



Interim Guideline on the Assessment and Management of Perfluoroalkyl and Polyfluoroalkyl Substances (PFAS)

Contaminated Sites Guidelines

Produced and published by

Department of Environment Regulation
168 St Georges Terrace, Perth, Western Australia

February 2016

Copyright © State of Western Australia 2016

All material is the copyright of the State of Western Australia. Permission is not given for any commercial use or sale of this material. No part of the contents of the publication may be reproduced by any process, electronic or otherwise, distributed, adapted, broadcast, performed in public or communicated to the public without the written consent of the Department of Environment Regulation, except as permitted under the *Copyright Act 1968*.

Disclaimer

The information contained in this document is provided by the Department of Environment Regulation in good faith. However, there is no guarantee of the accuracy of the information contained in this document and it is the responsibility of users to make their own enquiries as to its accuracy, currency, relevance and correctness.

The State of Western Australia and Department of Environment Regulation and their servants and agents expressly disclaim liability, in negligence or otherwise, for any act or omission occurring in reliance on the information contained in this document, or for any incident or consequential loss or damage of such act or omission.

The State of Western Australia is committed to providing quality information and has made every attempt to ensure the accuracy, currency, reliability and correctness of the information contained in this document. However, changes in circumstances and legislation after the time of publication may impact on the correctness or quality of this information.

In addition the accuracy, currency, reliability and correctness of links or references to information sources referred to or provided by third parties is outside the control of the State of Western Australia and it is therefore the responsibility of the user to make their own decisions on information found on those external sites. Confirmation of any of the information provided in this document may be sought from the relevant originating bodies or the department providing the information; however, users of this material should verify all relevant representations, statements and information with their own professional advisers.

The State of Western Australia and Department of Environment Regulation reserve the right to amend the content of this document at any time without notice.

The information contained in this document is general. It does not constitute, and should be not relied on as, legal advice. The State of Western Australia recommends that users of this information seek advice from a qualified lawyer on the legal issues affecting them before relying on this information or acting on any legal matter.

Questions regarding this report should be directed to:

Department of Environment Regulation
Locked Bag 33 Cloisters Square
PERTH WA 6850
Phone: +61 8 6467 5000
Fax: +61 8 6467 5562
Email: info@der.wa.gov.au
Web: www.der.wa.gov.au

Accessibility: this document is available in alternative formats and languages upon request.

Contents

1	Purpose	1
2	Introduction	2
3	Scope	2
4	Overview	3
5	Site Assessment	5
5.1	Conceptual Site Model.....	5
5.2	Fate and Transport in the Environment.....	7
5.3	Occurrence in the Australian Environment.....	8
5.4	Sampling and Analysis Quality Plans.....	9
5.5	Laboratory Analysis	9
5.6	Interim Screening Levels.....	10
6	Management of PFAS-impacted Sites	12
6.1	Source and Affected Sites.....	12
6.2	Affected Sites—Developments Undertaken by Persons not Responsible for the Remediation of the Affected Area.....	12
7	Remediation and Management	13
7.1	Remediation.....	13
7.2	Waste Disposal.....	15
	Bibliography	16
	Appendix 1. PFAS-specific Sample Collection Methods, Equipment, and Equipment Decontamination Methods	20
	Groundwater Well Drilling, Development, and Sampling	23
	Soil Drilling and Aquatic Sampling	24
	PFAS-specific Sample Handling and Processing Methods.....	25
	PFAS-specific Laboratory Analysis Specifications.....	26

1 Purpose

Perfluoroalkyl and polyfluoroalkyl substances (PFAS) are a family of manufactured chemicals which do not occur naturally in the environment. Perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA) are two of the most well-known PFAS and are contaminants of emerging concern in Australia and internationally. They have been identified in the environment at a number of known and suspected contaminated sites in Western Australia. PFAS have been detected worldwide in fauna, ecosystems and humans since first use in the 1950s (Danish EPA 2013 and 2015).

The purpose of this Guideline is to provide guidance on the assessment and management of PFAS within the legislative framework provided by the *Contaminated Sites Act 2003* (CS Act) and the *Contaminated Sites Regulations 2006* (CS Regulations), and the national site assessment framework provided in the *National Environment Protection (Assessment of Site Contamination) Measure 1999* (NEPM).

This Guideline should be read in conjunction with the Department of Environment Regulation's (DER) *Contaminated sites guideline assessment and management of contaminated sites* (DER 2014).

This document includes guidance on:

- the assessment and management of PFAS contamination;
- the assessment of risks to human health, the environment and environmental values;
- the availability and derivation of generic assessment levels; and
- remediation and management of PFAS impacted sites.

This Guideline has been prepared to assist environmental practitioners, including environmental consultants and auditors, when planning and implementing the assessment and management of contaminated sites. It will also assist when preparing reports to be submitted to DER and accredited contaminated site auditors under the CS Act and the CS Regulations. It may also be useful for other purposes, such as due diligence assessments. However, it may be necessary to discuss site-specific circumstances with DER, refer directly to the CS Act and CS Regulations and/or seek specific legal advice.

2 Introduction

DER has prepared this guideline to help landowners, industry, consultants, auditors and other interested parties understand the specific requirements for PFAS when investigating/assessing and remediating/managing contaminated sites in WA.

In WA, contaminated sites are regulated by DER through the CS Act and CS Regulations (available from the WA State Law Publisher at www.slp.wa.gov.au). DER works in consultation with the Department of Health in relation to public health issues at contaminated sites.

The NEPM provides guidance on the assessment of site contamination and is available at www.scew.gov.au/nepms/assessment-site-contamination. When referring to the NEPM, practitioners should also consult this website for errata and additional information provided in the NEPM toolbox. The *National Environment Protection Council Act 1994* limits the scope of the NEPM to site assessment and does not include guidance on remediation of contaminated sites.

DER provides additional guidance specific to WA within the Contaminated Sites Guidelines (CSG) series, which includes this guideline and is available at www.der.wa.gov.au/contaminatedsites.

Practitioners are expected to refer to the NEPM and DER guidelines when conducting site assessments. It is essential that practitioners keep up to date with current versions of guidance documents referred to herein and published errata.

3 Scope

The Guideline is intended for both internal and external audiences.

4 Overview

Perfluoroalkylated substances are a large group of compounds consisting of a fully fluorinated hydrophobic alkyl chain of varying length (typically 4 to 16 carbon atoms) and a hydrophilic end group. Within the PFAS group of compounds, the perfluoroalkyl acids and their salts are the most well-known. The main subgroups are the perfluoroalkyl carboxylic acids and the perfluoroalkane sulfonic acids and their respective salts.

