Australian Government Department of Defence





PFAS MANAGEMENT AREA PLAN REVISION 1

September 2023

ACKNOWLEDGEMENT OF COUNTRY

We respectfully acknowledge and pay respects to past, present and emerging Elders of the Traditional Owners of Country and First Nations cultures and countries upon which we live and work in. We extend our respects to our Aboriginal and Torres Strait Islander colleagues who we are working with, engaging with and learning from throughout this program and beyond. We also pay respect to the Aboriginal and Torres Strait Islander men and women who have contributed to the defence of Australia in times of peace and war.

ABOUT THIS DOCUMENT

This is the Defence PFAS Management Area Plan (PMAP) Revision 1 for RAAF Base Williamtown.

This PMAP Revision replaces the PMAP for RAAF Base Williamtown dated April 2019 (the 2019 PMAP).

The purpose of this PMAP is to document Defence's plan to manage potential risks to human health and the environment from PFAS on and off RAAF Base Williamtown. It provides an overview of the risk management actions undertaken to date, ongoing and future actions.

The NSW EPA and other relevant State and Local agencies have been consulted in the development of management actions outlined in this document.

EXECUTIVE SUMMARY

Background

In 2019 Defence published the RAAF Base Williamtown PFAS Management Area Plan (2019 PMAP) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination at the base and in surrounding areas.

Since the 2019 PMAP, Defence has implemented much of the plan and reassessed what is now needed to best manage these contamination risks. This PMAP revision sets out the updated plan to manage risks to human health and the environment from exposure to PFAS contamination.

Risk management actions may include remediation (clean-up) of PFAS, or other management measures that control exposure to PFAS. In managing PFAS contamination to reduce risks to human health and the environment, Defence prioritises:

- minimising exposure to PFAS
- preventing or minimising migration of PFAS
- keeping the community informed.

Minimising PFAS movement from the base will, in the long term, contribute to the reduction of PFAS concentrations in the surrounding environment. However, the process will take time and therefore other measures will also be implemented to reduce risks to human health and the environment.

Completed and ongoing remediation works

Defence has completed a number of investigation and remedial actions at the base:

- remediation of 10,800 tonnes of soil at the former Fire Training Area
- remediation of 1.6 billion litres of groundwater at the former Fire Training Area
- remediation of 935 million litres of groundwater at the Southern Area plume
- investigations that concluded that PFAS at the DEMS Landfill came from the now-remediated former Fire Training Area, and the landfill is no longer a significant source of PFAS;
- investigations that concluded that the North Eastern Landfill was not a significant source of PFAS, and
- remediation of approximately 1.1 billion litres of water from Lake Cochran.

Defence has also provided water connections to 342 individual premises that previously used impacted groundwater for domestic purposes.

A number of remedial actions were implemented that are still ongoing:

- pumping of surface water from the northern exit of Moors Drain from the base (765 million litres treated to date), and
- pumping of groundwater from the southern boundary of Lake Cochran (935 million litres treated to date).

Groundwater Strategy Review

To assess the effectiveness of the remedial works completed to date and to determine further risk management actions, Defence engaged a group of national and international experts to conduct a remediation strategy review.

The scope of the review was to evaluate the completed and ongoing risk management actions to identify the most effective and efficient combination of technologies and measures to achieve the remediation objectives for the base. The review also included consideration of surface water and soil.

The overall objective was to identify further actions that could reduce the discharge of PFAS in groundwater and surface water across the base boundary as far as reasonably practicable. The reduction of PFAS movement from the base is the most critical step in long-term reduction of PFAS concentrations off base in soil, surface water and groundwater.

The following additional actions were recommended:

Description	Status
Western Region	
Western plumes extraction system Pumping on the boundary of the western plumes to stop PFAS leaving the base in groundwater.	The extraction well design is in progress. Preparing to commence the works.
Former Fire Training Area Remediation of residual PFAS soil contamination in the source area for the western plumes.	To be completed prior to the removal of western plumes extraction system.
Central Region	
Former Fire Training Pad (part of Facility 165) Characterisation and remediation of the remaining PFAS soil at the Fire Training Pad.	Planning underway.
Sewage Treatment Plant Remediation of the Sewage Treatment Plant effluent lagoons, a PFAS source area.	Project with capital works delivery team, pending funding determination.
Southern Area plume water treatment Install groundwater extraction system in NSW EPA Primary Management Zone to intercept PFAS impacted groundwater south of the base. Extracted water will be pumped back to the base for treatment using ionic resin treatment technology.	Design and planning processes underway and nearing completion. Procurement for extraction wells and pipeline to start following completion of design.
Lake Cochran – surface water treatment Passive barrier system installed to manage surface water discharges.	Trial continues after pause due to very high rainfalls in the 2021/2022 period.
South of Lake Cochran – groundwater treatment Installation of a Permeable Reactive Barrier (PRB)	Planning underway.
Dawsons Drain Characterisation of PFAS discharge to Dawsons Drain	Sampling and monitoring process/system design is underway.
Eastern Region	
Moors Drain catchment Characterisation of the Moors Drain Catchment, an area that contains a PFAS source area	Sampling and monitoring process/system design is underway.
Upgrade of Moors Drain pumping system Depending on the outcomes of the catchment investigations, upgrading of the pump and treat system on Moors Drain.	Subject to completion of the above mentioned sampling and monitoring process/system design.

These proposed remedial actions will build on the extensive remedial works completed to date to further reduce the amount of PFAS leaving the base and contribute to the long-term reduction of PFAS in the off-base environment.

Defence will provide regular updates to the Williamtown community on the Defence <u>website</u> and through community information sessions.

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GLOSSARY

ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure 2013
AFFF	Aqueous film forming foams
Base	RAAF Base Williamtown
DSI	Detailed Site Investigation
ERA	Ecological Risk Assessment
HHERA	Human Health and Ecological Risk Assessment
HHRA	Human Health Risk Assessment
Management Area	The geographical area subject to Defence response actions. May include private or defence owned detached properties beyond the boundaries of the base
Off-site	Off-base (or other Defence property)
OMP	Ongoing Monitoring Plan (typically for surface water, groundwater and sediments)
On-site	On-base (or other Defence property)
PFAS NEMP	PFAS National Environmental Management Plan 2020 (as revised from time to time).
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
Remediation Action Plan (RAP)	Defines the purpose and objectives of the remediation, evaluates and determines the remediation options, and sets out performance measures.
Remediation Options Assessment	A review of possible remedial options assessed by effectiveness, cost and sustainability.
Risk assessment(s)	The HHERA, HHRA and/or ERA
Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination.
Source	A source can be primary or secondary. Primary sources are generally areas where AFFF was used or stored. Secondary sources may be an accumulation of contamination in the environment, such as in soil, sediments, or surface water bodies.
SFARP	So far as reasonably practicable.

