Australian Government
Defence

PFAS INVESTIGATION AND MANAGEMENT PROGRAM

SERVICE
COURAGE
RESPECT
INTEGRITY
EXCELLENCE

RAAF Base Darwin

ONGOING MONITORING PLAN

January 2025

ACKNOWLEDGEMENT OF COUNTRY

Defence acknowledges the Traditional Custodians of Country throughout Australia. Defence recognises their continuing connection to traditional lands and waters and would like to pay respect to their Elders both past and present.

Defence would also like to pay respect to the Aboriginal and Torres Strait Islander peoples who have contributed to the defence of Australia in times of peace and war.

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GLOSSARY

AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum
ARFF	Aviation Rescue and Fire Fighting
AS	Australian Standard
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013
Base	RAAF Base Darwin
BSM	Base Support Manager
BoM	Bureau of Meteorology
CFTA	Current Fire Training Area
COC	Chain of Custody
CSM	Conceptual Site Model
DIA	Darwin International Airport
DO	Dissolved Oxygen
DoH	Department of Health (NT)
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DSI	Detailed Site Investigation
EC	Electrical Conductivity
Eco	Ecological Exposure
EPA	Environment Protection Authority
ERA	Ecological Risk Assessment
FFF	Former Fuel Farm
FFTA	Former Fire Training Area
FSANZ	Food Standards Australia New Zealand
HEPA	Heads of EPA
HH	Human Health
HHRA	Human Health Risk Assessment
LOR	Limit of Reporting
Management Area	The geographical area subject to Defence risk management actions. May include private or Defence owned detached properties beyond the boundaries of the base.
mbgl	Metres below ground level
NATA	National Association of Testing Authorities
NHMRC	National Health and Medical Research Council

NT	Northern Territory
Off-site	Off-base (or other Defence property)
OMP	Ongoing Monitoring Plan
OMR	Ongoing Monitoring Report
On-site	On-base (or other Defence property)
PFAS	Per- and polyfluoroalkyl Substances
PFAS NEMP	PFAS National Environmental Management Plan
PFHxS	Perfluorohexane sulfonate
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PMAP	PFAS Management Area Plan
QA	Quality Assurance
QC	Quality Control
Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination
RAAF	Royal Australian Air Force
RAAF FS	RAAF Fire Station
SADFO	Senior Australian Defence Force Officer
SAQP	Sampling, Analysis and Quality Plan
SFARP	So Far as Reasonably Practicable
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.
SWL	Standing Water Level
TBA	To be advised
TOC	Total Organic Carbon
UST	Underground Storage Tank

1 INTRODUCTION

1.1 Background

In 2025 Defence prepared a PFAS Management Area Plan (PMAP) for managing risks to human health and the environment from per- and poly-fluoroalkyl substances (PFAS) contamination associated with Royal Australian Air Force (RAAF) Base Darwin (the base) and surrounding areas. An important requirement of the PMAP is to undertake ongoing monitoring of PFAS in the environment and to assess for changes in risks to human and ecological receptors from PFAS originating from the base.

This Ongoing Monitoring Plan (OMP) replaces the 2019 OMP.

1.2 Purpose

The OMP sets out requirements for collection of adequate data to identify and evaluate:

- Spatial, and temporal (including seasonal) variability of PFAS in the environment.
- Changes to sources, transport pathways and/or receptors, described as a conceptual site model (CSM) for the base.
- Whether risks to human and ecological receptors require review.
- The influence that risk management activities at the base, as outlined in the 2025 PMAP have had on PFAS in the environment.
- Whether the identified changes trigger an action and/or review.

The data collected may be used to inform where new risk management actions may be required, or to support a determination that remediation has been completed so far as reasonably practicable (SFARP).

1.3 Supporting information

The 2025 RAAF Base Darwin PMAP was used to inform the development of this OMP, along with the following relevant studies:

- RAAF Base Darwin Detailed Site Investigation – Per and Poly-fluoroalkyl Substances (PFAS) (Coffey, 2018a)
- RAAF Base Darwin Human Health Risk Assessment. (Coffey, 2018b)
- RAAF Base Darwin Supplementary Detailed Site Investigation Report (Coffey, 2018c)
- RAAF Base Darwin Ecological Risk Assessment (Coffey, 2018d)
- Baseline Mass Flux Investigation. RAAF Base Darwin PFAS Investigation (Tetra Tech Coffey, 2022)
- RAAF Base Darwin – PFAS Investigation, CFTA and Former ARFF Further Investigations 2022 (Tetra Tech Coffey, 2024a), and
- RAAF Base Darwin – PFAS Remediation, FFTA1 and Wrapped Stockpile Wrapped Stockpiles Validation Report (Tetra Tech Coffey, 2024b).

In developing this OMP, reference has been made to the Heads of EPA (HEPA) 2020 PFAS National Environmental Management Plan Version 2.0 (HEPA, 2020), (herein referred to as the PFAS NEMP), the National Environment Protection (Assessment of Site Contamination) Measure 2013 (ASC NEPM) and Defence estate, environmental and PFAS-specific strategies and guidance, and other information as provided in Appendix A.

1.4 Constraints and assumptions

This OMP has been prepared based on information available at the time of writing and relies on the findings of the DSI, risk assessments, mass flux assessments, remediation activities, ongoing monitoring program data, and management of risks documented in the 2025 PMAP Revision. Defence recognises that there may still be gaps in information, and if required these will be progressively addressed while impacted sites are being managed. Identified actions to manage risks and address gaps in data are outlined in the 2025 PMAP.

This document has been developed based on the following assumptions:

- The current legislative setting and guidance for the assessment of risks to receptors from PFAS contamination.
- The sampling of various media to monitor the behaviour of PFAS in the environment is often limited by climatic conditions with significant seasonal variation between the wet and dry seasons limiting collection of samples at some locations. It has been assumed that all sampling locations and media are available for the purposes of monitoring PFAS at the base.

2 SITE SETTING

2.1 Base description

RAAF Base Darwin is located on the Stuart Highway approximately seven kilometres from the business centre of Darwin, adjacent to the suburbs of Winnellie, Ludmilla, Coconut Grove, Millner, Jingili, Moil, Anula, Malak, Karama and the North Lakes Estate.

The base has an area of 1,278 hectares with McMillans Road and the Northlakes Estate/Marrara Sports Complex to the north, Amy Johnson Avenue to the east, Stuart Highway to the south and Bagot Road to the west. Darwin International Airport (DIA) occupies an area to the north of the base, but within the Management Area defined in the RAAF Base Darwin PMAP.

The base includes an operational joint civil-military airfield, with usage of runways and taxiways shared between RAAF air movements, international joint military exercises and civilian aviation traffic. The base has administrative, accommodation, recreational and operational support facilities, technical workshops, aircraft hardstands and aircraft pavements. In addition to civil aircraft operations, the airfield supports both Australian and international military aircraft operations.

2.2 Management area setting

The Management Area covers all of the base and discrete areas outside of the base including the surface water system of Rapid Creek and Ludmilla Creek, as well as groundwater beneath part of the suburb of Ludmilla, and groundwater under DIA. A layout of the base, the PFAS Management Area and PFAS source areas are presented in Figure 1. A summary of the Management Area setting is provided in Table 2-1.

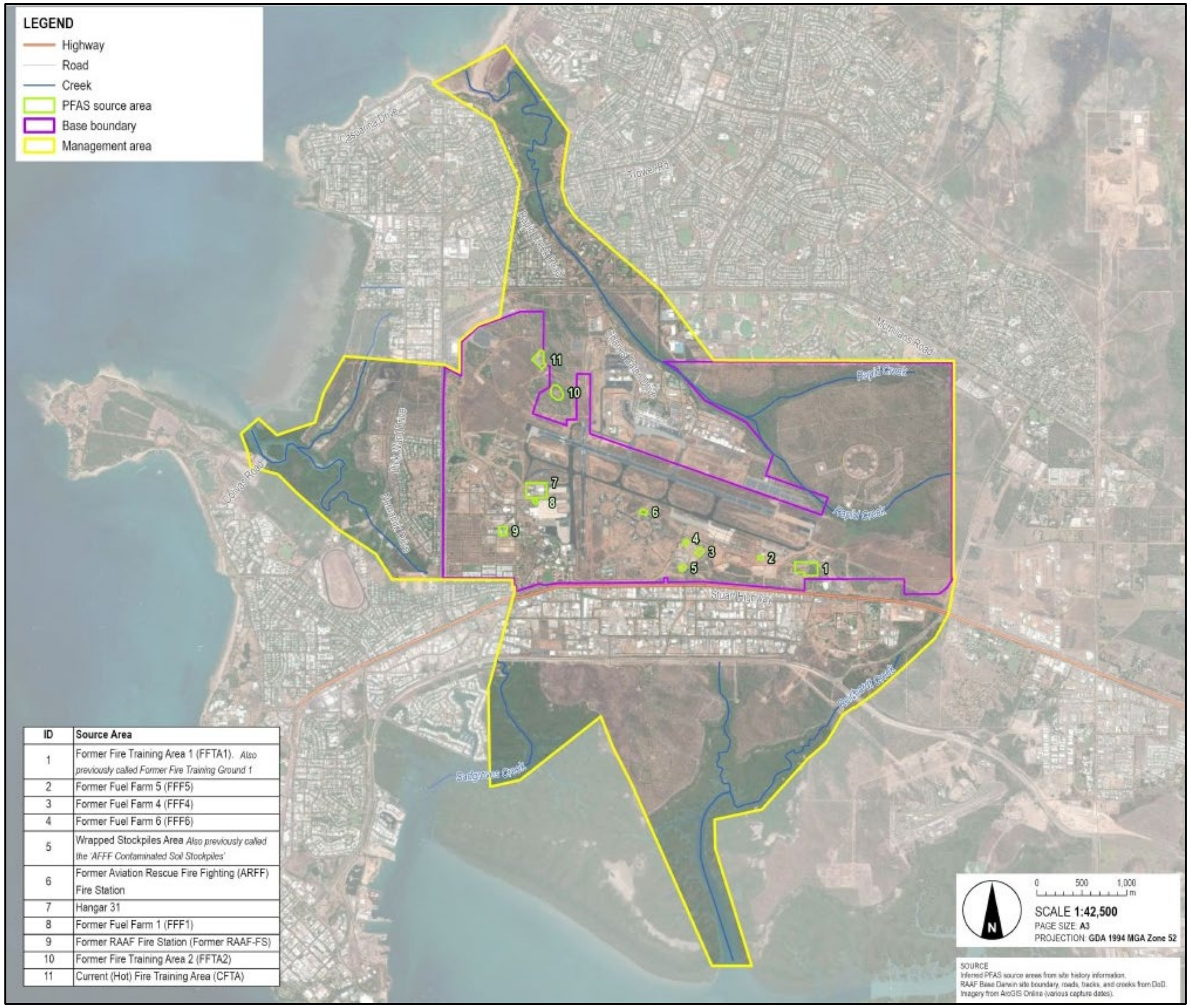

Figure 1. PFAS Management Area and PFAS source areas

Table 2-1. Management area setting

Aspect	Description
Regional meteorology	Darwin has a tropical climate with distinct monsoonal wet and dry seasons. Most of the rainfall occurs from November to April (wet season), although isolated rainfall events also occur at the beginning and end of the dry season. Evaporation is relatively constant with peaks during the wet season build-up. Maximum temperatures also occur during the wet season build-up, and minimum temperatures are reached in July. Average annual rainfall is 1,727 mm (BoM Aug 2024, Station 014015).
Topography	RAAF Base Darwin is relatively flat, compared to surrounding land which is gently undulating in nature. It is gently sloping at a height of 10 to 33 m Australian height datum (AHD) across a distance of several kilometres and slopes down along the northern and western boundaries. A topographic high runs approximately in line with the main runway and then to the north, parallel to Rapid Creek.
Geology and hydrogeology	The geology underlying the base comprises the following: • Unconsolidated sands, clayey sands and ferruginous clayey sands and soil. This layer is often described as lateritic or ferricrete and may appear to be gravels. This layer thickness is generally one to two metres thick but can range up to 10 m thick. • Bathurst Island Formation consisting of siltstone, claystone, sandy claystone, clayey sandstone, quartz sandstone, ferruginous sandstone, glauconitic sandstone and conglomerates towards the base of the unit. The unit ranges between 17 and 27 m thick on the base. • Burrell Creek Formation consisting of siltstone, shale, sandstone, and quartz pebble conglomerate. The top of this unit was generally encountered at depths of 35 m below ground level (mbgl). There are two aquifer systems underlying and in the vicinity of the base: • The unconfined water table aquifer consists of both the upper lateritic sediments and the Bathurst Formation. The two lithologies act as a single aquifer, and no significant confining layer is present. Groundwater levels in the upper aquifer may rise to ground level during the wet season due to recharge from surface water infiltration. In the wet season, groundwater is likely to flow through both units, however once groundwater levels drop in the dry season, groundwater flow is predominantly in the Bathurst Formation (siltstone). • The Burrell Creek Formation aquifer underlies the Bathurst Formation aquifer, and is a confined aquifer comprising siltstone, shale, and sandstone and quartz pebble conglomerate. Standing water levels in the upper unconfined aquifer are subject to significant seasonal variation and change by more than 10 m between wet and dry seasons on the northern and western portions of the base, and by approximately 5 m in the southern portion of the base. The groundwater flow direction in the upper unconfined aquifer follows surface topography with groundwater flowing: • to the north (towards Rapid Creek) from the southern side of the main runway • to the south (towards Sadgroves and Reichardt Creeks) south of the base boundary, and • to the west and southwest (towards Ludmilla Creek) south-west of the base boundary.