Certain PFAS have been identified as contaminants of emerging concern in Australia and internationally. These include perfluorooctane sulfonate (PFOS) and perfluorooctanoic acid (PFOA). PFAS also include polyfluorinated compounds (such as fluorotelomers 6:2FTS and 8:2FTS), which under certain circumstances, may break down to produce PFOA in the environment¹. Collectively, these substances are referred to in this document as PFAS.

PFAS are fluorosurfactants and have complex and unique properties compared with most other potential contaminants of concern, which makes them a particular challenge for environmental practitioners. PFAS are both hydrophobic and oleophobic and have extremely low surface tension (Lau *et al.* 2004).

PFAS have many versatile properties such as dirt, grease and water resistance; heat, chemical and abrasion resistance; low friction; surfactant and dielectrical properties; and thermal stability, versatility, strength, resilience and durability. Hence PFAS are widely used in a range of industrial applications, such as textiles, preservatives, fluoropolymer and fluoroelastomer production, surface treatment, food packaging, hydraulic oil for aeroplanes, cosmetics, floor wax, polish, paint and lacquer, as well as fire-fighting foams (Seow 2013).

PFAS are imported into Australia, mainly for use as mist suppressants in the metal plating industry, hydraulic fluid in aircraft, surfactants in the photographic industry, and in some types of fire-fighting foams (Aqueous Film-Foaming Foams (AFFF) and Alcohol-Type Concentrate (ATC)) used to extinguish Class B fires that involve flammable fuels². The PFAS used in AFFF reduce the surface tension of water and allow an aqueous film to spread over the flammable liquid and suppress vapours during fire-fighting.

PFAS are known to be persistent, bioaccumulative and toxic and, due to their persistence in the environment and moderate solubility, can be transported long distances (potentially kilometres) (Scheringer, 2009) in water and air, and transfer between different media (e.g. soil, sediment, surface water and groundwater).

In August 2010, nine new chemicals, including PFOS, PFOS salts and perfluorooctane sulfonyl fluoride (PFOSF), were added to Annex B³ of the Stockholm Convention on Persistent Organic Pollutants (Australia has yet to ratify this amendment)⁴. Details are provided in Table 1.

¹ Derived from the National Industrial Chemicals Notification and Assessment Scheme (NICNAS) which is a statutory scheme administered by the Australian Government Department of Health and its role is to aid in the protection of the Australian people and the environment by assessing the risks of industrial chemicals and providing information to promote their safe use (www.nicnas.gov.au/chemical-information).

² NICNAS – PFC derivatives and chemicals on which they are based Alert Factsheet (sourced from NICNAS website updated May 2013).

³ Annex B is a list of chemicals where the production and use, import and export is restricted.

⁴ <https://www.environment.gov.au/protection/chemicals-management/pops/new-pops>

Table 1. Details of PFOS, its salts and PFOSF listing on Annex B of the Stockholm Convention in 2010

Effect of listing of PFOS	Ban on production and use except for specified acceptable purposes and specific exemptions
<p>Acceptable purposes: (not time limited)</p>	<ul style="list-style-type: none"> • Photo-imaging • Photo-resist and anti-reflective coatings for semi-conductors • Etching agent for compound semi-conductors and ceramic filters • Aviation hydraulic fluids • Metal plating (hard metal plating) only in closed-loop systems • Certain medical devices (such as ethylene tetrafluoroethylene copolymer (ETFE) layers and radio-opaque ETFE production, in-vitro diagnostic medical devices, and CCD colour filters) • Fire-fighting foam • Insect baits for control of leaf-cutting ants from <i>Atta</i> spp. and <i>Acromyrmex</i> spp.
<p>Specific exemptions: (5 years initially, renewal possible)</p>	<ul style="list-style-type: none"> • Photo masks in the semiconductor and liquid crystal display (LCD) industries • Metal plating (hard metal) • Metal plating (decorative) • Electric and electronic parts for some colour printers and colour copy machines • Insecticides for control of red imported fire ants and termites • Chemically driven oil production • Carpets • Leather and apparel • Textiles and upholstery • Paper and packaging • Coatings and coating additives • Rubber and plastics

The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) has been working since 2002 to reduce the importation and use of some PFAS in Australia, notably PFOS and PFOA. Further information is available at www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/pfc-derivatives-and-chemicals-on-which-they-are-based-alert-factsheet.

5 Site Assessment

5.1 Conceptual Site Model

PFAS can be found in air, soil and water after release from the manufacture, use and disposal of products containing these chemicals.

In researching the site history and developing the conceptual site model, PFAS should be considered as a potential contaminant of concern if any of the industries, activities and land uses listed in Table 2 may have occurred at or adjacent to the site. The presence of secondary sources (areas connected to the primary source via a migration pathway such as a surface water drain) and the potential for bioaccumulation in the food chain should also be considered. The extent of investigation required should take into account the scale and longevity of activities at the site.

Practitioners should note that PFOA is also produced by the breakdown of some fluorotelomers, such as 8:2FTS, which can be used in stain, grease and water resistant surface treatment products; paints; coatings; cleaning products; fire-fighting foams; and engineered coatings.

The list provided is not exhaustive and it may be necessary to consider whether PFAS could be present as a result of other activities and/or land uses as further information is published.

Table 2. Potentially contaminating industries, activities and land uses leading to the potential presence of PFAS

Industry, Activity or Land Use	Source of PFAS
Airports, aviation facilities major hazard sites (e.g. refineries and major fuel storage sites) with fire-fighting facilities and/or training facilities Aircraft and vehicle crash sites and other major incident sites where large quantities of AFFF have been used	Surfactant in aqueous film forming foams (AFFF) containing PFAS* Aviation hydraulic fluid
Chrome plating baths	Mist suppressant
Manufacture of various commercial and domestic products	Surfactant for alkaline cleaners Emulsifier in floor polish/waxes Surfactant for etching acids for circuit boards Pesticide active ingredient for ant bait Water/solvent repellent for leather, paper Soil/water repellent for: <ul style="list-style-type: none"> - carpet; - fabric/upholstery; - apparel; and - leather and metal/glass. oil/water repellent for: <ul style="list-style-type: none"> - food packaging; - containers; - carbonless forms; and - masking papers. antistatic agent in photographic papers
Waste storage, treatment and disposal of the above products – including landfills, wastewater treatment works and depots	Landfill leachate Treated products including biosolids and wastewater (produced from primary and secondary treatment processes)

* Legacy AFFF contains PFOS and PFOA, newer AFFF formulations contain fluorotelomers such as 6:2 FTS to 10:2 FTS. These fluorotelomers may degrade in the environment and release PFOA.

