Jul-2016
Sample Description			
Method	**Test Microorganisms**	**Units**	**SS16MW11322**
20902	Coliforms	mpn/100mL	280
20902	E. coli	mpn/100mL	0
23144	Enterococci	cfu/100mL	21

Notes on the Interpretation of Results

PASS means that a sample is microbiologically fit-for-purpose, and FAIL means that a sample is not microbiologically fit-for-purpose.
The fitness-for-purpose of a water sample is determined by reference to relevant regulations and guidelines:

Drinking Water - *The Public Health Regulation 2005 and the Australian Drinking Water Guidelines 2011.* (Section 10.2.2 and microorganism factsheets)
Swimming and Spa Pool Water - *The Queensland Health Swimming and Spa Pool Water Quality and Operational Guidelines.* (Microbiological criteria)
Recycled Water - *The Public Health Regulations 2005.* (schedules 3B, 3C, 3D, 3E)

An interpretation may be made where none of the above guidelines or regulation apply. In such cases, an explanation for the interpretation will be provided on the report.

Maximum Acceptable Delays Between Sampling and Analysis (Holding Times)

Test Required	Maximum Sample Storage Time (hr)
Coliphages	72
Campylobacter	24
Clostridium perfringens (spores)	72
Clostridium perfringens (vegetative cells)	18
Cryptosporidium/Giardia	96
Total Coliforms/E. coli	18
Enterococci	18
Heterotrophic Colony Count	12
Legionella	48
Pseudomonas	12
Salmonella	18
Shiga-toxigenic E. coli	18
Vibrio cholerae	18

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0052373
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 20-Oct-2016
Date Commenced	: 24-Sep-2016
Laboratory Number/s	: 16KS1081

Submitting Authority :

Number of Samples :1

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : 6:2 Fluorotelomer sulfonic acid (6:2) is normally not reported in soil because of blank contamination.

Please note that samples are reported on a dry weight basis.

Results in this report have been authorised for release by M. du Plessis

Martha du Plessis
Chemist, Organics Laboratory
10-Nov-16

16KS1081

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Client Reference					Sample 1
Sample Type					Blank soil
Sampling Time / Date					14:00 19-10-2016
Sample Description					GC005(blank)
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS1081**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	**0.007**
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	**0.009**
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	**0.005**
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	**0.001**
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	**0.002**
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	**0.003**
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	**0.064**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0051931
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 15-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS993 – 16KS995

Submitting Authority :

Number of Samples :3

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : Please note that the water samples have been reported separately.
6:2 FTS is normally not reported in soil because of blank contamination.

Perfluorotetradecanoic acid (PFTeDA) has a low recovery

Results in this report have been authorised for release by M. du Plessis

M.duPlessis

Martha du Plessis
Chemist, Organics Laboratory
14-Oct-16

16KS993-16KS995

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Client Reference					Sample 3
Sample Type					Garden soil
Sampling Time / Date					14:20 14-09-2016
Sample Description					GC005
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS995**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	**0.011**
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	**0.012**
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	**0.005**
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	**0.005**
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	**0.004**
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	**0.002**
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	**0.004**
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	**0.001**
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	**0.008**
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	**0.037**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	<0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT : (QFESSC)

QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170
michael.logan@qfes.qld.gov.au

ATTN: Attn - Michael Logan

Laboratory Reference : SSP0051931
Client Order No. : SMITH_M
Date Received : 15-Sep-2016
Date Commenced : 19-Sep-2016
Laboratory Number/s : 16KS993-16KS995

Number of Samples : 3

Method/s of Analysis : 32403 - Perfluorinated Compounds in Water

Remarks : The liquid chromatography mass spectrometry screen (orbitrap) indicated the presence of the following substances below the LOR in the listed samples: 16KS993, 16KS994
6:2 Fluorotelomer sulfonic acid (6:2 FTS) < 0.01 ug/L

The following were not detected at the LOR below:
2-Perfluorooctyl ethanoic acid (FOEA) < 0.05 ug/L
2-Perfluorodecyl ethanoic acid (FDEA) < 0.05 ug/L
4:2 Fluorotelomer sulfonic acid (4:2 FTS) < 0.005 ug/L
8:2 Fluorotelomer sulfonic acid (8:2 FTS) <0.02 ug/L

Please note that NATA accreditation does not cover the performance of this service.

The soil sample 16KS995 (GC005) will be reported separately.

Martha du Plessis
Chemist, Organic Chemistry
28-Sep-16

NATA Accredited Laboratory 41

16KS993-16KS995

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Client Reference				GC001	GC003
Sample Type				Water Untreated	Water Tap Untreated
Sampling Time/Date				13:16 14-Sep-2016	14:16 14-Sep-2016
Sample Description				Southport Fire Station,Westread Drive	Southport Fire Station,Westread Drive
Method	Perfluorinated Compounds	Units	Reporting Limit	16KS993	16KS994
32403	Perfluorobutanoic acid	µg/L	0.005	**0.013**	< 0.01
32403	Perfluoropentanoic acid	µg/L	0.01	**0.02**	< 0.007
32403	Perfluorohexanoic acid	µg/L	0.005	**0.026**	< 0.005
32403	Perfluoroheptanoic acid	µg/L	0.005	**0.008**	< 0.005
32403	Perfluorooctanoic acid	µg/L	0.005	**0.012**	< 0.007
32403	Perfluorononanoic acid	µg/L	0.005	< 0.007	< 0.007
32403	Perfluorodecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluoroundecanoic acid	µg/L	0.005	< 0.01	< 0.01
32403	Perfluorododecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorotridecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid	µg/L	0.005	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid	µg/L	0.005	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid	µg/L	0.005	< 0.005	< 0.005
32403	Perfluorohexanesulfonic acid	µg/L	0.005	**0.043**	< 0.005
32403	Perfluorooctanesulfonic acid	µg/L	0.005	**0.12**	< 0.005
32403	Perfluorodecanesulfonic acid	µg/L	0.005	< 0.02	< 0.02

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0052034
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 23-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS1035 – 16KS1036

Submitting Authority :

Number of Samples :2

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : 6:2 Fluorotelomer sulfonic acid (6:2) is normally not reported in soil because of blank contamination.

Results in this report have been authorised for release by M. du Plessis

DuPlessis

Martha du Plessis
Chemist, Organics Laboratory
14-Oct-16

16KS1035-16KS1036

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Client Reference					Sample 1	Sample 2
Sample Type					Blank soil SWR	SWR soil yard
Sampling Time / Date					10:45 23-09-2016	10:45 23-09-2016
Sample Description					Soil Blank SWR	SWR soil yard
Method	**Perfluorinated Compounds**	**Guidelines**	**Units**	**Reporting Limit**	**16KS1035**	**16KS1036**
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	< 0.001	< 0.001
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	**0.003**	**0.010**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005	< 0.005

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: QFES Research and Scientific Branch
24 Corporate Drive
CANNON HILL QLD 4170

ATTN: Michael Logan

CC:

Laboratory Reference	: SSP0051950
Client Order Number	: Bott_R
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 16-Sep-2016
Date Commenced	: 27-Sep-2016
Laboratory Number/s	: 16KS1000 – 16KS1005

Submitting Authority :

Number of Samples :6

Reason for Analysis : Analysis for Perfluorinated Compounds in soil

Method/s of Analysis : 33946 – Perfluorinated Compounds in soil

Remarks : Please note that the water samples have been reported separately.

6:2 Fluorotelomer sulfonic acid (6:2 FTS) is normally not reported because of blank contamination in soils.