1 INTRODUCTION

1.1 Background and purpose

In May 2019 Defence published the <u>PFAS Management Area Plan (PMAP)</u> for RAAF Base Williamtown (the 'base'). The purpose of the 2019 PMAP was to outline measures to manage potential risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination at the base and the surrounding area. The location of the base is shown on Figure F1 in Appendix C.

PMAPs are updated as required to account for changes in circumstances, such as progress in remediation, new data, changes in policy, and advances in scientific information. Defence has substantially progressed the actions outlined in the 2019 PMAP, and conducted further investigations and monitoring.

This PMAP outlines the risk management actions that Defence has completed, actions currently underway, and actions that may be required in the future.

1.2 Management priorities

Risk management actions may include remediation (clean-up) of PFAS, or other management measures that control exposure to PFAS. In managing PFAS contamination to reduce risks to human health and the environment, Defence prioritises:

- minimising exposure to PFAS
- preventing or minimising migration of PFAS
- keeping the community informed.

Minimising PFAS movement from the base will, in the long term, contribute to the reduction of PFAS concentrations in the surrounding environment. However, the process will take time, and therefore other measures will also be implemented to reduce risks to human health and the environment.

1.3 Supporting information

This revised PMAP has been developed with the following considerations:

- the guidance provided by the PFAS National Environmental Management Plan Version 2.0 (HEPA January 2020) (NEMP) which provides nationally consistent environmental advice and standards for managing PFAS contamination
- the groundwater, surface water, sediment and biota monitoring conducted by Defence at Williamtown and reported in the ongoing monitoring interpretive reports
- outcomes of further investigation work conducted at potential sources that were identified in the 2019 PMAP (See Section 4), and
- the outcomes of the Williamtown Groundwater Strategy Review completed in 2022.

A comprehensive list of the previous studies and supporting documentation is provided in Appendix A.

1.4 Groundwater Strategy Review

Considerable remedial works and additional investigations have been completed in accordance with the 2019 PMAP. To assess the effectiveness of the completed remedial works and determine further risk management actions, Defence engaged a group of national and international experts to conduct a Groundwater Strategy Review.

Geosyntec Consultants Pty Ltd (Geosyntec) led the Strategy Review and were assisted by AECOM Australia Pty Ltd (AECOM), the lead environmental consultant at the base since 2015. Watershed HydroGeo Pty Ltd and JBS&G Australia provided additional groundwater modelling and remediation advice. The review team consulted with the NSW Environment Protection Authority and the NSW Technical Advisory Group.

The scope of the review was to evaluate the completed and current risk management actions to identify the most effective and efficient combination of technologies and measures to achieve the remediation objectives. The overall remediation objective is to reduce the discharge of PFAS in groundwater and surface water across the base boundary to the extent practicable. The reduction of PFAS movement from the base is the most critical step in long-term reduction of PFAS concentrations off base in soil, surface water and groundwater.

The review consisted of three tasks:

- evaluation of the efficacy of current, completed or former interim response management actions (now referred to as risk management actions)
- establishment of PFAS management goals and measurable end points for each remediation action, and
- development of a Remedial Options Assessment (ROA) to evaluate the available remedial technologies and decide what best suits the site conditions, and remedial objectives.

The outcomes of the review are presented in this PMAP revision.

1.5 Limitations and assumptions

This document has been developed based on the information available at the time of preparation, and the following assumptions:

- Proposed management / remediation were options based on the Groundwater Strategy Review and on current proven technologies available at the time of writing this document including:
 - management and remedial technologies summarised in the PFAS NEMP
 - additional technologies based on successful trials by Defence, and conducted by others within and outside of Australia (based on publicly available information).
- Remediation technologies that are not considered viable or feasible for use at the base or Management Area have been excluded (as recommended in PFAS NEMP). However, Defence will regularly review and assess remediation technologies and their applicability to the management of PFAS at the base.
- The application of base infrastructure development and access constraints at the time of this report.
- Access to off-base private properties will be granted, where required. It is noted that off-base access has not been granted in some key locations.

The PMAP will be revised if new information becomes available and the characterisation of risk changes, necessitating a revised management or remediation approach.

2 MANAGEMENT AREA

The PFAS Management Area comprises RAAF Base Williamtown and the NSW EPA Williamtown Management Area as defined by the NSW Government¹ on 19 November 2017. The Management Area is shown on Figure F1 in Appendix C.

The Management Area is divided into three management zones, each with tailored precautionary advice to residents to minimise exposure to PFAS originating from the base (<u>NSW EPA</u>):

- Primary Management Zone this area has significantly higher levels of PFAS detected and therefore the strongest advice applies
- Secondary Management Zone this area has some detected levels of PFAS, and
- Broader Management Zone the topography and hydrology of the area means PFAS detections could occur now and into the future.

The current land uses in the Management Area were considered by the NSW EPA when developing the precautionary advice, including:

- commercial / industrial activities
- residential and rural residential holdings with some agricultural properties
- Tilligerry State Conservation areas
- Hunter Water Corporation lands, currently undeveloped
- sand mining and quarry operations.

Changes to land uses occur over time and future revisions of the PMAP will consider these changes.

¹ <u>https://www.epa.nsw.gov.au/working-together/community-engagement/updates-on-issues/raaf-williamtown-contamination/williamtown-map</u>

3 EXTENT OF PFAS CONTAMINATION

This section provides a description of the PFAS sources on the base, the ways in which PFAS has moved in the environment (migration pathways), and the extent of PFAS in the environment outside the base. It also provides a summary of the potential human and ecological receptors that may be exposed to PFAS. This information is referred to as the Conceptual Site Model (CSM). A detailed CSM for Williamtown is provided in Appendix B.

This PMAP is based on the CSM, as it identifies:

- ongoing sources of PFAS and outlines the measures to control these sources
- PFAS migration pathways and outlines the measures to minimise PFAS leaving the base, and
- receptors (human or environmental) that might be exposed to PFAS, and what measures are in place to manage exposures.



Figure 1 – Sources / Pathways / Receptors

3.1 **PFAS sources and pathways**

Source areas can be primary or secondary. Primary sources are generally areas of PFAS contamination where aqueous foam forming film (AFFF) was used or stored, for example a fire training area. Secondary sources are areas where PFAS accumulates and then continues to feed into the environment.

In the 2019 PMAP, a total of 14 PFAS source areas were prioritised for risk management based on the amount of PFAS they contained. Since then, additional monitoring and investigation has improved the understanding of these source areas to inform the management requirements.