The potential for PFAS contamination to be present from non-AFFF sources is currently not well understood in Australia, particularly the presence of PFAS contamination in biosolids from sewage treatment plants and landfill leachate or its significance in relation to current background levels.

5.2 Fate and Transport in the Environment

PFOS and PFOA are manufactured chemicals which are not found naturally in the environment. They are chemically and biologically stable and are resistant to typical environmental degradation processes, including atmospheric photo-oxidation, direct photolysis and hydrolysis (US EPA 2014). As a group, PFAS are persistent in soil and water. PFAS are mobile in soil and leach into groundwater. Volatile fluorotelomers alcohols may be broken down into substances like PFOA, and atmospheric deposition can lead to contamination of soils and leaching into groundwater away from point sources (ATSDR 2015).

PFOS and PFOA are non-flammable and can resist degradation by acids, bases, oxidants, reductants, photolytic processes, microbes, and metabolic processes (Kissa 2001, Giesy and Kannan 2002).

Recent research, however, has shown that certain PFAS can undergo biotic transformation to produce PFOS and PFOA (Buck et al., 2011; Paul et al., 2009, Prevedouros et al., 2006, Liu and Avendaño 2013).

The role of microbial degradation has been the subject of much research over the last decade (Liu and Avendaño 2013). It was not recognised until recently that precursor biotransformation is a contributory factor to higher values of PFOS and PFOA in soil and water e.g. frequent detection of increased concentrations of PFOS and PFOA in effluent from wastewater treatment plants compared with the influent concentration (Becker et al., 2008; Loganathan et al., 2007; Murakami et al., 2009b; Schultz et al., 2006; Sinclair and Kannan, 2006), and higher values in groundwater compared with recharge concentration due to the biotransformation of precursors with time. Martin et al. (2010) have reported on precursor exposure scenarios that may be significant sources of PFOS exposure to humans and wildlife. Similarly, D'eon and Mabury (2011) demonstrated that precursor exposure could represent a significant proportion of observed PFAS in people.

Although the direct emissions of PFOA and PFOS have declined in recent years, it is becoming clear that exposure to various PFAS (which are converted into PFOS, PFOA and other perfluoroalkyl acids) is now a key factor for evaluating the total exposure and effect of PFAS.

The potential for precursor transformation to PFOS and PFOA and other PFAS metabolites should be considered in the overall potential for environmental and human exposure and evaluation of risk to human health, the environment and environmental values when assessing site contamination caused by PFAS.

PFOS and PFOA comprise a long carbon chain that is both lipid and water repellent. The stability of these compounds is due to the strength of the carbon-fluorine bonds. The vapour pressure for PFOS at 20°C is 2.48×10^{-6} mmHg and for PFOA is 0.017 mmHg. The atmospheric half-lives are 114 days and 90 days respectively.

PFOS and PFOA are moderately soluble and have surface water half-lives of 41 years and 92 years respectively. They can be transported to surface waters and groundwater (as a result of runoff and leaching) and are persistent in the environment. As a result, they can be transported long distances from the source site.

PFOS adsorbs to soil, sediment and sludge with distribution coefficients (K_d) ranging from 9.7 L/kg to 35 L/kg and does not desorb readily, once adsorbed to these matrices (Jensen *et al.* 2012). PFOS adsorption is strongly related to higher pH, organic carbon and clay content (Das *et al.* 2013); however, PFOA does not show the same sorption properties and is unlikely to be found in soil or sediment to the same extent as PFOS.

Limited information is publically available on the partitioning relationships between soil, sediment and water, however:

- soil and sediment adsorption is likely to increase with increasing organic carbon and clay content for PFOS; and
- leaching from soil to groundwater has been documented and the absence of soil impacts should not be taken as an indication that contaminated groundwater is not present (applicable to both PFOS and PFOA).

In summary, due to the contaminant fate and transport properties of PFOA and PFAS, these compounds may travel kilometres from the source site via surface water, groundwater and air.

PFAS have the potential to bioaccumulate and biomagnify in food webs as evidenced by their detection in fish and fish-eating birds. To date, PFOS is the only PFC that has been shown to accumulate to levels of concern in fish tissue (estimated bioconcentration factor of 1000 – 4000, US EPA 2014).

Human health

The Department has sought advice from the Department of Health regarding interim screening guidelines for protection of human health. The recommended interim approach is to consider PFOS as the primary indicator of whether further investigation/management of PFAS impacts is required (refer Table 4). Note, that the information provided on health based screening levels in this document should be read in conjunction with guidance published by the Department of Health.

The interim values will be reviewed and revised as and when further information is published by enHealth. It is anticipated that this will include screening values for both PFOS and PFOA.

5.3 Occurrence in the Australian Environment

PFAS (note: most of the reported data are for PFOS and PFOA) have been detected in the Australian environment, with the majority of published information relating to fire-fighting facilities and fire-fighting training grounds at airports (including Department of Defence sites) and major hazard installations.

Fire-fighting training grounds investigated to date appear to have high concentrations of PFAS. Consequently, all current and historical fire-fighting training grounds and areas where AFF has been stored or used in large quantities should be considered as a potential source of contamination.

Limited information is available at this time for other potential point sources of PFAS contamination in Western Australia such as landfills and wastewater treatment works.

5.4 Sampling and Analysis Quality Plans

The sampling methodology adopted should be generally consistent with methods for contaminated site investigation (refer to the NEPM and DER (2014), supplemented by measures specific to PFAS to prevent cross-contamination. Prevention of cross-contamination is particularly important due to the very low screening values applicable to some exposure pathways (refer section 5.6). The sampling procedure and order of sampling at each sampling location should take into account the nature of co-contaminants present.

Refer to Appendix 1 for detailed sampling procedures.

Refer to Schedule B2 of the NEPM for general guidance on developing data quality objectives (DQOs) and Sampling and Analysis Quality Plans (SAQP).

5.5 Laboratory Analysis

Schedule B3 of the NEPM states that comparable established standard methods sourced from recognised sources such as Standards Australia, the US EPA, the American Public Health Association (APHA), the American Society for Testing and Materials (ASTM) and the International Standards Organisation (ISO) should be used when analysis is required for contaminants not included in the NEPM.

