Australian Government
Defence

PFAS INVESTIGATION AND MANAGEMENT PROGRAM

SERVICE
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RAAF Base Townsville

PFAS ONGOING MONITORING PLAN

May 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.

Revision	Date	Revision details / status
Rev0	13 August 2024	Draft Revision of PFAS Ongoing Monitoring Plan for RAAF Base Townsville
Rev1	26 November 2024	Draft addressing Defence review comments
Rev2	13 January 2025	Draft addressing Defence review comments
Rev3	10 February 2025	Draft addressing Defence review comments
Rev4	3 March 2025	Draft addressing Defence review comments
Rev5	17 March 2025	Final Draft
RevA	9 May 2025	Final Report

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GLOSSARY

5AVN	5th Aviation
AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum
AS	Australian Standard
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013
Base	Royal Australian Air Force Base Townsville
CSM	Conceptual Site Model
DQI	Data Quality Indicators
DQO	Data Quality Objectives
DSI	Detailed Site Investigation
EIL	Ecological Investigation Level
ERA	Ecological Risk Assessment
FSANZ	Food Standards Australia New Zealand
HHRA	Human Health Risk Assessment
LOR	Limit of Reporting
LTEMP	Long-term environmental management plan
Management Area	The surface area extent of RAAF Base Townsville, including Sub-Management Area 1 (Former Fire Training Area), Sub-Management Area 2 (Former Fire Training Area), and Sub-Management Area 3 (5 Aviation Regiment, 5AVN).
Monitoring Area	The geographical area subject to Defence risk management actions. May include private or Defence owned detached properties beyond the boundaries of the base.
NATA	National Association of Testing Authorities
OCP	Organochlorine pesticides
Off-base	Outside the Defence property
On-base	On the Defence property
OLA	Ordnance loading area
OMP	Ongoing Monitoring Plan
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
PTFE	Polytetrafluoroethylene
QA	Quality Assurance
QC	Quality Control

Risk management actions	Remediation and management actions to address potential risks to receptors from PFAS contamination
SAQP	Sampling, Analysis and Quality Plan
SFARP	So Far As Reasonably Practical
SMA	Sub-Management Area
Source	A source can be primary or secondary and is the place or event from which the contamination originated. 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, groundwater, or surface water bodies.
TDI	Tolerable Daily Intake
TRV	Toxicity Reference Value

1 INTRODUCTION

1.1 Background

In December 2019, Department of Defence prepared a per- and poly-fluoroalkyl substances (PFAS) Management Area Plan (PMAP) for managing risks to human health and the environment from PFAS contamination associated with Royal Australian Air Force (RAAF), Townsville (the base) and surrounding areas. An important requirement of the PMAP is to undertake ongoing monitoring of PFAS in the on-base and off-base environment and to assess for changes in risks to human and ecological receptors from PFAS originating from the base.

This Ongoing Monitoring Plan (OMP) is a revision of the OMP presented as an attachment (Attachment 1) to the PFAS Management Area Plan (PMAP; Department of Defence, 2019) for RAAF Base Townsville. With the current update and revision of the PMAP, the OMP is now a standalone document.

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, including remediation activities, at the base, as outlined in the Department of Defence (2019) PMAP, have had on PFAS in the environment;
- whether the identified changes trigger an action and/or review; and
- whether the monitoring program (seasonality, locations, or media), based on measured data, needs to be modified.

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 (ie remediation SFARP).

The approach and quality of fieldwork performed for the OMP will be consistent with sampling procedures outlined in the *PFAS National Environmental Management Plan* (PFAS NEMP; HEPA, 2025), the *National Environment Protection (Assessment of Site Contamination) Measure 1999 (ASC NEPM, as amended in 2013)* to provide the required level of confidence in the quality of the environmental data collected during the program.

1.3 Supporting information

RAAF Townsville is a Department of Defence property subject to Commonwealth Government jurisdiction. This OMP has been prepared in general accordance with the following PMAP for the Management Area:

- Department of Defence (2019), PFAS Management Area Plan, RAAF Townsville. Issued December 2019.

In developing the OMP, reference has been made to the PFAS National Environmental Management Plan Version 3.0, 2025 (the 'PFAS NEMP'), the National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013 (the ASC NEPM) and Defence estate, environmental and PFAS-specific strategies and guidance, and other information as provided in the References section of this document.

It is noted that the PMAP is currently being updated.

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 detailed site assessments, risk assessments, mass flux assessments, remediation activities, ongoing monitoring program data, and management of risks documented in the PMAP (Department of Defence, 2019). Defence recognises that there may still be gaps in information, and if required, these will be progressively reviewed while impacted sites are being managed.

This document has been developed based on the following assumptions:

- There are currently limited proven technologies for the treatment and destruction of PFAS. The treatment techniques discussed in this OMP were current at the time of writing.
- There is currently limited Australian contractor capability to implement proven technologies for the treatment and destruction of PFAS, as well as restrictions on local landfill disposal of PFAS.

The monitoring focus is limited to impacts associated with PFAS only.

Information collected under the following work scopes conducted on-base and off-base has been relied upon for the development of this report. These reports are therefore subject to their own limitations and assumptions as outlined in those reports. These include:

- RAAF Base Townsville Detailed Site Investigation – PFAS, Volume 1 – 4 RevD (WSP, 2018a)
- RAAF Base Townsville Human Health Risk Assessment RevI, (WSP 2018b)
- RAAF Base Townsville Seasonal Monitoring Report (1 & 2) – PFAS, Volume 1 – 4 RevB (WSP, 2019a)
- RAAF Base Townsville Ecological Risk Assessment RevG (WSP, 2019b)
- RAAF Base Townsville Remedial Action Plan – Sub-Management Area 1 (WSP, 2021)
- RAAF Base Townsville PFAS Surface Water Mass Discharge Sub-Management Areas 1 and 2 (WSP, 2023a)
- RAAF Base Townsville PFAS Surface Water Mass Discharge – SMA2 and 3 (WSP, 2023b)
- RAAF Base Townsville PFAS Groundwater Mass Discharge 2023 (WSP, 2023c)
- RAAF Base Townsville Remediation Action Plan – Fire Station Locale (WSP, 2023d)
- RAAF Base Townsville Remediation Action Plan – Fuel Farm #2 (WSP, 2023e).
- RAAF Base Townsville, PFAS OMP Sampling and Analysis Quality Plan (AECOM, 2024a).
- RAAF Base Townsville Ongoing Monitoring Report (June 2023 – March 2024) (AECOM, 2024b).

2 SITE SETTING

2.1 Base description

The base is located in Townsville, North Queensland and is approximately 5 km west of the centre of Townsville. A site locality plan is provided in Figure 1, Appendix B. The base currently consists of a military and civilian airfield facility, with military accommodation areas (including a childcare facility), maintenance facilities, fuel and munitions storage, office facilities, recreation areas and open wetland areas. The Management Area comprises the boundary extent of the base with a total area of 740 ha. Three discrete sub-management areas (SMAs), referred to as Sub-Management Area 1 (SMA1), Sub-Management Area 2 (SMA2), and Sub-Management Area 3 (SMA3), have been identified on-base and are presented in Figure 2, Appendix B.

The surrounding area consists of the domestic Townsville Airport, residential and commercial suburbs of Garbutt, Rowes Bay, West End, Belgian Gardens, Pallarenda, Mount St John, Mount Louisa and Bohle (Townsville City Council areas). The base is also adjacent to the Townsville Town Common Conservation Park (the Town Common), a wetland listed on the Register of the National Estate.

The Monitoring Area for the OMP includes the base and surrounds in which monitoring is to be undertaken for groundwater, surface water quality, and sediment quality. The on-base area (ie the Management Area) includes adjoining Defence properties across Ingham Road (such as the 5th Aviation [5AVN]) Fire Water booster pumps site and Ruediger Park) in the southern portion of the base. On-base monitoring locations are also based around three primary source areas identified through previous investigations; these are identified as SMAs as the activities in these areas were considered to have resulted in the most substantial PFAS impacts to soil, surface water, sediment, and groundwater at the base. The SMAs are shown in Figure 2 in Appendix B.

Off-base monitoring locations within the Monitoring Area include residential areas that have a cumulative area of approximately 2,506 ha, which comprise the residential suburbs of Pallarenda, Rowes Bay, West End, and Belgian Gardens (Department of Defence PMAP, 2019). Land use within the off-base area is primarily residential; however, various public facilities and parklands also exist in these suburbs. The suburb of Garbutt is a mix of approximately 50% residential and 50% commercial. Garbutt State School is also located in the off-base region of the Monitoring Area. The suburbs of Mount Louisa, Mount St John and Bohle are zoned commercial/light industrial under the Townsville City Plan. The Town Common is zoned “Public Utilities – Townsville City Council (Reserves)” and “Special Uses – National Parks” under the Townsville City Plan. The Monitoring Area also includes the Bohle River and Bohle River estuary, which is used extensively for recreational fishing.

2.2 Monitoring area setting

The climate of Townsville is classified as tropical; however, due to its geographical location and localised influences of topography and landform, rainfall is lower than other locations on the coast of North Queensland. The months of November to April (wet season) are hot and humid, whereas May to October (dry season) is dry with warm days and cool nights. The average annual rainfall at the base is 1,129.4 mm, with the mean minimum rainfall of 10.1 mm in September and the mean maximum rainfall of 301.9 mm in February (BOM, 2024). Rainfall is variable year to year, with the potential for high rainfall periods to cause localised flooding during the wet season.

The pronounced wet season has a substantial bearing on the surface water and groundwater flow regimes across the Monitoring Area. Many of the watercourses (and drains) that flow through the on-base and off-base areas are ephemeral, with little to no water (ponded or flowing) present during the dry season. Within the off-base watersheds, permanent surface water is prevalent in the wetlands to the northwest of the RAAF Base, and in the intertidal reaches of Louisa, Mundy, and Three Mile creeks, and the Bohle River.

Groundwater flows in a generally northerly direction across the Monitoring Area towards the Town Common and Rowes Bay. An elongated piezometric high extends from Garbutt south of the base in a north-north-easterly direction through the southeast portion of the base. Therefore, groundwater flow from the base is partially radial, being westward from Sub-Management Area 3, north-westerly from the fire station (Sub-Management Area 2) and ordnance loading areas (OLAs), and north-easterly from the domestic airport facility area of the base. Groundwater flows westerly to Peewee Creek/Louisa Creek, north-westerly to the Town Common wetlands and north-easterly and easterly to the Mundy Creek catchment and Rowes Bay (WSP 2018a, 2019a).

The base and surrounds are generally flat and low lying associated with the Bohle River and Town Common wetlands system and is subject to flooding. The base and domestic airport have an elevation between 2 m AHD and 5 m AHD, which slopes slightly to the north and north-west, reaching sea level in the Town Common and on the beach at Pallarenda and Rowes Bay. Volcanic hills with a maximum height of 35 m AHD are present in Rowes Bay and Mount St John.

The general underlying geology of the Monitoring Area is Quaternary alluvium comprising of clay, silt, sand and gravel (Department of Defence PMAP, 2019). The soils underlying the majority of the Management Area (the base) comprise thin light grey-brown fine sandy loam or silty loam over dark grey heavy clays. The low-lying areas of the Town Common and Mundy Creek have soils comprised of fine sandy loam or loam overlying very dark greyish brown and olive heavy clays, or grey cracking clays. The coastal areas of Rowes Bay and Pallarenda have coarse sandy soils.

2.2.1 Surface water

The Monitoring Area has three main surface water catchments: the Bohle River drainage sub-basin (which includes Louisa Creek), Three Mile Creek, and Mundy Creek, each of which have a point of origin or flow-through path in the Monitoring Area (Figure 1). The surface water setting of the Monitoring Area is described as follows in the PMAP (Department of Defence, 2019):

<u>RAAF Base (On-base Area)</u>

Three main drainages flow into the base: Louisa Creek, Peewee Creek, and Mount St John Drain. The main inflow to the Management Area comes from Louisa Creek, with an upper catchment of approximately 745 ha that is largely urbanised. Peewee Creek drains an urban catchment of 156 ha to the south-east of the base. It is a small water course that flows into Louisa Creek at the base to the west of Sub-Management Area 3.

Drainage of a catchment to the west enters the base through the Mount St John Drain. The Mount St John Drain is separated from Louisa Creek by an elevated ridge line and the Mount St John water treatment plant (WTP). The primary flow path of the drain is north, away from the base; however, during high flow events there is potential for flow to back up around the ridge line into Louisa Creek, impacting the base.

The internal catchment of the base catchment is approximately 700 ha, most of which drains towards the north-west into the Louisa Creek flood plain and the Bohle Estuary. The catchment is made up of mostly mix grassed and wetland areas, including Lake Lydeamore, with the remainder being buildings and hardstand. There are localised drainage issues within the south-western section of the base due to the concentrated proportion of impervious area (Sub-Management Area 3) and limited hydraulic capacity of the drainage network. The on-base wetlands are generally internally draining, only discharging at times of heavy rainfall.

Four other drainage catchments exist on the base:

- A network of drains in the south-east corner of the base flow off-base to the east and then north into the Mundy Creek catchment and, in turn, Rowes Bay. The catchment consists of a mixture of hardstand, buildings and grassed areas, the largest grassed area being the former fire training grounds (Sub-Management Area 1).
- A drainage network runs north between the OLAs and Runway 01/19, which discharges from the base through valved pipework on the base's northern boundary. The discharge then runs northerly through a network of wetlands past the Rowes Bay Golf Club and into Three Mile Creek. A drain runs along the base's eastern boundary at the northern end of the base beyond Runway 01/19 and discharges at the base's north-eastern corner into the wetlands that run north past Rowes Bay Golf Club.
- A drainage network runs north between Runway 01/19 and the eastern boundary of the base. These drains run north and south and discharge into the drain at the end of Old Common Road. This watercourse flows east into Mundy Creek and then Rowes Bay.
- The area to the north of Runway 01/19 along the eastern boundary of the base appears to drain east into the watercourse that runs south-east to the north of the Belgian Gardens Cemetery, joining Mundy Creek before flowing into Rowes Bay.

Sections of the base adjacent to the runways subject to inundation have pumping networks designed to prevent flooding of the runways. Surface waters are pumped from sumps into the wetlands on the western, north-western, and northern sides of the base.

<u>Townsville Domestic Airport (On-base/Off-base Area)</u>

As Townsville Airport shares the same runway (Runway 01/19) as the base, the drains near the runway and on the eastern border of the base run through Townsville Airport, into the suburb of Rowes Bay, and exit at Mundy Creek.

<u>Townsville City Council Areas (Off-base Area)</u>

At the northern suburb of Pallarenda, Three Mile Creek runs from the Town Common and branches out south towards Rowes Bay and exits towards the ocean, north of Rowes Bay Park. The watercourse is part of the Bohle drainage division. Three Mile Creek is joined by the watercourse that drains the northern part of the base and the Rowes Bay Golf Club.

