PFAS Site Profile

PFAS Site Profiles were developed as part of the Environment Agency PFAS Risk Screening Project and represent an understanding of PFAS uses and occurrences from specific industry sectors at the time of writing in March 2024. This profile focuses on Civil and Military Airfields and Airports.

Civil and Military Airfields and Airports

1. INTRODUCTION

1.1 Overview

Per- and poly-fluoroalkyl substances (PFAS) are a broad group of more than 12,000 synthetic fluorinated organic chemicals. PFAS have been used in a wide variety of consumer products and industrial applications since the 1940s because of their unique chemical and physical properties, including oil, water and stain repellence, temperature and chemical resistance, and surfactant properties. These properties mean they are also extremely persistent in the environment. Some PFAS are bio-accumulative and toxic, and/or highly mobile.

Increasing awareness of the widespread presence of PFAS has heightened regulatory concerns about their potential risks to human health and the environment. To ensure effective actions are implemented the Environment Agency needs to better understand the potential sources of PFAS, the mechanisms of transport (pathways) and the relative significance of these substances in the environment.

As part of the Environment Agency PFAS risk screening project (Phases 1 to 4 carried out between 2020 to 2025) Jacobs developed individual site profiles for several potential high risk site types. They focus on specific industry sectors, representing potentially important sources of PFAS, whether from use or manufacture, with the potential for release into the environment.

The primary aim of these profiles is to help those parties involved in the regulation, investigation and remediation of sites where these problem chemicals present a risk to health and the wider environment. These are not definitive studies, but they introduce some of the technical considerations that need to be borne in mind when assessing a particular type of facility. Representing an understanding of PFAS at the time of writing (March 2024) and with published literature notably increasing continuously as practitioners and regulators seek to improve their understanding of PFAS, users must make their own appropriate assessments with current knowledge and specific to their site.

The reader is referred to Ross and Hurst (2019) and ITRC (2023) for more detailed information on PFAS chemistry, properties, fate and transport, risk assessment and remediation, to Glüge et al. (2020) for a review of the diversity of uses of PFAS, and to Ross (2023) for an overview of the uses of PFAS to assist with identification of sites of concern.

1.2 Site Profile Selection and Preparation

The site types for which site profiles have been developed in this project have been selected to represent potentially important users and sources of PFAS release to the environment in terms of quantity, frequency and historical records available.

Technical and scientific publications, fact-sheets, regulations, product websites, articles and online newspaper reporting interviews on the PFAS discussions were researched and reviewed to obtain information on the use of PFAS, with particular reference to the United Kingdom.

Each site profile includes site background information focused on PFAS use and identification of specific zones (where applicable), description of the processes involving PFAS, types of PFAS likely to be present, and an indication of the impact to water and soil. Brief examples and case studies from the literature are also provided.

For each site type a number of zones or activities have been identified where PFAS may be used. It should be recognised that not every site of this type will have all the activities identified. For example, a fire station site may be anything from a building where fire tenders containing Aqueous Film-Forming Foam (AFFF) are based (but filling, maintenance and training happen elsewhere) to a hub with a wide range of activities such as fire practice training, concentrate storage etc. in addition to vehicle storage.

Site profiles have been created for the following site types identified as potentially important potential sources of PFAS release to the environment:

- Civil and Military Airfields and Airports;
- Control of Major Accident Hazards (COMAH) Regulated Sites;
- Fire-fighting Grounds and Fire Stations;
- Landfills;
- Metal Manufacturing and Finishing;
- Military Bases (other than Air Transport Sites);
- Oil and Gas Industry (onshore exploration and extraction operations);
- Paper and Cardboard Manufacturing;
- Refineries and Fuel Sites;
- Textiles, Upholstery, Leather, Apparel and Carpets (TULAC) Manufacturing; and
- Waste Water Treatment Works.

PFAS Site Profile

Additional site profiles which do not relate directly to a particular site type have been developed for the following subject areas, which have potential applications within many different site types:

- Aqueous Film-Forming Foam (AFFF); and
- Fire Suppression Systems.

1.3 Methodology for Calculating Source Potential

For the purposes of the risk prioritisation project for which these site profiles were originally developed, an overall source potential has been developed for each site profile, based on professional judgment informed by the literature review. The source potential is constructed considering the magnitude and likelihood of PFAS presence and use in site profile zones.

The magnitude has been developed with a score of 1–5 (1 – low; 5 – high) based on the expected quantum of PFAS in the activity in the zone. For example, fire training practice using AFFF is recorded as high magnitude, because of the high volume and concentration of PFAS in this activity. Aircraft maintenance using hydraulic fluids containing PFAS is low magnitude because of the relatively low volume and concentration.

The likelihood for each activity is scored 1–5 (1 – low; 5 – high) based on the likelihood of a release to the environment occurring, taking into account frequency of activities where release may occur, and likelihood of loss of containment. For example, fire training practice using AFFF is likely to take place regularly at the same location over a period of years, with potential loss to ground or surface water, so is scored high. Although aircraft maintenance is likely to be undertaken all the time, significant accidental loss of containment is likely to be infrequent, so this is scored low.