Aspect	Description	
Surface water drainage	The base is drained by large open unlined drains, municipal drains and underground piping that discharge surface waters into: • Rapid Creek on the north and east sides of the base via Marrara Swamp. Rapid Creek is a freshwater stream that is fed by groundwater during the dry season and flows to the northwest prior to discharging to Beagle Gulf. The lower portion of Rapid Creek becomes estuarine prior to discharging to the marine environment at the mouth. • Sadgroves Creek on the south. Sadgroves Creek is an estuarine creek and tidally influenced. • Ludmilla Creek on the west. Ludmilla Creek is mixture of freshwater, estuarine and marine and flows to the west prior to discharging to Beagle Gulf. • A small central portion of the base on the southern boundary discharges to Reichardt Creek. The base drainage details are presented in the Supplementary DSI (Coffey, 2018c).	
Current and projected land uses (off-base)	North	The area directly north of the base is occupied by DIA, with the Marrara Swamp and native vegetation corridor surrounding Rapid Creek located further to the north of DIA. The suburbs of Marrara, Malak, Jingili and Millner are located to the north of the base.
	East	The areas to the east of the base are occupied by a mixture of nurseries, small farms, residential areas and industrial/commercial zones.
	South	The land to the south of the base is occupied by the Industrial suburb of Winnellie, and the Darwin Showgrounds. The residential suburb of The Narrows is directly to the southeast.
	West	The land to the west of the base is occupied by the residential communities of Bagot and Ludmilla, with the industrial portion of Coconut Grove located to the northwest of the base.

3 EXTENT OF PFAS CONTAMINATION

This section provides an outline of the PFAS sources, transport pathways for migration of PFAS from a source area, and potential receptors such as humans and ecosystems that may be exposed to PFAS from the base. This information is described as a Conceptual Site Model (CSM).

In preparation of this OMP, the CSM for RAAF Base Darwin and surrounding areas was reviewed for currency and updated. The CSM was updated to reflect changes in extent of PFAS contamination (Table 3-2, Section 3.1) and PFAS transport pathways (Table 3-3, Section 3.2) following the completion of remediation at the Former Fire Training Area 1 (FFTA1) and Wrapped Stockpiles Area in 2023 (Tetra Tech Coffey, 2024b).

For more detailed information informing the CSM, refer to the reports listed in Appendix A.

The composition of PFAS on RAAF Base Darwin is approximately 91% (w/w) of sum of PFOS+PFHxS, with the remaining 9% composed of a variable mixture of PFOA, PFHxA, PFBS, PFOSA, and minor other PFAS compounds. For the purposes of this OMP, where reference to PFAS is made, this refers to the sum of PFOS+PFHxS, unless otherwise stated.

3.1 Source areas

PFAS source areas can be primary or secondary. Primary sources are generally areas of residual PFAS contamination where aqueous film forming foam (AFFF) was used or stored, for example, a fire training area. Secondary source areas contain an accumulation of PFAS contamination in the environment, such as in soil, sediment, groundwater or surface water, which has migrated from a primary source area.

PFAS source areas identified through previous investigations are provided in Table 3-1 below. A map presenting these source areas is provided as Figure 1 in Section 2.2. Identified secondary sources of PFAS are outlined in Table 3-2.

Table 3-1. Known source areas of PFAS

ID	Source area	Extent of PFAS contamination
1	Former Fire Training Area 1 (FFTA1) (CSR_NT_000039)	This PFAS source area (approximately 5,000 m2) comprised a former fire training area where AFFF containing PFAS was sprayed onto fires and the ground during training activities between circa 1970s to 1990s. PFAS in this area was remediated in 2023 with PFAS impacted soils excavated and either removed from the site for thermal destruction or treated to reduce the mobility of PFAS and reinstated in the area beneath a clay cap. Approximately 16 kg of PFAS was remediated and approximately 5 kg of PFAS remains within soils at low concentrations around the perimeter of the remediation area. PFAS is present in shallow, perched groundwater during the wet season, and groundwater within the deeper siltstone aquifer throughout the year. Concentrations of PFAS in surface water at this source area range between 0.12 to 46.7 µg/L.

ID	Source area	Extent of PFAS contamination
2	Former Fuel Farm 5 (FFF5) (CSR_NT_000043)	This source area was a former fuel farm where PFAS containing AFFF was used in a fire suppression system installed in the above-ground fuel tank storage area. It is estimated that less than 1 kg[1] of PFAS is present in soils. Concentrations of PFAS in groundwater at this source area range between 1.7 to 76 µg/L. Concentrations of PFAS in surface water at this source area range between <0.01 to 0.68 µg/L.
3	Former Fuel Farm 4 (FFF4) (CSR_NT_000044)	This source area was formerly an active fuel farm where AFFF containing PFAS was used in a fire suppression system installed in the above-ground fuel tank storage area. The fuel farm infrastructure has since been decommissioned. Approximately 4.9 kg of PFAS is present in soils, primarily in the southern part of the source area. Concentrations of PFAS in groundwater in this source area range between 20 to 130 µg/L. Concentrations of PFAS in surface water at this source area range between 0.11 to 0.23 µg/L.
4	Former Fuel Farm 6 (FFF6) (CSR_NT_000045)	This source area was formerly an active fuel farm where AFFF containing PFAS was used in a fire suppression system installed in the above-ground fuel tank storage area. The fuel farm infrastructure has since been decommissioned. Approximately 1.8 kg of PFAS is present in soils, primarily in the northern part of the source area. Concentrations of PFAS in groundwater in this source area range between 1 to 108 µg/L. Concentrations of PFAS in surface water at this source area range between 0.26 to 3.6 µg/L.
5	Wrapped Stockpiles Area (CSR_NT_000047)	This source area (approximately 2,500 m^2) was remediated in 2023, with PFAS-contaminated soil stockpiles wrapped in plastic were removed from the area. The soils were treated to immobilise PFAS and reinstated into the FFTA1 remediation work area beneath the capping. Residual PFAS concentrations ranged up to 0.3 mg/kg in soils in a few isolated locations in the footprint of the area. No surface water has been observed to be present in this area during previous investigations.
6	Former Aviation Rescue and Fire Fighting (ARFF) Station (CSR_NT_000040)	This source area (approximately 15,000 m^2) was the former ARFF Station where PFAS containing AFFF was tested and drained from firefighting equipment onto the ground. Soil concentrations range up to 18 mg/kg and the mass of PFAS in this source area is estimated to be greater than 25 kg. Concentrations of PFAS in groundwater in this source area range up to 345 µg/L. Concentrations of PFAS in surface water at this source area range between 0.18 to 0.19 µg/L.

ID	Source area	Extent of PFAS contamination
7 & 8	Hangar 31 and Former Fuel Farm 1 (FFF1) (CSR_NT_000203 & CSR_NT_000205)	The Hangar 31 source area (approximately 15,000 m^2) comprises a large aircraft maintenance hangar that formerly contained an AFFF fire suppression system. Several foam deluge events were recorded for the hangar, with PFAS containing foams reportedly discharging from the hangar onto the soils surrounding the apron to the north and south. Shallow PFAS-impacted soils were removed in 2008 and stored at the Wrapped Stockpiles Area ahead of remediation completion in 2023. The FFF1 source area (approximately 3,500 m^2) was a former fuel farm where PFAS containing AFFF was used in a fire suppression system installed in the above-ground fuel tank storage area. Residual PFAS soil concentrations range up to 0.8 mg/kg, with an estimated 1 kg[1] of PFAS remaining in soils in this source area and concentrations in groundwater ranging up to 43 µg/L. Concentrations of PFAS in surface water at these source areas range between 0.03 to 1.65 µg/L.
9	Former RAAF Fire Station (RAAF FS) (CSR_NT_000255)	This source area was a former fire station and operated up to the 1990s. AFFF containing PFAS was tested and discharged from fire training equipment onto the ground. PFAS concentrations range up to 18 mg/kg with approximately 2.5 kg[1] present in soil. PFAS in groundwater range between 0.5 and 48 µg/L. Surface water PFAS concentrations in underground stormwater drains at the source area range between 0.02 µg/L to 10.3 µg/L. The wide range in concentrations is related to monsoonal stormwater flow conditions (0.02 to 0.04 µg/L) where the PFAS in the pipes is being diluted by upstream stormwater, and baseflow conditions (5.4 to 10.3 µg/L) which is from PFAS impacted groundwater infiltrating into the pipes.
10	Former Fire Training Area 2 (FFTA2) (CSR_NT_000091)	This source area (approximately 7,000 m^2) was used for fire training where props and off-specification fuels were burned and extinguished using AFFF containing PFAS. This area operated from the 1970s up until the 1990s. FFTA2 is located within DIA-occupied Commonwealth land, however Defence have committed to assessment and management of PFAS impacts in this source area. Concentrations of PFAS in soils range up to 30.6 mg/kg, with an estimated mass of 19.7 kg[1] in soils. Concentrations of PFAS in groundwater range between 0.07 to 0.08 µg/L. Surface water in this area is rarely observed with concentrations ranging between <0.01 to 0.08 µg/L.
11	Current (Hot) Fire Training Area (CFTA) (CSR_NT_000038)	This source area (approximately 4,500 m^2) was used for fire training activities from the late 1990s up until 2022. AFFF containing PFAS was phased out from approximately 2010. AFFF was historically sprayed onto a large mock up (LMU) airplane on a concrete pad and also tested on the ground around the pad during firefighting training exercises. Drainage from the training pad collected in underground storage tanks or discharged directly to ground adjacent. The LMU was removed from the area in 2023. Concentrations of PFAS in soils range up to 10 mg/kg, with an estimated 10.4 kg of PFAS in soils in the source area. Concentrations of PFAS in groundwater range between 7 to 15 µg/L. Concentrations of PFAS in surface water at this source area range between 0.001 to 1.18 µg/L.

Notes: 1 – The estimates of PFAS mass in several source areas is based on limited data points and there is some uncertainty in the estimates of mass in these areas.