Perfluorotetradecanoic acid (PFTeDA) has a low recovery

Results in this report have been authorised for release by M. du Plessis

M.duPlessis

Martha du Plessis
Chemist, Organics Laboratory
18-Oct-16

16KS1000-16KS1005

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Client Reference					Sample 1	Sample 1	Sample 3	Sample 4
Sample Type					soil	soil	Soil	Soil
Sampling Time / Date								
Sample Description					CRY-BLANK	CRY-YARD	CRR- BLANK	CRR-YARD
Method	Perfluorinated Compounds	Guidelines	Units	Reporting Limit	16KS1000	16KS1001	16KS1002	16KS1003
33946	Perfluorobutanoic acid (PFBA)		mg/kg	**0.005**	< 0.005	< 0.005	< 0.005	< 0.005
33946	Perfluoropentanoic acid (PFPeA)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorohexanoic acid (PFHxA)		mg/kg	**0.001**	< 0.001	**0.001**	< 0.001	< 0.001
33946	Perfluoroheptanoic acid (PFHpA)		mg/kg	**0.001**	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorooctanoic acid (PFOA)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorononanoic acid (PFNA)		mg/kg	**0.001**	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorodecanoic acid (PFDA)		mg/kg	**0.001**	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluoroundecanoic acid (PFUDA)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorododecanoic acid (PFDoA)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	Perfluorotridecanoic acid (PFTrDA)		mg/kg	**0.007**	< 0.007	< 0.007	< 0.007	< 0.007
33946	Perfluorotetradecanoic acid (PFTeDA)		mg/kg	**0.01**	< 0.01	< 0.01	< 0.01	< 0.01
33946	Perfluorobutanesulfonic acid (PFBS)		mg/kg	**0.001**	< 0.001	< 0.001	< 0.001	< 0.001
33946	Perfluorohexanesulfonic acid (PFHxS)		mg/kg	**0.001**	< 0.001	**0.012**	< 0.001	**0.003**
33946	Perfluorooctanesulfonic acid (PFOS)		mg/kg	**0.001**	< 0.001	**2.3**	**0.008**	**0.015**
33946	Perfluorodecanesulfonic acid (PFDS)		mg/kg	**0.002**	< 0.002	**0.017**	< 0.002	< 0.002
33946	2-Perfluorohexyl ethanoic acid (FHEA)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	2-Perfluoroocty ethanoic acid (FOEA)		mg/kg	**0.02**	< 0.02	< 0.02	< 0.02	< 0.02
33946	2-Perfluorodecyl ethanoic acid (FDEA)		mg/kg	**0.02**	< 0.02	< 0.02	< 0.02	< 0.02
33946	4:2 Fluorotelomer sulfonic acid (4:2 FTS)		mg/kg	**0.002**	< 0.002	< 0.002	< 0.002	< 0.002
33946	8:2 Fluorotelomer sulfonic acid (8:2 FTS)		mg/kg	**0.005**	< 0.005	< 0.005	< 0.005	< 0.005

Appendix B

Phase Two

Laboratory analyses Data

Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS – AMENDED REPORT

CLIENT: Raymond Bott
QFES
24 Corporate Drive
Cannon Hill QLD 4170

ATTN: Raymond Bott

Laboratory Reference	: SSP0052842
Laboratory Reference	: SSP0052843
Laboratory Reference	: SSP0052852
Client Project	:
Client Batch Reference	:
Date Received	: 24 Nov 2016
Date Commenced	: 28 Nov 2016
Laboratory Number/s	: 16KS1188-16KS1255

CC:

Submitting Authority	: QFES
Number of Samples	: 89
Reason for Analysis	: PFAS monitoring
Method/s of Analysis	: QIS 32403 – Perfluorinated Compounds in Water
Remarks	: Amended report - please destroy all copies of reports dated prior to this one

Dr Ashley Tronoff
Chemist, Organics Laboratory
13/12/2016

16KS1188-16KS1255

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Free PFAS – Table 1 of 5

Laboratory Reference No.: / Client Reference No.:	LOR (µg/L)	16KS1188 SWRCV-01	16KS1190 SWRCV-03	16KS1191 SWRCV-04	16KS1192 SWRCV-05	16KS1194 QCWW1-01	16KS1195 QCWW1-02	16KS1197 QCWW1-04	16KS1198 QCWW1-05	16KS1199 QCWW2-01	16KS1200 QCWW2-02
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	0.02	< 0.01	< 0.01	0.04	0.04	0.04	< 0.01	< 0.01	0.04
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.058	0.060	0.058	< 0.007	< 0.007	0.057
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.011	< 0.005	< 0.005	0.14	0.14	0.13	< 0.005	< 0.005	0.14
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	0.006	< 0.005	< 0.005	0.049	0.051	0.049	< 0.005	< 0.005	0.049
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	0.010	< 0.007	< 0.007	0.057	0.061	0.058	< 0.007	< 0.007	0.039
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.038	0.038	0.036	< 0.005	< 0.005	0.037
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.023	< 0.005	< 0.005	0.40	0.39	0.38	< 0.005	< 0.005	0.37
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.029	< 0.005	< 0.005	0.87	0.84	0.90	< 0.005	< 0.005	0.71
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	0.3	0.3	0.3	< 0.15	< 0.15	0.3
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	0.05	< 0.015	< 0.015	1.3	1.3	1.3	< 0.015	< 0.015	1.1

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Free PFAS – Table 2 of 5

Laboratory Reference No.:	LOR (µg/L)	16KS1203	16KS1204	16KS1205	16KS1206	16KS1208	16KS1209	16KS1211	16KS1212	16KS1214	16KS1216
Client Reference No.:		QCWW3-02	QCWW3-03	QCWW3-04	QCWW3-05	QCSS5-01	QCSS5-02	QCSS1-01	QCSS1-02	QCSS2-01	QCSS2-05
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	0.04	< 0.01	< 0.01	0.05	< 0.01	< 0.01	0.05	0.06	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	0.065	< 0.007	< 0.007	0.087	< 0.007	< 0.007	0.10	0.14	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.13	< 0.005	< 0.005	0.25	< 0.005	< 0.005	0.26	0.26	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	0.054	< 0.005	< 0.005	0.065	< 0.005	< 0.005	0.071	0.088	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	0.045	< 0.007	< 0.007	0.071	< 0.007	< 0.007	0.074	0.083	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.010	< 0.007	< 0.007	0.012	0.015	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	0.041	< 0.005	< 0.005	0.064	< 0.005	< 0.005	0.069	0.064	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.40	< 0.005	< 0.005	0.91	< 0.005	< 0.005	0.90	1.1	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.92	< 0.005	< 0.005	2.0	< 0.005	0.006	2.0	3.2	0.010
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	0.02	0.05	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	0.3	< 0.15	< 0.15	0.5	< 0.15	< 0.15	0.6	0.6	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	1.4	< 0.015	< 0.015	3.0	< 0.015	< 0.015	2.9	4.4	< 0.015

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Laboratory Reference No.:	LOR (µg/L)	16KS1217	16KS1218	16KS1219	16KS1221	16KS1223	16KS1224	16KS1226	16KS1228	16KS1229	16KS1232
Client Reference No.:		QCSS3-01	QCSS3-02	QCSS3-03	QCSS3-05	QCSS4-01	QCSS4-02	QCSS4-04	BRAH-02	BRAH-03	BRAH-06
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	0.07	< 0.01	< 0.01	< 0.01	0.15	0.16	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	0.11	< 0.007	0.014	< 0.007	0.40	0.39	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	0.26	< 0.005	0.027	< 0.005	0.23	0.23	0.009
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	0.076	< 0.005	0.014	< 0.005	0.22	0.25	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	0.091	< 0.007	0.012	< 0.007	0.042	0.056	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	0.014	< 0.007	< 0.007	< 0.007	0.047	0.049	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	0.071	< 0.005	0.011	< 0.005	0.027	0.027	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	1.0	< 0.005	0.10	< 0.005	0.065	0.059	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	2.7	< 0.005	0.24	< 0.005	0.059	0.054	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01	0.57	0.62	0.59
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	0.6	< 0.15	< 0.15	< 0.15	1.1	1.1	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	< 0.015	3.7	< 0.015	0.35	< 0.015	0.15	0.14	< 0.015

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Laboratory Reference No.:	LOR (µg/L)	16KS1233	16KS1234	16KS1236	16KS1237	16KS1239	16KS1240	16KS1241	16KS1243	16KS1245	16KS1246
Client Reference No.:		BRAH-07	BRAH-08	BRAN-02	BRAN-03	BRAN-05	BRW-01	BRW-02	BRW-04	BRW-06	BRRS-01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.04	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.021	< 0.007	< 0.007	0.13	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	0.018	0.022	0.008	0.007	0.058	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	0.006	0.020	< 0.005	< 0.005	0.062	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.010	< 0.007	< 0.007	0.022	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.011	< 0.007	< 0.007	0.015	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	0.06	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.017	< 0.005	< 0.005	0.025	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.033	< 0.005	< 0.005	0.036	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	0.11	< 0.01	< 0.01	0.97	0.57	0.51	0.48	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	0.2	< 0.15	< 0.15	0.4	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	< 0.015	< 0.015	0.05	< 0.015	< 0.015	0.07	< 0.015	< 0.015