PFAS can be transported from a source to human or environmental receptors by surface water and groundwater. These are referred to as "migration pathways". The groundwater and surface water flow directions within the Management Area are shown on Figure F3 in Appendix C. The Strategy Review categorised the PFAS migration pathways based on the natural catchments across the base and Management Area:

- Western Region characterised by the Former Fire Training Area (FFTA) source that is now remediated, and a PFAS groundwater plume extending south away from the source. A substantial proportion of the western plume is still on base, and this presents management opportunities that are detailed in Section 4.
- Central Region characterised by ongoing sources at the Former Fire Training Pad / Current Fire Station (Facility 165) and the Sewage Treatment Plant (Facility 410); with PFAS groundwater plumes extending south across the base boundary. The concentrations of PFAS south of the site and north of Cabbage Tree Rd were likely sourced from Lake Cochran, which was impacted when AFFF foams were still in use at the base. However, Lake Cochran is no longer considered a significant ongoing PFAS source to groundwater. PFAS in the central southern plume discharges into Leary's and Dawsons Drain.

• Eastern Region - characterised by likely sources at the Trade Waste Treatment Plant (Facility 480) and a Former Fuelling Area, with PFAS groundwater plumes extending east across the base boundary, and PFAS impacted surface water discharges to Moors Drain.

A summary of the PFAS source areas, migration pathways and current status is provided in Table 1. A map showing these source areas is presented in Figure 2 below and Figure F2 in Appendix C.



Figure 2 – Major PFAS Source Areas (Historical and Current)

No.	Source Area	Pathway	Current Status
Western Region			
1	Former Fire Training Area (FFTA) (Facility 479) (CSR_NSW_000499)	• The PFAS transport pathway in the Western Region is solely through groundwater. There is no indication that the surface drain forming the eastern boundary of the Western Region is transporting PFAS off-base.	 The FFTA soil was remediated in 2018. The remediation works involved the excavation of 10,800 tonnes of PFAS impacted soil, removing approximately 10.5 kg of PFAS from the environment. The FFTA groundwater is subject to ongoing management by a pump and treat system. PFAS in groundwater may still leave the southern base boundary and further action is required. Further details in Section 4.4.
2	Former DEMS Landfill (Facility 394) (CSR_NSW_000651)		 Detailed investigation conducted at former DEMS Landfill in 2020. No longer considered a PFAS source. PFAS previously detected in this area was in fact from the FFTA and future actions south of the DEMS landfill will address PFAS in this area (See Section 4.4). No remediation required.
Centi	ral Region		
3	Fire Station and Fire Training Pad / Foam Testing Facility (Facility 165) (CSR_NSW_000663)	 The major pathway for PFAS mass flux transport in the Central Region is via groundwater flowing beneath the southern boundary. There are four plumes in the Central Region - the Southern Area Plume, the STP Plume, the Lake Cochran Plume and the FTP Plume. Some surface water migration occurs through Lake Cochran and Dawsons Drain. 	 The soil was partially remediated in July 2020. Soil characterisation at the Foam Testing Facility was completed in October 2019, and outcomes were used to develop a remediation plan for the removal of additional PFAS impacted soil. The remediation works were implemented in 2019 and 2020, with a further 1,500 tonnes of PFAS impacted soil excavated and transported to RAAF Base Edinburgh for soil washing treatment. Approximately 13 kg of PFAS was removed from the environment.
4	Lake Cochran (CSR_NSW_001040)		 Historically, when PFAS foams were used, Lake Cochran received PFAS affected surface water runoff and was a significant historic source of PFAS to surface water and groundwater. It was the original source of the plumes located south of the base. Since PFAS foam use has ceased, investigations have demonstrated that Lake Cochran is now a negligible source of PFAS to groundwater. Remediation of Lake Cochran surface water treated between 2016 and 2020.

Table 1. Current status of source areas and pathway management

No.	Source Area	Pathway	Current Status
			• Further management is proposed for the groundwater pathway on the southern site boundary to manage residual PFAS migration (see Section 4.4).
5	Sewerage Treatment Plant (STP) (CSR_NSW_000673)		 Characterisation works of the STP and associated effluent lagoons were completed in 2021. Elevated PFAS concentrations in soil, sediment and surface water were reported in the vicinity of the STP, including the associated lagoons. There is likely to be seepage from the lagoon to groundwater, and spillage over the surrounding bunding is expected to occur from the lagoons overflowing during times of high rainfall and groundwater levels. There appears to be an increase in PFAS concentrations in shallow groundwater from upgradient to downgradient wells around the STP lagoons. Additionally, the broader groundwater data suggest that the elevated PFAS concentrations reported to the west of the STP are likely to be related to the Southern Area plume. Further management is proposed. This project is with the capital works delivery team and is pending funding determination.
Easte	ern Region		
6	Trade Waste Treatment Plant (TWTP) (Facility 480) / Hangar 8 (CSR_NSW_000498)	The major pathway for PFAS flux from the base in the eastern region is surface water. Surface water leaves the base in this area via the two branches of Moors Drain.	 Investigation of the TWTP undertaken in 2021 identified elevated PFAS concentrations in groundwater in the vicinity of the TWTP, however the highest concentrations were reported to the south near the junction of multiple TWTP sewer pipes. PFAS discharge concentrations from the TWTP were also much less than those reported in surface water leaving the base at Moors Drain. These results indicated that the TWTP is unlikely to be a significant contributor to the PFAS discharges from the Eastern Region. However, further investigations of the Eastern Region catchment are required to assess the source(s) of PFAS into the stormwater system.
7	North Eastern Landfill (CSR_NSW_000495)		 Detailed investigation at the North Eastern Landfill conducted between 2022 and 2023. No longer considered a significant PFAS source. The results of the investigations completed in 2023 indicated that the North Eastern Landfill is unlikely to be a significant ongoing PFAS source at the base. Although the modelling and plume shape data did suggest that it had been a significant historic source of PFAS impacts to groundwater.