Table 3-2. Secondary source areas of PFAS

Secondary source area	Extent of PFAS contamination
Open drains on-base, Rapid Creek and Ludmilla Creek	The sediments and water within on-base drains and creeks are secondary sources of PFAS and are the main surface water pathways where PFAS-impacted surface water leaves the base. Most on-base drains are ephemeral and only flow following heavy rainfall, noting that as groundwater levels rise during the wet season, groundwater may intersect and discharge into the drains towards the end of the wet season. The sediments within on-base drainage network is a potential secondary source of PFAS impacts. However, annual cleaning of the drains is undertaken, and the sediments removed from the drainage lines (and disposed off-base) to the extent practicable each year. Sediment sampling from on-base drains reported low concentrations of PFAS ranging from <0.005 mg/kg to 0.28 mg/kg adjacent to the CFTA. Rapid Creek and Ludmilla Creek are the main surface water receptors that receive PFAS impacts from groundwater and surface water discharge from the base. The flux of PFAS within the creeks' is partially tied to the volume of water that flows down the creeks, with between 10 to 27 kg of PFAS discharging to Rapid Creek (10-14 kg in a 'dry' wet season, and up to 27 kg in a 'wet' wet season), and between 6 to 7 kg of PFAS discharging to Ludmilla Creek each year. Concentrations of PFAS in sediments in the creeks and tributaries range from <0.005 to 0.39 mg/kg in Rapid Creek, and <0.005 to 0.12 mg/kg in Ludmilla Creek, with most samples reporting concentrations below the laboratory reporting limits.

3.2 Transport pathways

PFAS can travel from a source to human or environmental receptors via transport pathways, such as surface water, groundwater and stormwater. The transport pathways identified at, and surrounding the base are summarised in Table 3-3. The mass flux estimates provided have been sourced from the Supplementary DSI (2018c) and the Baseline Mass Flux Investigation (Tetra Tech Coffey, 2022),

Table 3-3. PFAS transport pathways

Source area	Transport mechanisms
FFTA1	PFAS moves in shallow perched groundwater within the shallower laterite soils during the wet season (and the deeper siltstone aquifer throughout the year) to the north and discharges to either shallow surface drainage channels approximately 250 m north of the area or into Rapid Creek approximately 750 m to the north. The flux of PFAS in groundwater prior to remediation was approximately 800 grams per year. The flux following remediation is expected to drop by 10% per year. PFAS migrates in surface water from the source area but is low and calculated to be less than 20 grams per year.

Source area	Transport mechanisms
FFF5	PFAS migrates in the siltstone groundwater aquifer to the north, with limited migration in the shallow perched laterite. The flux is estimated to be approximately 5 grams per year. PFAS migrates to the north towards Rapid Creek (approximately 900 m to the north).
FFF4	PFAS leaches from soils into the siltstone aquifer and moves to the north (and south in the late wet season) with approximately 450 grams per year leaving the source area. Most of the PFAS is inferred to flow to the north - eventually discharging to Rapid Creek 1,300 m to the north, except in the late wet season where groundwater flow directions reverses and PFAS migrates to the south across the base boundary and into the suburb of Winnellie. Limited PFAS migrates from the source area in surface water.
FFF6	PFAS leaches from soils into the siltstone aquifer and moves to the north (and south in the late wet season) with approximately 180 grams per year leaving the source area. Most of the PFAS is inferred to flow to the north – eventually discharging to Rapid Creek some 1,500 m to the north, except in the late wet season where groundwater flow directions reverses and PFAS migrates to the south across the base boundary and into the suburb of Winnellie. Limited PFAS migrates from the source area in surface water.
Former ARFF	PFAS leaches from the impacted soils in this area and migrates in groundwater towards Rapid Creek (approximately 1,350 m to the north). The PFAS migrates preferentially within a higher-permeability claystone that is discontinuous across the area at the top of the siltstone. During the late wet season, groundwater gradients can reverse, with some PFAS migrating south across the base boundary into the suburb of Winnellie. Limited PFAS migrates from the source area in surface water.
Hangar 31 and FFF1	PFAS migrates in deeper groundwater within the siltstone to the southwest from the source area, contributing to the down-gradient PFAS plume from the former RAAF FS prior to discharging across the western boundary. PFAS migrates in groundwater from this source area at a rate of approximately 50 grams per year. Leaching from the limited remaining PFAS in soils is not considered to be significant. Limited PFAS migrates from the source area in surface water.

Source area	Transport mechanisms
Former RAAF FS	PFAS leaches from soil impacts in this area and combines with the PFAS plume from the Hangar 31/FFF1 source areas in the siltstone aquifer in this area. The groundwater plume migrates west and south-west prior to discharging across the base's western boundary and into the suburb of Ludmilla and Bagot. A large below-ground stormwater pipe at the source area intercepts groundwater for part or all of the year and transports PFAS impacted water directly to Ludmilla Creek, approximately 900 m west of the area. The flux across the western base boundary in groundwater is calculated to be approximately 50 grams per year, however the flux in surface water along the below-ground stormwater drain is between 6 to 7 kg[1] per year. The groundwater PFAS plume in the vicinity and down-gradient of the source area has changed in the most recent ongoing monitoring report (OMR) (Tetra Tech Coffey, 2024c), with PFAS increasing in two monitoring wells on the western boundary. The increases in PFAS on the western boundary may be a short-lived effect from various unknown causes (such as increased rainfall infiltration, disturbance of PFAS impacted soils etc.), or an indication that the plume is expanding in this area.
FFTA2	PFAS leaches from soils in this area to shallow perched groundwater in the lateritic unit and deeper groundwater in the siltstone aquifer. The flux in shallow perched groundwater is estimated to be in the range of 2 to 15 grams per 90-day wet season, and approximately 7.5 grams per year in the deeper low-permeability siltstone[2]. The PFAS migrates in groundwater to the northeast and discharges to Rapid Creek, approximately 900 m down-gradient. Limited surface water occurs within the source area with most rainfall infiltrating into the soils rather than flowing from the source area as surface water. Due to the limited surface water present in this source area, no estimates of the flux of PFAS in surface water have been able to be calculated.
CFTA	PFAS leaches from soils in this area to shallow perched groundwater in the laterite and deeper groundwater in the siltstone aquifer. The flux in the low-permeability siltstone is approximately 20 grams per year and migrates to the north prior to discharging to Rapid Creek (approximately 950 m to the northeast). The flux in the shallow lateritic perched groundwater is calculated to be approximately 25 grams per 90-day wet season, with migration only occurring when the water table rises into the laterite. The perched groundwater flows to the north-east towards Rapid Creek and is inferred to discharge to the surface and contribute to the surface water flux approximately 450 m to the northeast of the source area. PFAS migrates in surface water from this source area at a rate of approximately 45 grams per year, mainly in the wet season. The surface water flows along open drains to the north, but rapidly infiltrates into soils and contributes to the shallow perched groundwater. No surface water drains in this area connect to Rapid Creek or other surface water drains.

Notes:
1 – There is some uncertainty and variability in the flux in stormwater from this source area due to the variability in where the PFAS impacted groundwater is entering the drain, and dilution effects due to rainfall induced stormwater from non-impacted areas up-stream and down-stream of the source area.
2 – Due to limited deep and shallow groundwater transects down-gradient of the FFTA2 source area, there are significant uncertainties in the mass-flux estimates from this source.

3.3 Receptors and risks

The receptors that may be exposed to potentially unacceptable concentrations of PFAS originating from the base, and the associated risks for those complete, or potentially complete exposure pathways are documented in the:

- Human Health Risk Assessment (HHRA – Coffey, 2018b), and
- Ecological Risk Assessment (ERA – Coffey, 2018d).

A summary of the receptors with an elevated risk from intake of PFAS at or originating at the base are listed in Table 3-4. Elevated human health and ecological exposure risks have been identified, based on conditions described in the DSI (Coffey, 2018a) and Supplementary DSI (Coffey, 2018c) reports and risks quantified in the HHRA (Coffey, 2018b) and ERA (Coffey, 2018d) reports. “Elevated” is defined as events that would lead to human exposure over the tolerable daily intake (TDI), ecological exposure over the screening benchmarks or no observed adverse effect level (NOAEL). A complete list of receptors considered are detailed in the HHRA and ERA.

Table 3-4. Receptors with potential elevated intake

Human health receptors	Ecological receptors
Consumers of eggs from domestic poultry watered with PFAS-impacted bore water in the suburb of Ludmilla.	Aquatic invertebrates, amphibians and fish in impacted waters of Rapid Creek and Ludmilla Creek.
Consumers of aquatic biota from Rapid Creek or the upper reach of Ludmilla Creek.	Plants and animals in direct contact with soils in source areas.
On-base construction or maintenance workers in direct contact with heavily impacted groundwater or effluent in source areas.	Birds and mammals that eat fish from Rapid Creek.
	Birds and mammals that eat plants, invertebrates and reptiles from source areas.

Table 3-5 provides a summary of identified risks which have been considered based on individual source areas or areas of environmental concern (as identified within the DSI, the HHRA and ERA). The details of how the risks were determined, i.e. what constitutes likelihood and consequence descriptors including a full list of risks identified in the DSI, Supplementary DSI, HHRA and ERA is included in Appendix D of the PMAP. To provide an indication of what each consequence category is based on, health and ecological risks are interpreted in isolation and the highest ranked risk is adopted. The elevated risks are described in the table for each source area and if the identified risk is a Human Health (HH) risk or an Ecological Exposure (Eco) risk as denoted by a ✓.

The risk assessment has not been revised since the completion of remediation works at FFTA1 and the Wrapped Stockpile Area. This will be reviewed following 12 months of remediation verification sampling .

Table 3-5. Risk assessment summary

Identified Risk	Risk ID	Source Areas	HH	Eco	Likelihood	Consequence	Risk
Soils							
Movement of soil to more sensitive areas may present an exposure risk to water ways or human health	A1, C1, H1	FFTA1, FFF4, FFF6, CFTA	✓	✓	Possible	Moderate	Medium
Direct contact with soil represents elevated exposure to terrestrial flora and fauna	A5, H8	FFTA1, CFTA		✓	Current	Moderate	High
Groundwater							
Migration of PFAS in groundwater represents a source of impact to Rapid Creek, resulting in human health exposure through consumption of fish, and ecological exposure to terrestrial and aquatic ecosystems	A2, C3, D3	FFTA1, FFF4, FFF6, ARFF	✓	✓	Current	Moderate	High
Migration of PFAS in groundwater represents a source of impact to Rapid Creek, resulting in human health exposure through consumption of fish and ecological exposure to terrestrial and aquatic ecosystems	B2, H5	FFF5, CFTA	✓	✓	Current	Minor	Medium
Migration of PFAS in groundwater water represents a source of impact to Ludmilla Creek (either via direct discharge or infiltration into stormwater drains that discharge to the creek), resulting in human health exposure through swimming or consumption of fish	F2, G4, G2	Hangar 31, FFF1, RAAF FS	✓		Current	Minor	Medium
Migration of PFAS in groundwater represents a source of impact to Ludmilla Creek (either via direct discharge or infiltration into stormwater drains that discharge to the creek), resulting in ecological exposure to terrestrial and aquatic ecosystems	F3, G5, G3	Hangar 31, FFF1, RAAF FS		✓	Current	Moderate	High
Surface Water / Effluent							
Surface water run off represents a source of impact to Rapid Creek, resulting in human health exposure through consumption of fish	H2	CFTA	✓		Current	Minor	Medium

Identified Risk	Risk ID	Source Areas	HH	Eco	Likelihood	Consequence	Risk
Surface water run off represents a source of impact to Rapid Creek, resulting in ecological exposure to terrestrial and aquatic ecosystems	H3	CFTA		✓	Current	Minor	Medium
Regular contact with effluent in tanks may represent significant human exposure	H7	CFTA	✓		Current	Moderate	High

Defence’s approach to managing potential risks to off-base receptors is based on reducing the flux of PFAS migrating from the base. The flux of PFAS migrating from the base and individual source areas has been calculated and refined in previous studies including the Supplementary DSI (Coffey, 2018c) and the Baseline Mass Flux Study (Tetra Tech Coffey, 2022).

4 ONGOING MONITORING PLAN

This section sets out the data quality objectives, monitoring scope and assessment requirements. Changes made to the 2019 OMP are summarised in the following sections, and supporting rationale is provided in Appendix D.

4.1 Sampling, analysis and quality plan

A sampling and analysis quality plan (SAQP) will be developed prior to implementation of the OMP. The SAQP provides information on data quality assurance procedures and measures including data quality indicators (DQI), sampling methodologies and analytical methods. The SAQP will be updated as required.

4.2 Data quality objectives

The Data Quality Objective (DQO) process is an iterative planning approach used to define the type, quantity and quality of data that is needed to inform decisions relating to the environmental condition of a site. The seven-step DQO process:

- clarifies the study objective
- defines the most appropriate collection of data as relevant to the study objective
- determines the conditions from which to collect data, and
- specifies tolerable limits on decision errors, which will be used as the basis for establishing the quantity and quality of data, needed to support the decision.