Drainage from the eastern and northern parts of Garbutt, Belgian Gardens, and the northern part of West End runs through a network of drains to the north, joining Mundy Creek and running into Rowes Bay. There are canals running through the south-western section of Garbutt, which flow west into Peewee Creek, which flows north from Mt Louisa, joining Louisa Creek in the wetlands to the west of the base. Canals/drainage flowing from Mount Louisa end on the south side of Mount St John. Drainage and some canals also run through the outside of the industrial area, north of Mount St John. The canals on the northern section flow into Louisa Creek.

The south-western section of Garbutt and most of the suburb of West End drain to the south, entering the unnamed lake between Ingham Road and Woolcock Street, which overflows eastward into National Creek. National Creek joins Ross Creek approximately 3.7 km east of the base, which then flows north-east, entering Cleveland Bay at the Port of Townsville.

The Town Common (Off-base Area)

The Town Common includes a large part of the estuarine system and drainage from the Bohle River, including Peewee Creek and Louisa Creek, and Three Mile Creek. Within the Town Common, a 1.07 ha perennial lake is located near Causeway Road and Freshwater Lagoon Road. The Town Common receives surface water runoff from the base and from the suburbs of Bohle, Mount Louisa, and part of Garbutt.

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.

3.1 Source areas

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

Primary source areas that have been identified through previous investigation up to 2024 are presented in Table 3.1. These investigations include the detailed site investigation (RPS/Wood 2019), annual mass discharge assessments (WSP, 2023a,b,c), remedial action plans (WSP 2021, 2023d,e) and the recent Ongoing Monitoring Report (AECOM 2024b). The information provided in the above-listed reports is being compiled in the Draft 2025 PMAP, which is currently being prepared for Defence.

The PMAP (Department of Defence, 2019) identifies three SMAs in the on-base region of the Management Area where specific activities were considered to have the most substantial PFAS impacts to soil, surface water, sediment, and groundwater. These areas are also where further assessment and management actions may be appropriate. Specifically:

- Sub-Management Area One (SMA 1) includes the Former Fire Training Area
- Sub-Management Area Two (SMA 2) includes the Fire Station Locale and Fuel Farm 2; and
- Sub-Management Area Three (SMA 3) includes the 5th Aviation Regiment (5AVN), which is a large area that includes aviation hangers.

A figure showing the key source areas is presented as Figure 2 in Appendix B.

Table 3.1: Known PFAS source areas, RAAF Base Townsville (to 2024)

Source area name	Contaminated Site Record (CSR) Number	PMAP Source	Catchment	Extent of PFAS Contamination
Former Fire Training Area	CSR_QLD_000246	SMA1	Mundy Creek Catchment	• Soils have been remediated through a combination of off-base treatment and disposal, off-base thermal destruction, and on-base soil stabilisation. • The surface water drainage channel has been upgraded to limit groundwater/surface water interaction and improve drainage through SMA1. • The stabilised soils and residual PFAS contamination are managed under a long-term environmental management plan (LTEMP). • Post-remediation monitoring will be undertaken as part of the **OMP** and **post remediation mass discharge assessments**.
Former Fuel Farm 1	CSR_QLD_000236	--		• Limited PFAS assessment due to the presence of critical Defence infrastructure (back-up power station and other smaller buildings); however, concentrations to date were moderate to high. • Re-evaluation of additional PFAS data to considered further investigation or management options. • **Ongoing monitoring** required.
Cadet Training Area (38 SQN and domestic area)	-	--		• Low concentrations of PFAS in soil and groundwater compared to other areas of the base. Although PFAS concentrations exceeded residential criteria adopted for this portion of the base, the Human Health Risk Assessment (HHRA) found health risks to be low. • Sources include historical fire training by cadets, and production of foam for open days. • No further action required.
Fire Station Locale	CSR_QLD_000245	SMA2	Bohle River / Louisa Creek / Town Common Catchment	• High concentrations of PFAS have been measured in soil, groundwater, and surface water, that is centrally located on-base and was historically used for sparging of fire truck tanks, equipment testing, and other fire response training activities. • Based on the mass discharge assessments completed for surface water and groundwater, SMA2 is the greatest contributor to PFAS migration from the base. • **Remediation actions** for this area scheduled for 2025.
Fuel Farm 2 Forecourt and Eastern Flank	CSR_QLD_000351 CSR_QLD_000679			

Source area name	Contaminated Site Record (CSR) Number	PMAP Source	Catchment	Extent of PFAS Contamination
5th Aviation Regiment (5AVN) facilities 5th Aviation Regiment (5AVN) wash bay	CSR_QLD_000680 CSR_QLD_000681	SMA3	Bohle River / Louisa Creek / Town Common Catchment	• Historical activities have included testing of deluge systems, including discharges and spills from hangars. • Moderate concentrations of PFAS have been measured in soil, groundwater, and surface water. • Groundwater and surface water from SMA3 discharge to the west (to the Louisa Creek catchment area). Baseline mass discharge assessment in surface water and groundwater completed. • Remediation and management options for SMA3 are limited due to the area's operational status and sealed ground (comprising buildings, concrete, tarmac and roads). • Re-evaluation of available data to consider further investigation or management options. • **Ongoing monitoring** required.
Disused runway 13/31. Historical training including the former burn pit adjacent to the western end of disused runway 13/31	CSR_QLD_000682	--		• Visual evidence of burn pits identified. • Moderate concentration of PFAS measured in soils. • Re-evaluation of available data to consider further investigation or management options. • **Further investigation** required to assess PFAS mass contribution and viability for remediation. • **Ongoing monitoring** required.
Former Fire Training Area (near OLAs)	CSR_QLD_000248	--		• Moderate concentrations of PFAS in soil and groundwater. • Re-evaluation of additional PFAS data to considered further investigation or management options. • **Ongoing monitoring** required.

Source area name	Contaminated Site Record (CSR) Number	PMAP Source	Catchment	Extent of PFAS Contamination
Former Fire Training Area (between Fire Station and Runway) and Emergency response adjacent to Runways 07/25 and 01/19 (Areas V, W, X and Y)	CSR_QLD_000244	--	Bohle River / Louisa Creek / Town Common Catchment	• Low concentrations of PFAS in soil. • No further action required.
Pad Brahman	-	--		• Low concentrations of PFAS measured in soil and groundwater. • No further action required.
Ingham Road sports field (including Ruediger Park)	-	--		• Low concentrations of PFAS measured in soil, groundwater, and surface water. • No further action required.
Former Fire Training Ground at the northern end of the main runway 01/19	CSR_QLD_000247		Three Mile Creek Catchment	• Visual evidence of burn pits was identified adjacent to the northern end of the main runway 01/19 (in service). • Moderate concentrations of PFAS measured in soils. • Re-evaluation of available data to consider further investigation or management options. • **Further investigation** required to assess extent, PFAS mass contribution and viability for remediation

- = No CSR Number assigned

-- = Source area located outside of a SMA.

3.2 PFAS migration pathways

Due to its high solubility, PFAS can travel from a source area to human or environmental receptors by surface water or groundwater. This migration mechanism is referred to as a transport pathway. The Detailed Site Investigation (DSI) for RAAF Base Townsville (WSP, 2018a) identified that the dominant transport pathway for PFAS from the base to sensitive receptors is via surface water including discharge of groundwater to surface water and pumping of excess stormwater from the active runways to the adjacent on-base wetlands.

Whilst groundwater pathways do exist, they are highly interconnected with surface water due to seasonal effects and the coastal low-lying position of the base, which regularly floods during the wet season resulting in surface expressions of groundwater from the rising water table. The extent of PFAS in groundwater is generally at lower concentrations than surface water within the Management Area.

These migration pathways, and the potential mass of PFAS migrating off-base was assessed as part of the PFAS Mass Flux Investigations for the three SMAs (WSP Golder, 2023), (WSP, 2023a), and (WSP, 2023b). These studies identified that the mass of PFAS migrating in surface water is substantially greater than the mass from the groundwater transport pathway. Comparison of the relative contribution of PFAS from surface water and groundwater from each of the SMAs is summarised in Table 3.2, which demonstrates that PFAS contribution from the base to the downstream extent of the Monitoring Area via surface water and groundwater migration pathways is dominated by SMA2.

Table 3.2: Comparison of surface water and groundwater migration pathways and relative mass contribution

Source	Annual ∑28 PFAS (g/year)		Percentage contribution to PFAS mass by source area	
	Surface Water	Groundwater	Surface Water	Groundwater
SMA1	510	14	4%	3%
SMA2	11,122	339	89%	71%
SMA3	928	127	7%	26%
Total	**12,560**	**480**	**100%**	**100%**

In addition to the three primary source areas, there may be additional sources at the base, contributing to the overall PFAS mass being discharged from the base. The total PFAS discharge leaving the base has not yet been assessed and investigations to date have been limited to the three primary source areas (SMA1 to SMA3).

3.3 Receptors and risks

The evaluation of risk to a set of identified human and ecological receptors via the above exposure pathways has been undertaken in the HHRA the Ecological Risk Assessment (ERA). A summary of the risks to human and ecological receptors is provided in Section 3.3.1 and Section 3.3.2, respectively.

3.3.1 Human receptors

The HHRA (WSP, 2018b) was completed to assess potential risk to human health associated with exposure to PFAS both on-base and off-base. The HHRA considered exposure to PFAS in soil, sediment, surface water, and groundwater and included uptake from home-grown fruit, vegetables, locally caught fish species.

A complete exposure pathway must exist for a person to be exposed to PFAS. If the exposure pathway is not complete, then no PFAS exposure will occur and, as a result, no risk to health exists. Conversely, if a complete exposure pathway does exist, then the total uptake or dose of PFAS over time, (that is, the amount of PFAS that enters a person's body), dictates the potential for an adverse health outcome. The health-based guideline levels used in the HHRA are based on the known dose-response relationship combined with several safety factors to account for uncertainties.

The HHRA process included a comparison of reported PFAS concentrations within the different media (for example, soil) to health-based investigation levels (HIL) or guideline values published by Australian regulators. This is considered a Tier 1 or screening level assessment. These criteria and guideline values are highly conservative and deliberately set at concentrations below levels where adverse health effects are not expected to occur in a general population. Therefore, if concentrations of PFAS are below the respective guideline values, adverse health effects are not expected to occur, even in sensitive individuals within a population. If PFAS concentrations exceed the guidelines in a Tier 1 or screening level assessment, a more detailed Tier 2 assessment is undertaken, refining the complete source, pathway receptor factors, to provide a more accurate estimate of the dose. The total amount of PFAS calculated is compared to the Tolerable Daily Intake (TDI) set by Food Standards Australia New Zealand (FSANZ) (2017). This is common HHRA practice and endorsed by national and international agencies.

The HHRA for RAAF Base Townsville concluded that the potential risk from exposure to PFAS both on-base and off-base was low and acceptable, except for the following based on conservative exposure assumptions:

- Eating locally caught fish: specifically, children eating high quantities of fish flesh, and adults and children eating average quantities of fish liver, and
- On-base workers incidentally ingesting groundwater during maintenance activities, particularly during the wet season when the water table is high.

Below is a summary of the key receptors and risk.

Table 3.3: PFAS Receptors and Risk – Human Health (Adapted from HHRA [WSP, 2018b])

Who? (Receptor Populations)	Where? (Source Location)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
Off-base						
Local residents	Off-base soil in yards	Touching soils or accidental ingestion (swallowing) of soil. Inhalation of soil and dust (soil-derived). This includes soils that have been irrigated with bore water.	Low	Low PFAS concentrations in soil.	PFAS levels measured within off-base **soil** from private residential land were below health-based investigation levels set for residential soil except for one location. The estimated total PFAS intake dose for the soil-based exposure scenario at that location was assessed and the risk was considered low.	Although no additional soil data have been collected, the screening criteria against which the screening was completed have changed (the guideline values are higher than they were previously). As the screening criteria have increased rather than decreased, the risk profile is unlikely to have changed as a result.
Local residents	Off-base garden produce	Eating fruit, vegetables, and poultry eggs irrigated with groundwater and grown/ collected at home.	Low	Concentrations of PFAS in home grown produce are low. Assumes 10% of food consumed daily comes from garden produce.	To supplement the analytical results, theoretical PFAS concentrations were calculated for the HHRA, based on the results of the Water Use Survey and the risk was considered low. It was also noted that the home grown produce, vegetables, fruit and poultry do not appear to be widely grown within the Monitoring Area.	As home-grown produce was not identified to be widely grown and irrigated with bore water off-base, this risk profile is unchanged. There was a low response rate for the Water Use Survey and due to changes in property ownership, water uses may have changed and therefore the risk profile may change over time.
Local residents	Off-base groundwater	Touching of or accidental ingestion (swallowing) of extracted groundwater used for irrigation of gardens and garden produce.	Low	Limited use of groundwater for irrigation.	The Water Use Survey indicated that 11% of residents had a groundwater bore used to irrigate lawns, gardens, vegetables or fruit trees. There are no guidelines for PFAS in irrigation water. Based on the risk assessment outcomes, the risk is low.	Although PFAS concentrations have exceeded the drinking water guidelines in groundwater monitoring wells, these wells are only used for irrigation. There was a low response rate for the Water Use Survey and due to changes in property ownership, water uses may have changed and therefore the risk profile may change over time.
Local residents and recreational users of local swimming pools and parks	Off-base groundwater	Touching of or accidental ingestion (swallowing) of extracted groundwater used for filling swimming pools.	Negligible	Based on the outcomes of the water use survey, groundwater is not used for drinking, filling of swimming pools (public or private) and other non-potable water uses.	No Water Use Survey respondents indicated using bore (groundwater) water or surface water as a primary source of drinking water or filling of pools. The off-base Monitoring Area is serviced by Townsville City Council supplied water which is primary water source for drinking and for filling pools. Based on the risk assessment outcomes, the risk is low.	Although PFAS concentrations have exceeded the drinking water guidelines in groundwater monitoring wells, these wells are not used for filling pools or drinking water. It is noted that there was a low response rate for the Water Use Survey and changes in land ownership may result in changes to water uses over time.