No.	Source Area	Pathway	Current Status
			 Based on the investigation works completed to date, the North Eastern Landfill is no longer prioritised for management. No remediation required
8	Vehicle Refuelling Facility, Transport Yard (near the TWTP) (CSR_NSW_000857)		 Investigation in the vicinity of the TWTP was undertaken in 2021. The results indicated that some portion of the PFAS in groundwater around the TWTP may be sourced from the Refuelling Facility located to the northeast of the TWTP. Further investigations of the Eastern Region catchment are required to assess the source(s) of PFAS into the stormwater system.
Other	Diffuse Sources	· ·	
9	Sediments containing PFAS in on-base drains.	 In the 2019 PMAP these were identified as possible diffuse PFAS sources. 	 Sediments in some areas of open drains were remediated in 2018. Sediments from the main arterial drainage lines were excavated and taken to a NSW EPA licensed landfill.
10	AFFF use associated with aircraft accidents and other emergency response (CSR_NSW_000507)	• They may contribute low levels of PFAS to groundwater and surface water across the base, but are less significant than the sources listed above.	 These source areas were not specific to any location. While small source areas may exist on the base from emergency responses, investigations have not identified any areas that require remediation or management. No remediation required.
11	Soil in saturated zone with adsorbed PFAS (excluding sources identified above) (CSR_NSW_000507)		 No specific areas have been identified in addition to those areas noted in this listing. No remediation is required beyond those areas noted. No remediation required
12	Shallow soil with adsorbed PFAS from surface runoff - flooding (excluding sources identified above) (CSR_NSW_000507)		 No specific areas warranting active remediation have been identified beyond the source areas listed above. It is noted that surface water transport does contribute to the large areas of low level PFAS detection on the base. No remediation required

3.2 Distribution of PFAS

PFAS has migrated away from source areas on the base via the surface water and groundwater pathways described above. In doing so it has spread throughout (and has been used to define) the Management Area. Apart from some areas where the PFAS is concentrated offsite, such as south of the Base, most of the Management Area is impacted with low levels of PFAS.

Figures showing the distribution of PFAS in groundwater (Figure F4), soil (Figure F5), surface water (Figure F6) and sediment (Figure F7) are provided in Appendix C. Additionally, the inferred extent of PFOS + PFHxS impacts in groundwater are shown on Figure F8 in Appendix C.

3.3 Receptors, risks and exposure management

3.3.1 Human receptors

More than 50 potential pathways through which humans could be exposed to PFAS from the base were assessed in the Human Health and Ecological Risk Assessment (HHERA). These pathways included exposure to elevated PFAS in soil, groundwater, surface water, sediment, land animals and seafood within the Management Area.

The HHRA concluded that unrestricted exposure to PFAS across the Williamtown Management Area may result in an exceedance of the tolerable daily intake (TDI). The TDI is a limit of consumption, under which no adverse health impacts are likely. The NSW Government subsequently issued precautionary advice in April 2017 (<u>Williamtown precautionary advice</u>) on how people within the Williamtown Management Area can reduce their exposure to PFAS. If this advice is followed, then individual exposure to PFAS is very unlikely to exceed the TDI.

Potential risks that were identified as elevated or unacceptable in the HHERA are listed in **Table 2** with corresponding exposure management advice from the <u>NSW EPA</u>. To address these risks Defence is continuing to implement risk management actions, as described in Section 4, to reduce PFAS leaving the base.

Risk ID	NSW Government precautionary advice
R01 – Ingesting groundwater Drinking groundwater with PFAS concentrations above drinking water guidelines (or use in cooking). Applies to NSW EPA Williamtown Management Area.	 NSW Government: Precautionary advice to minimise exposure by not using groundwater for drinking or cooking, Avoid swallowing groundwater when bathing, showering, swimming and paddling in the NSW EPA Williamtown Secondary and Broader Management Zones. Groundwater and bore water should not be used for any purpose in the NSW EPA Williamtown Primary Management Zone.
R02 – Ingesting groundwater Incidental ingestion of shallow groundwater (where PFAS concentrations are above drinking water guidelines) from indoor use, including showering, bathing, food preparation using extracted groundwater. Applies to NSW EPA Williamtown Primary Management Zone.	 NSW Government: Precautionary advice to minimise exposure by not using groundwater and bore water for any purpose in the NSW EPA Williamtown Primary Management Zone.
R03 – Ingesting groundwater	NSW Government:

Table 2. Potential human health risks

Incidental ingestion of shallow groundwater where PFAS concentrations are above drinking water guidelines, as a result of outdoor use (including swimming pools, sprinkler play, domestic irrigation). Applies to NSW EPA Williamtown Primary Management and Secondary Management Zones	• Precautionary advice to minimise exposure by not using groundwater for any purpose in the NSW EPA Williamtown Primary Management Zone.
R04 – Eating home produced eggs Eating eggs from home grown backyard poultry that are exposed to groundwater or surface water as their primary drinking water supply and/or consumed soil or plants that have accumulated PFAS from irrigation water. Applies to the NSW EPA Williamtown Management Area.	 NSW Government: Precautionary advice to minimise exposure by not consuming home-grown foods produced, including eggs in the NSW EPA Williamtown Primary Management Zone, Avoid eating eggs from the NSW EPA Williamtown Secondary and Broader Management Zones.
R05 – Eating home-grown vegetables Eating vegetables that have been irrigated with surface water or groundwater containing detectable PFAS concentrations and/or have been grown in soil that has been irrigated or flooded with water containing detectable PFAS concentrations. Applies to the NSW EPA Williamtown Management Area.	 NSW Government: Precautionary advice to minimise exposure by not consuming home-grown foods produced in the NSW EPA Williamtown Primary Management Zone, Avoid eating vegetables produced in the NSW EPA Williamtown Secondary and Broader Management Zones.
R06 – Ingesting groundwater Incidentally ingesting surface water through swimming/ outdoor recreational use (drains/creeks). Applies to the NSW EPA Williamtown Management Area.	 NSW Government Surface water should not be used for any purpose in the NSW EPA Williamtown Primary Management Zone. Avoid swallowing groundwater or surface water when bathing, showering, swimming and paddling (including in creeks and drains) in the Secondary and Broader Management Zones. Groundwater should not be used for swimming or paddling pools in the Secondary and Broader Management Zones.
R07 – Eating locally sourced cattle Eating locally grown cattle, which are exposed to surface water or groundwater as their primary drinking water supply and/or have consumed soil or plants that have accumulated PFAS from irrigation water. Applies to the NSW EPA Williamtown Management Area.	 NSW Government: Precautionary advice to minimise exposure by not consuming home-grown foods produced, including home-slaughtered meat in the NSW EPA Williamtown Primary Management Zone. Avoid eating home-slaughtered meat in the NSW EPA Williamtown Secondary and Broader Management Zones.
R08 – Drinking locally sourced milk Drinking milk from locally grown cattle, which are exposed to surface or groundwater as their primary source of drinking water and/or	 NSW Government: Precautionary advice to minimise exposure by not consuming home-grown foods produced, including milk in the NSW EPA Williamtown Primary Management Zone.

consumed soil or plants that have accumulated PFAS from irrigation water. Applies to the NSW EPA Williamtown Management Area.	 Avoid drinking milk produced in the NSW EPA Williamtown Secondary and Broader Management Zones.
R09 – Eating locally caught fish Eating high quantities of locally sourced finfish from the marine environment. Applies to Hunter River Estuary, Fullerton Cove and Tilligerry Creek.	 NSW Government: People who personally source and eat fish and seafood from the Hunter River Estuary, Fullerton Cove and Tilligerry Creek should limit the number of servings of individual species. Sourcing seafood from a variety of locations including the ocean and waterways outside these areas will assist in minimising exposure. The NSW government also provide the recommended maximum intake based on eating a single species caught from the Hunter River Estuary, Fullerton Cove and Tilligerry Creek.