The DQOs for monitoring are presented in Table 4-1. They have been prepared in line with the DQO process outlined in the ASC NEPM (Schedule B2).

Table 4-1. Data quality objectives

Process	Description
Step 1: State the problem	Confirmed PFAS contamination sources have been identified at the base that have led to the contamination of soil, groundwater and surface water, with PFAS measured within biota associated with surrounding surface water bodies. Advice has been provided to Northern Territory (NT) agencies regarding the consumption of biota in some water bodies surrounding the base, as well as various advice regarding management of maintenance activities on the base. It is important to that the concentrations of PFAS within the environment are monitored to ensure that health advice provided to the NT agencies is relevant, appropriate and ensures that risks to human health and environmental receptors are managed. Remediation of PFAS sources at the base is underway, which will result in a reduction of PFAS mass flux off the base.

Process	Description
Step 2: Identify the decision/goal of the study	The purpose of the OMP is to ensure that the concentrations of PFAS within groundwater, surface water and biota are monitored and compared against baseline conditions and to assess potential changes in risks to sensitive receptors (human and ecological receptors). This information will then assist Defence with managing and/or controlling exposure to contamination on-base, and allow NT government agencies to be provided with advice regarding managing and/or controlling exposure to off-base contamination. The secondary purpose is to monitor changes in the flux of PFAS moving off the base to inform whether remedial actions have been completed SFARP or whether alternative actions are required to achieve the objectives of the PMAP.
Step 3: Identify the information inputs	• Existing data relevant to PFAS in soil, waters and biota • Surface water and groundwater flow regimes • Location and types of human and environmental receptors
Step 4: Define the boundaries of the study	Based on the understood extent of contaminated surface water or shallow groundwater at the base the study area includes land and waterways on the base and in each direction towards, and including, the receiving water bodies. The Management Area is shown in Figure 1, Appendix B.
Step 5: Develop the analytical approach/decision rules	Primary environmental samples are to be collected and analysed for the 28 PFAS compounds included in Appendix E. PFOS, PFHxS and PFOA concentrations will be compared against screening levels relevant to the potential beneficial uses/environmental values of water to identify changes to risk profile. The relative concentrations of all (analysed) PFAS compounds over time in groundwater, surface water and aquatic biota samples will be used to assess changes in the extent or magnitude of contamination and any changes in risk to receptors.
Step 6: Specify performance or acceptance criteria	The ongoing monitoring program as a whole must reliably characterise the changes in PFAS contamination (including changes in flux) within surface water, groundwater and biota compared with the baseline conditions and describe the risk that the contamination poses to human or ecological receptors. Analytical data quality indicators to achieve these acceptance criteria are to be developed in the SAQP for each sampling event.
Step 7: Develop the plan for obtaining data	The methodology and rationale for obtaining relevant data for the OMP is described below.

4.3 Proposed monitoring intervals

Ongoing monitoring intervals for groundwater, surface water and biota monitoring is summarised in Table 4-2, and detailed in Section 4.4.

Table 4-2. Monitoring frequency

Matrix	Monitoring frequency	Approximate monitoring period
Groundwater	Twice yearly	End-wet season (March), end-dry season (October – December)
Shallow / perched groundwater and porewater[1]	Twice in wet season	January and March
Surface water – off-base	Twice yearly	End-wet season (March), start-wet season (nominally early December)
Surface water – on-base	Twice in wet season	Start-wet season (nominally early December), end-wet season (March)
Surface water – on- and off-base	Monthly through wet season (Dec-Apr) and twice in dry season	Selected on- and off-base surface water sampling locations to be monitored monthly during the wet season (December – April), with Rapid Creek and Ludmilla Creeks to be sampled twice during the dry season (June and August)
Aquatic biota	Annually	End-dry season or start-wet season (October – December)

Note: 1. Porewater refers to water collected from lysimeters.

The original 2019 OMP recommended sampling of groundwater and surface water twice yearly, and biota once annually at the frequencies in the above table. These sampling frequencies allowed variations between wet and dry seasons to be monitored to allow comparison of results against screening criteria and evaluation of changes in risks to be monitored.

However, further studies (Baseline Mass Flux Study, Tetra Tech Coffey, 2022) recommended additional sampling frequencies of key on- and off-base streams or drains to provide more data points across the wet and dry seasons to refine the ongoing calculation of the changes in mass flux in these water bodies.

4.4 Monitoring locations

The proposed monitoring locations are separated into groundwater, surface water and biota, with pore water included in the groundwater monitoring tables. The sampling locations have been grouped broadly by key PFAS monitoring areas for the base. Where relevant, the key monitoring areas have been further separated by source area.

4.4.1 Remediation area – FFTA1

Remediation area monitoring assesses the changes in PFAS behaviour and provides data to support assess if SFARP has been achieved. Two groundwater transects have been included comprising an inner transect (approximately 50 m down gradient) and outer transect (approximately 200 m down gradient), to allow the mass flux from the source area to be calculated in the next OMR.

Table 4-3. Remediation area monitoring plan

Sampling Media	Sampling Locations	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater	MW500, MW501, MW502	Twice annually	MW500 and MW501 to be sampled in the middle of the water column. MW502 to be sampled in middle of water column at end-of dry season sampling, and at two depths - 1 m below standing water level (SWL) and bottom third of water column during end of wet season sampling.	These wells monitor the groundwater conditions and PFAS concentrations beneath the remediated FFTA1 source area. Well MW502 is installed through the treated soils and groundwater rises into the treated soils at the end of the wet season. Concentrations in the shallow water are two orders of magnitude lower than in the siltstone, and a second deeper sample is to be collected from the siltstone during the end of wet season. These wells replace MW422 and MW235 that were historically present at the site and have since been destroyed during construction works. It is noted that only MW422 was monitored in the previous OMP.
Porewater	SL019, SL020	Twice per wet season		These two lysimeters in the remediated source area monitor shallow PFAS leaching from the treated soils and potential lateral migration of PFAS at the periphery of the remediation area and monitor whether PFAS is leaching from the soils.
Groundwater / perched groundwater	MW462, MW463, MW464, MW465, MW466, MW467	Twice per wet season	Sampling to be 1 m below SWL.	These wells form the inner flux transect down-gradient of FFTA1 and are in pairs of shallow and deep wells targeting perched groundwater in the shallow laterite and groundwater in deeper siltstone. These wells monitor the flux of PFAS from FFTA1.
Groundwater	MW454, MW344, MW455, MW135	Twice per wet season	Sampling to be 1 m below SWL.	These wells form the outer transect down-gradient of FFTA1 and monitor the flux of PFAS migrating from FFTA1.
Perched groundwater	MW456, MW457, MW458, MW459	Twice per wet season	Sampling to be near bottom of wells. Groundwater level loggers to be installed at start of wet season to monitor hydraulic gradient changes.	These wells monitoring PFAS mass-flux in perched groundwater in the outer transect down-gradient from FFTA1 to assess the effects of FFTA1 remediation on PFAS migration at this source area.
Surface water	SW312, SW170, SW152	Twice per wet season	Measure depth, flow velocity and width of surface water flow.	These locations monitor the surface water as it migrates down-stream from FFTA1. The data will be used to monitor remediation success.

4.4.2 Runway source areas

The source areas in this area include FFF4, FFF5, FFF6 and the former ARFF. The collection of groundwater and surface water data at these source areas will be used to monitor changes in PFAS in groundwater and changes in flux following remediation.

Table 4-4. Runway source areas monitoring plan

Sampling Media	Sampling Location	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater (FFF5)	MW297	Twice per wet season	1 m below SWL.	To monitor changes in PFAS concentrations from FFF5.
Groundwater (FFF4 & FFF6)	MW133, MW303	Twice per wet season	1 m below SWL.	To monitor changes in PFAS in the source areas and establish a transect between the source areas and Rapid Creek to monitor changes in flux.
Groundwater (ARFF)	MW115	Twice per wet season	1 m below SWL.	To monitor changes in PFAS in the source area.
Groundwater (Transect)	MW112, MW205, MW206, MW517	Twice per wet season	1 m below SWL.	To establish a transect between the source areas and Rapid Creek to monitor changes in flux.
Surface water	SW181 and SW178	Twice per wet season	Measure depth, flow velocity and width of surface water flow.	These locations confirm surface water concentrations migrating from the runway source areas.

4.4.3 Southern boundary and off-base to south

This area includes the wells along the southern boundary which assess the flux off-base to the south, as well as monitoring changes in the plume in the off-base suburb of Winnellie, and any changes in surface water quality in Sadgroves and Reichardt Creeks.

Table 4-5. Southern boundary and off-base to the south monitoring plan

Sampling Media	Sampling Location	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater – boundary transect	MW139, MW141, MW144 and MW506	Twice per wet season	1 m below SWL.	These wells are used to calculate the mass flux across the southern base boundary. The new well (to be installed) will refine the flux calculations in the area of high-permeability gravels.
Groundwater – off-base	MW176, MW180, MW200, MW211	Twice per wet season	1 m below SWL.	These wells monitor the changes in the off-base PFAS plume.
Surface water	SW143, SW133, SW132, SW162	Twice per wet season		These surface water locations monitor the concentrations of surface water leaving the base (SW162) and discharging into Sadgroves and Reichardt Creeks.

4.4.4 Western catchment

This area includes the Hangar 31/FFF1 source area, the former RAAF FS source area, the western boundary monitoring and the off-base plume in the suburb of Ludmilla and The Narrows.

Table 4-6. Western catchment monitoring plan

Sampling Media	Sampling Location	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater	MW405, MW215, MW107, MW108, MW103, MW126, MW128, MW201, MW452, MW148, MW451, MW146, MW147, MW118 MW209, MW210	Twice annually	1 m below SWL.	These wells monitor changes in PFAS concentrations in the source areas (MW405, MW215, MW103) and allow calculation of PFAS flux down gradient from Hangar 31/FFF1 (MW108 and MW107), RAAF FS (MW126), and the western boundary (MW146, MW148, MW147, MW452). Several wells also monitor the down-gradient plume conditions and/or act as off-base sentinel wells (MW128, MW118, MW209, MW210).
Surface water	SW160, SW278, SW310, SW125, SW120	Twice per wet season. SW125 also to be monitored monthly over the wet season and twice in the dry season (June and Aug).		SW160, SW278 and SW310 monitor PFAS migrating also the drains under Bukatilla Road near the RAAF FS source area. The increased sampling frequency for SW125 allows more accurate calculation of the flux discharging into Ludmilla Creek across the year.
Biota sampling	BIO016, BIO018	Once annually at start of wet season.	Target species to include Longbums at BIO016, and Finfish at BIO018.	The concentration data from the Biota sampling will be used to monitor potential risks to receptors and inform health advisories. BIO017 may be added depending on abundance of proposed target species.

4.4.5 Northern fire training areas

This area includes the CFTA and the FFTA2 source areas and monitoring will be undertaken to monitor the outcome of PFAS remediation at the CFTA, and flux from the source areas.

Table 4-7. Northern fire training areas monitoring plan

Sampling Media	Sampling Location	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater	MW503 (replacement for MW241), MW504, MW453, MW240, MW197	Twice annually	1 m below SWL. Wells MW197, MW240 and MW453 are generally dry at the end of the dry season sampling and are to be gauged, and if water present, opportunistically sampled during the event.	These wells monitor changes in PFAS concentrations in the source areas, and down-gradient in shallow groundwater.
Perched groundwater	MW476, MW477, MW478, MW479	Twice per wet season	At bottom of well. Data logger to be installed to monitor changes in gradient at MW477.	These wells form a transect for shallow PFAS migrating in perched groundwater and will be used to monitor changes following remediation.
Surface water	SW156, SW300	Twice per wet season	Opportunistic sampling of SW156 due to often limited surface water presence.	SW156 monitors (opportunistically) the concentrations of PFAS leaving the source area in surface water, prior to infiltrating to shallow groundwater and provides data as the exposed PFAS at the surface of the source area and how it is migrating. SW300 monitors surface water down-slope from the source areas and provides data on the contribution to Rapid Creek.