Who? (Receptor Populations)	Where? (Source Location)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
Local residents and recreational users	Off-base Surface water and sediments (in Mundy Creek, Bohle River, Louisa Creek, Town Common, Three Mile Creek)	Accidental ingestion and inhalation of water during swimming, boating, and other water activities.	Negligible	Low PFAS concentrations in sediments. Low to moderate PFAS concentrations in surface waters.	PFAS levels measured in surface water and sediments of local rivers, creeks, rivers and tributaries exceeded the health-based recreational screening criteria which have been developed to consider incidental ingestion and dermal exposures, however waterways in the off-base Monitoring Area are not deemed safe for swimming due to dangerous wildlife (as signposted with crocodile and stinger warnings).	The risk profile remains unchanged as the hazards associated with swimming in the creeks remain unchanged and therefore the assumptions made in the HHRA remain valid. The way in which the creeks and waterways are used may change over time and this may change the risk profile.
Recreational Anglers	Off-base Local waterways and tributaries within the off-base Monitoring Area (Mundy Creek, Bohle River, Louisa Creek, Town Common, Three Mile Creek)	Eating locally caught seafood.	Fish - Low for adults, marginal for a child consuming higher than average amounts of fish. Fish liver – marginal (for average intakes) to elevated risk. (for upper limit intakes)	Exposure scenarios considered fish flesh or fish liver (assuming the whole fish was consumed or utilised). Based on number of local fish meals eaten each week.	PFAS within the fish (flesh) samples were reported above the Food Standards screening criteria in estuarine waterways only. All other fish flesh results were reported below the food standards screening criteria.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Recreational users of Ingham Road Sports Field (Ruediger Park)	Off-base Soil at playing fields	Touching and accidental ingestion (swallowing) of soil. Inhalation of soil and dust (soil-derived).	Low	Low concentrations in publicly accessible soil.	PFAS levels measured within off-base **soil** at the Ingham Road Sports Fields were below health-based investigation levels set for public open space and therefore this pathway was not considered further.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Maintenance / utility workers off-base working in a trench or open ground	Off-base PFAS in soil, sediment and water	Touching and accidental ingestion (swallowing) of soil, sediment and water. Inhalation of soil and dust (soil-derived).	Low	Low PFAS concentrations in soils and sediments. Low to moderate PFAS concentrations in waters.	There are no available soil, sediment or water screening criteria for intrusive maintenance works, therefore the scenario was quantified in the risk assessment. The estimated total PFAS intake due to dust inhalation or contact with or	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.

Who? (Receptor Populations)	Where? (Source Location)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
					ingestion of water, soil or sediment was assessed, and the risk was low.	
On-base						
Defence personnel, contractors (including maintenance and utility workers), and visitors	On-base Soil	Touching and accidental ingestion of soil. Inhalation of soil and dust (soil-derived).	Low	Low PFAS concentrations in soil.	PFAS levels in on-base soils were lower than screening levels for industrial and commercial worker scenarios, and the risks to health are low and manageable. Exposures can be further managed and reduced through the implementation of standard health and safety procedures.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Defence personnel, contractors, and visitors	On-base Groundwater	Drinking extracted groundwater.	Negligible	No exposure pathway to groundwater	on-base groundwater is not extracted or used for drinking or irrigation; therefore, this exposure pathway does not exist for this receptor.	The risk profile remains unchanged as there is no new information to indicate a change.
Defence personnel, contractors (including maintenance and utility workers), and visitors	On-base Surface water and sediments	Direct contact with surface water and sediments.	Negligible to low	No exposure pathway to surface water and sediments.	Base personnel do not enter surface water bodies on-base to swim or boat. Therefore, no complete exposure pathways exist. There are no screening criteria for PFAS in sediments and the risk assessment concluded the risks to health from direct contact with on-base sediment were low. There are no specific water guidelines for maintenance and excavation workers, however PFAS concentrations in surface water are sufficiently low to not present a risk to health. Exposures can be further managed and reduced through the implementation of standard health and safety procedures	The risk profile remains unchanged as the assumptions made in the HHRA are still valid. The surface water screening criteria for recreational use have changed (the guideline values are now higher than they were previously). The risk profile therefore remains unchanged as more conservative measures were applied to the HHRA, and the risk was low.
Kindergarten – children and adult workers	On-base Exposure to PFAS in soils greater than 0.5 m deep	Inhalation of soil-derived dust.	Low	There is a potential elevated health risk for soils brought to the surface from depth. This exposure would occur under construction and	Soil PFAS concentrations exceeded the health-based investigation levels (for residential with garden/accessible soil) at depths greater than 0.5 m and therefore this scenario was further quantified in the HHRA. The risk to children from inhalation of dusts containing PFAS is considered low.	Whilst the soils at the kindergarten remain at depths greater than 0.5 m depth, the risk profile remains unchanged. Where soils at the kindergarten may be brought to the surface during construction or maintenance activities, a change in the risk profile may occur and

Who? (Receptor Populations)	Where? (Source Location)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
				base maintenance activities and therefore be managed under Defence procedures.	Soils brought to the surface from greater than 0.5 m deep are not suitable for re-use within the kindergarten area. The soils are suitable for re-use elsewhere on-base in accordance with the Defence PFAS Construction and Maintenance Framework (Department of Defence, 2021). Additional administrative controls may be required to manage disturbance of soils at the kindergarten, such as a long-term environmental management plan.	additional mitigations may be required to use the soils elsewhere on-base.
Kindergarten – children and adult workers	On-base Exposure to PFAS in surface soils and soils less than 0.5 m deep.	Direct contact pathways (oral ingestion, dermal contact and dust inhalation).	Low	Low PFAS concentrations in soil.	Soils that are readily accessible to users of the kindergarten (that is, soils less than 0.5 m deep) were lower than health-based investigation levels (for residential with garden/accessible soil).	Although no additional soil data have been collected the screening criteria against which the screening was completed have changed (the guideline values are higher than they were previously). The risk profile therefore remains unchanged as more conservative measures were applied to the HHRA.
Kindergarten – children and adult workers	On-base Sediment and surface water	Direct contact with sediments and surface water.	Negligible	No exposure pathway to surface water and sediments	There are no on-base drains, open pits, open stormwater drains and waterways at the kindergarten for children to swim in.	The risk profile remains unchanged as the assumptions made in the HHRA are still valid.
Maintenance / utility workers on-base working in a trench or open ground	On-base Groundwater in excavations	Touching and accidentally drinking groundwater during construction dewatering or installation of service trenches.	Marginal – wet season Low – dry season	PFAS concentrations in groundwater present a slightly elevated risk when groundwater is intersected during works.	There are no specific water guidelines for maintenance and excavation workers. PFAS concentrations in groundwater exceeded the drinking water criteria, although the groundwater is not used for drinking. The risk was considered low where groundwater was not intersected during works. However, when groundwater is intersected during works (which is more likely to occur when the water table is high during wet season), the risk increases from low to marginal. If groundwater is to be encountered during excavation, exposure can be controlled through work health and safety	The risk profile remains unchanged as there is no new information to indicate a change.

Who? (Receptor Populations)	Where? (Source Location)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
					protocols. As such, people are not exposed to PFAS in groundwater and the risks are low.	

[1] - Direct contact pathways – oral ingestion includes eating soils, drinking groundwater; incidental ingestion includes getting water in the mouth when swimming; touching soils or waters and then eating food without washing hands; dermal contact includes touching the soils; inhalation includes breathing in dust from soils

3.3.2 Ecological receptors

The ERA (WSP, 2019b) was undertaken to assess potential risk to the environment. The ERA assessed potentially complete exposure pathways associated with PFAS in surface water, sediment, and sediment pore water within the Monitoring Area for:

- lower order species (ie plants, terrestrial invertebrates, aquatic invertebrates and fish) – based on comparison to adopted screening benchmarks; and
- higher order species (ie predatory birds, mammals and reptiles) – based on quantitative food web modelling.

Arboreal mammals (ie mammals that spend most of their time in trees) were excluded from the ERA as they were considered to have a lower potential exposure compared to terrestrial animals. The ingestion of PFAS in groundwater was not evaluated as a separate exposure scenario as assessment of surface waters provided a better representation of potential ingestion exposures.

Key conclusions from the ERA are:

- There is a potential elevated risk to aquatic habitat species, specifically predatory mammals and invertivorous and omnivorous birds in wet season conditions.
- There is a potential risk for toxicity to mammals and predatory birds who eat aquatic biota including fish and crustaceans, based on biota tissue sample PFAS concentrations in fish, crustaceans and molluscs collected off-base.
- There are negligible toxicity risks for aquatic plants based on a comparison against adopted screening benchmarks.
- Some bioaccumulation of PFOS is potentially occurring through the food web (or food chain, where one organism eats another) for terrestrial and semi-terrestrial mammals, herbivorous birds, invertivorous and omnivorous birds, and predatory birds.

The ERA identified potential for direct toxicity effects to occur to lower order terrestrial/semi-terrestrial and aquatic species (ie plants, terrestrial invertebrates, aquatic invertebrates, fish), and for bioaccumulation of PFOS to occur to higher order species both on-base and off-base. PFOA concentrations in surface water, groundwater, and soils did not exceed adopted ecological screening criteria and were therefore not carried further in the ERA.

A summary of the ecological risk outcomes is presented in Table 3.4 for terrestrial and semi-terrestrial receptors and Table 3.5 for aquatic receptors, below.

Table 3.4: PFAS Receptors – Terrestrial Ecological Receptors (Land-based) (Adapted from ERA [WSP, 2019b])

Who? (Receptor Populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
On-base (Where - source location?)					
Herbivorous mammals (Pale Field Rat, Agile Wallaby)	Ingestion of food (eating plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Moderate	There is a potential for exposure to PFOS through bioaccumulation in the food web. PFOS concentrations in surface water, groundwater, and soil on-base exceeded the adopted ecological screening criteria at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	PFAS were not detected in any plant samples. The total intake doses modelled from dietary exposure for herbivorous mammals indicated the potential for bioaccumulation for both dry and wet seasons and therefore the risk was categorised as elevated. The exception being for the herbivorous Agile Wallaby whose modelled total intake during the wet season was assessed as low and acceptable. The total intake dose modelled from dietary exposure, for multiple bird species, indicated the potential for bioaccumulation all year round, therefore the risk was categorised as moderate.	No new site-specific information has been identified that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous birds (Magpie Goose, Wandering Whistling Duck)					
Invertivorous and omnivorous mammals (Canefield Rat, Lesser Long Eared Bat)	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).			The total intake dose modelled from dietary exposure for the Canefield Rat indicated the potential for bioaccumulation all year round and therefore the risk was categorised as moderate. The total intake dose modelled from dietary exposure for the Lesser Long Eared Bat was acceptable all year round. As there was variability between species in the modelled exposure due to seasonal conditions, the risk was categorised as moderate.	
Invertivorous and omnivorous birds (White-browed Crake, Little Pied Cormorant, Pacific Black Duck)				The total intake doses modelled from dietary exposure, for multiple bird species, indicated the potential for bioaccumulation all year round and therefore the risk was categorised as moderate.	

Off-base (Where?)					
Herbivorous mammals (Pale Field Rat, Agile Wallaby)	Ingestion of food (eating plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Low	PFOS concentrations in soils, surface water and groundwater exceeded the adopted ecological screening criteria at some locations off-base but were lower than on-base concentrations. Concentrations of PFOA in soil, groundwater and surface water off-base did not exceed adopted ecological screening criteria.	PFAS were not detected in any plant samples. The total intake doses modelled from dietary exposure for multiple species were acceptable all year round for all receptors modelled and therefore the risk was categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous birds (Magpie Goose, Wandering Whistling Duck)					
Invertivorous and omnivorous mammals (Canefield Rat, Lesser Long Eared Bat)	Ingestion of food (eating animals and plants containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).				
Invertivorous and omnivorous birds (White-browed Crake, Little Pied Cormorant, Pacific Black Duck)					
On-base and Off-base (Where?)					
Predatory mammals and reptiles* (Water Rat and Eastern Water Dragon)	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking).	Low	There is a potential for exposure to PFOS that may bioaccumulate through the food web. PFOS concentrations in surface water, groundwater and soil on-base and off-base exceeded the adopted ecological screening criteria with higher concentrations reported on-base. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	PFAS (specifically PFOS + PFHxS) concentrations in the liver were generally higher in predatory species. The total intake doses modelled from dietary exposure for predatory mammals and reptiles were acceptable all year round and therefore the risk has been categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Predatory birds (Swamp Harrier, Brahminy Kite, Black Kite)	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS.	Moderate		The total intake dose modelled from dietary exposure, for multiple bird species indicated the potential for bioaccumulation and therefore the risk was categorised as moderate.	

[1] - Excluding Freshwater Snake, Cann's Longnecked Turtle, and Australian Freshwater Crocodile.

TRV – Toxicity Reference Value.

Table 3.5: PFAS Receptors – Aquatic Ecological Receptors (Water habitat) (Adapted from ERA [WSP, 2019b])

Who? (Receptor Populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
On-base (Where?)					
Predatory mammals (Water Rat)	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking)	Moderate during wet season	There is a potential for exposure to bioaccumulate PFOS through the food web. PFOS concentrations in surface water, groundwater and soil on-base exceeded the adopted ecological screening criteria at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	The total intake doses modelled from dietary exposure for multiple species indicated the potential for bioaccumulation. The risk was categorised as elevated due to seasonal variability.	No new information has been identified that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Invertivorous and omnivorous birds and aquatic birds – birds that live in wetlands and forage in water (White-browed Crake, Little Pied Cormorant, Pacific Black Duck)	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking)	Moderate			
Off-base (Where?)					
Predatory mammals (Water Rat, Australian Snubfin Dolphin)	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking)	Low	PFOS concentrations in soils, surface water and groundwater exceeded the adopted ecological screening criteria for at some locations off-base but were lower than on-base. Concentrations of PFOA in soil, groundwater and surface water off-base did not exceed adopted ecological screening criteria.	The total intake doses modelled from dietary exposure for multiple species and satisfied the TRVs, all year round and therefore the risk was categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Herbivorous mammals (Dugong)	Ingestion of food (eating seagrass containing PFAS)				

Who? (Receptor Populations)	How? (Exposure Pathway)	What? (Assessment of Risk)	Why? (Reason for Risk)	Added Context	Has the Risk Profile Changed?
	and water (during feeding/breathing)				
Invertivorous and omnivorous birds, including aquatic birds – birds that live in wetlands and forage in water (White-browed Crake, Little Pied Cormorant)	Ingestion of food (eating plants and animals containing PFAS) and drinking water containing PFAS, incidental ingestion of soil/sediment (when eating and drinking)				
On-base and Off-base (Where?)					
Predatory birds (Eastern Great Egret, Little Black Cormorant)	Ingestion of food (eating mainly fish containing PFAS) and drinking water containing PFAS.	Low	There is a potential for exposure to bioaccumulate PFOS through the food web. PFOS concentrations in surface water, groundwater and soil on-base exceeded the adopted ecological screening criteria for at most on-base locations. PFOA concentrations in surface water, groundwater and soils did not exceed adopted ecological screening criteria.	The total intake dose modelled from dietary exposure for multiple species and satisfied the TRVs all year round and therefore the risk was categorised as low.	No new information has been discovered that would impact the findings of the ERA and therefore the risk profile remains unchanged.
Predatory reptiles (Freshwater Snake, Cann's Longnecked Turtle, and Australian Freshwater Crocodile, Eastern Water Dragon)	Ingestion of food (eating animals containing PFAS) and drinking water containing PFAS. Incidental ingestion of sediment considered for Eastern Water Dragon only				

TRV – Toxicity Reference Value.