The available standard methods from these sources include:

- **US EPA Method 537** – *Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS) (applicable to drinking water);*
- **ISO 25101** – *Water quality - Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) -- Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry (applicable to drinking water, ground water and surface water);*
- **ASTM D7968** – *Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS);* and
- **ASTM D7979** – *Standard Test Method for Determination of Perfluorinated Compounds in Water, Sludge, Influent, Effluent and Wastewater by Liquid Chromatography Tandem Mass Spectrometry (LC/MS/MS).*

Before September 2009 (publication of US EPA 537, version 1.1), there were no validated test methods or standardised data quality criteria. As a result, PFAS data generated before 2010 are unlikely to have been based on validated methods, making comparisons with more recent data produced via a validated method potentially problematic. The reliability of historical data should be considered on a case-by-case basis.

PFOS and PFAS commercial mixtures are generally made up of linear and branched isomers. The proportion of each isomer which occurs in environmental samples is affected by the original composition and subsequent transport and degradation and precursor transformation processes. Practitioners should ensure that the analytical laboratory uses a mixed linear/branched standard for calibration purposes and that the uncertainty in measurement is included in the laboratory reporting.

Practitioners should ensure that the proposed analytical laboratories (primary and secondary samples) will:

- use polypropylene or HDPE sample containers with polypropylene lids (check if the laboratory has a preference for either sample container type);
- use a mixed linear/branched standard for calibration purposes and the approach used in quantification;
- report analytical results representing the concentration of summed linear and branched isomers; and
- include the uncertainty in measurement in the laboratory reporting.

Practitioners should confirm the target analyte suite of PFASs (refer to table below for the minimum recommended suite) and that the required method reporting limits can be achieved.

Table 3. Minimum recommended analytical suite for PFAS

Abbreviation	Compound Name	Abbreviation	Compound Name
PFOS	Perfluorooctane sulfonate	PFBS	Perfluorobutane sulfonate
PFOA	Perfluorooctanoic acid	PFBA	Perfluorobutanoic acid
6:2 FTS	6:2 Fluorotelomer sulfonate	PFHxA	Perfluorohexanoic acid
8:2 FTS	8:2 Fluorotelomer sulfonate	PFHxS	Perfluorohexane sulfonate
PFHpA	Perfluoroheptanoic acid	PFPeA	Perfluoropentanoic acid

A case may be made for a reduced analytical suite once the contamination and risks arising have been adequately characterised.

5.6 Interim Screening Levels

There are as yet no formally recognised screening levels for PFOA, PFOS or PFAS in any media for use in Australia.

DER recommends that proponents and consultants adopt a staged approach to assessing and managing potential PFAS impacts. The interim screening levels in Table 4 may be used to indicate whether PFAS is likely to be a contamination issue for the site. If site data exceed the relevant levels, further assessment of the risk posed by the contamination is required or a conservative management approach should be adopted (as per DER 2014 and the NEPM).

Depending on site-specific circumstances and the site conceptual model, additional exposure scenarios which are not included in Table 4 may be relevant to the site. If this is the case, the procedures in the NEPM for deriving site-specific criteria should be followed or a pragmatic management approach adopted. Assessors should note that national work is underway to develop screening levels for human health and the environment, such as screening levels applicable to marine and terrestrial ecosystems and consumption of seafood.

As previously stated, information provided on health based screening levels in this document should be read in conjunction with guidance published by the Department of Health.

Table 4. Interim screening levels for soil, sediment, surface water and groundwater.

Exposure Scenario	PFOS	PFOA	Source and Comments
Soil			
human health residential*	4 mg/kg		DoH
human health industrial/commercial*	100 mg/kg		DoH/DER
Surface water and groundwater			
drinking water*	0.5 µg/L		DoH
non-potable and recreational uses*	5 µg/L		DoH
ecological – freshwater ⁺	0.00023 µg/L	19 µg/L	High conservation value systems (99% species protection)
	0.13 µg/L	220 µg/L	Slightly – moderately disturbed systems (95% species protection)
	2.0 µg/L 31 µg/L	632 µg/L 1,824 µg/L	Highly disturbed systems 90% species protection 80% species protection

* Values are provisional and will be revised as and when relevant information is published by enHealth.

+ Draft Australian and New Zealand Water Quality Guidelines applicable to aquatic organisms. The default guideline values may not account for effects which result from the biomagnification of toxicants such as PFOS in air-breathing animals or in animals which prey on aquatic organisms.

With regard to application of the ecological freshwater guidelines, the evaluation will need to include consideration of the nature of, and potential for dilution in, the receiving water body, the local background levels in the water body and the protection of top predators.

6 Management of PFAS-impacted Sites

6.1 Source and Affected Sites

DER expects that persons responsible for land known or suspected to be contaminated with PFAS will report the site (using the prescribed form [Form 1] available from www.der.wa.gov.au/your-environment/contaminated-sites) and undertake appropriate assessment and remediation action, commensurate with the risk posed to human health, the environment and environmental values (DER, 2014).

6.2 Affected Sites—Developments Undertaken by Persons not Responsible for the Remediation of the Affected Area

Under the CS Act, the person responsible for remediation of a source site is also responsible for the remediation of any associated affected sites. However, a developer of an affected site may be held responsible for any additional contamination caused by that development.

Where development of an affected site (as defined in the CS Act) requires dewatering and the groundwater has been impacted by PFAS, management measures should be undertaken which will not increase the pre-development risk to human health, the environment or any environmental value.

Dewatering may be required to facilitate the excavation of soils as part of a site development. It is possible that the soils of an affected site may have been impacted by PFAS in groundwater. The impacted soils should be managed so that they do not increase the predevelopment risk that the soil represents to human health, the environment or any environmental value. Potential options include:

- reinstatement of soil to the excavation (not applicable to contaminated sediments removed from drains) (commercial/industrial sites);
- placement of soil at another location on the site with a similar or higher contamination risk profile, providing that the volume of soil to be added is substantially less than the total mass of the contamination already present in that area (site-specific assessment required to establish what would be 'substantially less') (commercial/industrial sites);
- containment of soil on-site (residential and commercial/industrial); and
- off-site treatment and/or disposal (all sites).

The preferred solution will depend on the site-specific factors for the development (such as contaminant concentrations including presence of other contaminants, available time frame and volumes to be managed) and the overall risk profile of the source and affected sites.

7 Remediation and Management

7.1 Remediation

The assessment process outlined in DER (2014) recommends assessment of site contamination to the extent necessary to provide sufficient information to enable risk-based decision-making. If the risk assessment process identifies unacceptable risks to human health, the environment and/or environmental values, early action (i.e. clean-up and/or management) will be required to mitigate those risks.