4.4.6 Rapid Creek

This area includes Rapid Creek and groundwater wells close to the creek. Monitoring of groundwater, surface water and biota informs the changes in risks to human health and the overall flux of PFAS leaving the base.

Table 4-8. Rapid Creek monitoring plan

Sampling Media	Sampling Location	Sampling Frequency	Sampling Depth/Details	Rationale
Groundwater	MW156, MW194, MW195, MW518, MW191, MW185	Twice per year	1 m below SWL.	These wells monitor changes in PFAS concentrations immediately prior to groundwater discharging to Rapid Creek, and for a flux transect line for monitoring changes in flux discharge.
Surface water (Rapid Creek)	SW118, SW197, SW104, SW108, SW109, SW112, SW113	Twice per wet season. SW109 to be monitored monthly over the wet season, and twice in the dry (June & Aug)	Measure depth, flow velocity and width of surface water flow.	These locations monitor changes in PFAS along Rapid Creek and inform the risk assessments and PFAS flux calculations. The increased sampling at SW109 allows refinement of the PFAS flux in the Creek across the year.
Surface water (DIA drains)	SW114, SW115, SW168	Twice per wet season	Measure depth, flow velocity and width of surface water flow.	These drains monitor PFAS contributions to Rapid Creek from DIA land and inform the assessment of other potential sources of PFAS contributing to the flux in Rapid Creek.
Biota sampling	BIO024, BIO026, BIO028, BIO007	Once per year at start of wet season	Target species to include: BIO024, BIO026 and BIO028 – at least one sample of Redclaw (up to three), with other Finfish species targeted BIO007 – five Finfish samples	The concentration data from the Biota sampling will be used to monitor potential risks to receptors and inform health advisories. Depending on the availability of target species, additional freshwater locations (BIO019 and BIO020) may be added to allow collection of sufficient samples.

The locations of all sampling points are Shown on Figures 2 to 4 in Appendix B and in the Tables in Appendix C. Off-base monitoring locations will require the agreement of the landholder/leaseholder, refer to Section 8.

4.4.7 Biota sampling

In addition to collection of groundwater and surface water samples, aquatic biota (fish, molluscs and crustacea) sampling is recommended to supplement existing concentration data and support any future reviews of human exposure risk.

The biota sampling should be undertaken on an annual frequency at the end of the dry season or start of the wet season, when concentrations of PFAS in surface water are expected to be highest.

All biota sampling works should be incorporated into the SAQP, and appropriate ethics and fisheries licences should be obtained prior to sample collection. The SAQP should include specific details regarding sampling locations, sample collection methods, target species and sample preparation methods. This should be relatively consistent with previous works undertaken, including the following:

- Sample collection methodologies should be selected based on the most suitable method for the location and target species. These methods may include the following:
  - Angling with a fishing rod, reel and braid fishing line
  - Gill nets, and
  - Electrofishing.
- Target species will be based on those that are recognised as frequently consumed, and from the following three groups:
  - Diadromous or estuarine fish (Barramundi, Flathead, Javelin, Sweetlips, Mullet, Rockcod, Queenfish, Jewfish, etc.)
  - Molluscs (Longbums and Whelk), and
  - Crustaceans (Redclaw Crayfish).

The number of samples collected will vary based on what is caught. The sampling targets are outlined in Table 4-9.

Table 4-9. Biota sampling targets

Location	Target species	Target sample numbers
Rapid Creek – (Freshwater) upstream of Trower Road (BIO024, BIO026, BIO028 or new location)	Redclaw Crayfish *(C. quadricarinatus.)*	Minimum three of at least 100g
Ludmilla Creek (Estuarine area) – BIO016 or new location	Longbums *(Telescopium telescopium.)*	Five composite samples of 10 molluscs
Rapid Creek mouth (Casuarina Drive) – BIO007	Fish	Three samples of each of five species of commonly consumed fish species (15 total)
Ludmilla Creek Boat Ramp - BIO018	Fish	Three samples of each of five species of commonly consumed fish species (15 total)

As the target species for the freshwater portions of Rapid Creek are primarily Redclaw Crayfish, and that the numbers of specimens available can vary significantly from year to year, at least one sample of Redclaw is to be collected from the Rapid Creek Freshwater locations (BIO024, BIO026 and BIO028) as these are an important marker species as their larval form grows in sediments and doesn't leave the freshwater section. However, if the Redclaw species are low in numbers, alternative species may be able to be collected based on priority and abundance as detailed in Table 4-10.

Table 4-10. Recommended species to be included for Rapid Creek biota sampling

Priority based on abundance	Common name (scientific name)
A	Redclaw Crayfish (Cherax quadricarinatus)
B	Purplespotted Gudgeon (Mogurnda mogurnda)
B	Hyrtl's Catfish (Neosilurus hyrtlii)
C	Blackbanded Rainbowfish (Melanotaenia nigrans)
C	Western Rainbowfish (Melanotaenia australis)
C	Spangled Perch (Leiopotherapon unicolor)

Captured target fish should be euthanised in line with ethics approval, which may involve ice slurry, Aqui-S solution anaesthesia, clubbing, pithing and/or cervical dislocation.

For larger fish, complete tissue samples of edible fillet flesh should be collected. Whole gutted fish samples could be taken for smaller fish, if large fish are not able to be caught.

A clean polypropylene cover should be used over a chopping board, and new sterilised scalpel blades or washed stainless steel blades used for sample preparation.

4.5 Sample analysis

Samples will be analysed by a National Association of Testing Authorities (NATA)-accredited laboratory for a suite of PFAS as outlined in Appendix E, using NATA accredited methods.

Laboratory levels of reporting (LORs) must be selected to achieve the OMP objectives (Section 1.2) and the DQO's. The rationale for selecting LORs below the standard LOR must be provided.

Quality control and quality assurance measures will be outlined within the SAQP.

In addition to PFAS, field measurement of water quality parameters such as pH, electrical conductivity (EC), redox potential, dissolved oxygen (DO), temperature and total dissolved solids (TDS) will be undertaken on all surface and groundwater samples.

5 OTHER ASPECTS

A review of other aspects that may result in changes to the nature, extent, fate or transport of PFAS at the base and within the Management Area is to be undertaken prior to the commencement of each OMR. The purpose of this review is to update the CSM and assess any changes to receptors or risks that may be posed by changes within the Management Area, particularly associated with changes in land uses or water uses.

The area where the review is to be conducted is to incorporate the Management Area, and land within the catchments of Rapid Creek, Ludmilla Creek, Reichardt Creek and Sadgroves Creek. This review should, at a minimum, include a review of aspects outlined in Table 5-1, and any changes observed since the previous OMR.

Table 5-1. Other aspects for review for updated CSM

Review	Rationale	Location	Suggested source/s
Groundwater bore search	To identify whether any new groundwater bores, including for water supply or remediation, have been installed, and whether new receptors may be impacted as a result.	Off-base	Northern Territory, Department of Environment Parks and Water Security, Water Data Portal (https://ntg.aquaticinformatics.net/Data)
Land zoning	To identify where any changes in zoning may result in new sensitive receptors becoming exposed to PFAS.	Off-base	NT Atlas and Spatial Data Directory (https://www.ntlis.nt.gov.au/imfPublic/imf.jsp?site=nt_atlas)
Land-use	To identify where any new sensitive land uses may be occurring that may result in increased risks to receptors	Off-base	Aerial photograph review
	To identify any changes in receptors, or disturbance of PFAS that will require management or potential remediation.	On-base	Senior Australian Defence Force Officer (SADFO), base Manager (BM) base Infrastructure Advisor (BIA)
Proposed development and/or infrastructure use	To identify where any infrastructure or upgrades may alter PFAS surface water or groundwater behaviour, and whether this affects the CSM	Off-base	DIA, Department of Infrastructure, Transport, Regional Development, Communications and the Arts (DITRDCA), Northern Territory Government, City of Darwin
	To identify where upgrades to infrastructure may allow access to PFAS impacted soils or alter PFAS behaviour in surface water or groundwater that may be beneficially undertaken concurrent with other developments.	On-base	SADFO, BM and BIA

Review	Rationale	Location	Suggested source/s
Remediation works in progress or planned	To identify potential changes in PFAS behaviour off-base (including potential removal of off-base sources).	Off-base	DIA, Local government
	To identify any planned non-PFAS remediation works that may allow remediation of PFAS impacts or may result in changes to CSM.	On-base	SADFO / BSM
Potential PFAS releases	To inform potential changes in PFAS results off-base.	Off-base	NT EPA, NT Fire
	To inform potential changes in PFAS results on-base.	On-base	SADFO / BSM
Review of spoil management processes undertaken	To monitor ad-hoc PFAS testing in soils on the base to identify other potential source areas, or to assess potential impacts from beneficial spoil re-use area.	On-base	SADFO/BSM

Based on the current limited bore use, water use surveys are not considered to be relevant to the base. This requirement should be reconsidered if groundwater bore searches indicate increased bore use for industrial, rural or domestic purposes and /or the installation of new groundwater bores.

6 PFAS SCREENING CRITERIA

Screening criteria used to assess the potential risks to receptors as a part of the monitoring program were sourced from the PFAS NEMP. The screening criteria in the PFAS NEMP was developed based on guidance provided in the following:

- Department of Health (DoH). Health based Guidance Values for PFAS for use in site investigations in Australia. April 2017 (DoH, 2017a)
- DoH. Perfluorinated Chemicals in Food – Consolidated Report, April 2017 (DoH, 2017b)
- National Health and Medical Research Council (NHMRC), 2019. Guidance on PFAS in Recreational Water. August 2019 (NHMRC, 2019), and
- National Environment Protection (Assessment of Site contamination) Measure 1999 (ASC NEPM), Schedule B1, as amended ion 2013 (NEPC, 2013).

In November 2024, the NHMRC released draft health based drinking water guideline values for public consultation. Defence is considering how the draft guidelines, if adopted, may affect the management of PFAS at, and the community surrounding, RAAF Base Darwin. As an initial step, Defence is adopting a lower laboratory limit of reporting at select locations to understand any future implications. Until the revised PFAS guideline values are finalised and published, the current guideline values remain in effect.

Adopted PFAS screening values for groundwater, surface water and aquatic biota are provided in Table 6-1 below.

Table 6-1. PFAS screening criteria

Media	Pathway	Compound	Criteria	Comment / Reference
Groundwater and surface water	Freshwater Ecosystems	PFOS	0.00023 µg/L	HEPA (2020) NEMP 99% species protection.
		PFOA	19 µg/L	
Groundwater	Drinking water	PFOS+ PFHxS[1]	0.07 µg/L	The values presented in the HEPA (2020) are from DoH (2017a). DoH utilised the tolerable daily intake for PFOS and PFOA from Food Standards Australia New Zealand (FSANZ), 2017a and the methodology described in Chapter 6.3.3 of NHMRC Australian Drinking Water Guidelines, 2016 to establish drinking water values.
		PFOA	0.56 µg/L	
Surface water	Recreational use	PFOS+ PFHxS[1]	2 µg/L	The values presented in HEPA (2020) were based on NHMRC guidance on the assessment of PFAS in surface water. The NHMRC adjusted the ingestion rate with consideration of an event frequency (150 events / year) to calculate an annual ingestion rate of 30 L per year.
		PFOA	10 µg/L	
Aquatic biota	Crustaceans	PFOS and PFOS+ PFHxS	65 µg/kg	The values are presented in (DoH, 2017b) derived for the projection of children 2 to 6 years old.
		PFOA	520 µg/kg	

Media	Pathway	Compound	Criteria	Comment / Reference
	Finfish	PFOS and PFOS+ PFHxS	5.2 µg/kg	The values are presented in (DoH, 2017b) derived for the projection of children 2 to 6 years old.
		PFOA	41 µg/kg	

Note:1. HEPA (2020) notes where the criteria refer to the sum of PFOS and PFHxS, this includes PFOS only, PFHxS only, and the sum of the two

7 TRIGGERS FOR ACTION AND REVIEW

Several trigger points have been identified which should be incorporated into any future SAQPs prepared in relation to this OMP. The trigger points have been separated into monitoring event triggers, and OMR triggers.