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Laboratory Reference No.:	LOR (µg/L)	16KS1247	16KS1249	16KS1251	16KS1253	16KS1255
Client Reference No.:		BRRS-02	BRRS-04	BRKP-01	BRKP-03	BRKP-05
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	0.05	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	0.009	< 0.007	< 0.007	0.18	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	0.008	< 0.005	< 0.005	0.14	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	0.006	< 0.005	< 0.005	0.12	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	0.052	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	0.039	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	0.02	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	0.05	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	0.025	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	0.16	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	0.35	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	0.7	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	< 0.015	0.54	< 0.015

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Laboratory Reference No.:	LOR (µg/L)	16KS1189	16KS1191	16KS1192	16KS1193	16KS1194	16KS1196	16KS1198	16KS1199	16KS1201	16KS1202
Client Reference No.:		SWRCV-02	SWRCV-04	SWRCV-05	SWRCV-06	QCWW1-01	QCWW1-03	QCWW1-05	QCWW2-01	QCWW2-03	QCWW3-01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	0.01	0.08	0.08	< 0.01	< 0.01	0.08	0.08
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	0.010	0.072	0.076	< 0.007	< 0.007	0.058	0.076
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	0.033	0.42	0.41	< 0.005	< 0.005	0.39	0.43
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	0.011	0.038	0.038	< 0.005	< 0.005	0.033	0.041
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	0.015	0.064	0.055	< 0.007	< 0.007	0.065	0.056
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.008	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	0.008	0.033	0.034	< 0.005	< 0.005	0.032	0.033
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	0.040	0.38	0.41	< 0.005	< 0.005	0.42	0.49
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	0.040	0.94	0.90	< 0.005	< 0.005	0.78	0.87
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	0.7	0.7	< 0.15	< 0.15	0.6	0.7
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	< 0.015	0.09	1.4	1.3	< 0.015	< 0.015	1.2	1.4

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TOPA PFAS – Table 2 of 5

Laboratory Reference No.:	LOR (µg/L)	16KS1203	16KS1206	16KS1207	16KS1209	16KS1210	16KS1211	16KS1213	16KS1215	16KS1216	16KS1217
Client Reference No.:		QCWW3-02	QCWW3-05	QCWW3-06	QCSS5-02	QCSS5-03	QCSS1-01	QCSS1-03	QCSS2-02	QCSS2-05	QCSS3-01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.12	< 0.01	0.12	0.15	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.11	< 0.007	0.14	0.17	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.99	< 0.005	1.0	1.4	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.050	< 0.005	0.068	0.076	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.093	< 0.007	0.10	0.11	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.012	< 0.007	0.010	0.014	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.062	< 0.005	0.062	0.054	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	1.0	< 0.005	1.0	1.2	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	2.0	0.009	2.1	3.5	0.008	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	1.4	< 0.15	1.5	1.9	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	< 0.015	< 0.015	3.0	< 0.015	3.2	4.8	< 0.015	< 0.015

16KS1188-16KS1255

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TOPA PFAS – Table 3 of 5

Laboratory Reference No.:	LOR (µg/L)	16KS1218	16KS1220	16KS1222	16KS1223	16KS1225	16KS1226	16KS1227	16KS1230	16KS1231	16KS1233
Client Reference No.:		QCSS3-02	QCSS3-04	QCSS3-06	QCSS4-01	QCSS4-03	QCSS4-04	BRAH-01	BRAH-04	BRAH-05	BRAH-07
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.14	< 0.01	0.02	< 0.01	0.31	< 0.01	0.32	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.038	< 0.007	0.013	< 0.007	0.41	< 0.007	0.15	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	1.3	< 0.005	0.13	< 0.005	0.34	< 0.005	0.36	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.027	< 0.005	0.008	< 0.005	0.22	< 0.005	0.12	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.086	< 0.007	0.015	< 0.007	0.071	< 0.007	0.073	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.013	< 0.007	< 0.007	< 0.007	0.073	< 0.007	0.076	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.062	< 0.005	0.008	< 0.005	0.024	< 0.005	0.023	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	1.1	< 0.005	0.12	< 0.005	0.076	< 0.005	0.079	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	2.8	< 0.005	0.25	< 0.005	0.087	< 0.005	0.073	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	1.6	< 0.15	0.2	< 0.15	1.4	< 0.15	1.1	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	3.9	< 0.015	0.38	< 0.015	0.19	< 0.015	0.17	< 0.015

16KS1188-16KS1255

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Laboratory Reference No.:	LOR (µg/L)	16KS1234	16KS1235	16KS1236	16KS1238	16KS1240	16KS1242	16KS1244	16KS1245	16KS1246	16KS1248
Client Reference No.:		BRAH-08	BRAN-01	BRAN-02	BRAN-04	BRW-01	BRW-03	BRW-05	BRW-06	BRRS-01	BRRS-03
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	0.03	< 0.01	< 0.01	< 0.01	< 0.01	0.15	< 0.01	< 0.01	0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	0.050	< 0.007	< 0.007	< 0.007	< 0.007	0.15	< 0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.092	< 0.005	< 0.005	< 0.005	< 0.005	0.15	0.006	< 0.005	0.013
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	0.028	< 0.005	< 0.005	< 0.005	< 0.005	0.045	< 0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	0.053	< 0.007	< 0.007	< 0.007	< 0.007	0.048	< 0.007	< 0.007	0.009
Perfluorononanoic acid (PFNA)	0.007	< 0.007	0.023	< 0.007	< 0.007	< 0.007	< 0.007	0.021	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.026	< 0.005	< 0.005	< 0.005	< 0.005	0.025	< 0.005	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.045	< 0.005	< 0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	0.3	< 0.15	< 0.15	< 0.15	< 0.15	0.6	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	0.07	< 0.015	< 0.015	< 0.015	< 0.015	0.07	< 0.015	< 0.015	< 0.015

16KS1188-16KS1255

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TOPA PFAS – Table 5 of 5

Laboratory Reference No.:	LOR (µg/L)	16KS1250	16KS1252	16KS1254	16KS1255
Client Reference No.:		BRRS-05	BRKP-02	BRKP-04	BRKP-05
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.15	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.089	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	0.53	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.065	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.12	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.049	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	0.03	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	0.07	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.021	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.20	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	0.46	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	1.1	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.015	< 0.015	0.68	< 0.015

16KS1188-16KS1255

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Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS – AMENDED REPORT

CLIENT: Raymond Bott
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ATTN: Raymond Bott

Laboratory Reference	: SSP0052880
Laboratory Reference	: SSP0052927
Laboratory Reference	: SSP0052928
Laboratory Reference	: SSP0052929
Client Project	:
Date Received	: 29 Nov 2016
Date Commenced	: 05 Dec 2016
Laboratory Number's	: 16KS1266-16KS1352

CC:

Submitting Authority : QFES

Number of Samples : 39

Reason for Analysis : PFAS monitoring

Method's of Analysis : QIS 32403 – Perfluorinated Compounds in Water

Remarks : Amended report - please destroy the copy previously sent 05/01/2016

Dr Ashley Tronoff
Chemist, Organics Laboratory
11/01/2017

16KS1266-16KS1352

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Laboratory Reference No.:	LOR (µg/L)	16KS1266	16KS1267	16KS1269	16KS1271	16KS1273	16KS1285	16KS1286	16KS1287	16KS1288	16KS1289
Client Reference No.:		NRISA-01	NRISA-02	NRISA-04	NRISA-06	NRISA-08	CRG01	CRG02	CRG04	CRG06	CRG07
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.50	0.50	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	2.0	2.0	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	0.005	< 0.005	< 0.005	< 0.005	4.9	4.7	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.26	0.25	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	1.4	1.5	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.96	1.1	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.06	0.07	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.38	0.46	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	1.5	1.5	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.01	0.009	< 0.005	< 0.005	< 0.005	7.9	7.7	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.005	0.014	0.014	< 0.005	< 0.005	< 0.005	34	34	0.012
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.02	0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	6.9	6.9	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.23	0.22	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	11	10	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	0.02	0.02	< 0.02	< 0.02	< 0.02	44	43	< 0.02