4 ONGOING MONITORING PLAN

This section sets out the data quality objectives, monitoring scope, and assessment requirements for the OMP field work. Changes made to the previous OMP (Attachment to the PMAP; Department of Defence, 2019) are summarised in the following sections, and supporting rationale is provided in Appendix D.

4.1 Sampling, analysis, and quality plan

A 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), and sampling 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 are needed to inform decisions relating to the environmental condition of a monitoring location. 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	The base has historically been used as a Defence facility, which includes a fire station and a fire training centre. The fire station and fire training centre are understood to have included the use of AFFF during training activities. PFAS has historically been identified in soil, surface water, sediment, and groundwater at the site and the surroundings.
Step 2: Identify the goal of the study	The goals of the assessment are to: • evaluate the nature and extent (spatial and temporal) of PFAS impact in groundwater and surface water pathways associated with site sources of PFAS derived from AFFF. • monitor the migration of PFAS in groundwater and surface water from the base. • provide confirmation of the current understanding of risk. • provide supporting data for assessment of management actions originating from the PMAP.
Step 3: Identify the information inputs	The inputs required to achieve the goals of the assessment are: • available geological and hydrogeological data. • available previous investigation results, site information, and information from publicly available databases and government websites.

Process	Description
	• field observations. • laboratory analytical data for contaminants of potential concern in groundwater, surface water, and sediment collected in the Monitoring Area. • site assessment criteria for the media assessed.
Step 4: Define the boundaries of the study	The PFAS Monitoring Area considered in this OMP includes the RAAF Base and the surrounding residential suburbs as described in the PMAP for the base (refer to Figure 2, Appendix B for the boundaries). The vertical limits of the OMP will extend to the maximum depth of groundwater monitoring wells. The temporal boundaries will be from the date of the available historical data to the final sampling date for the assessment. The analytical detection limits (ie limit of reporting [LOR] by the analytical laboratory, Section 4.8) define a data boundary for which PFAS concentrations will be detected as part of the monitoring.
Step 5: Develop the analytical approach/decision rules	The purpose of this step is to define the parameters of interest, specify the action levels, and combine the outputs of the previous DQO steps into an 'if…then…' decision rule that defines the conditions that would cause the decision maker to choose alternative actions. The decision rules for the assessment (defined as screening triggers) are: • If PFAS concentrations are not detectable (<LOR) or measured below the screening criteria applicable to the monitoring location (eg on-base, off-base), it will be considered whether monitoring is to be continued or reduced – *Negligible potential to result in a risk profile change (Trigger 0)*. • If PFAS concentrations are detectable, above the adopted screening criteria applicable to the monitoring location (eg on-base, off-base), and have the potential to affect the risk profile for that location, further assessment and response required. • If PFAS is reported at a concentration that is greater than the 85th percentile of the existing data for the monitoring location and shows a visual increasing trend[1] for the previous three (3) wet seasons, then data verification will be undertaken. If verified, further assessment and mitigation responses will be required – *High potential to result in a risk profile change (Trigger 3)*. • If PFAS is reported at a concentration that is greater than the 65th percentile of the existing data for the monitoring location and shows a visual increasing trend[1] for the previous three (3) wet seasons, then further assessment may be considered – *Elevated potential to result in a risk profile change (Trigger 2)*. • If PFAS is reported at a concentration that is less than the 65th percentile of the existing data for the monitoring location and does not show a visual increasing trend[1] for the previous three (3) wet seasons, monitoring will be continued – *Low potential to result in a risk profile change (Trigger 1)*.

[1] At each monitoring location for groundwater, surface water, and sediment components, PFAS data (ie PFOS, PFOA, ∑PFOS and PFHxS, and ∑PFAS) will be plotted on time series plots and visually evaluated to identify increasing trends.

Process	Description
	Further information on the trigger screening process and potential response actions is provided in Section 7.
Step 6: Specify performance or acceptance criteria	The acceptable limits on decision errors to be applied in the investigation and the manner of addressing possible decision errors have been developed based on the DQIs of precision, accuracy, representativeness, comparability, and completeness and are presented in Table 4.2 and Table 4.3.
Step 7: Optimise the plan for obtaining data	The purpose of this step is to identify a resource-effective data collection design for generating data that satisfies the DQOs. This OMP has been designed considering the information and data obtained during the review of available site information and PMAP. The resource effective data collection design that is expected to satisfy the DQOs is described in detail in the following sections. To ensure the design satisfies the DQOs, DQIs (for accuracy, comparability, completeness, precision and reproducibility) have been established to set acceptance limits on field methods and laboratory data collected and are presented in Table 4.2 and Table 4.3.

4.3 Data Quality Indicators

The following DQIs have been established to set the QA and QC acceptance limits on field and laboratory data.

- **Representativeness** - The confidence (expressed qualitatively) that data are representative of each media present.
- **Comparability** - The confidence (expressed qualitatively) that data may be considered equivalent for each sampling and analytical event.
- **Accuracy** – A measure of the closeness of the results to the actual results. Accuracy is assessed through the comparison of results produced by the primary and secondary laboratories for the same sample and by measuring the extent to which an analytical result reflects the known concentration as measured by the recovery obtained from internal laboratory spikes.
- **Precision** – A measure of the repeatability of results by the laboratory. This is assessed through the analysis of duplicates both internally and externally and is calculated by using relative percentage differences (RPDs).
- **Completeness** – The percentage of acceptable data obtained compared to the amount of data needed to achieve a particular level of confidence in the results.

The quantitative and qualitative measures/criteria employed to enable application of the DQI parameters are described in Table 4.2, below.

Table 4.2: Summary of Data Quality Indicators

DQI	Field & Laboratory DQI Considerations
Representativeness	Appropriate media sampled according to OMP, all media identified in OMP sampled and analysed. Samples analysed using same laboratory procedures and within appropriate holding times. Appropriate collection, handling, storage, and preservation used. Potential for change in sample before analysis may decrease representativeness.
Comparability	Same approach to sampling by use of standard procedures on each occasion, use of qualified samplers, same types of sampling equipment used, same types of samples collected, same analytical methods used, same sample LORs, same laboratories, same units, same laboratory methods, and appropriate sample integrity. The laboratories used are required to be NATA registered and the methods used are required to be NATA endorsed for all the analyses undertaken.
Accuracy	This is assessed through compliance with standard procedures and analysis of field blanks, rinsates, reagent blanks, method blanks, surrogate spikes, reference materials, laboratory control samples, and laboratory-prepared spiked control samples. Different matrix effects can affect the recoveries of some analytes and therefore recoveries that fall outside this range may still be acceptable. Accuracy is assessed through the comparison of results produced by the primary and secondary laboratories for the same sample and by measuring the extent to which an analytical result reflects the known concentration as measured by the recovery obtained from internal laboratory spikes.
Precision	This is assessed through compliance with standard procedures by collection of field duplicates, analysis of primary and secondary laboratory field duplicates, analysis of laboratory duplicates.
Completeness	All critical locations sampled, all samples collected (from grid and depth); appropriate standard procedures used and complied with, use of experienced samplers, and documentation correct. All critical samples and analytes analysed according to OMP, use of appropriate laboratory methods and LORs, sample documentation complete, sample holding times in compliance. Acceptable data are obtained when samples are collected and analysed in accordance with the quality control procedures and the DQIs.

Acceptance limits set to quantitatively assess DQIs are in accordance with ASC NEPM (as amended in 2013) and Standards Australia (AS/NZS 5567.1-1998) as outlined in Table 4.3.

Table 4.3: Summary of Project Quality Acceptance Limits

Data Quality Indicator	DQI Indicator	Acceptance Limit
Representativeness	-	Generally, there is no quantifiable acceptance limit for representativeness.
Comparability	LORs	LORs equivalent within each sampling / analytical event for each media, and between sampling events.

Data Quality Indicator	DQI Indicator	Acceptance Limit
Accuracy	Field Method Blanks	Field method blanks will be collected of laboratory-supplied deionised water at rate of 1 per batch of deionised water to confirm the water being used is PFAS-free. Results should be below LORs.
	Rinsate Blanks	For PFAS samples, rinsates will be collected at a rate of at least one for every 10 primary samples but analysed at rate of 1 per day. If PFAS contamination is detected, additional rinsates samples will be submitted for analysis. Where dedicated sampling equipment is used (eg groundwater pumps which remain in bores or disposable bailers), no rinsate samples will be collected. Results should be below LORs.
	Trip Blanks	Submitted with each shipment of water samples to the laboratory and analysed as considered required. Trip blanks should be supplied by the laboratory (PFAS-free water in the same container used for the samples). Trip blanks are ordered from the laboratory and accompany the bottle order to site and the sample shipment from site. The trip blank remains in the cooler in the field for the duration of the sampling program. Results should be below LORs.
	Laboratory Method Blanks	Results should be below LORs.
	Laboratory Control Sample Spikes (LCS)	Analysed at a frequency of 10% of total samples analysed by the laboratory. Recoveries for most analytes should generally be within the range of 70% to 130%. This spike refers to a certified reference material or an independently prepared interference free matrix spiked with target analytes. Organic LCS' are almost exclusively blank water spiked with target analytes.
	Matrix Spikes	Analysed at a frequency of 10% of total samples analysed by the laboratory. Recoveries for most analytes should generally be within the range of 70% to 130%. Different matrix effects can affect the recoveries of some analytes and therefore recoveries that fall outside this range may still be acceptable. Matrix spikes refer to an intra-laboratory split sample, spiked with a representative set of target analytes. This spike monitors potential matrix effects on analyte recoveries.
	Surrogates	Surrogates are added or analysed with each batch of samples and recoveries should be within acceptable laboratory limits.

Data Quality Indicator	DQI Indicator	Acceptance Limit
Precision	Field Duplicates (Inter-laboratory duplicates)	Duplicates will be collected at a rate of 1 in 10 (ie 1 sample in 10 is analysed by the primary laboratory and 1 sample in 10 is analysed by the second laboratory. Refer to Section 4.3.1 for RPD calculations and acceptance limits.
	Field Duplicates (Intra-laboratory duplicates) (Blind duplicates)	Duplicates to be analysed at a rate of 1 in 10 samples will be a blind field duplicate analysed by the primary laboratory. Refer to Section 4.3.1 for RPD calculations and acceptance limits.
Completeness	Overall Completeness	95% of usable data is achieved from a data collection activity.

If anomalous data are identified from data collected in the field or during review of the field data with respect to DQIs, the potential cause for the anomalous results will be evaluated (eg change in analytical resolution, field or laboratory contamination, incorrect station location or transcription error). Anomalous data identified during this QA/QC analysis and confirmed by follow-up actions (eg review of field notes, re-analysis by lab) will be:

- flagged with recommendation for follow-up monitoring (ie for monitoring locations identified as critical for decision making [high risk profile locations]);
- flagged with consideration of the uncertainty during data interpretation; or
- excluded from the assessment.

Anomalous data and follow-up will be identified in the Sampling Event Report.

4.3.1 Relative percent difference calculations

The Primary (intra-laboratory) and Secondary (inter-laboratory) duplicates are duplicate samples of the primary sample collected during sampling. The primary duplicates are labelled differently to the primary sample, and both primary duplicates are submitted to the primary laboratory for analysis (NATA accredited for the analysis required). The secondary duplicate is sent to the quality control laboratory (secondary laboratory; which will also be NATA accredited for the analyses required) for analysis to compare the results obtained between the two laboratories.

The primary and secondary duplicate results are compared with primary sample results using RPDs. RPDs are calculated according to the following formula:

$$\mathrm{RPD} = \left|\frac{A - B}{A + B}\right| \times 200$$

Where A is the concentration of the primary laboratory result per analyte and B is the corresponding duplicate result.

RPD values can range from 0% (indicating perfect correlation between results) to 200% (indicating complete divergence in results). In calculating RPD values, the following protocol types will be adopted according to the circumstance.

- **Type 1**: Where the two laboratories have reported levels below their LORs, a RPD of <50% will be assigned in the table.

- **Type 2A**: Where one laboratory has reported a value below a LOR and the other has identified detectable contaminant concentrations, a RPD will be calculated. This will be achieved using the LOR for the undetected sample, and comparing that to the concentration of the detected sample.
- **Type 2B**: Similar to Type 2A RPDs, except that the primary and secondary laboratories have different LORs and a reported value from one laboratory may be below a LOR from the other and may result in an elevated RPD.
- **Type 3**: Where both laboratories report detectable amounts of contaminant, a RPD will be calculated.

4.4 Proposed monitoring intervals

The complete groundwater, surface water, and sediment sampling program across the Monitoring Area will be performed annually during the wet season, which will be timed to occur in March/April. Dry season sampling for surface water quality will be limited to a subset of the annual wet season monitoring locations and include fourteen (14) permanent downstream waterbodies (ie Mundy Creek, Louisa Creek and Bohle River, and Three Mile Creek, and permanent wetland waterbodies). Dry season sampling will be timed to occur in September/October. Further, surface water quality sampling in the intertidal monitoring locations in the creek and river reaches will be timed to occur on the ebb tide.

The seasonality and frequency of sampling events will be reviewed after every sampling event and updated/changed where necessary based on the value addition of data produced to the OMP objectives. The OMP, per this update, will be undertaken for an initial period of two years (or as instructed by Defence), with the initial sampling event to be completed in September/October 2024. The proposed schedule for the seasonal sampling events across the initial two-year period is presented in Table 4.4 below.

Table 4.4: Proposed Fieldwork Schedule

Sampling Round	Description of Work	Proposed Schedule
Round 1	Dry season groundwater, surface water quality, and sediment sampling per the previous OMP (attachment to the PMAP; Department of Defence 2019)	September/October 2024
Round 2	Wet season groundwater, surface water quality, and sediment sampling	March/April 2025
Round 3	Dry season surface water quality sampling at the permanent wetland waterbodies and downstream reaches of Mundy Creek, Louisa Creek and Bohle River, and Three Mile Creek	September/October 2025

4.5 Groundwater sampling locations

There are 79 groundwater monitoring wells in the Monitoring Area identified for ongoing monitoring, which will be limited to the wet season sampling event. These wells are located across the RAAF Base and RAAF Base boundary (on-base locations), and Townsville City Council controlled public spaces (off-base locations). The rationale for monitoring well selection for each area is summarised in Table 4.5.