The magnitude and likelihood are then multiplied to give the source potential (scored 1–25). It should be noted that these scores are generic and subjective and are based on professional judgment and should continue to be refined as more information becomes available. Further refinement could include expansion to consider changes in practice over the years as pollution prevention practices have improved.

2. BACKGROUND TO CIVIL AND MILITARY AIRFIELDS AND AIRPORTS

The use of PFAS at civil and military airport and airfield sites (air transport sites) has been responsible for a number of well documented incidents, where release of PFAS at air transport sites has resulted in impact on drinking water (Nordic Council of Ministers, 2019). In 2022, it was revealed that a drinking water supply in the vicinity of a UK airfield had been impacted by PFOS (The Guardian, 2022). Many other cases have been documented around the world where PFAS contaminated groundwater, surface water and soil have been identified in the vicinity of air transport sites. In the UK, at least one airport has been subject to *in situ* remedial treatment of PFAS contaminated groundwater (Regenesis, 2022).

Military airbases have been a particular focus of attention in some countries, with targeted investigations identifying PFAS impacts requiring further management to reduce environmental impacts. In the context of US military sites, it has been observed that "many classes of PFASs are observed in groundwater at essentially every AFFF-impacted site investigated to date" (ESTCP, 2017).

The main source of PFAS at air transport sites is fluorinated fire-fighting foam, released into the environment during training, as accidental releases, and in response to emergency incidents. Reference should be made to the site profile for AFFF (CL:AIRE, 2026l). Particular activities associated with AFFF release to the environment include training grounds, hangar fire suppression systems and runway foaming. Intensive use of AFFF may result in contamination of concrete, which may then become an ongoing source of PFAS, which is leached from the concrete through rainfall runoff (Baduel et al., 2015). The use of AFFF at air transport sites is discussed in more detail below.

Non-polymeric PFAS have been used as additives in aviation hydraulic fluids to prevent evaporation, fires and corrosion (OECD, 2013). In particular, the fully fluorinated 8 carbon cyclic PFAS, perfluoroethylcyclohexane sulfonate (PFECHS), was used in aircraft hydraulic fluids from the late 1940s (MPART and HHWG, 2020). PFECHS has been reported at elevated concentrations in environmental media around the world, and various reports have linked the detection of PFECHS in the environment to its use in aviation in general and at airports in particular (MPART and HHWG, 2020; de Solla et al., 2012).

Additional uses of PFAS in aviation are fluoropolymers such as polytetrafluoroethylene (PTFE), which are extensively used in various mechanical components (e.g. semiconductors, wiring, tubing, piping, seals, gaskets, cables, etc.) (OECD, 2013). PFAS are also used in specialist coatings, as lubricants, and in heat transfer / coolants (Glüge et al., 2020).

The following areas of airports and airfields have been identified with a potential for PFAS use and release:

- Fire training grounds: can include aircraft fire training structures, crash crew staging areas, spray test areas, extinguisher test areas; may also be used for training by local municipal fire services and others;
- Fire stations: storage of foam concentrates and containers; fill points; washdown areas; spray test areas;
- Historical crash or flammable liquid fire locations, and crash debris storage areas; fire tender crash sites;
- Hangars with foam fire suppression systems; foam concentrate substances may be stored in tanks within the hangars; hangar fire suppression systems are reported to have been sensitive to accidental foam release caused by false alarms;
- Hangars where aircraft maintenance is undertaken, mechanical shops where heavy-duty vehicles and appliances are maintained and repaired, with potential release areas of other substances potentially containing PFAS (hydraulic fluids, waxes, greases, hydraulic fluid, specialty paint);

- Areas where the runway was foamed in the past in preparation for hard landings (this is no longer recommended good practice);
- Tank farms/fuel farms with foam fire suppression systems;
- AFFF demonstration areas or areas where foam parties or salutes were conducted;
- Surface water drainage systems and tanks (and sediment), soakaways and effluent discharge points;
- On-site landfills which may have received waste construction materials, soils or sediment impacted by PFAS; and
- Areas of the airport where pesticides or herbicides containing fluorinated compounds are applied (National Academies of Sciences, Engineering and Medicine, 2023).

In 2023, the US National Research Council published a 'PFAS Source Differentiation Guide for Airports' (National Academies of Sciences, Engineering and Medicine, 2023) which is a comprehensive review of PFAS use and characterisation associated with airports in the USA. It provides much useful additional detail on PFAS use within airports, although it should be acknowledged that regulatory requirements and common airport practices may be different in the UK.