16KS1266-16KS1352

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Free PFAS – Table 2 of 2

Laboratory Reference No.:	LOR (µg/L)	16KS1290	16KS1291	16KS1292	16KS1293	16KS1294	16KS1295	16KS1296	16KS1297	16KS1298	16KS1300
Client Reference No.:		CRA04	CRS03	CRRK01	CRRK02	CRRK04	CRP01	CRP02	CRP05	CRA01	CRA03
Perfluorobutanoic acid (PFBA)	0.010	0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.023	< 0.007	< 0.007	0.011	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	0.008	< 0.005	< 0.005	< 0.005	0.021	< 0.005	< 0.005	0.063	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	0.011	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.019	< 0.007	< 0.007	0.011	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.010	< 0.007	< 0.007	0.008	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	0.006	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	0.021	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.033	< 0.005	< 0.005	< 0.005	0.024	< 0.005	< 0.005	0.49	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	0.064	< 0.005	0.017	< 0.005	0.099	< 0.005	< 0.005	0.41	0.017	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	0.10	< 0.02	< 0.02	< 0.02	0.13	< 0.02	< 0.02	0.93	< 0.02	< 0.02

16KS1266-16KS1352

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TOPA PFAS – Table 1 of 2

Laboratory Reference No.:	LOR (µg/L)	16KS1266	16KS1268	16KS1270	16KS1272	16KS1273	16KS1285	16KS1345	16KS1346	16KS1289	16KS1347
Client Reference No.:		NRISA-01	NRISA-03	NRISA-05	NRISA-07	NRISA-08	CRG01	CRG03	CRG05	CRG07	CRG08
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	4.1	< 0.01	4.8
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	5.8	< 0.007	6.5
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	0.008	0.008	< 0.005	< 0.005	< 0.005	19	< 0.005	23
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	1.3	< 0.005	1.4
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	2.0	< 0.007	2.0
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.94	< 0.007	0.92
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.10	< 0.01	0.1
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.53	< 0.01	0.57
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	1.3	< 0.005	1.4
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.009	0.008	< 0.005	< 0.005	< 0.005	8.7	< 0.005	8.9
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	0.011	0.017	< 0.005	< 0.005	< 0.005	34	< 0.005	38
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.06	< 0.02	0.06
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	34	< 0.15	39
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	0.02	0.03	< 0.02	< 0.02	< 0.02	44	< 0.02	48

16KS1266-16KS1352

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TOPA PFAS – Table 2 of 2

Laboratory Reference No.:	LOR (µg/L)	16KS1292	16KS1348	16KS1349	16KS1295	16KS1299	16KS1350	16KS1351	16KS1298	16KS1352
Client Reference No.:		CRRK01	CRRK03	CRRK05	CRP01	CRA02	CRP03	CRP04	CRA01	CRS05
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.05	< 0.01	< 0.01	< 0.01	0.12	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.015	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	0.10	< 0.005	< 0.005	< 0.005	0.89	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.013	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.051	< 0.007	< 0.007	< 0.007	0.076	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.020	< 0.007	< 0.007	< 0.007	0.011	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	0.032	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.027	< 0.005	< 0.005	< 0.005	0.59	< 0.005	0.010
Perfluorooctanesulfonic acid (PFOS)	0.005	0.027	< 0.005	0.17	< 0.005	< 0.005	< 0.005	0.46	0.025	0.024
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	0.3	< 0.15	< 0.15	< 0.15	1.1	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	0.03	< 0.02	0.20	< 0.02	< 0.02	< 0.02	1.1	0.02	0.03

16KS1266-16KS1352

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Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

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CC:

Laboratory Reference	: SSP0052930
Laboratory Reference	: SSP0052931
Laboratory Reference	: SSP0052936
Laboratory Reference	: SSP0052937
Laboratory Reference	: SSP0052938
Laboratory Reference	: SSP0052944
Laboratory Reference	: SSP0052952
Client Project	:
Client Batch Reference	:
Date Received	: 24 Nov 2016
Date Commenced	: 06 Dec 2016
Laboratory Number/s	: 16KS1303-16KS138

Submitting Authority : QFES

Number of Samples : 82

Reason for Analysis : PFAS monitoring

Method/s of Analysis : QIS 32403 – Perfluorinated Compounds in Water

Remarks :

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16KS1303-16KS1384

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Free PFAS – Table 1 of 4

Laboratory Reference No.:	LOR (µg/L)	16KS1352	16KS1303	16KS1304	16KS1305	16KS1306	16KS1307	16KS1308	16KS1309	16KS1310	16KS1313
Client Reference No.:		CRS05	CRD01	CRD02	CRD04	CRM01	CRM02	CRM04	CRS01	CRS02	NCB01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.18	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	0.011	< 0.007	0.41	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.007	< 0.005	0.008	< 0.005	1.1	< 0.005	< 0.005	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	0.28	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.40	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.10	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	0.005	< 0.005	0.005	< 0.005	0.37	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.010	0.053	< 0.005	0.009	< 0.005	3.6	< 0.005	< 0.005	0.007	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	0.015	0.35	< 0.005	0.066	0.020	6.7	< 0.005	< 0.005	0.038	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	2.5	< 0.15	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	0.02	0.41	< 0.02	0.08	< 0.02	11	< 0.02	< 0.02	0.05	< 0.02

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Free PFAS – Table 2 of 4

Laboratory Reference No.:	LOR (µg/L)	16KS1314	16KS1315	16KS1316	16KS1317	16KS1318	16KS1319	16KS1320	16KS1321	16KS1322	16KS1323
Client Reference No.:		NCB02	NCB03	NCB05	NCM01	NCM02	NCC01	NCC02	NCC04	NCC05	NCN01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.06	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.18	< 0.007	< 0.007	< 0.007	< 0.007	0.008	0.008	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	0.12	< 0.005	< 0.005	< 0.005	< 0.005	0.026	0.028	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.063	< 0.005	< 0.005	< 0.005	< 0.005	0.006	0.007	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.025	< 0.007	< 0.007	< 0.007	< 0.007	0.013	0.013	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	0.11	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.017	0.019	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.049	< 0.005	< 0.005	< 0.005	< 0.005	0.16	0.16	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	0.036	< 0.005	0.13	< 0.005	< 0.005	< 0.005	< 0.005	0.32	0.32	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	0.2	< 0.15	0.5	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	0.04	< 0.02	0.18	< 0.02	< 0.02	< 0.02	< 0.02	0.49	0.50	< 0.02

16KS1303-16KS1384

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Free PFAS – Table 3 of 4

Laboratory Reference No.:	LOR (µg/L)	16KS1324	16KS1325	16KS1326	16KS1332	16KS1333	16KS1334	16KS1335	16KS1336	16KS1337	16KS1338
Client Reference No.:		NCN02	NCN04	NCM04	FNCS_02	FNCS_03	FNCS_04	FNCN_01	FNCN_03	FNCN_05	FNCN_06
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	0.07	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.014	< 0.007	< 0.007	0.028	< 0.007	0.14	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.018	0.023	< 0.005	< 0.005	0.075	< 0.005	0.34	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	0.005	0.010	< 0.005	< 0.005	0.023	< 0.005	0.096	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	0.011	0.019	< 0.007	< 0.007	0.044	< 0.007	0.12	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.008	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.036	< 0.005	0.040	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.034	0.031	< 0.005	< 0.005	0.29	< 0.005	0.62	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.23	0.060	< 0.005	< 0.005	0.93	< 0.005	0.67	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.42	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.11	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	0.2	< 0.15	0.8	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	0.26	0.09	< 0.02	< 0.02	1.3	< 0.02	1.3	< 0.02	< 0.02