Table 4.5: Rationale for Groundwater Monitoring Locations

<table>
<tr><th>Area</th><th>Where do data inform spatial and temporal variation in PFAS concentrations?</th><th>Where do data inform changes in PFAS concentrations in response to management measures?</th><th>Supplemental ongoing monitoring recommendations</th></tr>
<tr><td>On-base Monitoring Locations</td><td>On-base areas up, down, and cross-gradient of source areas</td><td>Wells down-gradient of source areas</td><td>None recommended at this time.</td></tr>
<tr><td>Off-base: Townsville Town Common</td><td rowspan="4">Groundwater regions down-gradient of the base</td><td rowspan="2">Wells to the north of the base</td><td>Wells adjacent to Louisa Creek to assess PFAS migrating from the drainage channels and Louisa Creek to groundwater
Wells parallel and perpendicular to the PFAS plume to assist with understanding concentrations changes in these alignments.</td></tr>
<tr><td>Off-base: Pallarenda Residential</td><td>None recommended at this time.</td></tr>
<tr><td>Off-base: Rowes Bay</td><td rowspan="2">Wells to the northeast of the base</td><td>None recommended at this time.</td></tr>
<tr><td>Off-base (down-gradient): Bohle River and Bohle Industrial Estate</td><td>Wells parallel and perpendicular to the PFAS plume to assist with understanding concentrations changes in these alignments.</td></tr>
<tr><td>Off-base (upgradient): Bohle River and Bohle Industrial Estate</td><td rowspan="2">Groundwater region up-gradient of the base</td><td rowspan="2">Data do not inform changes from management measures, but provide an up-gradient reference data set for comparison</td><td>None recommended at this time.</td></tr>
<tr><td>Off-base: Belgian Gardens and Garbutt</td><td>None recommended at this time.</td></tr>
</table>

The groundwater locations to be gauged and sampled as part of the wet season sampling event are provided in Table 4.6 (on-base) and Table 4.7 (off-base) and presented in Figure 3, Appendix B. Grid coordinates for the groundwater monitoring locations are provided in Table C.1, Appendix C.

Table 4.6: Groundwater Gauging and Sampling Locations – On-base

Catchment	Key Source Area	Monitoring Locations	Number of Wells
Mundy Creek Catchment	Sub-Management Area 1 – Former Fire Training Area	MW026, MW033, MW034, MW061, MW063, MW118, MW119, MW120, MW222, MW224, MW232	11
	Fuel Farm#1		
	Runway 01/19	MW140	1
Bohle River/ Louisa Creek/ Town Common Catchment	Sub-Management Area 2 – includes a Former Fire Training Area, Fire Station and Fuel Farm #2	MW005, MW015, MW016, MW021, MW046, MW054, MW055, MW058, MW080, MW081, MW083, MW090, MW109, MW110, MW139, MW251	16
	Former Fire Training Area (near current OLAs)	MW136, MW243, MW265	3
	Disused Runway 13/31	MW245, MW246	2
	Northwest of Runway 07/25	MW112	1
	Sub-Management Area 3 – includes 5th Aviation Regiment Precinct	MW009, MW038, MW114, MW142, MW247, MW248	6
	South of Ingham Road – External Defence Properties (ID 0875, 1273, 1274)	MW226, MW227, MW229	3
	Western side of base	MW056, MW057, MW122, MW135, MW244, MW255, MW300	7
Three Mile Creek Catchment	Former Fire Training Area, north of Runway 01/19	MW241, MW242, MW470	3
Total			**53**

Table 4.7: Groundwater Sampling Locations – Off-base

Catchment	Key Source Area	Monitoring Locations	Number of Wells
Mundy Creek Catchment	Former Fire Training Area (SMA1) Fuel Farm #1	MW213, MW215, MW216, MW217, MW218, MW220, MW221, MW225, MW256, MW263, MW264, MW266, MW267, MW268, MW270	15
Bohle River/ Louisa Creek/ Town Common Catchment	Off-base – Townsville Town Common, north of the base	MW201, MW203, MW205, MW206	4
	Off-base – Louisa Creek and Bohle River and Bohle Industrial Estate, west of the base	MW262	1
	Former Fire Training Area, north of Runway 01/19	MW208, MW211, MW301, MW467, MW471	5

Catchment	Key Source Area	Monitoring Locations	Number of Wells
Three Mile Creek Catchment	Off-base – Suburb of Pallarenda, northeast of the base	MW253	1
Total			**26**

4.6 Surface water sampling locations

The 46 surface water sampling locations for the wet and dry season sampling events are provided in Table 4.8 (on-base) and Table 4.9 (off-base) and presented in Figure 4, Appendix B. Grid coordinates for the groundwater monitoring locations are provided in Table C.2, Appendix C.

These locations have been selected to maintain consistency with the recent monitoring completed within the Monitoring Area. Surface water locations are co-located with sediment sampling locations, and surface water will be collected at these locations where present.

Table 4.8: Surface Water Sampling Locations – On-base

Catchment Area	Key Source Area	Surface Water Sampling Locations		Number of Locations	
		Dry Season	Wet Season	Dry Season	Wet Season
Mundy Creek Catchment	Former Fire Training Area (SMA1)	Nil	SW001, SW010, SW132, SW133, SW145, SW156	0	6
	Fuel Farm #1				
	Former Fire Training Area, north of Runway 01/19	Nil	SW106	0	1
Bohle River / Louisa Creek / Townsville Town Common	Sub-Management Area 2 – includes a Former Fire Training Area, Fire Station and Fuel Farm #2	SW016, SW112, SW125	SW012, SW016, SW112, SW125, SW158, SW160, SW161, SW162	3	8
	Sub-Management Area 3 – includes 5th Aviation Regiment Precinct	Nil	SW014, SW123, SW169, SW170	0	4
	Former Fire Training Area (near current OLAs)	SW126, SW131	SW013, SW126, SW131	2	3
Three Mile Creek Catchment	Former Fire Training Area, north of Runway 01/19	SW102	SW102	1	1
Total				**6**	**23**

The listed off-base surface water sampling locations are downgradient of both on-base PFAS sources including urban residential, and commercial and industrial suburbs.

Table 4.9: Surface Water Sampling Locations – Off-base

Catchment Area	Key Source Area	Surface Water Sampling Locations		Number of Locations	
		Dry Season	Wet Season	Dry Season	Wet Season
Mundy Creek Catchment	Former Fire Training Area (SMA1)	SW109	SW108, SW109, SW113, SW114, SW115, SW116, SW117, SW118, SW119, SW208	1	10
	Fuel Farm #1				
	Former Fire Training Area, north of Runway 01/19	Nil	SW209	0	1
Bohle River / Louisa Creek / Townsville Town Common	Off-base – Townsville Town Common, north of the base	SW203, SW204, SW205, SW206, SW207	SW017, SW021, SW110, SW111, SW203, SW204, SW205, SW206, SW207	5	9
	Off-base – Louisa Creek and Bohle River and Bohle Industrial Estate, west of the base	SW202	SW202	1	1
Three Mile Creek Catchment	Former Fire Training Area, north of Runway 01/19	Nil	SW107	0	1
	Off-base – Suburb of Pallarenda, northeast of the base	SW210	SW210	1	1
Total				**8**	**23**

4.7 Sediment sampling locations

The 46 sediment sampling locations for the wet season sampling events are provided in Table 4.10 (on-base) and Table 4.11 (off-base) and presented in Figure 4, Appendix B. These locations have been maintained in conjunction with the surface water sampling locations to continue to monitor sediment concentrations as sediment represents a secondary pathway for PFAS transport within the Monitoring Area.

Table 4.10: Sediment Sampling Locations – On-base

Catchment Area	Key Source Area	Sediment Sampling Locations	Number of Locations
Mundy Creek Catchment	Former Fire Training Area (SMA1)	SD001, SD010, SD132, SD133, SD145, SD156	6
	Fuel Farm #1		
	Former Fire Training Area, north of Runway 01/19	SD106	1
Bohle River / Louisa Creek /	Sub-Management Area 2 – includes a Former Fire	SD012, SD016, SD112, SD125 SD158, SD160, SD161, SD162	8

Catchment Area	Key Source Area	Sediment Sampling Locations	Number of Locations
Townsville Town Common	Training Area, Fire Station and Fuel Farm #2		
	Sub-Management Area 3 – includes 5th Aviation Regiment Precinct	SW014, SW123, SW169, SW170	4
	Former Fire Training Area (near current OLAs)	SD013, SD126, SD131	3
Three Mile Creek Catchment	Former Fire Training Area, north of Runway 01/19	SD102	1
Total			**23**

The listed off-base sediment sampling locations are downgradient of both on-base and off-base PFAS sources and include urban residential, and commercial and industrial suburbs.

Table 4.11: Sediment Sampling Locations – Off-base

Catchment Area	Key Source Area	Sediment Sampling Locations	Number of Locations
Mundy Creek Catchment	Former Fire Training Area (SMA1)	SD108, SD109, SD113, SD114, SD115, SD116, SD117, SD118, SD119, SD208,	10
	Fuel Farm #1		
	Former Fire Training Area, north of Runway 01/19	SD209	1
Bohle River / Louisa Creek / The Town Common	Off-base – Townsville Town Common, north of the base	SD017, SD021, SD110, SD111, SD203, SD204, SD205, SD206, SD207	9
	Off-base – Louisa Creek and Bohle River and Bohle Industrial Estate, west of the base	SD202	1
Three Mile Creek Catchment	Former Fire Training Area, north of Runway 01/19	SD107	1
	Off-base – Suburb of Pallarenda, northeast of the base	SD210	1
		Total	**23**

4.8 Sample analysis

Samples will be analysed by a NATA accredited laboratory for a suite of PFAS compounds as outlined in Tables E.1 and E.2, Appendix E, using NATA accredited procedures. Given that the guidelines currently adopted for this OMP are above the standard LORs (refer to Section 6), standard LORs are currently considered sufficient for the OMP.

Defence recognises the potential changes to drinking water PFAS guidelines proposed by National Health and Medical Research Council (NHMRC, 2024) (see Section 6 for added information), which if approved will come into effect in 2025. As described in Section 6.1, Defence will adopt lower laboratory LORs for drinking water at select monitoring locations for the analysis of groundwater and surface water samples from off-base monitoring locations that have consistently reported PFAS measurements at or below the standard LOR. This will be implemented as a pre-emptive step for the OMP to characterise and assess the exposure risk to human health for the consumption of water should the new drinking water guidelines be adopted.

Standard and low-level LORs are provided in Tables E.1 and E.2, Appendix E, respectively.

The suite of PFAS compounds analysed for the OMP may be revised if required to meet the OMP objective based on changes to screening criteria requirements or updates to the human and ecological risk profiles.

5 OTHER ASPECTS

Defence bases are dynamic in their operation, which includes ongoing infrastructure upgrades and re-development activities. With legacy PFAS contamination recognised at bases in Australia (eg Lavarack Barracks), these activities, which are conducted under the oversight of management and development plans and corresponding monitoring programs, provide information that furthers the understanding of the extent of contamination at the bases and the key pathways to off-site migration and risk. For RAAF Base Townsville, some of the specific activities include remediation works across the base and at select legacy sites, and Defence infrastructure projects (eg civil works, remediation projects). Project works under the PMAP and base Infrastructure that have been completed or are scheduled to be undertaken are described in Section 5.1 and Section 5.2, respectively. These works need to be considered as part of the OMP implementation and/or interpretation of the sampling event monitoring data.

There is information that will be gathered from activities (eg public surveys) other than the monitoring data collected under the OMP that may affect the CSM (Section 5.3) for the RAAF Base PFAS Remediation Project. This supplemental information will be used to continue to evaluate the potential or complete source-pathway-receptor linkages in the Monitoring Area and includes identification of changes in local consumption habits or water uses, which may result in a change to a source-pathway-receptor linkage or pathway (eg a linkage changes from potential to complete).

5.1 PMAP investigation / remediation

PMAP delivery works commenced at the base include:

Table 5.1: PMAP Project Works

Area of the Base	Works Completed	Scheduled Works	Consideration for OMP
Former Fire Training Area (Sub-Management Area 1)	Development of RAP Remediation and Validation Program (2022-23)	Post Remediation Monitoring as part of OMP. Post Remediation Mass Flux Assessment. Monitoring well replacement.	Post-remediation monitoring (required by the RAP and LTEMP) has been incorporated into the OMP, and replacement wells to be installed now that remediation activities have been completed. Once these replacement wells are added they should be included within the OMP. Lost wells resulting from remediation activities include MW013, MW116, MW126, and MW129; existing wells in this area currently used for post-remediation monitoring in the OMP include MW026, MW033, MW034, MW118, MW119, and MW120. Changes in OMP monitoring data expected because of remediation works.
Sub-Management Areas 1, 2, and 3	Mass Discharge Assessment (baseline)	Implementation of Mass Discharge assessment for two wet seasons post remediation.	Results from the Mass Discharge assessment to be considered in the interpretation of OMP.
Fuel Farm#2 and Fire Station Locale (Sub-Management Area 2)	Delineation Investigation Development of RAP	Remediation Program (dry season of 2025).	Post-remediation monitoring to be incorporated into the OMP, and replacement wells to be installed. Changes in OMP monitoring data because of remediation works.

5.2 On-base infrastructure projects

Construction projects implemented since the implementation of the OMP, which may influence interpretation of the OMP data, include:

Table 5.2: Infrastructure Project Works

Area of the Base	Works Completed	Scheduled Works	Consideration for OMP
Army Aviation Project at 5AVN (Sub-Management Area 3)	Investigation of contamination associated with planned civil works and construction and redevelopment of infrastructure at 5AVN. Beneficial re-use of PFAS impacted soils within the works area.	Civil works and construction and redevelopment of infrastructure at 5AVN. To be completed between 2025 and 2028.	Results of OMP monitoring in the vicinity of 5AVN may fluctuate during earthworks.
North Queensland Mid-Term Refresh	Civil earthworks across the base including the excavation and re-location of spoil.	Civil works and construction and redevelopment of infrastructure at RAAF Base. To be completed by 2025.	Results of OMP monitoring in the vicinity of earthworks may fluctuate during earthworks.

5.3 Conceptual Site Model considerations

The following are key aspects of the Human Health and Ecological CSMs that are to be considered in combination with the review of the OMP monitoring data, as changes in PFAS concentrations in groundwater, surface water, or sediment may increase the potential risk to sensitive receptors.

5.3.1 Human health CSM

- Change in human exposure to soils and groundwater via direct contact pathways either on-base or off-base.
- Changes in the consumption habits of home grown produce to greater than 10%, and changes to levels of PFAS within home grown produce.
- Changes in the consumption of seafood from the Mundy Creek, Three Mile Creek, and Town Common (Louisa Creek and Bohle River) catchments, and changes to levels of PFAS within local seafood.

5.3.2 Ecological CSM

- Changes to biota tissue PFAS concentrations in fish, crustaceans, and molluscs collected off-base, which may increase potential risk for toxicity to mammals and predatory birds who rely on these aquatic biota for sustenance.
- Increases in concentrations of PFAS within the biota due to the bioaccumulation potential of PFOS through the food web for terrestrial and semi-terrestrial mammals, herbivorous birds, invertivorous and omnivorous birds, and predatory birds.