3.3.2 Ecological Risks

Potential risks to ecological receptors that were identified as elevated or unacceptable in the ERA (AECOM, 2018a) are listed in **Table 3**. To minimise these risks Defence continues to implement risk management actions (as detailed in Section 4) to reduce PFAS leaving the base.

Table 3. Elevated ecological risks

Risk ID	Description
R10	Toxicity to terrestrial and aquatic organisms from direct exposure to PFAS in soil, sediment or surface water.
R11	Consumption of organisms that have been exposed to PFAS where bioaccumulation is occurring.

4 **RISK MANAGEMENT ACTIONS**

This section outlines the actions that Defence is and will continue to undertake to manage the risks associated with PFAS that are described in Section 3.

4.1 Background

In developing actions to address potential risks to receptors from PFAS contamination, Defence considers:

- whether an option is proportional to risks
- the sustainability and longevity of an option (environmental, economic and social) in achieving an appropriate balance between benefits and effects
- views of the jurisdictional regulator and other stakeholders
- availability of best-practice management systems, treatments and technologies
- site specific issues (including transformation, cross-contamination, and remobilisation)
- logistical and operational constraints
- effectiveness and validation status of technology
- success measures for the treatment or remediation outcomes
- the need for ongoing operations, management, maintenance or monitoring
- the net environmental benefit.

Defence prioritises source management and pathway management as preferable to receptor management, but these components may also be progressed concurrently.

4.2 Implementation

Defence takes a risk-based approach to implementing actions under this PMAP, and considers value for money in the use of public resources. Defence engages consultants to implement the PMAP.

Key factors for progressing and prioritising PMAP response actions include:

Mitigating PFAS migration and protecting human health	Implementation of practicable solutions to prevent or minimise the migration of PFAS beyond the Defence property boundary, and measures to protect the community from exposure.
Higher risks	The relative level of risk being addressed, including changes in land use.
Outcomes of completed works	Outcomes from further studies, technology trials or validated remedial works may change the profile or priority of source areas or works.
Linked actions	Whether the implementation of one response action is dependent on the implementation of another response action.
Use of public resources	Application of the Commonwealth Procurement Rules (issued under the <i>Public Governance, Performance and Accountability</i> <i>Act 2013</i>) including the Defence Infrastructure Panel – Environment, Heritage and Estate Engineering Services 2020- 2025, to achieve value for money in procurement; and to use

	public money in an efficient, effective, economical and ethical manner. Cost-effectiveness may be facilitated through:
	 grouping the implementation of similar response actions within one or more Management Areas
	• aligning Defence infrastructure and maintenance plans with a PFAS response action.
Mandatory approvals	Timeframes for mandatory approvals and notification processes.
New legislation or policy	Development of relevant legislation, policy, guidelines and whole-of-government positioning.
Science and technology Stakeholder input	The availability of new relevant science and technology. Information from stakeholders that may impact a risk profile.

4.3 Completed and ongoing risk management actions

The status of the actions described in the 2019 PMAP are provided in Table 4.

Action	Description	Status
Exposure management	Testing of private groundwater water supply bores Assessment of PFAS impact at the point of potential use.	 Defence continues to test private groundwater bores either via the Ongoing Monitoring Program (refer to Section 4.5) or ad-hoc sample requests from people living within the Management Area.
Exposure management	Bottled water supply Provision of interim water supply pending long term solution.	 Bottled water was supplied to eligible residents until such time that a longer-term solution was in place (i.e. town water connections or rainwater tanks).
Exposure management	Town water connections Provision of permanent alternative water supply.	 Completed Provided town water connections to 342 properties and provided rainwater tanks to 12 properties (where town water connections could not be provided) that previously used impacted groundwater for domestic purposes. Ongoing Defence has committed to pay the annual service fee and ongoing usage charges levied by Hunter Water Corporation (HWC) for all eligible properties connected to town water for a period of six years from the date of connection. Additionally, Defence has committed to pay for rainwater tank top ups for all eligible properties for a period of six years from the date of connection.
Source management	FFTA remediation - groundwater	 Completed System was commissioned in July 2018, and has treated 1.6 billion litres of water.

Table 4. Status of 2019 PMAP recommended actions

Action	Description	Status
	Removal of PFAS impacted groundwater by a pump and treat system, and treatment using ionic resin treatment technology. Disposal of clean treated water by on-base grass irrigation via sprinklers.	 with approximately 30 kg of PFAS being removed from the environment (as of July 2023). The system has been effective at treating large volumes of water and reducing PFAS concentrations in the area, with reduction in groundwater plume at the FFTA. Planned works The FFTA remediation is complete. The Strategy Review recommended further management of PFAS by moving the pump and treat system to the base boundary to prevent movement of PFAS groundwater over the southern boundary. This system will be redeployed for boundary pumping. The extraction well design is in progress and preparation has commenced for the works.
Source management	FFTA - Soil Excavation of soil with high PFAS concentration	 Completed In 2018, 10,800 tonnes of PFAS contaminated soil was excavated and stored in a purpose-built containment cell prior to off-base disposal to a licenced landfill. Approximately 11 kg of PFAS was removed from the environment. PIanned works PFAS impacted soil remains at the FFTA. Further remediation of the soil is being considered but is not required until the pump and treat extraction system is turned off on the western plumes.
Source management	Lake Cochran surface water Interception of PFAS impacted surface water by a water treatment plant using activated carbon filtration. Treated water was discharged to Dawsons Drain.	 Completed The water treatment plant was commissioned in November 2016 and treated 1.1 billion litres of PFAS impacted water, with approximately 8 kg of PFAS being removed from the environment. It was later identified that the primary pathway for PFAS discharging from Lake Cochran was via groundwater, as such the plant was decommissioned in 2021. Planned works Additional risk management actions are currently ongoing or proposed for Lake Cochran (refer to Section 4.4). These include continuation of the passive surface water treatment trial and trial of a passive carbon barrier system for groundwater.
Pathway management	Southern Area plume water treatment Install groundwater extraction system in NSW EPA Primary	 An on-base water treatment plant was commissioned in May 2019 to target the Southern Area plume prior to Defence