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Laboratory Reference No.:	LOR (µg/L)	16KS1369	16KS1371	16KS1373	16KS1374	16KS1376	16KS1378	16KS1379	16KS1381	16KS1382	16KS1383
Client Reference No.:		NRFB_01	NRFB_03	NRFB_05	NRFB_06	NRAY_02	NRAY_04	NRAY_05	NRHH_02	NRHH_03	NRHH_04
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.024	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.050	< 0.005	< 0.005	0.008	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.012	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.031	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.060	0.01	< 0.005	0.011	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.061	0.012	< 0.005	0.086	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2	0.6	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	0.11	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	< 0.02	< 0.02	0.12	0.02	< 0.02	0.1	< 0.02	< 0.02

16KS1303-16KS1384

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Laboratory Reference No.:	LOR (µg/L)	16KS1301	16KS1302	16KS1303	16KS1353	16KS1354	16KS1355	16KS1306	16KS1356	16KS1357	16KS1309
Client Reference No.:		CRS04	CRS06	CRD01	CRD03	CRD05	CRA05	CRM01	CRM03	CRM05	CRS01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.03	< 0.01	0.01	0.02	< 0.01	0.76	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.013	< 0.007	0.015	< 0.007	< 0.007	0.34	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.014	0.17	< 0.005	0.041	0.014	0.005	2.0	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.006	< 0.005	< 0.005	0.17	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.008	< 0.007	0.011	< 0.007	< 0.007	0.49	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.11	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.005	< 0.005	0.006	0.006	< 0.005	0.32	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.011	0.059	< 0.005	0.012	0.030	< 0.005	2.9	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.025	0.37	< 0.005	0.12	0.063	0.020	5.1	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	0.2	< 0.15	< 0.15	< 0.15	< 0.15	3.9	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	0.04	0.43	< 0.02	0.14	0.1	0.02	8.2	< 0.02	< 0.02

16KS1303-16KS1384

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Laboratory Reference No.:	LOR (µg/L)	16KS1310	16KS1313	16KS1314	16KS1343	16KS1344	16KS1317	16KS1319	16KS1358	16KS1359	16KS1360
Client Reference No.:		CRS02	NCB01	NCB02	NCB04	NCB06	NCM01	NCC01	NCC03	NCC06	NCC07
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.03	< 0.01	0.11	< 0.01	< 0.01	< 0.01	0.03	0.03
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.027	< 0.007	0.20	< 0.007	< 0.007	< 0.007	0.022	0.011
Perfluorohexanoic acid (PFHxA)	0.005	0.006	< 0.005	0.10	< 0.005	0.23	0.008	< 0.005	< 0.005	0.15	0.17
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.12	< 0.005	0.071	0.012	< 0.005	< 0.005	0.008	0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.070	< 0.007	0.042	0.008	< 0.007	< 0.007	0.022	0.023
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.025	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	0.02	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	0.11	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.018	0.020
Perfluorohexanesulfonic acid (PFHxS)	0.005	0.008	< 0.005	< 0.005	< 0.005	0.054	< 0.005	< 0.005	< 0.005	0.17	0.17
Perfluorooctanesulfonic acid (PFOS)	0.005	0.043	< 0.005	0.041	< 0.005	0.13	< 0.005	< 0.005	< 0.005	0.33	0.35
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	0.5	< 0.15	0.7	< 0.15	< 0.15	< 0.15	0.2	0.2
TOTAL C4-C10 Sulfonic acids	0.020	0.05	< 0.02	0.04	< 0.02	0.19	< 0.02	< 0.02	< 0.02	0.51	0.54

16KS1303-16KS1384

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Laboratory Reference No.:	LOR (µg/L)	16KS1323	16KS1361	16KS1362	16KS1363	16KS1364	16KS1365	16KS1333	16KS1366	16KS1335	16KS1367
Client Reference No.:		NCN01	NCN03	NCN05	NCM03	NCM05	FNCS_01	FNCS_03	FNCS_05	FNCN_01	FNCN_02
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.04	< 0.01	0.03	< 0.01	< 0.01	0.08	< 0.01	0.43
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.026	< 0.007	< 0.007	0.053	< 0.007	0.34
Perfluorohexanoic acid (PFHxA)	0.005	0.007	< 0.005	0.16	< 0.005	0.10	< 0.005	< 0.005	0.33	< 0.005	1.6
Perfluoroheptanoic acid (PFHpA)	0.005	0.007	< 0.005	0.006	< 0.005	0.017	< 0.005	< 0.005	0.027	< 0.005	0.21
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.030	< 0.007	0.033	< 0.007	< 0.007	0.069	< 0.007	0.43
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.038
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.02
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.007	< 0.005	< 0.005	< 0.005	< 0.005	0.038	< 0.005	0.054
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	0.049	< 0.005	0.039	< 0.005	< 0.005	0.29	< 0.005	0.65
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	0.25	< 0.005	0.072	< 0.005	< 0.005	0.83	< 0.005	0.57
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	0.2	< 0.15	0.2	< 0.15	< 0.15	0.6	< 0.15	3.0
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	0.30	< 0.02	0.11	< 0.02	< 0.02	1.2	< 0.02	1.3

16KS1303-16KS1384

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Laboratory Reference No.:	LOR (µg/L)	16KS1368	16KS1338	16KS1369	16KS1370	16KS1372	16KS1374	16KS1375	16KS1377	16KS1379	16KS1380
Client Reference No.:		FNCF_04	FNCN_06	NRFB_01	NRFB_02	NRFB_04	NRFB_06	NRAY_01	NRAY_03	NRAY_05	NRHH_01
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.31	< 0.01	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.33	< 0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.42	< 0.005	< 0.005	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.17	< 0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.17	< 0.007	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	< 0.007	0.066	< 0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.05	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	0.03	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.070	0.01	< 0.005	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	0.072	0.014	< 0.005	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	1.5	< 0.15	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	0.14	0.02	< 0.02	< 0.02

16KS1303-16KS1384

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TOPA PFAS – Table 5 of 5

Laboratory Reference No.: / Client Reference No.:	LOR (µg/L)	16KS1382 NRHH_03	16KS1384 NRHH_05
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	0.023
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	0.012
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	0.088
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	0.10

16KS1303-16KS1384

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Queensland Government

Forensic and Scientific Services
HealthSupport Queensland

CERTIFICATE OF ANALYSIS

CLIENT: Raymond Bott
QFES
24 Corporate Drive
Cannon Hill QLD 4170

ATTN: Raymond Bott

CC:

Laboratory Reference	: SSP0053053
Client Project	:
Date Received	: 29 Nov 2016
Date Commenced	: 12 Dec 2016
Laboratory Number/s	: 16KS1406-16KS1411

Submitting Authority : QFES

Number of Samples : 8

Reason for Analysis : PFAS monitoring

Method/s of Analysis : QIS 32403 – Perfluorinated Compounds in Water

Remarks :

Dr Ashley Tronoff
Chemist, Organics Laboratory
11/01/2017

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Free PFAS – Table 1 of 1

Laboratory Reference No.:	LOR (µg/L)	16KS1406	16KS1407	16KS1409	16KS1411
Client Reference No.:		BREN01	BREN02	BREN04	BREN06
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.20	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.62	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	1.1	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.24	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.18	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.12	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexadecanoic acid (PFHxDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.18	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	3.3	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	2.4	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
1H,1H,2H,2H-Perfluorohexanesulfonic acid (4:2FTS)	0.005	< 0.005	< 0.005	< 0.005	< 0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid (6:2FTS)	0.010	< 0.01	< 0.01	0.06	< 0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid (8:2FTS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorohexyl ethanoic acid (FHEA)	0.200	< 0.2	< 0.2	< 0.2	< 0.2
Perfluorooctyl ethanoic acid (FOEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorodectyl ethanoic acid (FDEA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	2.4	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	6.0	< 0.02