Understanding changes in consumption habits or use of surface water bodies could be through anecdotal evidence or via conducting a local community survey (eg repeating the Water Use Survey). Obtaining additional data in support of updating the CSM is not part of the OMP; however, if information is acquired through the OMP that suggests a change in consumption habits or water use (eg consumption of home-grown poultry/eggs), the resultant change in the Risk Profile will be assessed. Monitoring changes in PFAS concentrations within ecological receptors is not part of the OMP; however, if notable increases in surface water or sediment are observed during the OMP monitoring, this may lead to further assessment of PFAS concentrations within biota.

6 PFAS SCREENING CRITERIA

PFAS screening criteria for perfluorooctane sulfonate (PFOS), perfluorooctanoic acid (PFOA), and perfluorohexane sulfonate (PFHxS) were derived in the PFAS NEMP (HEPA, 2025) using methods consistent with assumptions set out in the NEPM (as amended in 2013). The water criteria to be adopted for the OMP are outlined in Table 6.1.

Table 6.1: PFAS screening criteria

Pathway	Compound[1]	Criteria	Comments
Human Health Receptors			
Drinking Water	PFOS + PFHxS	0.07 µg/L	The values are from the PFAS NEMP (HEPA, 2025) Off-base groundwater and surface water results will be compared to these criteria.
	PFOA	0.56 µg/L	
Recreational use – surface water	PFOS + PFHxS	2 µg/L	The values are from the PFAS NEMP (HEPA, 2025) On-base and off-base surface water and groundwater results will be compared to these criteria.
	PFOA	10 µg/L	
Ecological Receptors			
Freshwater and marine water (95% species protection values)	PFOS	0.13 µg/L	The values are from the PFAS NEMP (HEPA, 2025). Off-base surface water results will be compared to these criteria.
	PFOA	220 µg/L	

(1) Per the PFAS NEMP (HEPA, 2025), where the guideline values refer to the sum of PFOS and PFHxS, this includes PFOS only, PFHxS only, and the sum of the two.

It is noted that at the time this report was prepared no PFAS NEMP (HEPA, 2025) endorsed criteria was available for PFAS in sediments. However, guideline criteria will be reviewed annually and updated based on the HEPA endorsed criteria at the time.

It is also noted that if PFAS are detected in groundwater and surface water samples, comparison to the PFAS screening criteria presented in Table 6.1 represents the initial screening trigger for the OMP. If these screening criteria are exceeded, the consequential screening process is to determine if the data indicate the potential for a change in the risk profile to the sensitive receptors at that monitoring location or to downstream sensitive receptors. This is then followed by further assessment that considers the magnitude of PFAS relative to previously collected data and recent data trends, using a weight of evidence approach. The triggers and screening approach are described in Section 7.

6.1 Draft changes to Australian Drinking Water Guidelines (October 2024)

In October 2024, the NHRMC released draft health-based drinking water guidelines for public consultation. Defence is considering how the draft guidelines, if adopted, may affect its PFAS Investigation and Management Program, and communities surrounding the Defence Estate. An initial step to this is the adoption of a lower laboratory LOR at select locations to understand any future implications; these select locations would comprise groundwater and surface locations that consistently report PFAS measurements at or below the standard LOR (eg groundwater monitoring wells in Pallarenda [MW253], Bohle River [MW205], Mundy Creek [MW215 and MW217] and Three Mile Creek [MW467], and surface water monitoring locations in Mundy Creek [SW108], the Bohle River [SW202, SW203, SW204, and SW206] and in Three Mile Creek at Pallarenda [SW210]. Until the revised PFAS guidelines are finalised and published, the current Australian Drinking Water Guidelines, as they are applied for screening in the OMP, will remain in effect.

7 TRIGGERS FOR ACTION AND REVIEW

PFAS compounds (ie PFOS, PFOA, and ∑PFOS and PFHxS) are detected in groundwater, surface water, and sediment at many on-base and off-base monitoring locations. As a result, identifying and implementing appropriate triggers when PFAS has a presence that extends from the on-base area to downstream areas is a critical component of Defence's approach to managing risks to sensitive receptors from PFAS contamination. The following data screening triggers and the associated responses will be considered during this OMP:

- If PFAS concentrations are not detectable (<LOR) or measured below the screening criteria applicable to the monitoring location (eg on-base and off-base monitoring areas), monitoring will be continued, reduced, or ceased – ***Negligible potential to result in a risk profile change (Trigger 0)***.
- If PFAS concentrations are detectable, above the adopted screening criteria applicable to the monitoring location (eg on-base and off-base monitoring areas), and have the potential to affect the risk profile for that location, further assessment and response required.
- If PFAS is reported at a concentration that is greater than the 85th percentile of the existing data for the monitoring location and shows a visually increasing trend[2] for the previous three (3) wet seasons, then data verification will be undertaken. If verified, further assessment and mitigation responses will be required – ***High potential to result in a risk profile change (Trigger 3)***.
- If PFAS is reported at a concentration that is greater than the 65th percentile of the existing data for the monitoring location and shows a visually increasing trend for the previous three (3) wet seasons, then further assessment may be considered – ***Elevated potential to result in a risk profile change (Trigger 2)***.
- If PFAS is reported at a concentration that is less than the 65th percentile of the existing data for the monitoring location and does not show a visual increasing trend for the previous three (3) wet seasons, monitoring will be continued – ***Low potential to result in a risk profile change (Trigger 1)***.

For this OMP, the screening trigger process will focus on groundwater data and surface water quality. Screening will not apply to the sediment quality data unless it is a response action to an elevated risk or high-risk trigger. This is because the evaluation of a change to risk profile at a monitoring location based on sediment PFAS concentrations is subject to uncertainty primarily because:

- sediment PFAS concentrations cannot be screened against guidelines; there are no current sediment guidelines or environmental investigation levels for sediment in the NEMP (HEPA, 2025) or from other national environmental agencies; and
- there are uncertainties in sediment PFAS concentrations sources (eg PFAS bound to sediment, PFAS in porewater), the representativeness of concentrations at the monitoring location (water body, creek course, drain), sampling technique and repeatability, equilibrium between the sediment and porewater, and season, and linkage to risk profile for human health and/or ecological risk.

For groundwater and surface water quality, a weight of evidence approach throughout the Monitoring Area based on PFAS concentration, concentration trends, and potential for change in risk profile is to

[2] At each monitoring location for groundwater, surface water, and sediment components, PFAS data (ie PFOS, PFOA, ∑PFOS and PFHxS, and ∑PFAS) will be plotted on time series plots and visually evaluated to identify increasing trends over the past three wet seasons.

be adopted for an evaluation of risk and response. The screening process applicable to the OMP is illustrated in Figure 7.1.

In the screening trigger process for groundwater and surface water quality, reference is made to comparing measured PFAS concentrations to applicable screening criteria, which are listed in Table 6.1. These screening criteria will not be applied to all collected data. Instead, the screening criteria will be applicable to the monitoring location within the Monitoring Area (Table 7.1). For example, groundwater and surface water quality PFAS concentrations within the on-base area will be limited to screening against PFAS NEMP 3.0 (2025) Recreational Water guidelines. This is because the risk profile for on-base is limited to the potential for body contact and exposure of groundwater and surface water; the primary pathway is potential for contact and exposure to workers from surface water/groundwater exposure during irrigation or during construction and excavation activities. There is no potable use of the water sources or cultivation of produce for consumption on-base.

Table 7.1: Monitoring guidelines used for comparison to site-specific and media specific data

Monitoring Area	Monitoring Component	Applicable Guideline	Rationale and Risk Potential
On-base	Groundwater	PFAS NEMP 3.0 (2025) Recreational Water	Dermal contact and incidental ingestion – very low risk
	Surface Water	PFAS NEMP 3.0 (2025) Recreational Water	Dermal contact and incidental ingestion – very low risk
Off-base	Groundwater	PFAS NEMP 3.0 (2025) Recreational Water	Dermal contact and incidental ingestion – very low risk
		PFAS NEMP 3.0 (2025) Drinking Water	Water consumption from residential bores and eating produce irrigated with groundwater – very low risk
	Surface Water	PFAS NEMP 3.0 (2025) Recreational Water	Dermal contact and incidental ingestion – very low risk
		PFAS NEMP 3.0 (2025) Drinking Water	Water consumption – very low risk
		PFAS NEMP 3.0 (2025) 95% Eco Marine Water	Wildlife and aquatic life – negligible to high risk

Outside of the RAAF Base monitoring area, groundwater and surface water monitoring data in the suburbs of Garbutt, Mount Louisa, Rowes Bay, and Pallarenda will be compared the guidelines that represent the greater potential for risk exposure. For example:

- Groundwater – guideline references for groundwater NHMRC (2019) Recreational Water and NEMP Drinking Water (HEPA, 2025), as groundwater sources have the potential for body contact (dermal) and incidental ingestion exposure and as a potential supply for irrigation (lawns, home grown produce [fruits and vegetables]) and drinking water consumption. Although use of groundwater as a drinking water supply for off-base locations was identified as an incomplete pathway in the HHRA for the RAAF Base Monitoring Area (WSP, 2018b), it is acknowledged that PFAS has a low-risk potential to be inadvertently ingested through recreational contact and from direct consumption of home grown produce where PFAS is present in groundwater sourced for irrigation water.
- Surface Water – guidelines for surface water include NHMRC (2019) Recreational Water and NEMP Interim Freshwater and Marine 95% (HEPA, 2025) guidelines, as surface water draining from the base has the potential for recreational body contact (dermal) and incidental ingestion exposure in the drains, creeks, or public area irrigation. Additionally, there is potential for wildlife,

freshwater and marine aquatic biota exposure (eg uptake, ingestion, and assimilation) and human exposure (eg consumption of local seafood).

Measured PFAS data for each groundwater and surface water monitoring location will be screened against 65th and 85th percentile concentrations derived from the location dataset. The use of 65th and 85th percentiles in the trigger screening is currently based on the general sample count per monitoring location during an OMP (eg ~12 data points since 2018). These screening thresholds represent reasonable upper bound concentrations to assist in flagging the potential for changes to risk profile based on measured results, without being too conservative or not being conservative enough in the screening process; the objective of the screening of the measured concentrations is to flag PFAS levels from the sampling event that represent elevated concentrations so that the data are reviewed accordingly. With the limited amount of data, these screening percentiles are considered reasonable thresholds for further review. As more data are collected in future OMP sampling events, these percentile thresholds can be modified to reflect the larger dataset. Although not identified in the screening trigger framework, the screening process also considers if the measured concentration represents the highest concentration measured at a monitoring location over the period of the OMP (this query is a requirement of the sampling event data review).

The final data screening trigger is to determine if the monitoring data at a monitoring location indicate an increasing trend. For the OMP, the analysis of an increasing trend is limited to a visual assessment of increasing trends instead of using a statistical method. The use of a graphical display (plots or conditional array settings in the dataset [eg Excel tools]) to discern increasing PFAS trends over time is a reasonable and effective approach in the trigger screening process. With the transition of the OMP to focus on wet season sampling, the trend analysis focuses on wet season data, particularly the prior three wet seasons as available. The trigger for further evaluation is that there are consecutive increases in concentration over three wet season sampling events, regardless of measured concentration. The trigger for further evaluation is that there are consecutive increases in concentration over three wet season sampling events, regardless of measured concentration. The use of a visual assessment is because the current dataset (commencing in 2018 for many of the OMP monitoring locations) is small (an approximate maximum of 12 samples), which is further reduced by focusing on wet season data and therefore challenging to apply a statistical trend analysis with an adequate confidence level. Further, there is some conjecture regarding a trend analysis that could be meaningfully applied to these data for determine significant trends; the commonly applied Mann-Kendall or similar is not considered appropriate because of the low data count and because of the variable conditions and timing of sample collection at the monitoring locations between seasons. As data increase from future OMP sampling events, application of a statistical trend analysis for the OMP and data evaluation through the screening trigger framework will continue to be investigated.

For the On-going Monitoring Report (OMR), the visual trend analysis will be used to also evaluate whether PFAS concentrations trends are decreasing, especially for known sources areas on-base under remediation. A decreasing trends evaluation will be used to inform the progress of remediation with reduction in PFAS contribution from the source area and to the determination of remediation So Far As Reasonably Practical.

At the onset of the data review at the conclusion of the screening process, there is provision to subjectively evaluate the measured data and the screening where an elevated or high potential for risk profile change is identified. These include considering the following questions:

- Are the data verified? (ie data validation completed and data valid, consideration of site-specific conditions at the time of sampling that may provide added context the result [eg a high result because the sample was collected from a stagnant pond])

- Are the data consistent with the CSM for the site? (ie the data are expected in that range, the data are representative of a location in a source catchment or down-gradient of known sources where remediation/investigation is planned or underway)
- Are the data consistent with the identified Risk to Receptors implying there is no change to the Risk Profile (ie the risk to receptors identified in section 3 has not changed based on the measured result)

If the answer to all questions is “Yes”, the screening result can be downgraded with a supporting statement provided in the screening table and a note that no further response is required. If the answer to any of these questions is “No”, the screening outcome as derived remains and the response action identified in the screening table.

Response Actions to triggers will be site specific and thus be dependent on risk profile. Examples of the response actions are provided below.