2.1 Training Grounds

Fire-fighting training grounds are considered a particular source of AFFF release to the environment at airport sites because of the regulatory requirements for regular live training using foams, and past practice with regard to disposal of effluent from training exercises. The standard set-up for a fire training rig is understood to comprise a fuselage trainer rig on a concrete pad with a fuel supply. Foam may either be provided by mobile fire tenders or from a fixed hose with foam tank. The concrete pad would normally have gully drainage around it, taking effluent to an interceptor and then to the surface water drainage system. The interceptor was intended to remove unburned fuel hydrocarbons. The standard rig was not designed to capture waste AFFF or PFAS. The interceptor would be ineffective at reducing any PFAS from the waste water effluent. After the fire was extinguished, it was common practice to use hoses to flush visible foam to the grassed areas around the concrete pad. Increasing awareness of the environmental risks associated with PFAS has led to a move towards improved containment of waste water so that it can be tankered off site.

Documented examples of environmental impact associated with airport fire training grounds include Ronneby in Sweden, Jersey Airport (Nordic Council of Ministers, 2019) and Guernsey Airport (Ross et al., 2018).

2.2 Runway Foaming

Between the 1960s and the 1980s it was a recognised practice in the UK to divert planes requiring an emergency landing to designated Master Emergency Diversion airfields, where there was equipment to allow foaming of the runway in case of a crash landing, creating a foam 'carpet' or 'blanket'. A Ministry of Defence film documents this practice at Manston in 1965, including the use of a 'Pyrene' runway foamer. The exact composition of these foams is unknown. The Pyrene company manufactured foam fire extinguishers which used carbon tetrachloride (Safelincs Ltd, 2022), but it is not known if this technology was also used for foam blankets. Protein foams were also developed and in use prior to the development of fluorinated foams. Given that the film predates the patenting of PFAS-based AFFF by the US Navy (with 3M), it is assumed that the original Pyrene system was based on earlier non-PFAS foam systems. It seems likely, however, that once AFFFs were available then they would have been used in runway foaming.

No documented examples of environmental contamination associated with runway foaming have been identified. However, the volume of foam required, and dates of operation indicate this could be a potentially significant source.

2.3 Aircraft Hangar Foam Fire Suppression Systems

Aircraft hangars may be fitted with fixed foam fire suppression systems. While in normal use, the likelihood of release of foam from a suppression system may generally be considered low, although release may have occurred during commissioning or system operation tests. There is however evidence that aircraft hangar systems are particularly prone to accidental discharge.

In the USA there is a requirement for fixed foam fire suppression systems in certain types of aircraft hangars, to provide protection from fires including fuel spills. A study was undertaken by the University of Maryland (UMD) in 2019 after concerns were raised over the tendency for these systems to inadvertently discharge causing significant life safety issues, property damage, and major financial and environmental impacts. UMD (2019) surveyed insurance companies, operators, and the National Air Transportation Association. One hundred and seventy-four incident reports of foam discharges were received from 11 sources in the period 2004 – 2019, both in response to fires (37 incidents) and accidental discharges (137 incidents), mostly reported by insurance companies. The majority (85%) of reports received were from the USA. The remaining 15% of reports originated from 8 other (unnamed) countries.

Accidental discharge of foam from hangars can result in substantial environmental damage as the foam is likely to be discharged to surface water drainage systems or to soft ground where infiltration to groundwater may occur. Documented examples of environmental damage associated with accidental hangar foam discharge include Schiphol Airport and Toronto Airport (Nordic Council of Ministers, 2019; Awad et al., 2011).

2.4 PFAS in Concrete, Asphalt and Other Porous Media

There is emerging concern related to the potential for PFAS to impregnate concrete and be released by leaching and desorption following rainfall events for decades after use of PFAS at the site has ceased. Baduel et al. (2015) investigated concrete at a fire training ground in Australia and detected PFAS in a concrete core at depths of up to 12 cm. Desorption studies suggested that leaching of the PFAS from the concrete pad could result in it remaining a source of PFAS for many decades. Another study by Thai et al. (2022) at a fire training ground, found PFOS both in a concrete core (up to 10,000 µg/kg) and in ponded water on the surface (up to 100 µg/l). Repeated tests with rainfall simulations showed similar maximum concentrations of PFOS, suggesting recurring release of the PFAS from the AFFF impacted concrete.

No documented occurrences of PFAS release from contaminated concrete have yet been identified in the UK.

2.5 Types of Fire-Fighting Foam Used at Airports

There is evidence that some civilian airports in the UK and overseas have consciously moved away from using fluorinated fire-fighting foams. Others maintain stocks of fluorinated foam for emergency use, but use fluorine-free foam for training purposes.

An article published on the Chemical & Engineering News website (Reisch, 2019) indicates that London's Heathrow Airport switched to fluorine-free foams in 2013 after a 15-month evaluation project. The article reports that two incidents at Heathrow Airport in 2013 showed that fluorine-free foams worked as well as fluorine foam. The article suggests that maintenance crews washed the runoff into drains feeding the airport's water treatment plant. A previous incident in 2008, when fluorosurfactant-containing foam was used, is reported to have required collection and disposal of the effluent to prevent release to the environment.