Due to the chemical properties of PFOS, PFOA and other PFAS (low volatility and resistance to biodegradation, photolysis and hydrolysis), there are only a limited range of remediation options currently available. For contaminated soils and sediments these include landfill disposal, encapsulating contaminated soil or sediments in purpose built lined repositories, direct and indirect thermal desorption and pyrolysis.

For groundwater, the most common treatment methodology is extraction and filtration through granular activated carbon (GAC). This has been shown to be effective for removing PFOS at $\mu\text{g/L}$ concentrations; however, it is reportedly not as efficient at removing PFOA and other PFCs (ASTSWMO 2015). Other adsorbents (such as powdered activated carbon, polymers, maize-straw-derived ash, alumina and montmorillonite) have also been used, though not all are commercially proven. The spent adsorbent containing the contamination requires regeneration/chemical treatment or disposal (note that high temperature, greater than 1100°C , is required for destruction).

Treatment of large volumes of low concentration PFAS in groundwater is extremely challenging and it is likely that a management approach for diffuse groundwater plumes will need to be adopted as an interim measure to control unacceptable risks.

The table below summarises the technologies currently available in Australia, other than containment (mention of product names does not constitute product endorsement by DER).

Table 5. Treatment technologies currently available in Australia.

Process	Australian Examples	media
Adsorption	Granular activated carbon (GAC), resins, ion exchange polymers, MyCelx™ Various providers in Australia	Water and wastewater
Reverse osmosis	Various providers in Australia	Water and wastewater
Pyrolysis	PLASCON® - high temperature plasma arc www.toxfreeblog.wordpress.com/2014/09/08/pfos-and-pfoa/	Soil and water
Thermal desorption	In-direct and direct-fired thermal desorption www.cleanup2015.com.au/pdf/301_350/0307.pdf	Soil and wastes
Immobilisation*	Rembind® - blend of activated carbon, aluminium hydroxide, kaolin and other proprietary additives www.ziltek.com.au/rembind.html matCARE™ - amine modified clay sorbent www.crccare.com/products-and-services/technologies/matcare	Soil and wastewater

Refer to DER (2014) for further information regarding remediation and validation requirements.

7.2 Waste Disposal

Stockpiles of impacted soils must be managed to prevent contaminants leaching to groundwater or adversely affecting surface water bodies.

Contaminated soil (and other solid wastes), groundwater and wastewater must be correctly identified and transported by a licensed waste disposal contractor when being transported to an appropriate treatment or disposal facility.

Disposal to sewer is subject to a trade effluent disposal agreement with Water Corporation.

Pending the publication of waste classification criteria for PFAS in WA, DER recommends the following options:

- disposal at a class IV landfill containment cell (double-lined and with appropriate leachate control to mitigate emissions to the environment); or
- prepare a case for an alternative disposal option for submission to DER, which is based on a detailed assessment of the toxicity of the contaminants of concern (by an experienced toxicologist) and risk to sensitive receptors.

The procedures outlined in the *Landfill Waste Classification and Waste Definitions 1996 (As amended December 2009)* should be followed when assessing contaminant concentration in soil and wastes for disposal.

Bibliography

Airservices Australia 2015, *Managing PFC Contamination at Airports Interim Contamination Management Strategy and Decision Framework*, June 2015

ASTSWMO 2015, *Perfluorinated Chemicals (PFCs): Perfluorooctanoic Acid (PFOA) & Perfluorooctane Sulfonate (PFOS) Information Paper*, August 2015. The Association of State and Territorial Solid Waste Management Officials (ASTSWMO) Remediation and Reuse Focus Group and US EPA Federal Facilities Research Centre, Washington. <https://clu-in.org/download/contaminantfocus/pops/POPs-ASTSWMO-PFCs-2015.pdf>

ASTM D7968-14 Standard Test Method for Determination of Perfluorinated Compounds in Soil by Liquid Chromatography Tandem Mass spectrometry (LC/MS/MS). American Society for Testing and Materials (ASTM).

ASTM D7979-15 Standard Test Method for Determination of Perfluorinated Compounds in Water, Sludge, Influent and Wastewater by Liquid Chromatography Tandem Mass spectrometry (LC/MS/MS). American Society for Testing and Materials (ASTM).

ATSDR, *Perfluoroalkyls*, Agency for Toxic Substances and Disease Registry, <http://www.atsdr.cdc.gov/substances/toxsubstance.asp?toxid=237> (accessed 16 December 2015)

Becker AM, Gerstmann S, Frank H. 2008, Perfluorooctane surfactants in waste waters, the major source of river pollution. *Chemosphere* **72**:115–21.

Benbrahim-Tallaa L, Lauby-Secretan B, Loomis D, Guyton KZ, Grosse Y, El Ghissassi F, et al. IARC Monograph Working Group, 2014 Carcinogenicity of perfluorooctanoic acid, tetrafluoroethylene, 1,2-dichloroethane, 1,2-dichloropropane and 1,3-propanesulfone. *Lancet Oncology* 15(9):924-5

Buck RC, Franklin J, Berger U, Conder JM, Cousins IT, de Voogt P, Jensen AA, Kannan K, Mabury SA, and van Leeuwen SP. 2011, Perfluoroalkyl and polyfluoroalkyl substances in the environment: terminology, classification, and origins. *Integr Environ Assess Manag* **7**:513–41.

Contaminated Sites Act 2003

https://www.slp.wa.gov.au/legislation/statutes.nsf/main_actsif_c.html

Contaminated Sites Regulations 2006

https://www.slp.wa.gov.au/legislation/statutes.nsf/main_subsif_c.html

Danish EPA 2015. *Perfluoroalkylated substances: PFOA, PFOS and PFOSA Evaluation of health hazards and proposal of a health based quality criterion for drinking water, soil and ground water*. Environmental project No. 1665, 2015

Danish EPA 2013. *Survey of PFOS, PFOA and other perfluoroalkyl and polyfluoroalkyl substances*. Part of the LOUS-review Environmental Project No. 1475, 2013.

Das P, Megharaj, M, and Naidu R 2013, Perfluorooctane sulfonate release pattern from soils of fire training areas in Australia and its bioaccumulation potential in the

earthworm *Eisenia fetida*. *Environmental Science and Pollution Research*, DOI 10.1007/s11356-013-1782-y

D'eon JC, Mabury SA. Is indirect exposure a significant contributor to the burden of perfluorinated acids observed in humans? *Environ Sci Technol* 2011;45:7974–84.