Trigger 0 *(negligible potential for risk profile to change at the monitoring location or down-gradient from the monitoring location)*

- Consider if monitoring location should be removed from OMP (based on consistency of non-detected data)
- Continue monitoring at that location

Trigger 1 (*low potential for risk profile to change at the monitoring location or down-gradient from the monitoring location*):

- On-base and off-base advisories, if applicable and where necessary (OMP reporting, Defence notifications)
- Continue OMP monitoring at that location

Trigger 2 (*elevated potential for risk profile to change at the monitoring location or down-gradient from the monitoring location*)

- Review upstream PFAS source area activities
- Review upstream and adjacent catchment data (all media)
- Follow-up monitoring, if required
- Consider and implement mitigation and source control

Trigger 3 (*high potential for risk profile to change at the monitoring location or down-gradient from the monitoring location*):

- Immediate follow-up monitoring for data verification
- Review upstream PFAS source area activities
- Review upstream and adjacent catchment data (all media), including consideration of data assessed as part of the human health and ecological risk assessments for the area / receptor group. For example, further review and/or consideration of biota PFAS concentrations may be warranted.
- Review remediation area / investigation study area activity or land disturbance
- Consider addition of supplemental monitoring locations (groundwater wells, surface water stations)
- Implement mitigation and source control

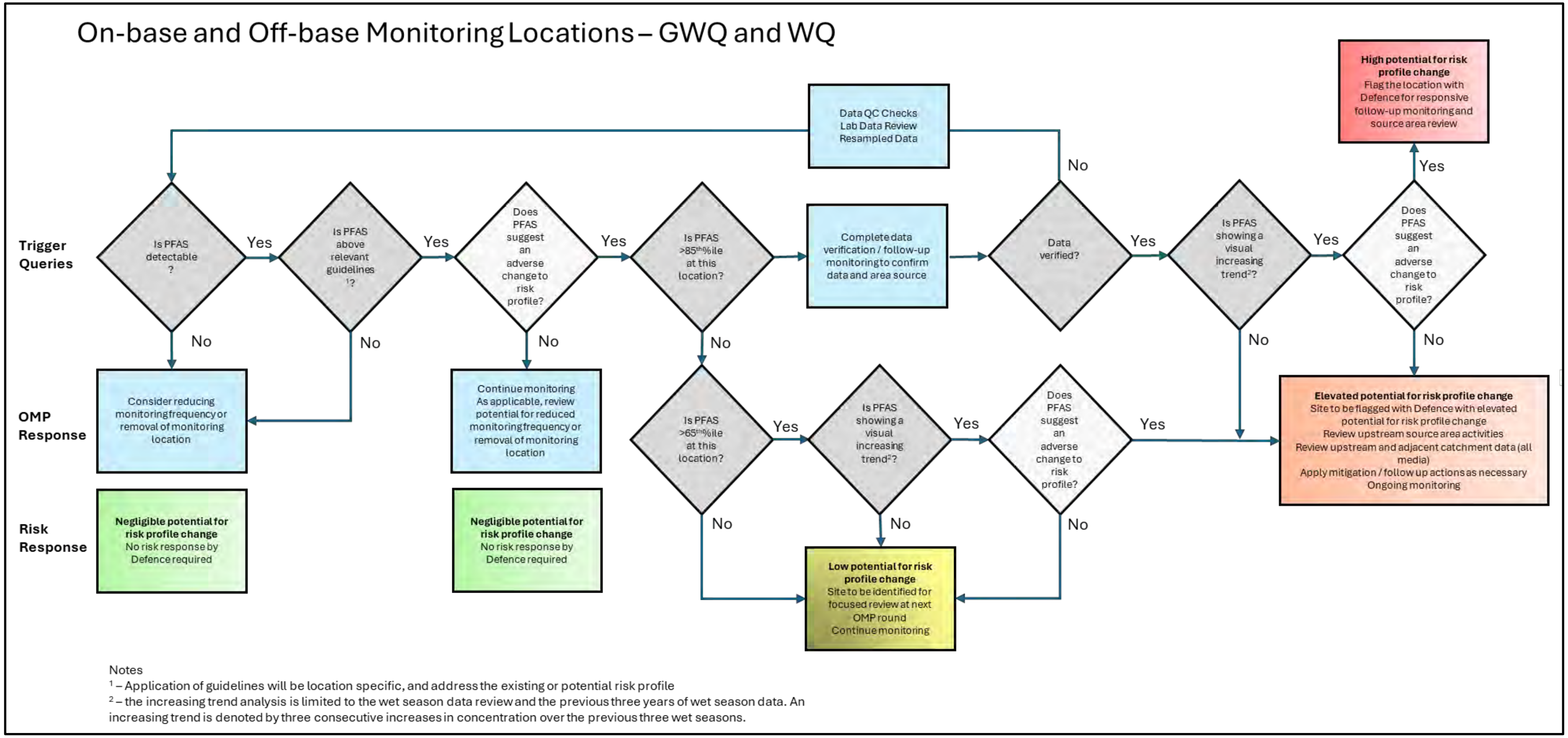


Figure 7.1: PFAS Screening Trigger Framework, RAAF Base Townsville

8 REPORTING REQUIREMENTS

8.1 Reporting

After each monitoring event, information, field, and laboratory data will be documented in the Sampling Event Report (SER). At the end of a specified monitoring period (typically 12 months but this timeframe may vary), the whole data set (including the current and historic data) including the CSM will be reviewed, and an OMR prepared.

The SER will include a letter summarising the key observations and significant changes in the on-base and off-base concentrations including a screening trigger assessment that will inform if results indicate a potential change in risk profile at a monitoring location or catchment region within the Monitoring Area. The report will also include an appendix including observations made during fieldwork, analytical result tables that includes comparisons with PFAS guidelines, laboratory analytical certificates and QA/QC reports. In addition, it is planned that the SER include a dashboard type review of the data will be created and shared with the Defence for easy interpretation of data.

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, per the CSM for the base, and if identified, update the CSM
- potential for changes in risks to human and environmental receptors
- the influence that risk management activities, including remediation activities, at the base, as outlined in the PMAP (Department of Defence, 2019), have had on PFAS in the environment, and
- whether the identified changes trigger a prescribed action and/or review
- whether the monitoring program, based on measured data, needs to be modified.

The SER and OMR will be prepared in accordance with Defence guidance documentation.

8.2 Stakeholder engagement

Engagement with a range of stakeholders, such as Queensland government agencies, Local Councils, other agencies, and the community will be undertaken. A stakeholder engagement plan will be prepared and/or updated to manage the engagement process.

Where off-base monitoring is undertaken and a stakeholder(s) has a specific interest in the results from a particular monitoring location, a separate letter will be provided to the stakeholder(s) presenting the results of the monitoring event. There are currently no sampling locations located on private property.

The OMP will be published on the Defence website, along with the current PMAP and OMR.

APPENDIX A REFERENCES

RAAF Base Townsville is a Department of Defence property subject to Commonwealth Government jurisdiction. The collection and assessment of PFAS data for the OMP will be completed in accordance with the below outlined legislation, policy, standards, and guidance documents.

Commonwealth legislation

- Australian and New Zealand Governments (ANZG) 2018, Australian and New Zealand Guidelines for Fresh and Marine Water Quality.
- Environmental Protection and Biodiversity Conservation Act 1999.
- Food Standards Australia New Zealand (FSANZ) (2017) Perfluorinated Chemicals in Food. Australian Government, Food Standards Australia New Zealand.
- HEPA 2025, PFAS National Environmental Management Plan, Version 3.0.
- National Environment Protection Council (NEPC) 1999. National Environment Protection (Assessment of Site Contamination) Amendment Measure 2013 (No. 1).
- National Health and Medical Research Council (NHMRC), National Resources Management Ministerial Council (NRMMC) 2011, (version 3.8, updated September 2022) Australian Drinking Water Guidelines Paper 6 National Water Quality Management Strategy.
- NHMRC 2019, Guidance on Per and Polyfluoroalkyl substances (PFAS) in Recreational Water.
- NHMRC 2024, NHMRC Statement: Per- and polyfluoroalkyl substances (PFAS) in drinking water. Available at: https://www.nhmrc.gov.au/health-advice/environmental-health/water/PFAS-review/NHMRC-statement-PFAS.
- Standards Australia 1998a, Water Quality—Sampling. Part 1: Guidance on the Design of Sampling Programs, Sampling Techniques and the Preservation and Handling of Samples (AS/NZS 5667.1:1998).
- Standards Australia 1998b, Water Quality—Sampling. Part 4: Guidance on sampling from lakes, natural and man-made (AS/NZS 5667.4:1998).
- Standards Australia 1998c, Water Quality—Sampling. Part 11: Guidance on Sampling of Groundwaters (AS/NZS 5667.11:1998).
- Standards Australia 1998d. Water Quality—Sampling. Part 12: Guidance on Sampling of Bottom Sediments (AS/NZS 5667.12:1998).

Defence policy, standards and guidance

- Defence Environmental Policy.
- Defence Estate Strategy 2016-2036.
- Defence Environmental Strategy 2016-2036.
- Defence Contamination Management Manual 2018.
- Defence PFAS Construction and Maintenance Framework Version 2.1 2019.
- RAAF Base Townsville, PFAS Management Area Plan 2019.

State/Territory legislation and policy

The following state legislation and policy does not have jurisdiction on the base, although may be applied when potential environmental harm may occur to off-base environments and receptors:

- Environmental Protection Act 1994 (QLD).
- Environmental Protection Regulation 2019 (QLD).
- Environmental Protection (Water and Wetland Biodiversity) Policy 2019 (QLD).

Other references not listed above

- AECOM (2024a), PFAS OMP RAAF Base Townsville, Sampling and Analysis Quality Plan, 27 February 2024. Prepared for Department of Defence. February 2024.
- AECOM (2024b). Ongoing Monitoring Report (June 2023 – March 2024), RAAF Base Townsville. Draft submitted to Department of Defence. October 2024.
- BOM (2024) Climate statistics for Australian locations. Townsville AERO. http://www.bom.gov.au/climate/averages/tables/cw_032040_All.shtml.
- WSP (2018a) RAAF Base Townsville Detailed Site Investigation – PFAS, Volume 1 – 4 RevD,
- WSP (2018b). RAAF Base Townsville Human Health Risk Assessment RevI.
- WSP (2019a). RAAF Base Townsville Seasonal Monitoring Report (1 & 2) – PFAS, Volume 1 – 4 RevB.
- WSP (2019b) RAAF Base Townsville Ecological Risk Assessment RevG.
- WSP (2021). Remedial Action Plan – Sub-Management Area 1, RAAF Townsville. WSP Australia Pty Ltd, December 2019, October 2021.
- WSP (2023a). PFAS Surface Water Mass Discharge Sub-Management Areas 1 and 2: RAAF Base Townsville. Submitted to Department of Defence. March 2023.
- WSP (2023b), PFAS Surface Water Mass Discharge - SMA2 and 3 RAAF Base Townsville. WSP Australia Pty Ltd, June 2023.
- WSP (2023c), PFAS Groundwater Mass Discharge 2023, RAAF Base Townsville. WSP Australia Pty Ltd, June 2023.
- WSP (2023d). Remediation Action Plan – Fire Station Locale, RAAF Base Townsville. Submitted to Department of Defence. June 2023.
- WSP (2023e). Remediation Action Plan – Fuel Farm #2, RAAF Base Townsville. Submitted to Department of Defence. June 2023.

APPENDIX B FIGURES

KEY MAP

LEGEND

- Management Area
- Monitoring Area Boundary
- Suburb Boundary
- Wetlands
- Lake Lydeamore
- Drainage Catchment Boundary
- Watercourse

0 1,000 2,000 3,000 4,000

1:50,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

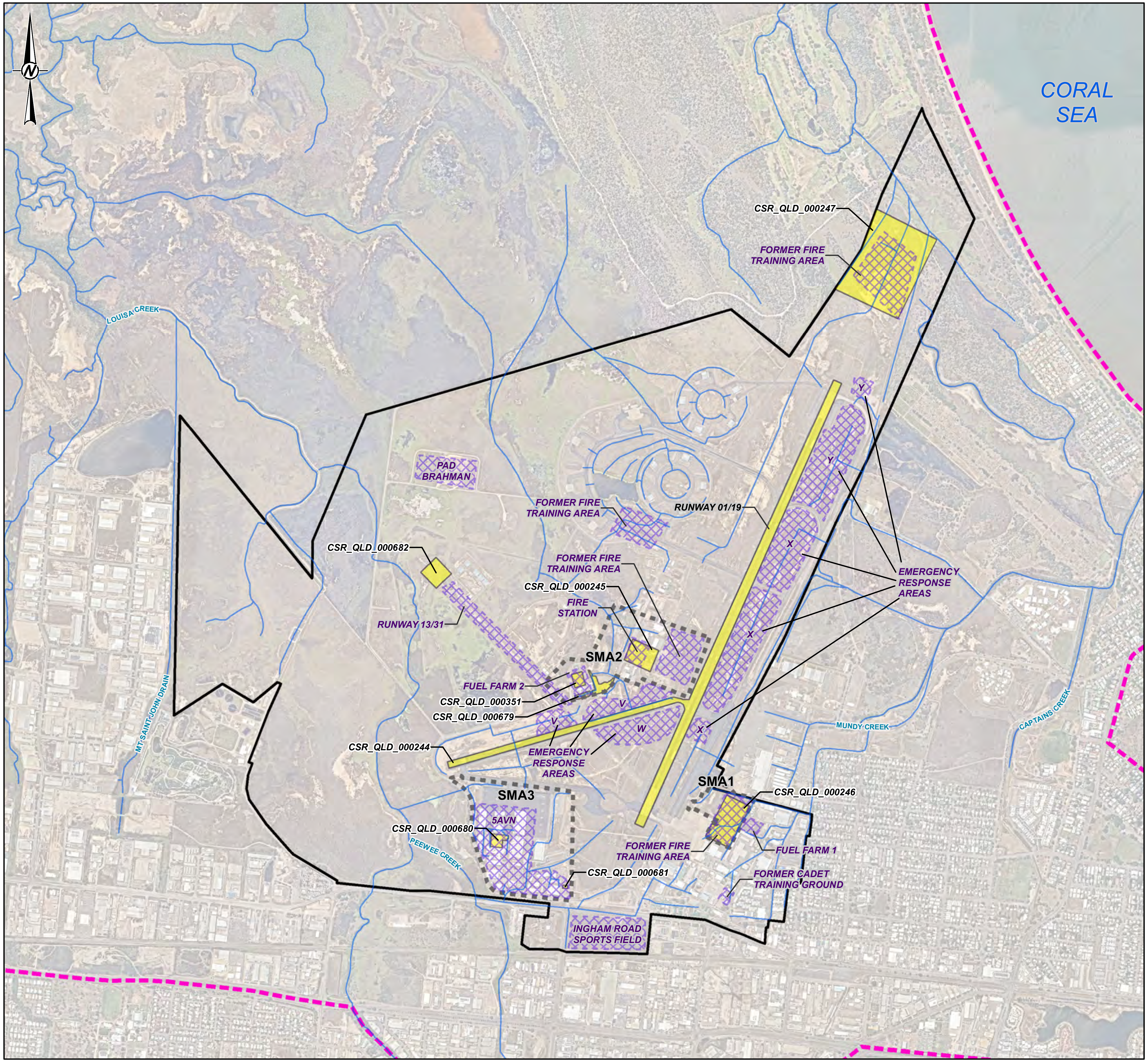
PROJECT
RAAF TOWNSVILLE ONGOING MONITORING PROGRAM

TITLE
SITE LOCALITY

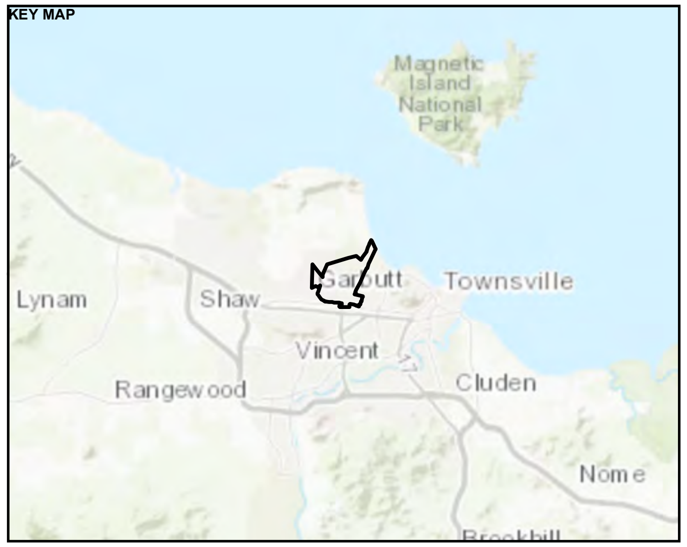
CONSULTANT

YYYY-MM-DD	2025-04-15
DESIGNED	-
PREPARED	MAH
REVIEWED	JF
APPROVED	AH

REPORT	REV.	FIGURE
PS210238-008-R	A	1



KEY MAP



LEGEND

- Monitoring Area Boundary
- Management Area
- Sub-management Area (SMA) (PMAP
- Contaminated Site Record (CSR)
- Potential PFAS Source Area (Identified in DSI, 2018)