According to the 'PFAS Source Differentiation Guide for Airports' (National Academies of Sciences, Engineering and Medicine, 2023), from the late 1960s until 2019, the US Department of Defense military specification for AFFFs purchased for use at US military sites (MIL-F-24385) required the inclusion of PFAS (fluorocarbon surfactants). Although this military specification MIL-F-24385 was amended in 2019 to remove the requirements for fluorosurfactants in AFFF, the performance specification remained unchanged and could only be met with the use of fluorinated foams (U.S. Department of Defense, 2020). In 2023, a new performance specification for fluorine-free foams was released by US DOD (MIL-PRF-32725) (U.S. Department of Defense, 2023). As stated by the Nordic Council of Ministers (2019), it is reasonable to assume that fluorinated AFFFs conforming to MIL-F-24385 have been used in military airbases in Europe including the UK.

3. CASE STUDIES

Seven sites, identified from literature reviews, were reviewed as case studies with examples of PFAS contamination associated with Civil and Military Airfields and Airports. The findings are listed in Table 1.

4. PROCESS

PFAS may be released into the environment from airfields and airports in the form of surface water runoff and waste water discharge, indirect discharge or leaching to groundwater.

Table 1. Case studies.

1. Ronneby, Sweden
This case study is summarised in a paper by Nordic Council of Ministers (2019). During 2013, water quality monitoring identified elevated PFAS in groundwater at Ronneby, Sweden, and further testing confirmed that treated drinking water at the local municipal water works was also impacted, with PFOS the predominant contaminant, present at up to 8,000 ng/l. As a result, the supply of drinking water was stopped from this location. The source of the contamination was identified as the fire training site at the nearby airport. Fire training activities using PFOS containing AFFF were undertaken at the airport from the mid-1980s. In Sweden, fire-fighting foams containing PFOS were phased out from 2003 to 2008, and Swedish airports and the Swedish military started using fluorine-free alternatives from June 2011. Biomonitoring of the local population showed 20–50 times higher levels of PFAS in exposed individuals compared to a reference group.
2. Jersey Airport, Channel Islands, UK
The airport started using AFFF in training exercises in 1991, in order to meet requirements of UK Airport Fire Services. From late 1991, foam was discharged regularly at the fire training ground and allowed to disperse to groundwater and be washed away by rainwater. In 1993, it was discovered that foaming water was emerging from an excavated land drain in a field associated with a farm to the northwest of the fire training ground (State of Jersey, 2004). At the same time, the private water supply of that farm was discovered to have been contaminated by material giving rise to a brown colouration and substantial foaming. Using both PFOS and PFHxS as indicator compounds the plume was tracked, identifying which watercourses and ponds had been contaminated. Other properties with private water supplies were also affected and had to be connected to mains supply. It was concluded that the most probable source of the contamination was the use of fire-fighting foam for fire training purposes at Jersey Airport's Fire Training Ground (FTG) (Jersey Airport, 2022). Further contamination at the site has been mitigated by discontinuing use of PFOS-containing foams and strict controls over the wash down areas of the FTG. As part of the remediation works there is a programme of monitoring to assess the impact of the remedial works on groundwater quality.
3. Guernsey Airport, Channel Islands, UK
PFAS were identified in the surface waters which supply the island's drinking water reservoir. Concentrations of PFOS detected in the reservoir, were linked back to firefighting foam (AFFF) use at the airport (Ross et al., 2018). PFOS-containing AFFF was used at Guernsey Airport from the 1970s until 2002 when its use was discontinued. Impacted areas included the fire training area, fire station and former fire training area, crash sites and the location of an incident where a fire tender had overturned with the loss to ground of foam concentrate. Most of the remediation work to deal with the PFOS pollution was undertaken as part of a wider Guernsey Airport redevelopment carried out between 2012 and 2014. Large areas of contaminated soil were removed from hotspots within the airfield, and groundwater is now captured and passed through a specially-designed treatment plant to remove PFOS (Ross et al., 2017; PWC, 2016).

Table 1. Case studies (continued).