Action	Description	Status
	Management Zone to intercept PFAS impacted groundwater south of the base. Extracted water will be pumped	obtaining approval to install the system off- base.
		• The on-base system has treated 935 million litres of water (as of July 2023).
	using ionic resin treatment technology.	• Approximately 12.6 kg of PFAS has been removed from the environment.
		Planned works
		Design and planning processes are underway and nearing completion. Procurement for extraction wells and pipeline to start following completion of design. To enable construction of the off- base pipeline, the Commonwealth has been listed as a "public authority" under the Environmental Planning and Assessment Regulation 2021.
		Treated water disposal options are being reviewed.
Source	Sewage Treatment Plant	Completed
management (Facility 410) Review outcomes of works to manage PFAS in wastewater generated from the Base.	 Defence has also completed an options assessment to determine the most technically efficient, long-term solution to the management of wastewater (including PFAS in the wastewater) from the base. 	
	demonstration trial is being undertaken to manage both wastewater and solid waste from the treatment plant. Evaluating potential options for management of wastewater	 As part of the two-stage technological demonstration trial, wastewater and solid waste (biosolids) characterisation works were completed in April 2022.
		Planned works
from the base including the option to connect to Hunter Water Corporation (HWC) sewage system.	• Further management is proposed. This project is with the capital works delivery team, and is pending funding determination.	
Pathway	Moors Drain Surface Water	Ongoing
managementTreatment (Northern Brand Interception and treatment of PFAS impacted surface wat discharging under Medowie Road to the northern branch Moors Drain using ionic resi technology.Treated water discharged to Moors Drain.	Treatment (Northern Branch) Interception and treatment of PFAS impacted surface water discharging under Medowie Road to the northern branch of Moors Drain using ionic resin	 System was commissioned in June 2017 and has treated 765 million litres of water (as of July 2023). Approximately 3 kg of PFAS has been removed from the environment. Planned works
	Treated water discharged to Moors Drain.	 A Moors Drain catchment assessment will be undertaken to better understand PFAS sources in this catchment (refer to Section 4.4). Sampling and monitoring process/system design is underway.
		 Based on the outcomes of the additional investigation, potentially modify the Moors Drain water treatment system to optimise PFAS capture, which may include treating discharges from Moors Drain southern branch, in addition to the northern branch.

Action	Description	Status			
Source management	Infrastructure construction / upgrade projects - soil and water management in areas with PFAS impacts Testing and stockpiling of PFAS impacted soil. Treatment of PFAS impacted surface and groundwater via deployable activated carbon treatment plant. Disposal of treated water by on-Base irrigation. Includes work associated with the New Air Combat Capability (NACC) and Air Traffic Control (ATC) projects.	 Defence has implemented a national framework for the management of PFAS impacted soil and water in construction and upgrade projects (refer to Defence PFAS Construction and Maintenance Framework). This document was prepared in accordance with the PFAS NEMP (2020). Implementation is ongoing. 			
Pathway management	Base open drains clearing A program was undertaken to remove a nominal 200 mm thickness of surface sediment from selected open drains across the base.	 Defence removed PFAS impacted surface sediment from 2.7 kilometres of selected open drains across the base. The sediment was disposed of at an EPA licensed landfill. 			
Pathway management	Regional Drainage Study Assessment and modelling of drainage network around the Base including the Dawsons Drain/ Fullerton Cove, and Moors Drain/ Tilligerry Creek catchments.	 A regional drainage study was completed in 2018. The focus of the study was to construct a computer flood model to provide a detailed assessment of the performance of the local drainage network and test engineering options to improve its performance (Umwelt, 2018). The study helped to inform the CSM and Defence management actions. Planned works Defence is working with other stakeholders and land owners to examine whether there are any opportunities to improve flood management down gradient of the base (See Section 4.4). 			
-	Discontinue use of legacy AFFF containing PFAS (3M lightwater formulation) at the base	 From 2004, Defence commenced phasing out its use of legacy firefighting foams containing PFOS and perfluorooctanoic acid (PFOA) as active ingredients. 			
-	Manage use of AFFF containing other PFAS (such as Ansulite formulation) for emergency response	 From 2004 Defence commenced transitioning away from legacy fire fighting foams to a more environmentally safe firefighting product called Ansulite. Ansulite does not contain PFOS and PFOA as active ingredients, only in trace amounts. Ansulite is used by Defence only in emergency situations where human life is at risk, or in controlled environments to test equipment. For land-based vehicles and appliances, Defence has completed its 			

Action	Description	Status
		transition to fluorine-free foams. Defence continues to monitor developments on fire suppression products and systems and progressively upgrades its own use based on these developments.

4.4 Planned works - further risk management actions

Substantial remedial works and additional investigations were completed between 2019 and 2023 in accordance with the 2019 PMAP. The Groundwater Strategy Review subsequently made further recommendations to enhance the reduction of PFAS leaving the base and ultimately contribute to the long-term reduction of PFAS in the Management Area. These planned actions are summarised in Table 5.

Action	Description	Status	Reason / timeframe		
Western Region					
Pathway management	Western plumes extraction system Preventing PFAS in groundwater leaving the base	In planning The extraction well design is in progress. Preparing to commence the works.	 The current FFTA groundwater extraction system will be turned off and instead groundwater will be extracted from the boundary due south of the FFTA. This will allow capture of the PFAS impacted groundwater from the FFTA before it leaves the base. The current FFTA pumping has been effective but is providing diminishing returns in PFAS removal. The extraction system will consist of a series of groundwater wells on the southern base boundary that will extract up to 1 ML of water per day. 		
Source management	FFTA Remediation of residual PFAS soil contamination in the source area.	Proposed To be completed prior to removal of western plumes extraction system	 While excavation of PFAS contaminated soil was completed in 2018, further remediation may be required to address residual soil impacts. Suggested soil remedial methods may include in situ stabilisation or excavation and disposal. As the residual PFAS will be captured by the western plumes extraction system described below, this is a low priority item. The remediation will have to be completed prior to the removal of the western plumes extraction system. 		
Central Regional	on				
Source management	Former Fire Training Pad (part of Facility 165) Characterisation and remediation of the FTP (part of Facility 165).	In planning Planning underway.	 Soil characterisation at the Fire Training Pad was completed in 2019, and outcomes were used to develop a remediation plan for the removal PFAS impacted soil. Soil at the former FTP is one of the largest source masses remaining on the base and will continue to leach PFAS to groundwater and surface water. Further soil characterisation and remediation are proposed at the Former FTP to determine if remedial works are required. Suggested soil remedial methods may include in situ stabilisation or excavation and disposal. The scope of any remediation will be limited by the presence of the exiting aboveground and underground infrastructure. 		
Source management	Sewage Treatment Plant	In planning Capital works project	• Characterisation works of the STP and associated effluent lagoons were completed in 2021. PFAS in soils are likely contributing to groundwater impacts in the area.		