16KS1406-16KS1411

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TOPA PFAS – Table 1 of 1

Laboratory Reference No.: / Client Reference No.:	LOR (µg/L)	16KS1406 BREN-01	16KS1408 BREN-03	16KS1410 BREN-05	16KS1411 BREN-06
Perfluorobutanoic acid (PFBA)	0.010	< 0.01	< 0.01	0.41	< 0.01
Perfluoropentanoic acid (PFPeA)	0.007	< 0.007	< 0.007	0.78	< 0.007
Perfluorohexanoic acid (PFHxA)	0.005	< 0.005	< 0.005	2.0	< 0.005
Perfluoroheptanoic acid (PFHpA)	0.005	< 0.005	< 0.005	0.24	< 0.005
Perfluorooctanoic acid (PFOA)	0.007	< 0.007	< 0.007	0.20	< 0.007
Perfluorononanoic acid (PFNA)	0.007	< 0.007	< 0.007	0.11	< 0.007
Perfluorodecanoic acid (PFDA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01
Perfluoroundecanoic acid (PFUdA)	0.010	< 0.01	< 0.01	< 0.01	< 0.01
Perfluorododecanoic acid (PFDoA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorotridecanoic acid (PFTrDA)	0.050	< 0.05	< 0.05	< 0.05	< 0.05
Perfluorotetradecanoic acid (PFTeDA)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
Perfluorobutanesulfonic acid (PFBS)	0.005	< 0.005	< 0.005	0.19	< 0.005
Perfluorohexanesulfonic acid (PFHxS)	0.005	< 0.005	< 0.005	3.6	< 0.005
Perfluorooctanesulfonic acid (PFOS)	0.005	< 0.005	< 0.005	2.7	< 0.005
Perfluorodecanesulfonic acid (PFDS)	0.020	< 0.02	< 0.02	< 0.02	< 0.02
TOTAL C4-C14 Carboxylic acids	0.150	< 0.15	< 0.15	3.7	< 0.15
TOTAL C4-C10 Sulfonic acids	0.020	< 0.02	< 0.02	6.4	< 0.02

16KS1406-16KS1411

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Queensland Government

Forensic and Scientific Services
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CERTIFICATE OF ANALYSIS

CLIENT: Raymond Bott
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ATTN: Raymond Bott

Laboratory Reference	: SSP0053906
Client Order Number	:
Quote Number	:
Client Project	:
Client Batch Reference	:
Date Received	: 16-02-2017
Date Commenced	: 17-02-2017
Laboratory Number/s	: 17KS295-297

CC:

Submitting Authority : QFES

Number of Samples : 3

Reason for Analysis : PFAS monitoring

Method/s of Analysis : QIS 32403 – Perfluorinated Compounds in Water

Remarks : Total Fluorinated Organics is the sum of the total oxidisable precursors (TOPA C4-C14) perfluoroalkyl carboxylic acids plus (C4-C10) perfluoroalkyl sulfonic acids.

Please note that the TOPA method is not validated

DduPlessis

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01/03/17

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Client Reference				Sample 1	Sample 2	Sample 3
Sample Type				Water	Water	Water
Sampling Time / Date						
Sample Description				BRAN170213-01	BRAH170213-01	BRW170213-01
Method	Free Perfluoroalkyl Compounds (PFAS)	Units	Reporting Limit	17KS295	17KS296	17KS297
32403	Perfluorobutanoic acid (PFBA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluoropentanoic acid (PFPeA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorohexanoic acid (PFHxA)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluoroheptanoic acid (PFHpA)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorooctanoic acid (PFOA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorononanoic acid (PFNA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorodecanoic acid (PFDA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluoroundecanoic acid (PFUDA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluorododecanoic acid (PFDoA)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorotridecanoic acid (PFTrDA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid (PFTeDA)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid (PFHxDA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid (PFBS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorohexanesulfonic acid (PFHxS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorooctanesulfonic acid (PFOS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorodecanesulfonic acid (PFDS)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorooctyl ethanoic acid (FOEA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorodecyl ethanoic acid (FDEA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Total (C4-C14) Free perfluoroalkyl carboxylic acids	µg/L	0.15	<0.15	<0.15	<0.15
32403	Total (C4-C10) Free perfluoroalkyl sulfonic acids	µg/L	0.02	<0.02	<0.02	<0.02

Client Reference				Sample 1	Sample 2	Sample 3
Sample Type				Water	Water	Water
Sampling Time / Date						
Sample Description				BRAN170213-01	BRAH170213-01	BRW170213-01
Method	TOPA Perfluoroalkyl Compounds	Units	Reporting Limit	17KS295	17KS296	17KS297
32403	Perfluorobutanoic acid (PFBA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluoropentanoic acid (PFPeA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorohexanoic acid (PFHxA)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluoroheptanoic acid (PFHpA)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorooctanoic acid (PFOA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorononanoic acid (PFNA)	µg/L	0.007	< 0.007	< 0.007	< 0.007
32403	Perfluorodecanoic acid (PFDA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluoroundecanoic acid (PFUDA)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	Perfluorododecanoic acid (PFDoA)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorotridecanoic acid (PFTrDA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorotetradecanoic acid (PFTeDA)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorohexadecanoic acid (PFHxDA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorobutanesulfonic acid (PFBS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorohexanesulfonic acid (PFHxS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorooctanesulfonic acid (PFOS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	Perfluorodecanesulfonic acid (PFDS)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.005	< 0.005	< 0.005	< 0.005
32403	6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.01	< 0.01	< 0.01	< 0.01
32403	8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.02	< 0.02	< 0.02	< 0.02
32403	Perfluorooctyl ethanoic acid (FOEA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Perfluorodecyl ethanoic acid (FDEA)	µg/L	0.05	< 0.05	< 0.05	< 0.05
32403	Total (TOPA C4-C14) perfluoroalkyl carboxylic acids	µg/L	0.15	<0.15	<0.15	<0.15
32403	Total (C4-C10) perfluoroalkyl sulfonic acids	µg/L	0.02	<0.02	<0.02	<0.02
32403	Total Fluorinated Organics	µg/L	0.20	<0.20	<0.20	<0.20

Appendix C

Quality Assurance and Quality Control

Notes
If blanks are reporting values greater than one tenth the limit of reporting, samples are blank corrected
For each ten samples a minimum of on duplicate sample is prepared
For each twenty samples a matrix spike is included in the batch
There is always a background of 6:2 FTS in instrument and a pre column is used to reduce the level.
The below labelled compounds are used as isotope dilution in each sample
Labelled Perfluorobutanoic acid
Labelled Perfluorohexanoic acid
Labelled Perfluorooctanoic acid
Labelled Perfluorononanoic acid
Labelled Perfluorodecanoic acid
Labelled Perfluoroundecanoic acid
Labelled Perfluorododecanoic acid
Labelled Perfluorohexanesulfonate
Labelled Perfluorooctanesulfonate
Labelled Perfluorohexyl ethanoic acid
Labelled Perfluorooctyl ethanoic acid
Labelled Perfluorodectyl ethanoic acid
Labelled 1H,1H,2H,2H-Perfluorooctanesulfonate

Batch F60718MP Contains packages SSP51089 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS		DUPLICATE DIFF. (%RPD)	BLANK	LOR (µg/L)
	SPIKE	SPK_689	16KS687	DUP_687	DUP_687		
Perfluorobutanoic acid	159	131	0.42	0.41	2	< 0.005	0.005
Perfluoropentanoic acid	137	142	0.84	0.77	9	< 0.01	0.010
Perfluorohexanoic acid	96	94	1.10	1.00	10	< 0.005	0.005
Perfluoroheptanoic acid	132	120	0.44	0.41	7	< 0.005	0.005
Perfluorooctanoic acid	90	94	0.37	0.34	8	< 0.005	0.005
Perfluorononanoic acid	101	98	0.28	0.26	7	< 0.005	0.005
Perfluorodecanoic acid	114	105	0.01	0.01	0	< 0.005	0.005
Perfluoroundecanoic acid	125	103	0.02	0.02	0	< 0.005	0.005
Perfluorododecanoic acid	104	116	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotridecanoic acid	9	7	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotetradecanoic acid	8	13	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexadecanoic acid	19	82	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctadecanoic acid	25	72	< 0.01	< 0.01		< 0.01	0.010
Perfluorobutanesulfonic acid	101	106	0.31	0.30	3	< 0.005	0.005
Perfluorohexanesulfonic acid	104	99	4.90	5.10	4	< 0.005	0.005
Perfluorooctanesulfonic acid	110	104	5.90	7.20	20	< 0.005	0.005
Perfluorodecanesulfonic acid	18	15	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctyl ethanoic acid	NA	NA	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodectyl ethanoic acid	NA	NA	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorohexanesulfonic acid	132	102	< 0.005	< 0.005		< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	97	88	0.099	0.107	8	< 0.01	0.01
1H,1H,2H,2H-Perfluorodecanesulfonic acid	43	64	0.002	0.001	---	< 0.02	0.02