DER 2014, *Assessment and management of contaminated sites*, Contaminated sites guidelines, Department of Environment Regulation.
<http://www.der.wa.gov.au/contaminatedsites>

DEC 2009, Landfill Waste Classification and Waste Definitions 1996 (as amended December 2009)

Department of Health, 2015, *PFC derivatives and chemicals on which they are based alert FactSheet*, National Industrial Chemicals Notification and Assessment Scheme (NICNAS), <http://www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/pfc-derivatives-and-chemicals-on-which-they-are-based-alert-factsheet> (accessed 16 December 2015)

Department of Health, 2015, *Perfluorinated chemicals (PFCs) Factsheet*, National Industrial Chemicals Notification and Assessment Scheme (NICNAS)
<http://www.nicnas.gov.au/communications/publications/information-sheets/existing-chemical-info-sheets/perfluorinated-chemicals-pfcs-factsheet> (accessed 16 December 2015)

ECHA/RAC, 2011 Committee for Risk Assessment RAC Opinion proposing harmonised classification and labelling at Community level of Perfluorooctanoic acid (PFOA).

Geosyntec, 2016 *Methodology for soil, sediment, groundwater and surface water sampling and analyses for PFAS investigations* unpublished report prepared for the Public Transport Authority.

Giesy, J. P., and Kannan, K. 2002. Perfluorochemical surfactants in the environment. *Environmental Science and Technology*, **36**, 146A–152A.

Giesy JP, Naile JE, Khim JS, Jones PD and Newsted JL 2010 Aquatic toxicology of perfluorinated chemicals, *Reviews of Environmental Contamination and Toxicology* 202, DOI 10.1007/978-1-4419-1157-5_1

Guanghui D and W J G M Peijnenburg 2013. , Physicochemical Properties and Aquatic Toxicity of Poly- and Perfluorinated Compounds. *Environmental Science and Technology*, **43**:598–678, 2013.

ISO 25101:2009. *Water quality – Determination of perfluorooctanesulfonate (PFOS) and perfluorooctanoate (PFOA) – Method for unfiltered samples using solid phase extraction and liquid chromatography/mass spectrometry*. International Standards Organisation.

Jensen, J., Ingvertsen, S.T. and Magid, J. 2012. Risk evaluation of five groups of persistent organic contaminants in sewage sludge. Environmental Project No. 1406. Danish EPA, Copenhagen.

JIS K 0450-70-10:2011. Testing methods for perfluorooctane-sulfonate (PFOS) and perfluorooctanoate (PFOA) in industrial waters and wastewater. Japanese Standards Association

Kissa, E. 2001. *Fluorinated surfactants and repellants* (2nd ed.). New York: Marcel Decker.

Lau, C., Butenhoff, J. L., and Rogers, J. M. 2004. The developmental toxicity of perfluoroalkyl acids and their derivatives. *Toxicology and Applied Pharmacology* **198**, 231–241.

Liu J and S M Avendaño 2013. Microbial degradation of polyfluoroalkyl chemicals in the environment: A review. *Environment International* 61 (2013) 98–114.

Loganathan BG, Sajwan KS, Sinclair E, Senthil Kumar K, Kannan K. 2007, Perfluoroalkyl sulfonates and perfluorocarboxylates in two wastewater treatment facilities in Kentucky and Georgia. *Water Res* **41**:4611–20.

Martin JW, Asher BJ, Beeson S, Benskin JP, Ross MS. 2010, PFOS or PreFOS? Are perfluorooctane sulfonate precursors (PreFOS) important determinants of human and environmental perfluorooctane sulfonate (PFOS) exposure? *J Environ Monitoring* **12**:1979–2004.

Murakami M, Shinohara H, Takada H. 2009, Evaluation of wastewater and street runoff as sources of perfluorinated surfactants (PFSSs). *Chemosphere* **74**:487–93.

National Environment Protection (Assessment of Site Contamination) Measure 1999
<https://www.comlaw.gov.au/Details/F2013C00288>

Paterson, L, T S Kennedy and D Sweeney 2008 Remediation of perfluorinated alkyl compounds at a former fire-fighting training area, Remediation Technologies Symposium, 2008, Environmental Services Association of Alberta

Paul AG, Jones KC, Sweetman AJ. 2009, A first global production, emission, and environmental inventory for perfluorooctane sulfonate. *Environ Sci Technol* **43**:386–92.

Prevedouros K, Cousins IT, Buck RC, Korzeniowski SH. 2006, Sources, fate and transport of perfluorocarboxylates. *Environ Sci Technol* **40**:32–44.

Qi P, Wang Y, Mu J and Wang J, 2011, Aquatic predicted no-effect concentration derivation for perfluorooctane sulfonic acid. *Environmental Toxicology and Chemistry* **30**(4):836-842 Perfluorooctane Sulfonate (PFOS), Office of Solid Waste and Emergency Response, Memorandum, US EPA 2009

Riddel N, G Arsenault, J P Benskin, B chittim, J W Martin, A McAlees and R McCrindle, 2009 Branched perfluorooctane sulfonate isomer quantification and characterisation in blood serum by HPLC/ESI-MS(/MS) *Environ Sci Technol* **43**:7902–7908.

Scheringer M. 2009, Long-range transport of organic chemicals in the environment. *Environ Toxicol Chem* **28**:677–90.

Schultz MM, Higgins CP, Huset CA, Luthy RG, Barofsky DF, Field JA. 2006, Fluorochemical mass flows in a municipal wastewater treatment facility. *Environ Sci Technol* **40**:7350–7.

Seow J. 2013. *Fire fighting foams with perfluorochemicals- Environmental Review*. Department of Environment and Conservation. Western Australia.

Sinclair E, Kannan K. 2006, Mass loading and fate of perfluoroalkyl surfactants in wastewater treatment plants. *Environ Sci Technol* **40**:1408–14.

United Nations Environment Programme, 2009 *Stockholm convention persistent organic pollutants. SC-4/17: listing of perfluorooctane sulfonic acid, its salts and perfluorooctane sulfonyl fluoride*. Retrieved 2013 August 7, from <http://chm.pops.int/Portals/0/download.aspx?d=UNEP-POPS-COP.4-SC-4-17.English.pdf>.

US EPA 2009 Method 537: Determination of selected perfluorinated alkyl acids in drinking water by solid phase extraction and liquid chromatography/tandem mass spectrometry (LC/MS/MS), version 1.1, September 2009. National Exposure Research Laboratory, Office of Research and Development, US Environmental Protection Agency.