Table 5: Status of additional management actions

Action	Description	Status	Reason / timeframe		
	Remediation of the Sewage Treatment Plant effluent lagoons, a PFAS source area (Source Area #6)		 This project is with the capital works delivery team, and is pending funding determination. 		
Pathway management	Southern Area plume water treatment	In planning Planning underway	• Extracted water will be pumped back to the base for treatment using ionic resin treatment technology.		
	Install groundwater extraction system in NSW EPA Primary Management		 Design and planning processes underway and nearing completion. Procurement for extraction wells and pipeline to start following completion of design. 		
	Zone to intercept PFAS impacted groundwater south of the base.		 To enable construction of the off-base pipeline, the Commonwealth has been listed as a "public authority" under the Environmental Planning and Assessment Regulation 2021. 		
			Treated water disposal options are being reviewed.		
Source management	Lake Cochran – surface water treatment Install and trial a passive barrier system to manage surface water discharges.	Current Trial continues after pause due to very high rainfalls in the 2021/2022 period.	 A passive carbon-based surface water remediation system has been installed on both the inlet and outlet from Lake Cochran (August 2020), however it has not been fully commissioned due to high water levels since its installation and its overall performance cannot be quantified. Initial results have indicated good PFAS removal of about 98%. Following completion of the trial, the system will be assessed for potential modification and enhancement for long-term deployment on the base. 		
Pathway management	South of Lake Cochran – groundwater treatment Installation of a permeable reactive barrier	In planning Planning underway	 When the Southern Plumes extraction system (off-base) is commissioned (see below), a trial passive groundwater barrier will be installed along the southern boundary of the base to replace the current extraction wells. Permeable reactive barriers (PRBs) are commonly used to treat groundwater and this will be one of the first barriers installed in Australia to treat PFAS. As such, it will be treated as a technology trial. The barrier consists of a deep vertical trench (or underground wall) filled with media such as carbon to absorb the PFAS as the groundwater naturally flows through it. 		
Investigations	Dawsons Drain Characterisation of PFAS discharge to Dawsons Drain	In planning Sampling and monitoring process/system design is underway.	 Additional data will be collected to characterise discharges of PFAS via Dawsons Drain from the base. 		

Eastern Reg	ion			
Pathway management	Moors Drain catchment Characterisation of the Moors Drain Catchment, an area that contains a PFAS source area (Source Area #5)	In planning Sampling and monitoring process/system design is underway.	•	Characterisation of the Moors Drain Catchment identified an extensive network of lined and unlined surface drains and subsurface drainage pipes in the Eastern Region that flow to the three Moors Drain discharge points in the Eastern Region. The drainage pipe system was designed to be "leaky" (pipes are butt-jointed) to capture shallow groundwater and lower the water table, so as to reduce surface expression of groundwater.
			•	The results from water collected from the drainage networks suggested that direct stormwater runoff to the drains is not significantly increasing the mass loading of PFAS, but rather may be diluting the increased groundwater loading to the drains and drainage pipe due to rising groundwater levels and entrainment of PFAS previously trapped in the vadose zone.
			•	Additional data will be collected to more accurately locate the source(s) of the discharge to the southern branch of Moors Drain.
Pathway management	Upgrade of Moors Drain pumping system Depending on the outcomes of the catchment investigations, upgrading of the pump and treat system on Moors Drain.	Subject to completion of the above mentioned sampling and monitoring process/system design	•	Based on the outcomes of the additional investigation, potentially modify the Moors Drain water treatment system to optimise PFAS capture, which may include treating discharges from Moors Drain southern branch, in addition to the northern branch.

4.6 Treatment technology trials

Defence works with Australian research groups and industry partners to better understand PFAS and improve knowledge on how to clean up or prevent PFAS contamination in the environment.

Studies range from small laboratory tests, through to field level testing of new remediation technologies. Several studies have been completed at the base since 2019. Some examples are provided below.

PFAS treatment trial – soil washing PFAS impacted soils from Foam Testing Facility remediation works were transported to South Australia and were treated at RAAF Base Edinburgh using a purpose-built soil washing plant.	The facility treated around 1,500 tonnes of soil containing PFAS. The treatment removed approximately 98% of PFAS from coarse sand material and the concentrated PFAS waste was transported to Victoria for thermal destruction research. The trial found that the treatment process was most effective for coarse sands, but to a lesser degree for fine sands (96% reduction) and gravel (91% reduction).
PFAS treatment trial – soil stabilisation PFAS impacted soils from Foam Test Facility remediation works were transported to South Australia and were treated at RAAF Base Edinburgh using carbon stabilisation methods.	The stabilisation consisted of mixing soil with a small amount of activated carbon to prevent the PFAS from moving from the soil during rainfall events. A purpose-built rainfall simulator was used to assess the effectiveness of carbon stabilisation under high intensity rainfall events, with and without the addition of activated carbon. The trial found that 1% weight/weight of activated carbon substantially reduced the concentrations and loads of PFAS in both surface water runoff and leachates from the soil. The effectiveness of carbon stabilisation has been confirmed by work with the CSIRO and the University of Adelaide. It is likely that stabilisation will feature in remedial options for the proposed works described in Section 4.4 of this document.
PFAS treatment trial – PFAS destruction technology Defence trialled an Electrochemical PFAS destruction technology on PFAS concentrate and wastewater at the base.	The technology was trialled between May and August 2021. It used electricity and a catalyst material (a substance that facilitates a reaction) to break down PFAS to inorganic fluoride without creating hazardous waste. During the trial, 54,000 litres of PFAS impacted waste solution, comprising 13,200 litres of AFFF concentrate and 20,800 litres of PFAS impacted wastewater were treated. The electrochemical PFAS destruction technology removed 99.9% of PFOS, PFOA and PFHxS; and 96.4% of total organic fluorine in wastewater.

4.7 Ongoing monitoring

Defence continues to monitor PFAS concentrations in the environment at the base and Management Area through an ongoing monitoring program. This allows for the timely identification and management of emerging risks and informs Defence's approach to the management of PFAS. Monitoring requirements are outlined in an Ongoing Monitoring Plan (OMP). The OMP is designed to be reviewed annually, and, if required, amended to ensure it continues to provide the data needed to identify important changes in PFAS concentrations and distribution. The results from the Ongoing Monitoring Program are shared with the NSW EPA and are provided in PFAS Ongoing Monitoring Interpretive Reports², available on the <u>Defence website</u>. These reports provide the PFAS data and an analysis of what important changes in concentrations may mean to humans or the environment.

Overall, the monitoring since the 2019 PMAP was issued shows decreases in PFAS concentrations in some source areas associated with remedial activities. Broadly, the PFAS concentrations in the Management Zones off base are stable. Significant decreases in PFAS concentrations off-base will be slow to manifest.