4. Schiphol Airport, Netherlands
Kwadijk et al. (2014) studied the accidental release of AFFF which took place at Schiphol Amsterdam Airport, also described by Nordic Council of Ministers (2019). In July 2008, an error in the sprinkler-system at a hangar released 10,000 litres of AFFF, containing 143 kg of PFOS, into the surrounding environment. The release spread into waste water reservoirs, which then leaked and caused substantial contamination of soil and surface water. The foam involved was FC-203CF Light Water AFFF, known to contain PFOS (Kwadijk et al., 2014). Although PFBS, PFHxS, and PFOS were monitored, the dominant PFSA found in all samples was PFOS. They conclude that PFSA spills can lead to exceedances of environmental quality standards in the short term, with concentrations remaining elevated even after 3 years (Kwadijk et al., 2014). Nordic Council of Ministers (2019) reported the cost of remediation was estimated as €30–40 million.
5. Hamilton, Ontario, Canada
A study undertaken by de Solla et al. (2012) reported elevated concentrations of PFAS in surface water and biota downstream of Hamilton International Airport in Ontario. PFAS studied included PFCAs, PFSAs, several per- and poly-fluorinated compound precursors (e.g. perfluorooctane sulfonamide, PFOSA), and a cyclic perfluorinated acid used in aircraft hydraulic fluid PFECHS. They concluded that the airport was a likely major source of PFAS contamination in the Welland River, even though there was no known spill event or publicly reported use of AFFF associated with a fire event at the airport.
6. Australian Government Department of Defence
The Australian Department of Defence (DoD) has a PFAS Investigation & Management Program, comprising a national program to proactively review, investigate and implement a comprehensive approach to manage the impacts of PFAS on and in the vicinity of its bases around Australia (Australian Government Department of Defence, 2022). In the interests of transparency, the DoD has made available results of site assessment and testing at their sites. Case studies have also been presented at technical conferences in the UK. Examples include Royal Australian Air Force (RAAF) Base Tindal (Coffey Environments Australia Pty Ltd, 2018), which is located in a remote part of the Northern Territory. The township of Katherine is located on the Katherine River about 15 km north of the base, hydraulically downgradient. In the dry season, groundwater is abstracted for water supply and irrigation, and provides baseflow to the hot springs and the river. Investigation has confirmed that groundwater at the site has been impacted by PFAS, with the primary sources identified as the base fire station and fire training ground, which had been in operation from the 1980s. Minor sources were also identified associated with fuel farms and the mechanical equipment maintenance area. The remote location reduces the likelihood of other potential PFAS sources being present in the vicinity. Further investigation has identified PFOS and PFHxS present in groundwater at concentrations well above drinking water standards (up to 7 µg/l) as far as the town and river located 15 km downgradient from the source, and within springs and water abstraction points. Monitoring shows the river and associated biota are impacted for many kilometres downgradient of the site, with advisories against consumption of fish from the river up to 60 km downstream of the site.
7. Foam incident at a Heathrow Airport Hangar
In May 2020, there were news reports that the fire suppression system in one of the hangars at Heathrow Airport had a technical issue causing foam to be released. Tonnes of foam fire-retardant were sprayed (McShane, 2020). Photos published online show the hangar flooded with foam and also foam dispersed outside the hangar. It is unclear from the news articles what type of foam was released (for example, if it was a fluorinated foam containing PFAS) and what clean-up or containment was implemented. It is noted that, although located within the airport boundary, the hangar is operated by an airline rather than the airport operator. This incident illustrates the reality of the scenario of foam loss through accidental triggering of a foam suppression system in the UK.

Key processes and activities by which PFAS may be released include:

- Use of AFFF in fire-fighting training and emergency response;
- Use of AFFF in fire suppression systems, testing, maintenance and accidental release;
- Accidental spills or loss of AFFF in storage and transport
- Use and loss of hydraulic fluids;
- Use of PFAS in engineering workshops (degreasing, plating, surfactants);
- Release in rainfall events of residual PFAS adsorbed to concrete /asphalt from past activities;
- Discharge to drain or ground of wash water including fire tanks;
- Waste water discharge;
- Discharge of landfill leachate (if landfill is present on site); and
- Application of pesticides and herbicides.

Reference should also be made to the site profiles for Fire-Fighting Grounds and Fire Stations (CL:AIRE, 2026c) and AFFF (CL:AIRE, 2026l).

5. KEY PFAS CONTAMINANTS OF CONCERN

Civil and military airfields and airports have the potential for a wide range of PFAS to be present, with the majority released via AFFF use. Reference should be made to the site profile for AFFF (CL:AIRE, 2026l).

The actual PFAS present at any one site will be variable dependent on the AFFF formulations used, which will have varied over time. While some generalities may be drawn associated with the dates of operation and use, and the date of phasing out of PFOS-based AFFF and the introduction of fluorotelomer chemistry, actual practice varied. Records of AFFF type and composition are also likely to be poor.

One study by Schultz et al. (2004) of three US airbases found markedly different PFAS distribution in groundwater at each of the sites. One site which operated from the 1950s to 1988 had 25% PFSAs and 75% PFCAs. Another site which had been operational from 1980 – 1992 had 82% FTS, 16% PFSAs and only 2% PFCAs, implying contamination from fluorotelomer based AFFF. A third site which had been operational from the 1950s until 1993 showed varied PFAS present at different locations around the site including FTS, PFCA and PFSA.

The fingerprint relating to the relative distribution of PFAS may be used to investigate and differentiate multiple sources of PFAS release. The type of AFFF used by the US Department of Defense is controlled by Military Specification (MILSPEC), which means that in the USA it may be possible to differentiate some AFFF from military sources from other sources based on the PFAS signature (Higgins, 2021). Similar controls on foam procurement and supply are not known to have existed within particular sectors in England, and therefore differentiation between AFFF sources may be more difficult.