US EPA 2014, *Emerging Contaminants – Perfluorooctane Sulfonate (PFOS) and Perfluorooctanoic Acid (PFOA), Emerging Contaminants Fact Sheet – PFOS and PFOA, March 2014*. http://www.epa.gov/sites/production/files/2014-04/documents/factsheet_contaminant_pfos_pfoa_march2014.pdf (accessed 16 December 2015)

UK EA 2009 *Review of human health and environmental risks associated with land application of mechanical – biological treatment outputs* (Revision 1) Report SC030144/R5 Environment Agency
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/291684/scho0609bqer-e-e.pdf

Appendix 1. PFAS-specific Sample Collection Methods, Equipment, and Equipment Decontamination Methods

The material in Appendix 1 has been adapted from Geosyntec (2016) *Methodology for soil, sediment, groundwater and surface water sampling and analyses for PFAS investigations* unpublished report prepared for the Public Transport Authority.

Table A1. Known or commonly-suspected sources of environmental sample contamination during PFAS investigations, and recommended mitigation practices and alternatives

Product	Mitigation Practice	Alternative Product or Practice When PFAS Sampling is to be Undertaken
Clothing and food		
New clothing	Prohibited for sampling personnel ¹	All field clothing to be washed a minimum of six times after purchase before using at the site
Clothing with stain-resistant, rain-resistant, or waterproof coatings/ treated fabric (e.g. GORE-TEX [®])		Avoid sampling during rain if possible; polyethylene rain gear (e.g. disposable LDPE), vinyl, or polyvinyl chloride (PVC) clothing are acceptable
Tyvek [®] clothing		None
Fast food wrappers and containers		Use rigid plastic containers or bags or stainless steel containers for all food brought to site
Pre-wrapped foods and snacks (e.g. chocolate bars, energy bars, granola bars, potato chips etc.)		Food brought to the site must be contained in plastic (rigid containers or bags) or stainless steel containers
Sampling equipment and containers		
Teflon [®] -containing or -coated field equipment (tubing, bailers, tape, plumbing paste, etc.)	Prohibited at site ²	High Density Polyethylene (HDPE) or silicone tubing, and HDPE or polypropylene field equipment recommended
Teflon [®] -lined lids on containers (e.g. sample containers, rinsate water storage containers)	Prohibited at site ²	Polypropylene lids ³ for sample containers and polypropylene or HDPE containers for rinsate
Glass sample containers with lined	Contact with samples	Use polypropylene or HDPE for sample containers ³ ; glass jars are acceptable

Product	Mitigation Practice	Alternative Product or Practice When PFAS Sampling is to be Undertaken
lids	prohibited	provided lids are unlined or are lined with HDPE
Other products		
Aluminium foil	Prohibited at site ¹	Thin HDPE sheeting (commonly used as drop cloths for painting or home improvement) can be used
Self-sticking notes and similar office products (e.g. 3M Post-it notes)	Prohibited at site ²	Avoid the use of these products at the site
Waterproof paper, notebooks, and labels	Prohibited at site ²	Standard paper and paper labels
Drilling fluid containing PFAS	Prohibited for use at site ²	PFAS-free drilling fluids
Detergents and decontamination solutions (e.g. Decon 90 [®] Decontamination Solution)	Prohibited for all equipment	Follow water-only decontamination approach
Reusable chemical or gel ice packs (e.g. BlueIce [®])	Prohibited for sample storage and transport	Ice contained in plastic (polyethylene) bags (double bagged)

Notes

¹ Sampling personnel includes all personnel who:

- are directly involved in the collection, handling, and/or processing of samples prior to the samples leaving the site;
- handle any part of well development equipment that directly contacts bore water being sampled;
- handle any part of equipment that directly contacts surface water or aquatic sediment;
- are within 2–3m of the borehole during soil sampling; or
- are within 2–3m of the collection and processing area on aquatic vessels during sediment or surface water sampling.

Personnel are not included as sampling personnel if they remain at least 2–3m away from sample collection areas prior to and during sampling.

² Entire sample collection and processing area, including vehicles used by sampling personnel.

³ USEPA and ASTM method for the analysis of PFAS in solid and liquids specify polypropylene or HDPE with polypropylene lids. Check with the laboratory in regards to preference for polypropylene or HPDE.

Groundwater Well Drilling, Development, and Sampling

Conventional groundwater drilling and well development practices can generally be used to install monitoring wells where groundwater samples will be analysed for PFAS. Exceptions to this statement, requiring alternative action, include:

1. Decontamination of drilling equipment must avoid the use of detergents. All equipment must be scrubbed with a plastic brush and rinsed thoroughly in tap water to clean away any debris or material on exposed surfaces and then triple-rinsed in distilled or deionised water (Grade 3 or Millipore water).
2. Sampling must include submission of sample(s) representing any water used by the driller for drilling purposes.
3. Equipment that contacts well water within the well (pumping equipment, water meters, etc.) must not contain or be coated with Teflon[®] unless the Teflon[®] is internal to the equipment and does not contact the external environment.
4. Class 18 u-PVC casing must be used, with a lower section of slotted screen (also minimum Class 18 u- PVC). Well casing must be installed as either a pre-packed screen (stainless steel) or using conventional well construction methods if the borehole is cased to termination depth in order to prevent collapse, and the addition of gravel pack to appropriate depths around the screened interval can be measured and confirmed. Do not re-use u-PVC material which has been used previously at sites where PFAS is known or suspected to be present.
5. Prior to well development, any personnel that handles decontaminated well development equipment that directly contacts bore water must wash their hands with soap and rinse thoroughly in tap water before donning a clean, new pair of disposable nitrile gloves. A new pair of nitrile gloves must be worn for each different well developed. Additional hand washing prior to donning the new pair of gloves is necessary if the old pair of gloves was compromised or if the personnel's ungloved hands touched items that may represent potential PFAS contamination (refer Table A1) since last being washed.
6. Following the completion of well development, purged groundwater must be transported by a licensed waste disposal contractor for appropriate disposal at a facility licensed to receive PFAS-impacted materials.
7. Equipment recommended for obtaining groundwater samples includes low-flow peristaltic pumps using silicone or HDPE tubing or polypropylene HydraSleeves (or similar products). Sampling equipment must not be decontaminated and/or reused at different locations. If the depth to groundwater prevents the use of peristaltic pumps, then bladder pumps may be considered; however, bladders and other internal parts (check balls, o-rings, compression fittings) must not be made of Teflon. Bladders must be changed between sample locations and it is recommended that O-rings also be changed between sample locations.
8. Table A1 should be reviewed to identify other products that may contaminate the well during drilling and development or obtaining the groundwater sample. If in doubt about a particular product or item in contact with environmental media to be sampled or in close proximity to operations, collect and analyse a rinsate sample using laboratory-supplied PFAS-free water.