Trigger values have been developed based on the historic and current PFAS concentrations in ground water, surface water and biota, and are focused on identifying where there are material changes in the concentrations of PFAS. Material changes vary between trigger points, media and sampling locations (on-base versus off-base), but include:

- Where a concentration has increased above an adopted screening criteria at the point of human or ecological exposure (such as within a creek, biota sample or groundwater bore used for potable water supply or recreational uses).
- Where there has been an increase in concentrations by more than an order of magnitude.

These trigger points and proposed further actions are summarised in the table below.

Table 7-1. Trigger levels and actions

Locations	Trigger Point	Action
OMP monitoring event triggers		
Locations previously below laboratory LOR for PFAS	Detection of PFAS compounds	Check and confirm with the laboratory that the concentration measured was not reported in error, or a quality assurance/quality control discrepancy. If concentration is confirmed by laboratory as correct and Quality Assurance (QA) / Quality Control (QC) review (including potential re-test of primary sample) does not identify any discrepancies that may have led to the result, review the change in the context of the overall CSM and whether the change is material or not. If material change confirmed, undertake review of potential cause for changes (particularly increase in risk) and develop potential management actions (if required). Consider assessment of this result against the CSM and HHRA. Review OMP and consider adjusting monitoring rounds and/or locations. Consider additional investigation of known or potential source areas.

Locations	Trigger Point	Action
All monitoring locations	PFAS concentrations report a new high concentration compared with previous OMP data.	Undertake QA/QC checks with laboratory/data to confirm concentrations (including potential re-test of primary sample). Review the change in the context of the overall CSM and whether the change is material or not. If material change, undertake confirmation sampling as soon as practical to confirm results. If material change confirmed, undertake review of potential cause for changes (particularly increase in risk) and develop potential management actions (if required). Consider assessment of this result against the CSM and HHRA. Review OMP and consider adjusting monitoring rounds and/or locations. Consider additional investigation of known or potential source areas.
All monitoring locations	Groundwater monitoring well or lysimeter is not able to be sampled as it is dry, blocked, damaged, decommissioned, inaccessible, lost etc.	Attempts should be made to locate/repair/unblock the monitoring well/lysimeter. If this is not successful, a contingency location should be sampled instead. If no suitable contingency location can be identified, the monitoring well/lysimeter should be reinstalled in a similar location, depth and screen interval.
OMR triggers		
All monitoring locations	PFAS concentrations show an increasing or decreasing trend (using statistical analysis) where they have not shown a similar trend in the previous OMR.	Review the change in the context of the overall CSM and whether the change is material or not. Review OMP monitoring locations and frequencies. Consider additional investigation of known or potential source areas. Consider updating the HHRA if risk profile requires adjustment. For off-base locations, consider providing latest information to Territory Agencies or NT EPA for their consideration in potentially amending administrative controls such as health advisories.

Locations	Trigger Point	Action
Mass flux transects or receiving water bodies	PFAS mass moving across flux transects at source areas, base boundaries or receiving water bodies are statistically increasing. Where there are insufficient mass flux estimates for statistical analysis, the initial trigger will be where PFAS concentrations in the majority of transect wells exceed the historical maximum, and concentrations are statistically increasing.	Undertake review of input data (including QA/QC, rainfall data, water flow data, hydraulic gradient assumptions etc) and assumptions to confirm validity of mass flux calculations, and whether sensitivity analysis affects mass flux interpretation. Review the change in the context of the overall CSM and HHRA and consider additional monitoring (if required). For off-base locations, consider providing latest information to Territory Agencies for their consideration in potentially amending administrative controls such as health advisories.

8 REPORTING REQUIREMENTS

8.1 Reporting

After each monitoring event, a brief monitoring event summary will be submitted to Defence within two weeks of receiving the analytical results. This summary report will highlight any anomalies recorded in the sampling process and from the analytical results (such as new exceedances or maximum concentrations).

A factual report will also be submitted after each monitoring event. The factual report will include field and laboratory documentation, observations recorded and a summary of any location where a new high or low concentration of PFAS has been reported in the monitoring event.

At the end of a specified monitoring period (typically 12 months but may vary) the whole data set (including the current and historic data) will be reviewed, and an OMR prepared.

The OMR will report on the objectives of the OMP, which are to identify and evaluate:

- spatial, and temporal (including seasonal) variability of PFAS in the environment
- changes to sources, transport pathways or receptors, described as a CSM for the base
- changes in risks to human and environmental receptors
- the influence that risk management activities at the base, as outlined in the 2025 PMAP have had on PFAS in the environment
- changes in PFAS flux from key source areas and pathways, and
- whether the identified changes trigger a prescribed action and/or review (Section 7).

8.2 Stakeholder engagement

Engagement with a range of stakeholders, such as DIA, NT EPA, NT DoH, other agencies, and the Darwin community will be undertaken. A stakeholder engagement plan will be prepared and updated from time to time to manage the engagement process.

Where off-site monitoring is undertaken, a separate letter will be provided to the relevant landholder presenting the results of the monitoring event. In the event that a new detection of PFAS and/or an increase in concentrations above Drinking Water Guidelines occurs at private location, the relevant stakeholder will be contacted by phone or in person to discuss the results prior to provision of a letter summarising the results.

Defence publishes OMRs on the publicly accessible website for the community to have access to the latest ongoing monitoring data and interpretations.

APPENDIX A REFERENCES

Coffey (2018a) RAAF Base Darwin Detailed Site Investigation – Per and Poly-fluoroalkyl Substances (PFAS). 754-MELEN199421-R05. 5 February 2018, Coffey Environments Australia Pty Ltd, Melbourne.

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Coffey (2018d) RAAF Base Darwin Ecological Risk Assessment. 754-MELEN199421-R09. 23 October 2018. Coffey Environments Australia Pty Ltd, Melbourne.

Department of Defence (2019) RAAF Base Darwin. PFAS Management Area Plan. July 2019.

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Department of Health (DoH, 2017b). Perfluorinated Chemicals in Food – Consolidated Report, April 2017

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NHMRC (2019) National Health and Medical Research Council (NHMRC), 2019. Guidance on PFAS in Recreational Water. August 2019

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Tetra Tech Coffey (2022), Baseline Mass Flux Investigation. RAAF Base Darwin PFAS Investigation, Department of Defence. 754-MELEN199421-R26.

Tetra Tech Coffey. (2024a). Department of Defence, RAAF Base Darwin – PFAS Investigation, CFTA and Former ARFF Further Investigations 2022, 754-MELEN199421_R34

Tetra Tech Coffey. (2024b). Department of Defence, RAAF Base Darwin – PFAS Remediation, FFTA1 and Wrapped Stockpile Wrapped Stockpiles Validation Report, 754-MELEN199421_R40

Tetra Tech Coffey. (2024c). Department of Defence, Ongoing Monitoring Report, June 2023 – April 2024, RAAF Base Darwin, 754-MELEN338204_R12

APPENDIX B FIGURES

Figure 1 – Base location, Management Area and Source Areas

Figure 2 – Groundwater sampling locations

Figure 3 – Surface water sampling locations

Figure 4 – Biota sampling locations

LEGEND

- Creek
- PFAS source area
- Base boundary
- Management area

ID	Source Area
1	Former Fire Training Area 1 (FFTA1). *Also previously called Former Fire Training Ground 1*
2	Former Fuel Farm 5 (FFF5)
3	Former Fuel Farm 4 (FFF4)
4	Former Fuel Farm 6 (FFF6)
5	Wrapped Stockpiles Area *Also previously called the 'AFFF Contaminated Soil Stockpiles'*
6	Former Aviation Rescue Fire Fighting (ARFF) Fire Station
7	Hangar 31
8	Former Fuel Farm 1 (FFF1)
9	Former RAAF Fire Station (Former RAAF-FS)
10	Former Fire Training Area 2 (FFTA2)
11	Current (Hot) Fire Training Area (CFTA)

SOURCE
Inferred PFAS source areas from site history information.
RAAF Base Darwin site boundary, roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2021).

0 500 1,000 m

N

SCALE 1:40,000
PAGE SIZE: A3
PROJECTION: GDA 1994 MGA Zone 52

DEPARTMENT OF DEFENCE

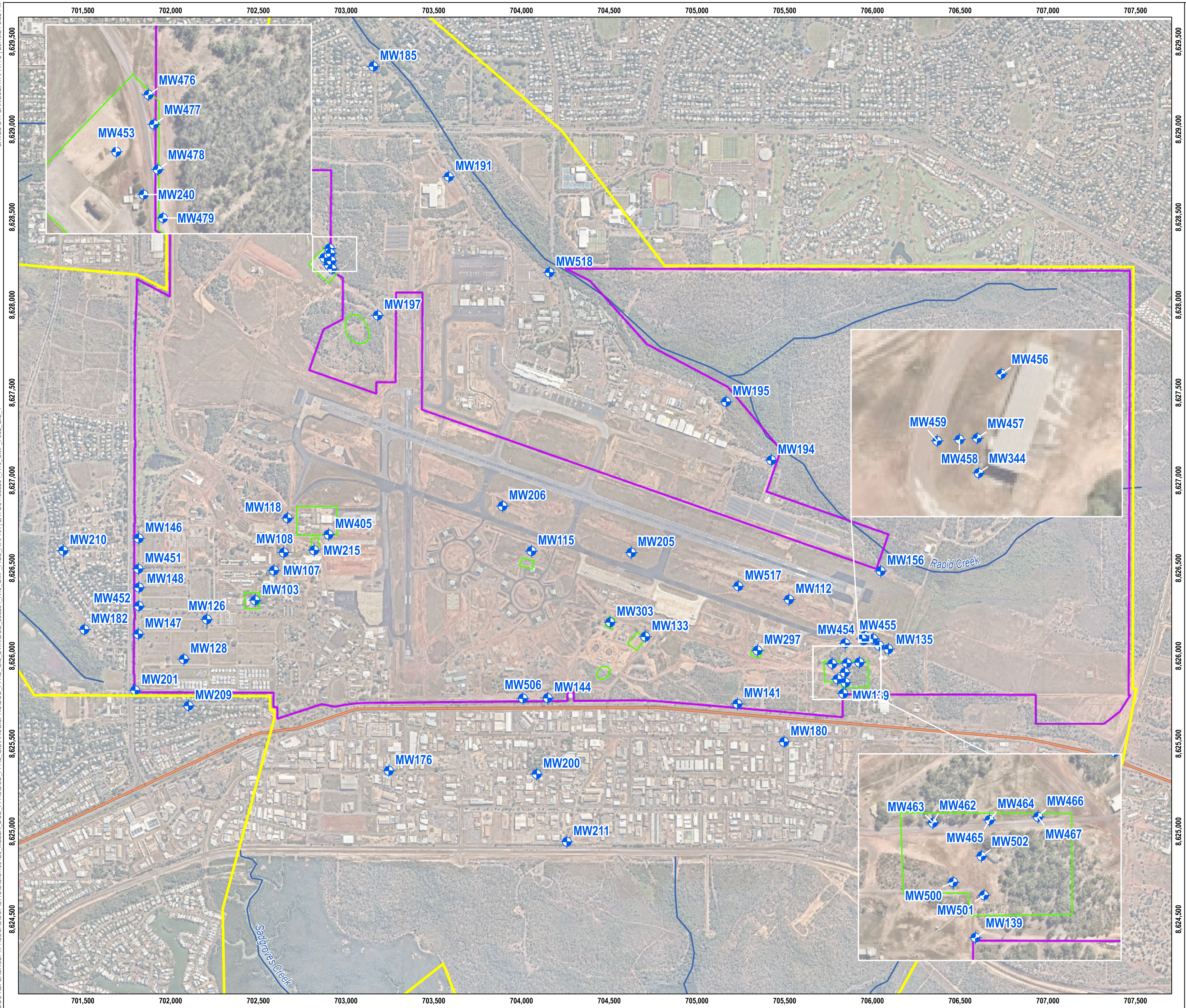
RAAF BASE DARWIN - ONGOING MONITORING PLAN

FIGURE 1

Base location, Management Area and Source Areas

TETRA TECH COFFEY

DATE: 16.09.24 PROJECT: 754-MELEN338204 FILE: 338204_R10_OMP_F001_GIS



LEGEND

- Groundwater sampling location
- Stuart highway
- Creek
- PFAS source area
- Management area
- Base boundary

SOURCE
Inferred PFAS source areas from site history information.
RAAF Base Darwin site boundary, roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2021).