The 'PFAS Source Differentiation Guide for Airports' (National Academies of Sciences, Engineering and Medicine, 2023) includes a detailed review of PFAS data related to airports and other sources in the USA, and proposes PFAS composition may be used to aid source differentiation between airport derived sources of PFAS and other sources. This provides much useful information and insight into the challenges associated with forensic analysis of PFAS. It should be noted that the airport practice and different regulations and supply chain may mean that some findings may be less applicable in the UK.

The fully fluorinated cyclic PFAS PFECHS was marketed for use in aviation hydraulic fluids and has been associated with air transport sites.

6. SOURCE POTENTIAL FOR CIVIL AND MILITARY AIRFIELDS AND AIRPORTS

Following the methodology set out in section 1.3, source potential has been developed for each site profile zone and detailed in Table 2.

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Table 2. Site Profile Zone Source Potential.

Site Profile – Zones	Magnitude	Likelihood	Source Potential	PFAS presence and use
Old fire-fighting training grounds and practice areas	5	5	25	Historically foams were used directly on the ground and in pits where fire was staged for training. Large quantities of AFFF were used and released to the ground with high frequency. Currently this practice is improved and runoff likely to be contained, therefore the source potential of 25 is related to the old practice and can be reduced in more recent fire-fighting training grounds.
Hangars with foam fire suppression systems	5	4	20	Foam likely to be released during tests of the fire suppression system and/or malfunction. Hangar suppression systems have been identified as particularly prone to accidental discharge compared to other fire suppression systems. Foam is stored in tanks within the hangar and used in case of fire emergency, spraying from the ceiling.
Waste water system	3	5	15	Runoff of waste water from paved areas is collected by drains. The waste water runoff can contain PFAS if an uncontrolled release of PFAS containing material has occurred on a paved area. PFAS may be absorbed into concrete drains and act as an ongoing source of PFAS after use has ceased on a site. Oil water separators, where present in the waste water system, are ineffective in retaining the PFAS. Waste water may be collected and discharged via on-site or off-site waste water treatment works which may not have been designed to treat for PFAS.
Crash sites (planes and fire engines)	5	2	10	Historically foam was used directly on the ground and in unprotected areas with runoff released to the ground or collected by drains. Currently this practice is improved and runoff is more likely to be contained.
Vehicle washing area	2	5	10	Area where fire engines are washed, and tanks rinsed. PFAS containing materials can be released to the waste water or used in cleaning products.
Landfills	3	3	9	On-site landfills which may have received waste construction materials, soils or sediment impacted by PFAS. Leachate can contain PFAS and potentially impact the groundwater.
Fire stations	2	4	8	Foam containing PFAS stored in tanks within fire stations, fire engines and pumps at vehicle fill points. Release to the environment may be via accidental spills. It is considered that relatively low quantities of PFAS will be released in these areas. Current tanks may be provided with leak alarms and fire engines with sophisticated systems to avoid spills.

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Table 2. Site Profile Zone Source Potential (continued).

Site Profile – Zones	Magnitude	Likelihood	Source Potential	PFAS presence and use
Areas where the runway was foamed in preparation for hard landings	5	1	5	Foam taken from fire station to the runway area via fire engines and tanks. Tests of the application system may have been done on unpaved ground. Repeated application before the hard landing, foam washed to ground after use. Runway foaming is no longer considered good practice.
Tank farms/fuel farms	5	1	5	Fuel farms likely to have foam fire suppression systems. Foam is stored in tanks. Major release during accident. Minor release from accidental spills from the tanks. Foam released due to accidents or testing is likely to be collected and discharged via drains and/or oil water separator to a WWTW.
Surface water drainage systems and tanks soakaways and effluent discharge points	1	3	3	Sediments likely to be contaminated by PFAS and to slowly release PFAS to the water environment. Waste water treatment processes may not have been designed to treat PFAS.
Hangars and mechanical shops where maintenance of aircraft, heavy-duty vehicles and appliances is undertaken	1	2	2	Replacement of airplane components, hydraulic fluid, and application of waxes, greases, and specialty paint. Considered likely to be low quantity.
Concrete or other semi porous hardstanding areas where PFAS have been used	1	2	2	Past adsorption of PFAS to concrete and other semi-porous surfaces. Slow release of PFAS from concrete can potentially impact surface water and groundwater.
Areas where pesticides or herbicides are applied	1	1	1	PFAS contained in herbicides and pesticides and likely to be spread within the site as ground control routine. Accidental release of mixture containing PFAS may occur in the pesticides storage area. Considered to be low quantity.

IMPORTANT NOTES FOR READERS OF THE PFAS SITE PROFILES

The PFAS Site Profiles are based on available online literature and review of readily available technical publications at the time of writing (2020-2024). The authors recognise that additional information may be available that has not been used in this study.