Soil Drilling and Aquatic Sampling

Conventional soil drilling and aquatic sampling (surface water and sediment) can generally be used to obtain samples for analysis of PFAS. Exceptions to this statement include:

1. Decontamination of soil drilling and sampling equipment and of sediment sampling equipment (cores, grabs) must avoid the use of detergents. Equipment must be scrubbed with a plastic brush and rinsed thoroughly in tap water to clean away any debris of material on exposed surfaces and then triple-rinsed in distilled or deionised water (Grade 3 or Millipore water).
2. Equipment that contacts soil, sediment, or surface water must not contain or be coated with Teflon[®] unless the Teflon[®] is internal to the equipment and does not contact the external environment.
3. Prior to sample collection, any personnel that handles decontaminated soil, sediment, or surface water sampling equipment that directly contacts the environmental media to be sampled must wash their hands with soap and rinse thoroughly in tap water before donning a clean, new pair of disposable nitrile gloves. A new pair of nitrile gloves must be worn for each different sampling location. Additional hand washing prior to donning the new pair of gloves is necessary if the old pair of gloves was compromised or if the personnel's ungloved hands touched items that may represent potential PFAS contamination (refer Table A1) since last being washed.
4. Surface water must be collected by inserting a capped sampling container (polypropylene or HDPE) with the opening pointing down to avoid the collection of surface films. At the time of container opening, the container must be more than 10cm from the sediment bed and more than 10cm below the surface water level and as close to the centre of the channel as possible, where practicable. Point the container up so that gloved hands, sample container, and sampler are downstream of where sample is being collected.
5. Soil and sediment core samples must be collected directly from single-use PVC liners that must not be decontaminated or reused at different locations.
6. For aquatic samples collected from shore or via wading, ensure that waders are constructed of fabric that has not been treated with waterproofing coatings (refer Table A1).
7. Table A1 should be reviewed to identify other products that may contaminate the sampling area or surface water, sediment, or soil sample. If in doubt about a particular product or item in contact with environmental media to be sampled or in close proximity to operations, collect and analyse a rinsate sample using laboratory-supplied PFAS-free water.
8. Support personnel that handle any part of equipment that directly contacts surface water or aquatic sediment, personnel that are within 2–3m of the borehole during soil sampling, or personnel that are within 2–3m of the collection and processing area on aquatic vessels during sediment or surface water sampling, are considered subject to the same restrictions related to precautionary measures for clothing and food, as applied to sampling personnel (refer Table A1).

PFAS-specific Sample Handling and Processing Methods

Conventional sample handling and processing practices can generally be applied to groundwater, surface water, soil, and sediment samples for analysis of PFAS.

Exceptions to this statement include:

1. Prior to sampling, the sampling personnel must wash their hands with soap and rinse thoroughly in tap water before donning a clean, new pair of disposable nitrile gloves. A new pair of nitrile gloves must be worn for each sample collected. Additional hand washing prior to donning the new pair of gloves is necessary if the old pair of gloves was compromised or if the personnel's ungloved hands touched items that may represent potential PFAS contamination (refer Table A1) since last being washed.
2. Teflon[®]-coated materials and aluminium foil may not come into contact with the sample (refer Table A1). Sample handling equipment or tools made of HDPE or stainless steel are acceptable, provided they are decontaminated prior to use via scrubbing and rinsing thoroughly in tap water to clean away any debris or material and then triple-rinsed in distilled or deionized water (Grade 3 or Millipore water).
3. Samples containers must be comprised of polypropylene or HDPE (refer Table A1). Glass containers with lined lids are prohibited. Prior to sampling, confirm sample container composition (polypropylene versus HDPE) with the selected analytical laboratory.
4. For each sample, the required minimum volume of surface water and groundwater is 250mL per USEPA (2009) and the required minimum amount of soil or sediment is at least 2g on a dry weight basis per ASTM (2014). These sampling requirements may vary by laboratory. Prior to sampling, confirm sample size requirements with the selected analytical laboratory.
5. For drinking water, each 250mL sample bottle may be required to contain a small amount (1.25g) of Trizma[®], a buffering reagent that removes free chlorine from chlorinated drinking water (USEPA, 2009), or similar sample additive as specified by the selected analytical laboratory. Prior to sampling drinking water for PFAS analysis, confirm the need for additive with the selected analytical laboratory.
6. During sample processing and storage, minimise the exposure of the sample to light.
7. As noted in Table A1, the use of chemical or gel-based coolant products (e.g. BlueIce[®]) to maintain samples at 4°C following sample collection is prohibited. The acceptable alternative is ice which has been double-bagged (polyethylene plastic) and secured to avoid meltwater from contacting sample containers in the esky during overnight or same-day delivery to the analytical laboratory.
8. Table A1 should be reviewed to identify other products that may contaminate the sampling processing area. If in doubt about a particular product or item in contact with environmental media to be sampled or in close proximity to operations, collect and analyse a rinsate sample using laboratory-supplied PFAS-free water.
9. Support personnel that are within 2–3m of the processing area are considered subject to the same restrictions related to precautionary measures for clothing and food, as applied to sampling personnel (refer Table A1).

PFAS-specific Laboratory Analysis Specifications

During communication with the selected analytical laboratory prior to sampling or during pre-project communications with candidate analytical laboratories, it is recommended to confirm the following:

1. The laboratory uses polypropylene or HPDE sample containers with polypropylene lids, and if there is a preference for either sample container type.
2. The analytical method being followed by the laboratory conforms to a standard agency or association analytical protocol (e.g., USEPA 537, USEPA 537-Modified for solids or waters, ASTM D7968, ASTM D7979, ISO 25101:2009, etc.) and the laboratory is NATA accredited for PFAS analysis.
3. The target analyte list of PFAS and the required method reporting limits can be achieved.
4. Sample results will represent the sum of the linear and branched isomers for each PFAS. Many PFAS (e.g. PFOS) have several isomeric forms that may show up as separate or partially-merged peaks in the analytical chromatograms. It must be confirmed that these peaks will be integrated and the areas summed such that the result represents the concentration of the sum of the linear and branched isomers, per USEPA (2009). Laboratories must also note in their analytical reports the type of analytical standards used (linear and/or branched) and the approach used in quantification.
5. Reagent or ultra-pure water used in the laboratory will be confirmed to be free of PFAS above the method reporting limit during the analyses and that this water can be provided in HPDE containers with polypropylene lids for use at the site for conducting equipment rinsate sampling (as needed).