N

0 250 500 m

SCALE 1:21,000
PAGE SIZE: A3
PROJECTION: GDA 1994 MGA Zone 52

DEPARTMENT OF DEFENCE

RAAF BASE DARWIN - ONGOING MONITORING PLAN

FIGURE 2

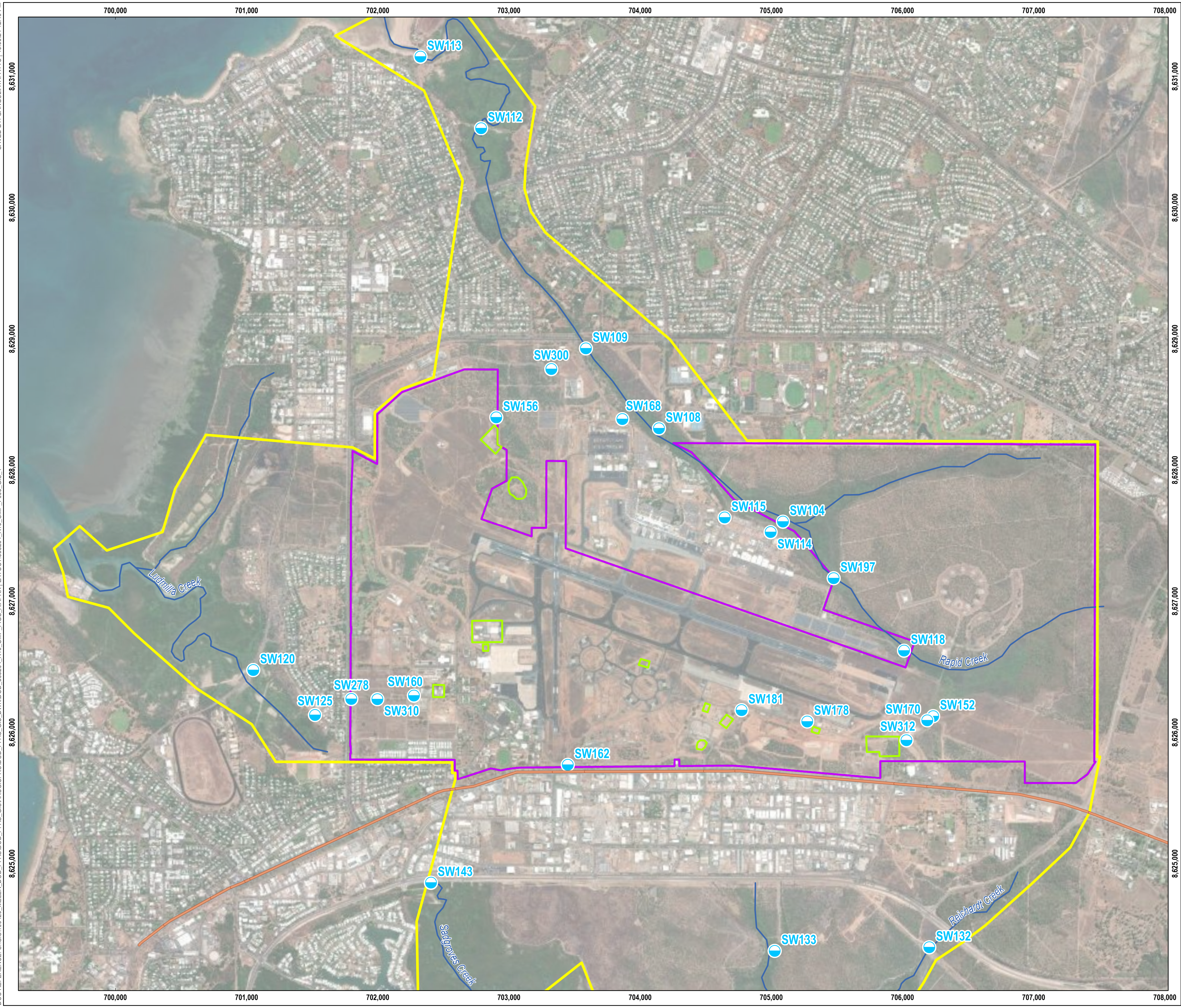
Groundwater sampling locations

TETRA TECH COFFEY

DATE: 05.05.25 PROJECT: 754-MELEN338204 FILE: 338204_R10_OMP_F002_GIS

SAVED BY: GANGULATAPATTU 25.10.24 3:52 PM

DOC REFERENCE: \\TT.LOCAL\COFFEY\MELEN\DOD_PFAS\DOD_PFAS_GIS\ARCGIS\PRO\DOD_PFAS_GIS_DWN\DOD_338204_R10_OMP_FIGS_A.APRX | LAYOUT 338204_R10_OMP_F002_GIS_1



LEGEND

- Surface water sampling location
- Creek
- Stuart highway
- Management area
- PFAS source area
- Base boundary

SOURCE
Inferred PFAS source areas from site history information.
RAAF Base Darwin site boundary, roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2021).

0 500 1,000 m

SCALE **1:28,000**
PAGE SIZE: **A3**
PROJECTION: **GDA 1994 MGA Zone 52**

DEPARTMENT OF DEFENCE

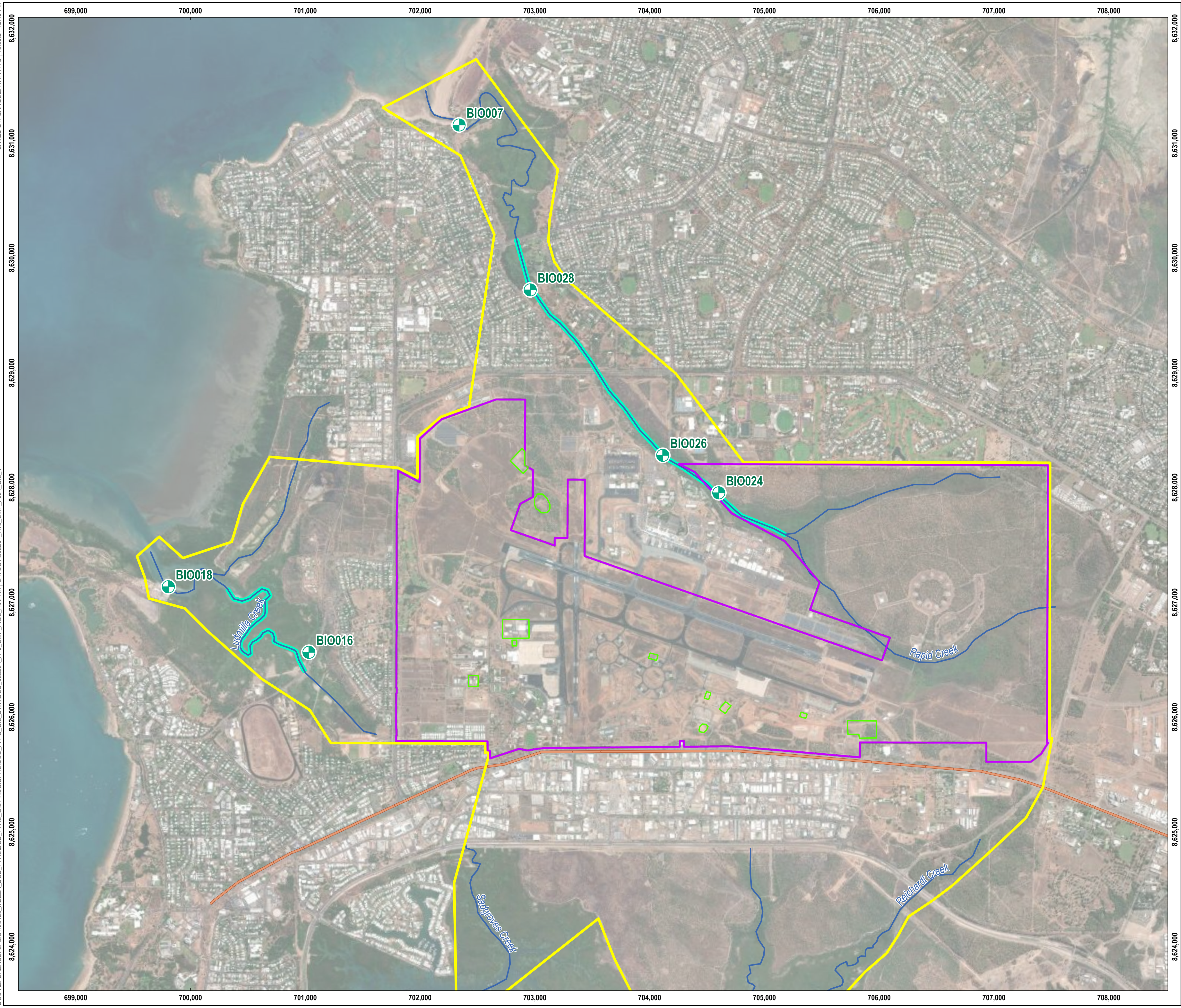
RAAF BASE DARWIN - ONGOING MONITORING PLAN

FIGURE 3

Surface water sampling locations

TETRA TECH COFFEY

DATE: **16.09.24** PROJECT: **754-MELEN338204** FILE: **338204_R10_OMP_F003_GIS**



LEGEND

- OMP aquatic biota sample location
- Stuart highway
- OMP aquatic biota sample section
- Creek
- PFAS source area
- Base Boundary
- Management area

SOURCE
Inferred PFAS source areas from site history information.
RAAF Base Darwin site boundary, roads, tracks, and creeks from DoD.
Imagery from Nearmap (06-06-2021).

0 500 1,000 m

N

SCALE 1:32,000
PAGE SIZE: A3
PROJECTION: **GDA 1994 MGA Zone 52**

DEPARTMENT OF DEFENCE

RAAF BASE DARWIN - ONGOING MONITORING PLAN

FIGURE 4

Biota sampling locations

TETRA TECH COFFEY

DATE: **16.09.24** PROJECT: **754-MELEN338204** FILE: **338204_R10_OMP_F004_GIS**

SAVED BY: GANGULATAPATTU | 16.09.24 12:49 PM

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APPENDIX C SAMPLE LOCATION INFORMATION

Table C1. Groundwater monitoring network

Location ID	On- /Off-base	Source Area / Location	Easting	Northing
MW500	On-base	FFTA1	705801.0	8625869.7
MW501	On-base	FFTA1	705848.1	8625844.9
MW502	On-base	FFTA1	705842.9	8625905.7
MW462	On-base	FFTA1	705771.4	8625954.8
MW463	On-base	FFTA1	705771.4	8625954.8
MW464	On-base	FFTA1	705854.8	8625958.7
MW465	On-base	FFTA1	705854.8	8625958.7
MW466	On-base	FFTA1	705926.3	8625963.3
MW467	On-base	FFTA1	705926.3	8625963.3
MW454	On-base	FFTA1	705844.8	8626071.9
MW344	On-base	FFTA1	705951.3	8626089.4
MW455	On-base	FFTA1	706004.5	8626097.6
MW135	On-base	FFTA1	706091.2	8626039.1
MW456	On-base	FFTA1	705956.9	8626113.9
MW457	On-base	FFTA1	705950.9	8626098.0
MW458	On-base	FFTA1	705946.5	8626097.6
MW459	On-base	FFTA1	705941.1	8626097.3
MW297	On-base	FFF5	705345.5	8626030.7
MW133	On-base	FFF4	704705.7	8626109.9
MW303	On-base	FFF6	704505.4	8626191.8
MW115	On-base	ARFF	704057.2	8626597.2
MW112	On-base	Runway transect	705524.8	8626321.4
MW205	On-base	Runway transect	704625.9	8626588.5
MW206	On-base	Runway transect	703891.9	8626853.7
TBA[1] (New well b/w MW205 and MW112)	On-base	Runway transect	705235.9	8626397.3
MW139	On-base	Southern boundary	705834.1	8625785.6
MW141	On-base	Southern boundary	705231.1	8625726.9
MW144	On-base	Southern boundary	704149.6	8625760.1
TBA[1] (New well west of 144)	On-base	Southern boundary	*TBA*	*TBA*
MW176	Off-base	Winnellie	703244.1	8625345.7
MW180	Off-base	Winnellie	705496.7	8625510.4