The OMP outlines triggers and actions that Defence will undertake if certain results or trends are reported from the sampling. This includes actions to confirm the accuracy of results, notification to the NSW EPA and other agencies upon new PFAS detections or increasing trends and implementing additional investigations and risk management actions if the monitoring data indicates changes to the current risk profile.

² Formerly referred to as Annual Interpretive Report (AIR)

5 NEXT STEPS

Defence will carry out the risk management actions set out in this PMAP and continue to reassess its actions based on a range of factors, such as the outcomes of remediation, monitoring results, changes to government policy settings, site conditions and scientific methodologies and technologies.

Defence will review, and if required revise the PMAP to ensure the PMAP remains current, relevant and prioritises the right actions to protect human health and the environment. Defence will continue to engage with the community, Port Stephens Council, and other stakeholders, and make sure that information is available in an easily accessible form.

It is not possible to remove all PFAS from the environment. Remediation will be undertaken so far as reasonably practicable, and unacceptable risks that may remain will be identified through monitoring, and appropriately managed.

In determining what is reasonably practicable, a range of aspects will be considered, including:

- level of risk from PFAS to human and ecological receptors
- hydro-geological profile of the site and the soil profile
- nature and extent of PFAS contamination
- availability of proven technologies suitable for the characteristics of the site
- logistical and operational constraints of the site and
- financial and sustainability aspects of each technology.

At completion of remediation, an independent professional, accredited as a site auditor in NSW will assess whether remediation has been conducted so far as reasonably practicable. The PMAP will then be updated to reflect a transition to ongoing monitoring and long-term management of remaining risks.

APPENDIX A References

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APPENDIX B Conceptual Site Model

This Appendix provides visualisations of the source – pathway – receptor relationships in the form of a Conceptual Site Model.

APPENDIX B Conceptual Site Model



Source

Source						
Former AFFF Training (Soil excavated, groundwater treatment ongoing)	Not a significant source	Former AFFF EmergencyResponse	Legacy Soil Impact from past training	Former Foam Dis- charge in Hangars	Spillage/overflow	No longer a significant ongoing source
Migration Pathway						
Soil Impact Leaching to groundwater Groundwater migration Impact to vegetation	Groundwater impacted	PFAS Runoff to site surface water drains Sorbtion/leaching from pavements	PFAS Runoff to surface water drains Surface water leaching and runoff NB. Current system no discharge: water captured and treated. Groundwater ingress to drainage network when High groundwater levels	Foam / water runoff to trade waste drainage to Trade Waste Treatment Plant (Facility 480)	Treated water still containing PFAS discharged to Sewerage Treatment Plan (Facility 410) Leaching to groundwater Surface water losses from drainage and trade waste network Groundwater ingress to drainage network	Drain leakage to groundwater when water table is low (losi drains) Inflow of contaminated groundwater into drains when water table is high (gaining drains) Flow of impacted surface water and losses from drainage network Groundwater migration and ingress to drainage network
Receptor						
Site fauna	Site fauna	Site fauna			Site fauna	Aquatic and terrestrial biota i.e. fish, eels, invertebrates, amphibians, birds, mammals (drinking)
Site personnel	Site personnel	Site personnel	Site personnel	Site personnel	Site personnel	

HWC bores

HWC bores





10-50 μg/L 0.2-10 μg/L

Ground Impacts



Fill Impacted soil Impacted sediment Leaching to ground water Groundwater

> size A3



ing

Not to Scale

1 of 1 ππε Figure F8: Conceptual Site Model



DEPARTMENT OF DEFENCE

Disclaimer Spatial data used under licence from Land and Property Management Authority, NSW © 2015. AECOM makes no representations or warranties of any kind, about the accuracy, reliability, completeness, suitability or fitness for purpose in relation to the map content.

APPENDIX C Additional figures

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- Figure F1: RAAF Base Williamtown and Management Area
- Figure F2: Key PFAS source areas
- Figure F3: Shallow groundwater and surface water flow
- Figure F4: Groundwater results
- Figure F5: Soil results
- Figure F6: Surface water results
- Figure F7: Sediment results
- Figure F8: Inferred extent of PFOS+PFHxS in groundwater

APPENDIX C Additional figures



FIGURE F1: SITE LOCATION AND MANAGEMENT AREA

Legend



Primary Management Zone

Secondary Management Zone

Broader Management Zone





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FIGURE F3: SHALLOW GROUNDWATER AND SURFACE WATER FLOW

Legend RAAF Base Williamtown Primary Management Zone Secondary Management Zone Broader Mangement Zone

Inferred Groundwater Flow Direction

Groundwater Elevation Contour (Shallow Wells; mAHD)

Surface Water Flow Direction

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FIGURE F4: GROUNDWATER ANALYTICAL RESULTS - PFOS+PFHXS - MAY 2021

Legend

end	PFOS + PFHxS (µg/L)
RAAF Base Williamtown	> 50
Primary Management Zone	■ > 10 - 50
Secondary Management Zone	■ > 0.07 - 10
Broader Mangement Zone	> Limit of Reporting - 0.07

- < Limit of Reporting</p>
- Groundwater Monitoring Location (Not Sampled)



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FIGURE F5: SOIL ANALYTICAL RESULTS - PFOS+PFHXS - MAY 2021 Legend PFOS + PFHxS (mg/kg)

- RAAF Base Williamtown
- ♦ > 10
- Primary Management Zone
 - ♦ > 1 10
- Secondary Management Zone 🔶 > 0.3 1 ♦ > Limit of Reporting - 0.3
- Broader Mangement Zone
- < Limit of Reporting</p>
- Soil Location (Not Sampled)



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FIGURE F6: SURFACE WATER ANALYTICAL RESULTS - PFOS+PFHXS - MAY 2021

• > 10 - 50

Legend

- PFOS + PFHxS (µg/L) wn ● > 50
- RAAF Base Williamtown
- Primary Management Zone
- Secondary Management Zone • > 2 10
- Broader Mangement Zone
- > Limit of Reporting 2
- < Limit of Reporting</p>
- Surface Water Location (Not Sampled)



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FIGURE F7: SEDIMENT WATER ANALYTICAL RESULTS – PFOS+PFHXS – MAY 2021 Legend PEOS + PEHXS (mg/kg)

• > 1 - 10

end	PFOS + PFHxS (mg/kg)
RAAF Base Williamtown	● >10

Primary Management Zone

- Secondary Management Zone 🔶 > 0.3 1
- Broader Mangement Zone
- < Limit of Reporting</p>

Sediment Location (Not Sampled)



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FIGURE F8: INFERRED EXTENT OF GROUNDWATER IMPACTS - PFOS+PFHXS





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