The published literature on PFAS occurrence and distribution is vast and continually expanding. For example, the Interstate Technology and Regulatory Council web resource cited in the PFAS Site Profiles as "ITRC (2023)" was substantially updated in January 2026.

The purpose of the PFAS Site Profiles is to provide regulators and other interested parties with researched advice on how to assess problem sites that may be impacted by legacy use or release of PFAS. The profiles do not seek to address the specific circumstances of each site as these will be unique. As such, the PFAS Site Profiles should be read with the following reservations in mind:

- Practices can vary between different sites and therefore individual sites may not have been exposed to the typical PFAS contaminants of concern as detailed in each site profile;
- Site exposure to PFAS contaminants of concern may vary based on practices and equipment used on site; and
- Given the longevity of PFAS in the environment, site profiles may refer to practices which are no longer followed, and subsequently may omit current practices which avoid contamination.

DISCLAIMER

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PFAS Site Profile

ACRONYMS AND ABBREVIATIONS

Note: this list of acronyms and abbreviations includes those used across all the site profiles and therefore may include some acronyms and abbreviations not used within this profile.

General Acronym / Abbreviation	Definition	General Acronym / Abbreviation	Definition
AFFF	Aqueous Film-Forming Foam	HSE	Health and Safety Executive
ALARP	As Low As Reasonably Practicable	ITRC	Interstate Technology and Regulatory Council
AR-FFFP	Alcohol resistant film-forming fluoroprotein foam	LCMS	Liquid Chromatography Mass Spectrometry
BOW	Bilge and oily waste water	LPG	Liquified Petroleum Gas
CA	Competent Authority	MAPP	Major accident prevention policy
CAS	Chemical Abstracts Service	MILSPEC	Military Specification
CAFS	Compressed Air Foam System	MSDS	Material Safety Data Sheets
CDOIF	Chemical and Downstream Oil Industries Forum	NAPL	Non Aqueous Phase Liquid
CIMAH	Control of Industrial Major Accident Hazards	NCM	Nordic Council of Ministers
CIP	Chemicals Investigations Programme	NIHHS	Notification of Installations Handling Hazardous Substances Regulations
CLP	Classification Labelling and Packaging	NORM	Naturally occurring radioactive material
CO_2	Carbon dioxide	OECD	Organization for Economic Cooperation and Development
COMAH	Control Of Major Accident Hazards	ONR	Office for Nuclear Regulation
CPI	Confederation of Paper Industries	PCM	Paper and Cardboard Manufacturing
DoD	Department of Defence (Australia)/Defense (USA)	PNEC	Predicted No-Effect Concentrations
DoE	Department of Environment	PPB	Parts Per Billion
DWS	Drinking Water Standards	PPE	Personal protective equipment
ECF	Electrochemical fluorination	RAAF	Royal Australian Air Force
EOF	Extractable Organic Fluorine	REACH	Registration, Evaluation, Authorization and Restriction of Chemicals
EPA	Environmental Protection Agency (for Denmark)	STM	Surface treatment of metals
EPR	Environmental Permitting Regulations	TOP	Total Oxidisable Precursor
EQS	Environmental Quality Standard	TULAC	Textiles, Upholstery, Leather, Apparel and Carpets
EU	European Union	UBA	Umwelt Bundesamt (German Environment Agency)
FCM	Food Contact Material	UK WIR	United Kingdom Water Industry Research
FFF	Fire-Fighting Foam	UMD	University of Maryland
FFFP	Film-Forming Fluoroprotein	US EPA	United States Environmental Protection Agency
FP	Fluoroprotein	WWTP	Waste Water Treatment Plant
FPP	Fire Prevention Plans	WWTW	Waste Water Treatment Works
FRS	Fire and Rescue Service		

ACRONYMS AND ABBREVIATIONS

Note: this list of acronyms and abbreviations includes those used across all the site profiles and therefore may include some acronyms and abbreviations not used within this profile.