Location ID	On- /Off-base	Source Area / Location	Easting	Northing
MW200	Off-base	Winnellie	704086.9	8625326.5
MW211	Off-base	Winnellie	704258.6	8624941.2
MW405	Off-base	Hangar 31/FFF1	702900.8	8626691.5
MW215	Off-base	Hangar 31/FFF1	702818.5	8626602.0
MW107	Off-base	Hangar 31/FFF1	702589.3	8626487.5
MW108	Off-base	Hangar 31/FFF1	702645.2	8626588.9
MW103	On-base	RAAF FS	702481.9	8626317.1
MW126	On-base	RAAF FS	702206.6	8626207.7
MW128	On-base	RAAF FS	702075.7	8625981.4
MW201	On-base	Western Boundary	701797.7	8625804.3
MW452	On-base	Western Boundary	701819.4	8626284.1
MW148	On-base	Western Boundary	701819.7	8626389.6
MW451	On-base	Western Boundary	701816.6	8626496.2
MW146	On-base	Western Boundary	701818.2	8626669.6
MW147	On-base	Western Boundary	701816.1	8626124.5
MW118	Off-base	Ludmilla	702666.9	8626785.2
MW209	Off-base	The Narrows	702102.4	8625715.8
MW210	Off-base	Ludmilla	701388.7	8626600.0
MW503	On-base	CFTA	702933.6	8628235.1
MW504	Off-base	DIA land at CFTA	702979.9	8628361.4
MW453	On-base	CFTA	702876.2	8628267.7
MW240	On-base	CFTA	702901.9	8628227.5
MW197	Off-base	DIA land at FFTA2	703180.6	8627939.9
MW476	On-base	CFTA	702906.5	8628321.4
MW477	On-base	CFTA	702911.6	8628293.5
MW478	On-base	CFTA	702915.2	8628251.0
MW479	On-base	CFTA	702920.2	8628205.4
MW156	On-base	Head of Rapid Creek	706047.4	8626483.3
MW194	Off-base	Rapid Creek near solar farm	705423.9	8627115.0
MW195	Off-base	Rapid Creek near Dogs Home	705166.5	8627447.7
MW193	Off-base	Rapid Creek near Henry Wrigley Drv	704143.6	8628184.6
MW191	Off-base	Rapid Creek at Osgood Drv	703585.7	8628730.2
MW185	Off-base	Millner	701509.1	8626151.0
SL019[1]	On-base	FFTA1	TBA	TBA

Location ID	On- /Off-base	Source Area / Location	Easting	Northing
SL020[1]	On base	FFTA1	TBA	TBA

Note: 1. These wells/ lysimeters are not yet installed and the details of their final names and locations will be updated when installed.

Table C2. Surface water monitoring network

ID	On- /Off-base	Source Area/ Location	Easting	Northing
SW312	On-base	FFTA1	706030.5	8625939.5
SW170	On-base	FFTA1	706189.0	8626092.1
SW152	On-base	FFTA1	706234.0	8626124.0
SW181	On-base	FFF4	704773.8	8626169.6
SW178	On-base	FFF5	705274.3	8626083.2
SW143	Off-base	Sadgroves Creek	702406.0	8624854.0
SW133	Off-base	Reichardt Creek west	705026.0	8624335.0
SW132	Off-base	Reichardt Creek east	706204.2	8624362.2
SW162	On-base	Southern boundary	703449.0	8625753.0
SW160	On-base	RAAF FS	702276.0	8626280.0
SW278	On-base	Western Boundary	701799.0	8626254.0
SW310	On-base	RAAF FS	701997.2	8626253.5
SW125	Off-base	Ludmilla Creek	701522.0	8626133.0
SW120	Off-base	Ludmilla Creek	701051.6	8626475.5
SW156	On-base	CFTA	702904.0	8628401.0
SW300	Off-base	Osgood Drive	703323.2	8628768.8
SW118	Off-base	Head of Rapid Creek	706012.0	8626623.0
SW197	Off-base	Rapid Creek near solar farm	705475.6	8627175.4
SW104	Off-base	Rapid Creek near Dogs Home	705089.0	8627606.0
SW108	Off-base	Rapid Creek behind Airport hotels	704144.0	8628317.0
SW109	Off-base	Rapid Creek near McMillans Road	703587.0	8628927.0
SW112	Off-base	Rapid Creek near weir	702788.0	8630605.0
SW113	Off-base	Rapid Creek near boat ramp	702326.0	8631150.0
SW114	Off-base	DIA drain near Dogs Home	704995.0	8627526.0
SW115	Off-base	DIA drain near air-traffic control tower	704644.3	8627637.4
SW168	Off-base	DIA drain near general aviation area	703865.0	8628388.0

APPENDIX D OMP REVIEW

Table D1. OMP monitoring location and frequency review

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
Groundwater						
MW500, MW501, MW502	Yes	Yes	Yes	Yes	Include in OMP	Important for monitoring changes in FFTA1 following remediation and to replace wells MW422 and MW235
MW462, MW463 MW464, MW465 MW466, MW467 MW454, MW344 MW455, MW135 MW456, MW457 MW458, MW459	Yes	Yes	Yes	Yes	Include in OMP	To monitor the flux migrating from FFTA1 to provide a line of evidence as to whether SFARP has been achieved.
MW206 (and new well near MW112)	Yes	Yes	Yes	Yes	Include in OMP	To monitor the flux migrating from runway source areas to assess effectiveness of remediation.
New well to west of MW144	Yes (unknown)	Yes	No (unknown)	No (unknown)	Install and include in OMP	To confirm the mass flux in groundwater migrating across southern boundary and refine baseline mass flux.

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
MW108	Yes	Yes	Yes	Yes	Include in OMP	This well forms part of the down-gradient transect from Hangar 31/FFF1 and provides a better understanding of plume migration from the source area to allow re-calculation of the mass flux in annual reporting.
MW126	Yes	Yes	Yes	Yes	Include in OMP	As the plume dynamics have changed down-gradient of the RAAF-FS, monitoring the plume immediately down-gradient and the flux that is passing the Bukatilla Road drains has become an important aspect to monitor how the mass is migrating down-gradient, and to establish baseline conditions down-gradient of the source area and drains. This well sits in the centreline of the plume, and whilst MW128 (approximately 300 m down-gradient) also monitors the plume centre line, this well forms the centre of the flux transect and is key in monitoring flux changes in this area.
MW147, MW451, MW452	Yes	Yes	Yes	Yes	Include in OMP	To better understand and monitor flux moving off the base in a westerly / south-westerly direction. These wells have been provisionally added to prior OMPs as they inform the western boundary mass flux transect and monitor changes in risk to off-base receptors in Ludmilla. This well has also had a significant increase in the PFAS concentrations over recent years and will allow off-base flux to be monitored more effectively.

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
MW146, MW201 MW118	Yes	Yes	Yes	Yes	Include in OMP	based on assessment of groundwater flux in the southwestern corner of the base, the groundwater plume appears to be moving in this direction and is potentially migrating off-base in this corner of the base. Monitoring of these wells will provide a sentinel for further plume migration in this direction. Furthermore, the impact of the base on the groundwater conceptualisation in the area is not well understood.
MW504	Yes	Yes	Yes	Yes	Include in OMP	New well is proposed to monitor the primary pathway down-gradient from CFTA in the shallow high-permeability lateritic component of the soil profile. The well depth is targeting the shallow lateritic flow, but not the deeper siltstone. This is also to allow unit-specific hydraulic conductivity testing to be performed to inform flux calculations and monitor post-remediation improvement in groundwater conditions.
MW476, MW477, MW478, MW479	Yes	Yes	Yes	Yes	Include in OMP	Shallow perched wells at CFTA that monitor the down-gradient mass flux in the perched aquifer. Will be important to assess effectiveness of remediation.
SL019, SL020	Yes	Yes	Yes	Yes	Include in OMP	Lysimeters installed at FFTA1 to monitor leaching from treated PFAS soils.

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
Surface water						
SW312	Yes	Yes	Yes	Yes	Include in OMP	Monitor PFAS in surface water flow from FFTA1 remediation area.
SW101	Yes	Yes	Yes	Yes	Remove from OMP and replace with SW118	Location SW101 is difficult to access due to permit and access requirements for this area of the base. Propose to replace with accessible SW118 approximately 300 m downstream, but accessible and historically has reported same concentrations.
SW278 & SW300	Yes	Yes	Yes	Yes	Include in OMP	These locations monitor groundwater PFAS entering drainage pipes down-stream from RAAF FS and inform PFAS discharge in surface water to Ludmilla Creek
SW124	Yes	No	No	No	Remove from OMP	Except for occasional detects at or slightly above LOR, results have historically generally been below LOR and no increasing trend in observed.
SW300	Yes	Yes	Yes	Yes	Include in OMP	This location monitors PFAS in surface water coming from the CFTA and FFTA2 source areas prior to discharge to Rapid Creek and informs the contribution of PFAS mass from the source areas.

Location	Does the location inform the nature of PFAS at the site	Does the location inform the extent of PFAS at the site	Does the location inform the risk profile at the site	Does the sampling frequency inform the risk profile	OMP Review Outcome	Reason
SW197	Yes	Yes	Yes	Yes	Include in OMP	Monitoring well MW194 (located on Rapid Creek near the eastern end) has reported fluctuations in PFAS concentrations throughout the OMP period. However, the adjacent Rapid Creek surface water monitoring point (SW197) was not part of the OMP and warrants ongoing sampling with the well to monitor the groundwater/surface water interaction at this location, and whether the groundwater concentrations and flux in this area is having a material effect on surface water flux. It is also on the plume centreline from ARFF, FFF4 and FFF6.

APPENDIX E PFAS ANALYTICAL SUITE

Target analytes		Target LOR (µg/L)
Perfluoroalkane sulfonic acids		
PFBS	Perfluorobutane sulfonic acid	0.01
PFPeS	Perfluoropentane sulfonic acid	0.01
PFHxS	Perfluorohexane sulfonic acid	0.01
PFHpS	Perfluoroheptane sulfonic acid	0.01
PFOS	Perfluorooctane sulfonic acid	0.01 0.001 in select wells
PFDS	Perfluorodecane sulfonic acid	0.01
Perfluoroalkyl carboxylic acids		
PFBA	Perfluorobutanoic acid	0.05
PFPeA	Perfluoropentanoic acid	0.01
PFHxA	Perfluorohexanoic acid	0.01
PFHpA	Perfluoroheptanoic acid	0.01
PFOA	Perfluorooctanoic acid	0.01
PFNA	Perfluorononanoic acid	0.01
PFDA	Perfluorodecanoic acid	0.01
PFUnDA	Perfluoroundecanoic acid	0.01
PFDoDA	Perfluorododecanoic acid	0.01
PFTrDA	Perfluorotridecanoic acid	0.01
PFTeDA	Perfluorotetradecanoic acid	0.01
Perfluoroalkyl sulfonamides		
FOSA	Perfluorooctane sulfonamide	0.01
MeFOSA	N-Methyl perfluorooctane sulfonamide	0.02
EtFOSA	N-Ethyl perfluorooctane sulfonamide	0.02
MeFOSE	N-Methyl perfluorooctane sulfonamidoethanol	0.05
EtFOSE	N-Ethyl perfluorooctane sulfonamidoethanol	0.05
MeFOSAA	N-Methyl perfluorooctane sulfonamidoacetic acid	0.01
EtFOSAA	N-Ethyl perfluorooctane sulfonamidoacetic acid	0.01
(n:2) Fluorotelomer sulfonic acids		
4:2 FTS	4:2 Fluorotelomer sulfonic acid	0.01
6:2 FTS	6:2 Fluorotelomer sulfonic acid	0.01
8:2 FTS	8:2 Fluorotelomer sulfonic acid	0.01
10:2 FTS	10:2 Fluorotelomer sulfonic acid	0.01