Notes

PFTrDA, PFTeDA, PFHxDA, PFDS, FOEA, FDEA Blank spike recovery
PFTrDA, PFTeDA, PDFS, FOEA, FDEA Matrix spike SPK_689

Batch F60913MP Contains packages SSP51857 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS		DUPLICATE DIFF. (%RPD)	BLANK	LOR (µg/L)
	SPIKE	SPK_956	16KS955	DUP_955	DUP_955		
Perfluorobutanoic acid	91	89	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoropentanoic acid	95	123	< 0.01	< 0.01	---	< 0.01	0.010
Perfluorohexanoic acid	82	56	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	106	148	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	90	74	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorononanoic acid	97	100	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanoic acid	91	93	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroundecanoic acid	85	78	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorododecanoic acid	88	95	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotridecanoic acid	72	67	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotetradecanoic acid	80	59	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexadecanoic acid	44	18	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctyl ethanoic acid	134	33	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodectyl ethanoic acid	NA	NA	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorohexanesulfonic acid	80	83	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	101	164	< 0.02	< 0.02	---	0.007	0.02
1H,1H,2H,2H-Perfluorodecanesulfonic acid	103	306	< 0.005	< 0.005	---	< 0.005	0.02

Notes

FDEA Blank spike recovery below LCL
PFHxDA, FDEA Matrix spike SPK_956 recovery below LCL

Batch F60919MP Contains packages SSP51590 SSP51931 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS		DUPLICATE DIFF.(%RPD)	BLANK	LOR (µg/L)
	SPIKE	SPK_994	16KS993	DUP_993	DUP_993		LOR
Perfluorobutanoic acid	105	100	0.013	0.011	17	< 0.005	0.005
Perfluoropentanoic acid	100	95	0.020	0.020	0	< 0.01	0.010
Perfluorohexanoic acid	105	96	0.026	0.024	8	< 0.005	0.005
Perfluoroheptanoic acid	92	87	0.008	0.006	29	< 0.005	0.005
Perfluorooctanoic acid	110	106	0.012	0.011	9	< 0.005	0.005
Perfluorononanoic acid	108	93	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanoic acid	117	101	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroundecanoic acid	111	99	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorododecanoic acid	107	99	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotridecanoic acid	85	80	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorotetradecanoic acid	76	66	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexadecanoic acid	46	18	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorobutanesulfonic acid	106	91	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	111	103	0.043	0.039	10	< 0.005	0.005
Perfluorooctanesulfonic acid	104	101	0.120	0.110	9	< 0.005	0.005
Perfluorodecanesulfonic acid	100	93	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexyl ethanoic acid	110	68	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctyl ethanoic acid	134	63	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodectyl ethanoic acid	91	70	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorohexanesulfonic acid	100	101	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	109	78	< 0.02	< 0.02	---	0.003	0.020
1H,1H,2H,2H-Perfluorodecanesulfonic acid	106	102	< 0.005	< 0.005	---	< 0.005	0.005

Notes

PFHxDA Matrix spike SPK_994 recovery below LCL

F60928MP Contains packages SSP51976 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1032	16KS1031	DUP_1031	DUP_1031		
Perfluorobutanoic acid	106	100	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	96	93	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	100	90	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	110	106	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	98	90	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	103	93	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	104	98	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	105	97	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	97	85	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	90	107	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	82	81	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	56	34	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	99	88	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	103	86	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	102	97	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	94	106	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorooctyl ethanoic acid	111	101	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	93	79	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	109	146	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	110	100	< 0.010	< 0.010	---	0.0006	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	105	125	< 0.020	< 0.020	---	< 0.020	0.020

Batch F61128AT Contains packages SSP52842 SSP52843 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1190	16KS1188	DUP_1188	DUP_1188	16KS1204	DUP_1204	DUP_1204	16KS1218	DUP_1218	DUP_1218		
Perfluorobutanoic acid	111	60	< 0.010	< 0.010	---	0.040	0.040	0	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	113	99	< 0.007	< 0.007	---	0.065	0.054	18	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	105	111	< 0.005	< 0.005	---	0.130	0.140	7	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	113	85	< 0.005	< 0.005	---	0.054	0.048	12	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	113	171	< 0.007	< 0.007	---	0.045	0.044	2	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	121	98	< 0.007	< 0.007	---	0.007	0.006	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	96	90	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	102	92	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	130	102	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	50	65	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	39	60	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	33	52	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	102	94	< 0.005	< 0.005	---	0.041	0.036	13	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	106	95	< 0.005	< 0.005	---	0.400	0.410	2	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	111	65	< 0.005	< 0.005	---	0.760	0.750	1	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	87	66	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	99	133	< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	143	120	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	111	127	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	110	127	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	174	95	< 0.010	< 0.010	---	0.040	0.040	0	< 0.010	< 0.010	---	0.030	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	98	113	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFTeDA Blank spike recovery below LCL

Batch F61130AT Contains packages SSP52852 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1229	16KS1228	DUP_1228	DUP_1228	16KS1243	DUP_1243	DUP_1243		
Perfluorobutanoic acid	103	84	0.150	0.160	6	0.040	0.040	0	< 0.010	0.010
Perfluoropentanoic acid	102	209	0.400	0.410	2	0.130	0.140	7	< 0.007	0.007
Perfluorohexanoic acid	98	72	0.230	0.230	0	0.058	0.062	7	< 0.005	0.005
Perfluoroheptanoic acid	89	126	0.220	0.260	17	0.062	0.066	6	< 0.005	0.005
Perfluorooctanoic acid	87	NA	0.042	0.048	13	0.022	0.022	0	< 0.007	0.007
Perfluorononanoic acid	110	151	0.047	0.047	0	0.015	0.016	6	< 0.007	0.007
Perfluorodecanoic acid	100	133	< 0.010	< 0.010	---	0.009	0.010	11	< 0.010	0.010
Perfluoroundecanoic acid	77	94	< 0.010	< 0.010	---	0.030	0.020	40	< 0.010	0.010
Perfluorododecanoic acid	82	74	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	76	80	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	58	62	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	34	22	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	92	110	0.027	0.027	0	0.006	0.006	0	< 0.005	0.005
Perfluorohexanesulfonic acid	97	168	0.065	0.070	7	0.025	0.020	22	< 0.005	0.005
Perfluorooctanesulfonic acid	86	168	0.059	0.065	10	0.036	0.036	0	< 0.005	0.005
Perfluorodecanesulfonic acid	113	105	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	96	88	< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	71	73	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	151	109	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	97	164	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	77	NA	0.570	0.310	59	0.008	0.010	24	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	116	125	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFOA, 6:2FTS Matrix spike Spk_1229 recovery below LCL

6:2FTS DUP_1228 RPD <30%

Batch F61205AT Contains packages SSP52880 SSP52927 SSP52928 SSP52929 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1282	SPK_1297	16KS1281	DUP_1281	DUP_1281	16KS1286	DUP_1286	DUP_1286	16KS1296	DUP_1296	DUP_1296		
Perfluorobutanoic acid	95	105	106	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	105	121	108	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	110	117	91	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	93	104	97	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	113	112	94	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	104	117	97	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	113	103	105	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	117	102	104	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	114	106	106	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	59	49	53	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	44	31	42	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	2	11	2	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	89	95	117	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	108	116	74	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	104	103	80	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	89	82	76	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	144	89	115	< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	74	88	184	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	NA	53	NA	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	99	94	82	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	76	90	99	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	119	121	96	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFTeDA, PFHxDA, FDEA Blank spike recovery below LCL
PFTeDA, PFHxDA Matrix spike SPK_1282 recovery below LCL
PFTeDA, PFHxDA, FDEA Matrix spike SPK_1297 recovery below LCL

Batch F61207AT Contains packages SSP52952 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1333	16KS1332	DUP_1332	DUP_1332	16KS1374	DUP_1374	DUP_1374		
Perfluorobutanoic acid	123	125	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	104	97	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	109	102	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	101	99	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	119	104	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	114	110	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	114	105	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	127	115	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	111	95	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	47	58	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	17	24	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	NA	NA	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	100	89	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	104	110	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	113	108	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	86	71	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	117	144	< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	65	35	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	NA	NA	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	96	94	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	77	73	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	98	86	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFTeDA, PFHxDA, FDEA Blank spike recovery below LCL
PFTeDA, PFHxDA, FDEA Matrix spike SPK_1333 recovery below LCL