PFAS Acronym / Abbreviation	PFAS Definition	PFAS Acronym / Abbreviation	PFAS Definition
10:2 FTOH	10:2 Fluorotelomer alcohol	HFPO-DA	Hexafluoropropylene oxide-dimer acid
10:2 FTS	10:2 Fluorotelomer sulfonate or sulfonic acid	HFPO-TA	Hexafluoropropylene oxide-trimer acid
10:2 FTUCA	10:2 Fluorotelomer unsaturated carboxylic acids	MeFOSAA	Methylperfluorooctanesulfonamidoacetic acid
11Cl-PF3OUdS	11-Chloroeicosafluoro-3-oxaundecane-1-sulfonic acid (F-53B Minor)	PAP	Polyfluorinated alkyl phosphates
12:2 FTS	12:2 Fluorotelomer sulfonate or sulfonic acid	PASF	Perfluoroalkane sulfonyl fluoride substances
14:2 FTS	14:2 Fluorotelomer sulfonate or sulfonic acid	PFA	Perfluoralkoxy polymer
12:2 FTAB	12:2 Fluorotelomer sulfonamido betaine	PFAA	Perfluoroalkyl acid
4:2 FTS	4:2 Fluorotelomer sulfonate or sulfonic acid	PFAS	Perfluoroalkyl and Polyfluoroalkyl Substances
5:3 FTCA	5:3 Fluorotelomer carboxylic acid	PFBA	Perfluorobutanoate or Perfluorobutanoic acid
6:2 FTAB	6:2 Fluorotelomer sulfonamidoalkyl betaine (see also CMDFPAH)	PFBS	Perfluorobutyl sulfonate or Perfluorobutyl sulfonic acid
6:2 FTCA	6:2 Fluorotelomer carboxylic acid	PFC	Perfluorinated Compound
6:2 FTOH	6:2 Fluorotelomer alcohol	PFCA	Perfluoroalkyl carboxylic acid
6:2 FTS	6:2 Fluorotelomer sulfonate or sulfonic acid (see also TDFOSA)	PFDA	Perfluorodecanoate or Perfluorodecanoic acid
6:2 FTUCA	6:2 Fluorotelomer unsaturated carboxylic acids	PFDoA	Perfluorododecanoate or Perfluorododecanoic acid
6:2 diPAP	6:2 Fluorotelomer phosphate diester	PFECA	Perfluoroalkyl ether carboxylic acid
8:2 Cl-PFESA	8:2 Chlorinated perfluoroalkyl ether sulfonic acid	PFECHS	Perfluoroethylcyclohexane sulfonate
8:2 FTOH	8:2 Fluorotelomer alcohol	PFESA	Perfluoroalkyl ether sulfonic acid
8:2 FTS	8:2 Fluorotelomer sulfonate or sulfonic acid	PFHpA	Perfluoroheptanoate or Perfluoroheptanoic acid
8:2 FTUCA	8:2 Fluorotelomer unsaturated carboxylic acids	PFHpS	Perfluoroheptane sulfonate or Perfluoroheptane sulfonic acid
9Cl-PF3ONS	9-Chlorohexadecafluoro-3-oxanonane-1-sulfonic acid (F-53B Major)	PFHxA	Perfluorohexanoate or Perfluorohexanoic acid
ADONA	4,8-Dioxa-3H-perfluorononanoic acid	PFHxS	Perfluorohexane sulfonate or Perfluorohexane sulfonic acid
CMDFPAH	Carboxymethyldimethyl-3-[[(3,3,4,4,5,5,6,6,7,7,8,8,8-tridecafluorooctyl)sulphonyl]amino]propylammonium hydroxide; a synonym of 6:2 FTAB used in UKWIR reports	PFNA	Perfluorononanoate or Perfluorononanoic acid
EtFOSA	N-ethyl-perfluorooctane sulfonamide	PFOA	Perfluorooctanoate or Perfluorooctanoic acid
EtFOSAA	N-ethyl-perfluorooctane sulfonamido acetic acid	PFOS	Perfluorooctane sulfonate or Perfluorooctane sulfonic acid
EtFOSE	N-ethyl-N-(2-hydroxyethyl) perfluorooctane sulfonamide	PFOSA	Perfluorooctane sulfonamide (FOSA)
F-53B	Trade name for chlorinated polyfluoroalkyl ether sulfonic acids (9Cl-PF3ONS and 11Cl-PF3OUdS)	PFOSE	Perfluorooctane sulfonamido ethanol
FASA	Perfluoroalkane sulfonamide	PFPA	Perfluoropentanoate or Perfluoropentanoic acid
FBSA	Perfluorobutane sulfonamide	PFPE	Phosphate ester salts
FOSA	Perfluorooctane sulfonamide	PFPeA	Perfluoropentanoic acid
FOSAA	Perfluorooctane sulfonamidoacetic acid	PFPeS	Perfluoropentane sulfonate or Perfluoropentane sulfonic acid
FOSE	Fluorooctane sulfonamido ethanol	PFPS	Perfluoropentane sulfonate
FTCA	Fluorotelomer carboxylic acid	PFSA	Perfluoralkane sulfonic acid
FTMAC	Fluorotelomer methacrylate	PFUnDA	Perfluoroundecanoate or Perfluoroundecanoic acid
FTOH	Fluorotelomer alcohol	POSF	Perfluorooctane sulfonyl fluoride
FTS	Fluorotelomer sulfonate	PTFE	Polytetrafluoroethylene
FTSA	Fluorotelomer sulfonic acid	TDFOSA	3,3,4,4,5,5,6,6,7,7,8,8,8-Tridecafluorooctane-1-sulfonic acid; a synonym for 6:2 FTS used in UKWIR reports
Gen-X	Trade name for HFPO-DA		