Batch F61206AT Contains packages SSP52930 SSP52931 SSP52936 SSP52937 SSP52938 SSP52944 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1303	SPK_1324	16KS1352	DUP_1352	DUP_1352	16KS1313	DUP_1313	DUP_1313	16KS1323	DUP_1323	DUP_1323		
Perfluorobutanoic acid	101	104	109	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	96	104	90	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	100	105	108	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	81	96	86	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	104	101	105	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	96	111	101	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	96	107	107	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	99	114	104	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	88	112	102	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	55	66	59	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	48	63	48	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	15	23	12	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	84	97	77	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	106	96	109	0.010	0.009	11	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	99	118	105	0.015	0.013	14	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	82	67	78	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	95	99	99	< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	106	90	88	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	119	71	54	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	97	112	91	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	71	78	73	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	< 0.010	---	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	105	93	148	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFHxDA Blank spike recovery below LCL
PFHxDA Matrix spike SPK_1303 recovery below LCL

Batch F61212AT Contains packages SSP53053 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_1407	16KS1406	DUP_1406	DUP_1406		
Perfluorobutanoic acid	99	96	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	102	100	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	98	100	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	101	99	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	106	106	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	97	97	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	96	106	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	104	102	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	108	119	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	55	61	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	44	58	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	5	13	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	102	95	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	107	106	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	102	100	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	84	69	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexyl ethanoic acid	131	110	< 0.20	< 0.20		< 0.20	0.20
Perfluorooctyl ethanoic acid	90	73	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	70	39	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	100	96	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	96	89	< 0.010	< 0.010	---	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	94	93	< 0.020	< 0.020	---	< 0.020	0.020

Notes

PFHxDA Blank spike recovery below LCL
PFHxDA Matrix spike SPK_1407 recovery below LCL

Batch F71010MP Contains packages SSP57053 Water analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (µg/L)		DUPLICATE DIFF. (%RPD)	BLANK (µg/L)	LOR (µg/L)
	SPIKE	SPK_7528	17KE7527	DUP_7527	DUP_7527		
Perfluorobutanoic acid	80	104	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoropentanoic acid	117	115	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorohexanoic acid	108	111	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoroheptanoic acid	118	103	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanoic acid	117	106	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorononanoic acid	118	86	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorodecanoic acid	107	81	< 0.010	< 0.010	---	< 0.010	0.010
Perfluoroundecanoic acid	81	72	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorododecanoic acid	119	102	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorotridecanoic acid	63	70	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorotetradecanoic acid	68	72	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorohexadecanoic acid	65	78	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorobutanesulfonic acid	132	94	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorohexanesulfonic acid	128	99	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorooctanesulfonic acid	95	85	< 0.005	< 0.005	---	< 0.005	0.005
Perfluorodecanesulfonic acid	72	66	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorooctyl ethanoic acid	102	NA	< 0.050	< 0.050	---	< 0.050	0.050
Perfluorodectyl ethanoic acid	96	NA	< 0.050	< 0.050	---	< 0.050	0.050
1H,1H,2H,2H-Perfluorohexanesulfonic acid	136	110	< 0.005	< 0.005	---	< 0.005	0.005
1H,1H,2H,2H-Perfluorooctanesulfonic acid	420	NA	< 0.010	< 0.010	---	< 0.010	0.010
1H,1H,2H,2H-Perfluorodecanesulfonic acid	111	94	< 0.005	< 0.005	---	< 0.005	0.005

Notes

FOEA, FDEA Matrix spike SPK_7528 recovery below LCL

Batch G60919MP Contains packages SSP51857 SSP51931 SSP51950 SSP51976 SSP52034 Soil analysis	BLANK SPIKE RECOVERY (%)	MATRIX SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (mg/kg)		DUPLICATE DIFF. (%RPD)	DUPLICATE ANALYSIS (mg/kg)		DUPLICATE DIFF. (%RPD)	BLANK (mg/kg)	LOR (mg/kg)
	SPIKE	SPK_958	16KE957	DUP_957	DUP_957	16KE1036	DUP_1036	DUP_1036		
Perfluorobutanoic acid	94	97	< 0.005	< 0.005	---	< 0.005	< 0.005	---	< 0.005	0.005
Perfluoropentanoic acid	81	61	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorohexanoic acid	99	110	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluoroheptanoic acid	80	64	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluorooctanoic acid	97	100	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorononanoic acid	99	97	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluorodecanoic acid	100	102	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluoroundecanoic acid	99	122	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorododecanoic acid	101	110	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorotridecanoic acid	59	11	< 0.007	< 0.007	---	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorotetradecanoic acid	49	17	< 0.01	< 0.01	---	< 0.01	< 0.01	---	< 0.01	0.010
Perfluorobutanesulfonic acid	85	67	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluorohexanesulfonic acid	100	125	< 0.001	< 0.001	---	< 0.001	< 0.001	---	< 0.001	0.001
Perfluorooctanesulfonic acid	99	NA	< 0.001	< 0.001	---	0.010	0.010	0	< 0.001	0.001
Perfluorodecanesulfonic acid	57	35	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorohexyl ethanoic acid	92	107	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorooctyl ethanoic acid	106	86	< 0.020	< 0.020	---	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorodectyl ethanoic acid	100	137	< 0.020	< 0.020		< 0.020	< 0.020		0.000	0.020
1H,1H,2H,2H-Perfluorohexanesulfonic acid	100	75	< 0.002	< 0.002	---	< 0.002	< 0.002	---	< 0.005	0.002
1H,1H,2H,2H-Perfluorodecanesulfonic acid	87	99	< 0.005	< 0.02	---	< 0.02	< 0.02	---	< 0.02	0.020

Notes

PFTrDA, PFTeDA, PFOS Matrix spike SPK_957 recovery below LCL

Batch G61024MP Contains packages SSP52373 Soil analysis	BLANK SPIKE RECOVERY (%)	DUPLICATE ANALYSIS (mg/kg)		DUPLICATE DIFF. (%RPD)	BLANK (mg/kg)	LOR (mg/kg)
	SPIKE	16KS1081	DUP_1081	DUP_1081		
Perfluorobutanoic acid	112	0.007	0.007	0	< 0.005	0.005
Perfluoropentanoic acid	89	0.009	0.010	11	< 0.002	0.002
Perfluorohexanoic acid	101	0.005	0.005	0	< 0.001	0.001
Perfluoroheptanoic acid	89	0.001	0.001	0	< 0.001	0.001
Perfluorooctanoic acid	99	0.002	0.002	---	< 0.002	0.002
Perfluorononanoic acid	99	0.002	0.002	0	< 0.001	0.001
Perfluorodecanoic acid	101	0.001	0.001	---	< 0.001	0.001
Perfluoroundecanoic acid	102	0.002	0.002	---	< 0.002	0.002
Perfluorododecanoic acid	100	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorotridecanoic acid	70	< 0.007	< 0.007	---	< 0.007	0.007
Perfluorotetradecanoic acid	68	< 0.010	< 0.010	---	< 0.010	0.010
Perfluorobutanesulfonic acid	85	0.001	0.001	---	< 0.001	0.001
Perfluorohexanesulfonic acid	97	0.003	0.003	0	< 0.001	0.001
Perfluorooctanesulfonic acid	101	0.064	0.063	2	< 0.001	0.001
Perfluorodecanesulfonic acid	77	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorohexyl ethanoic acid	96	< 0.002	< 0.002	---	< 0.002	0.002
Perfluorooctyl ethanoic acid	104	< 0.020	< 0.020	---	< 0.020	0.020
Perfluorodectyl ethanoic acid	96	< 0.020	< 0.020		< 0.020	0.020
1H,1H,2H,2H-Perfluorohexanesulfonic acid	94	< 0.002	< 0.002	---	< 0.002	0.002
1H,1H,2H,2H-Perfluorodecanesulfonic acid	90	< 0.005	< 0.005	---	< 0.005	0.005

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