0 500 1,000 1,500

1:20,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.
2. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
3. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
RAAF TOWNSVILLE ONGOING MONITORING PROGRAM

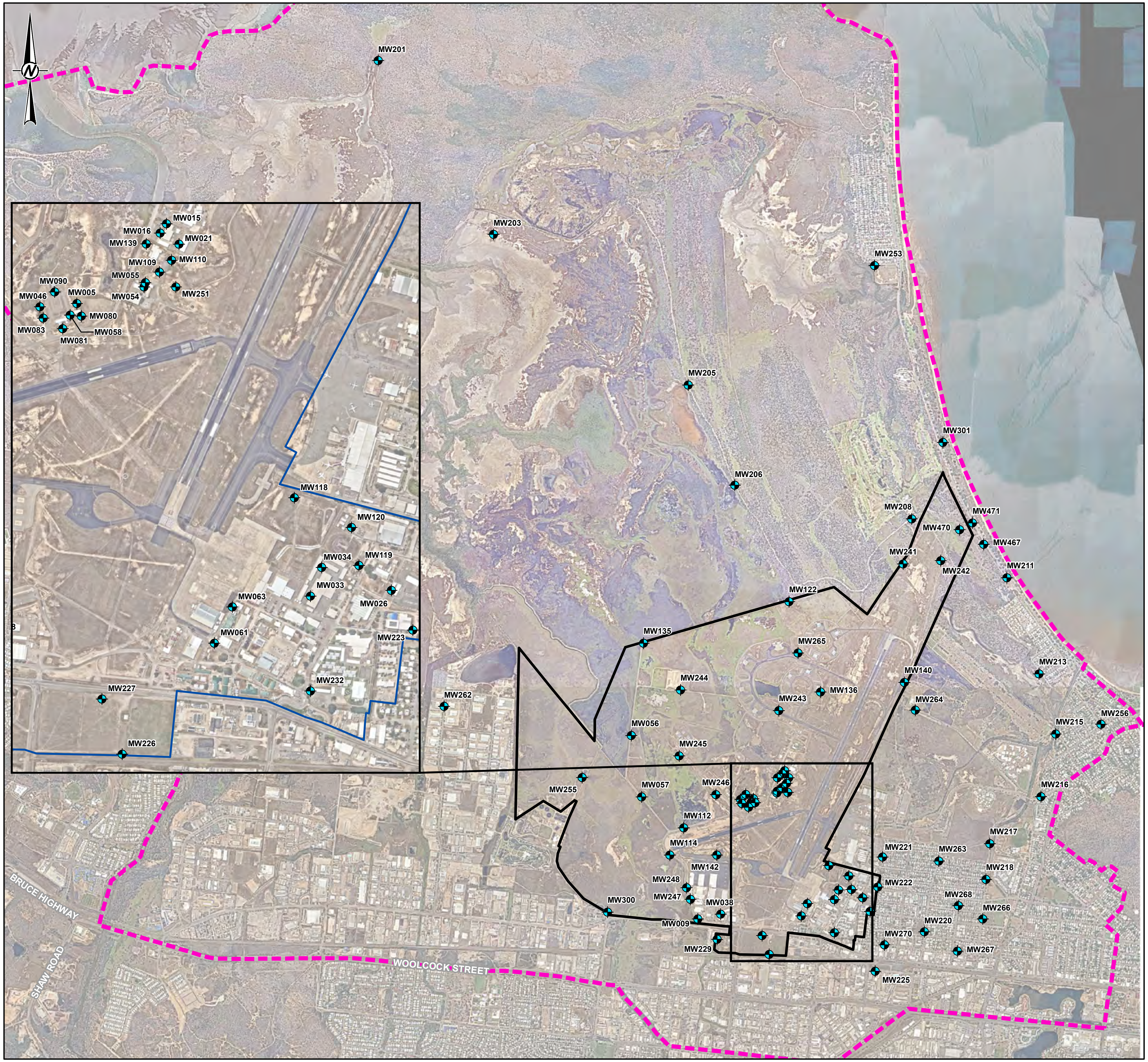
TITLE
SITE LAYOUT AND KEY SOURCE AREAS

CONSULTANT

YYYY-MM-DD	2025-04-15
DESIGNED	-
PREPARED	MAH
REVIEWED	CJ
APPROVED	AH

REPORT	REV.	FIGURE
PS210238-008-R	A	2

25mm IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ISO A3



KEY MAP

LEGEND

- Monitoring Area Boundary
- Management Area
- Groundwater Monitoring Location

0 500 1,000 1,500 2,000 2,500

1:35,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
RAAF TOWNSVILLE ONGOING MONITORING PROGRAM

TITLE
GROUNDWATER MONITORING LOCATIONS

CONSULTANT

wsp

YYYY-MM-DD	2025-04-15
DESIGNED	-
PREPARED	MAH
REVIEWED	JF
APPROVED	AH

REPORT PS210238-008-R | REV. A | FIGURE 3

KEY MAP

LEGEND

- Monitoring Area Boundary
- Management Area
- Watercourse
- Co-located Surface Water / Sediment Sampling Location

0 500 1,000 1,500 2,000 2,500 3,000

1:40,000 METRES

NOTE(S)
1. PROJECTION: GDA 1994 MGA ZONE 55.

REFERENCE(S)
1. KEY MAP SOURCED FROM ESRI ONLINE BASEMAPS.
2. STATE REFERENCE DATA SOURCED FROM DATA.QLD.GOV.AU.
3. AERIAL IMAGERY SOURCED FROM NEARMAP.COM.

CLIENT
DEPARTMENT OF DEFENCE

PROJECT
RAAF TOWNSVILLE ONGOING MONITORING PROGRAM

TITLE
SURFACE WATER AND SEDIMENT SAMPLING LOCATIONS

CONSULTANT

YYYY-MM-DD	2025-04-15
DESIGNED	-
PREPARED	MAH
REVIEWED	JF
APPROVED	AH

REPORT	REV.	FIGURE
PS210238-008-R	A	4

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APPENDIX C SAMPLE LOCATION INFORMATION

Table C.1: Groundwater Monitoring Locations

Location Code	Easting	Northing	Location Code	Easting	Northing
MW118	475690.6	7870672	MW227	475076.8	7870030
MW005	474996.4	7871292	MW229	474663.3	7869993
MW015	475281.9	7871548	MW056	473873.2	7871871
MW016	475261.6	7871518	MW057	473967.4	7871307
MW021	475321.9	7871481	MW122	475323.6	7873101
MW046	474878.8	7871282	MW135	473984.1	7872722
MW054	475211	7871345	MW241	476371.5	7873451
MW055	475214.8	7871358	MW242	476632	7873501
MW058	474975.1	7871255	MW245	474313	7871685
MW080	475010.8	7871252	MW255	473421.1	7871483
MW081	474951.6	7871212	MW265	475406.6	7872629
MW083	474888.6	7871246	MW300	473655.5	7870244
MW090	474925.5	7871329	MW470	476893.7	7873764
MW109	474925.8	7871330	MW205	474396.5	7875095
MW110	475299	7871430	MW206	474823.3	7874173
MW139	475218	7871483	MW208	476452.1	7873863
MW246	474650	7871325	MW201	471544.9	7878084
MW251	475312.2	7871346	MW203	472606.1	7876485
MW009	474484.2	7870184	MW262	472149.2	7872140
MW038	474694.3	7870227	MW253	476109.5	7876194
MW114	474227.3	7870770	MW301	476738	7874569
MW142	474659.7	7870770	MW211	477326.7	7873325
MW247	474382.5	7870469	MW213	477622.9	7872438
MW248	474417	7870363	MW215	477775.3	7871883
MW136	475614.6	7872270	MW216	477640.5	7871307
MW140	476385	7872361	MW256	478194.1	7871973
MW243	475230	7872100	MW264	476484	7872102
MW244	474324	7872289	MW467	477115.1	7873630
MW112	474355.7	7871023	MW471	477011.5	7873827
MW026	475999.2	7870377	MW217	477169	7870873
MW033	475741.6	7870359	MW218	477134.5	7870545
MW034	475777.5	7870450	MW221	476182.6	7870754
MW061	475435.3	7870208	MW225	476116.7	7869701
MW063	475492.3	7870323	MW263	476700.7	7870713
MW119	475896.5	7870456	MW267	476870.9	7869884

Location Code	Easting	Northing	Location Code	Easting	Northing
MW120	475872.2	7870577	MW220	476567	7870065
MW222	476140.5	7870476	MW266	477105.5	7870184
MW223	476068.8	7870249	MW268	476880	7870303
MW232	475741	7870056	MW270	476201	7869943
MW226	475140.7	7869853			

79 groundwater gauging and wet season monitoring locations.

Coordinate System: GDA94 MGA Zone 55

Table C.2: Surface Water / Sediment Monitoring Locations

Location Code	Easting	Northing	Dry Season	Wet Season
SD/SW001	476040	7870492		Yes
SD/SW010	475936	7870030		Yes
SD/SW106	474416	7872840		Yes
SD/SW132	475257	7873084		Yes
SD/SW133	473842	7870190		Yes
SD/SW145	473939	7872337		Yes
SD/SW156	474533	7869520		Yes
SD/SW012	469061	7870100		Yes
SD/SW013	474729	7869820		Yes
SD/SW014	476677	7873745		Yes
SD/SW016	476731	7873120	Yes	Yes
SD/SW112	477200	7873180	Yes	Yes
SD/SW123	477563	7872630		Yes
SD/SW125	477987	7872490	Yes	Yes
SD/SW126	475087	7873492	Yes	Yes
SD/SW131	474733	7874275	Yes	Yes
SD/SW158	475135.93	7871293.07		Yes
SD/SW160	475247.42	7871555.98		Yes
SD/SW161	474992.92	7871222.1		Yes
SD/SW162	469238	7872657		Yes
SD/SW102	473578	7871760	Yes	Yes
SD/SW108	476227.99	7871810.67		Yes
SD/SW109	477592	7871540	Yes	Yes
SD/SW113	477064	7871730		Yes
SD/SW114	477778	7871930		Yes
SD/SW115	476417	7871040		Yes
SD/SW116	476800	7871410		Yes
SD/SW117	476175	7870700		Yes
SD/SW118	474663	7869200		Yes
SD/SW119	474357.51	7870728.62		Yes
SD/SW208	474440	7871312		Yes
SD/SW209	475066	7872220		Yes
SD/SW017	474744	7872240		Yes
SD/SW021	476148	7870575		Yes
SD/SW110	475854.19	7870654.9		Yes
SD/SW111	475837.81	7870633.04		Yes
SD/SW202	469063	7876563	Yes	Yes

Location Code	Easting	Northing	Dry Season	Wet Season
SD/SW203	468609	7877503	Yes	Yes
SD/SW204	471799.09	7874452.42	Yes	Yes
SD/SW205	470781	7875395	Yes	Yes
SD/SW206	470781	7875395	Yes	Yes
SD/SW207	477888	7872271	Yes	Yes
SD/SW107	476826	7873010		Yes
SD/SW210	476391	7875788	Yes	Yes
SD/SW169	473874.85	7871912.89		Yes
SD/SW170	474051.44	7871185.14		Yes

46 sediment and surface water wet season monitoring locations, in which 14 of these monitoring locations are sampled for surface water in the dry season.

Coordinate System: GDA94 MGA Zone 55

APPENDIX D OMP REVIEW

The following changes to the existing OMP are proposed at this time.

Table D.1: 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*
All surface water and groundwater well locations	*Yes*	*Yes*	*Yes*	*Yes – the reduced frequency still informs risk profile*	*The reduction in seasonal monitoring to sampling only during the wet season at groundwater and surface water / sediment sampling locations, except for the permanent waterbodies (eg on-base wetlands) and watercourses (eg intertidal locations in the Mundy Creek, Louisa Creek and Bohle River, and Three Mile Creek catchments)*	*Previous mass flux studies at RAAF Townsville (eg WSP 2023a,b,c) show that surface water is the dominant PFAS migration pathway. Also, water flow through the ephemeral on-base and off-base watersheds is generally limited to the wet season as shown in the OMP implementation.* *During the dry season, many of the on-base and off-base drain locations are dry or pooled, stagnant watercourses. The exceptions are those that are permanent wetlands and watercourses (eg Mundy Creek, Three Mile Creek, Louisa Creek and the Bohle River). As a result, annual monitoring will be focused on wet season sampling of surface watercourses / drains when flow through the Monitoring Area is occurring and PFAS is being mobilised from the on-base area. The OMP has retained the permanent waterbodies (wetlands) and the downstream tributaries, which will be sampled in the dry season.* *Groundwater and sediment represent secondary pathways for downstream PFAS contribution from on-base source areas. With elevated potential for surface water*

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
						interactions with groundwater (eg elevated groundwater levels) and sediment (eg sediment mobilization and sediment/water interactions) during the wet season (when PFAS has the greatest potential to mobilise to downstream receiving environments), sampling events will be limited to the wet season sampling event. *The sampling frequency reduction for groundwater, surface water (non-permanent water sources), and sediment to an annual basis is supported by the seasonal data collected to date over the period of the OMP (2017 to 2024) (Figures D.1, D.2, and D.3). The data illustrate a general consistency in PFAS concentrations between seasons and within monitoring areas for each of the sampled media. Where discernible differences occur between season (eg surface water where dry season concentrations are higher than wet season concentrations), the differences are generally small and mostly explainable by seasonal condition (eg for dry season surface water concentrations, elevated concentrations are potentially attributable to ponded water subject to evapo-concentration factors). The reduction in sampling frequency will retain value in understanding PFAS concentrations in the Monitoring Area and generate data that can be expected to inform the risk profile, and changes in risk profile, in the receiving environment.*

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***
Removal of Rainfall Event sampling program	-	-	-	-	*The removal of the rainfall event sampling does not limit the ability to meet the objectives of the OMP*	*The rainfall event monitoring has been included in the OMP for several years; the data collected from this sampling program have been consistent with the information collected from the wet season OMP sampling and the mass flux assessments. Progressing the OMP as planned (ie focus on wet season sampling) and continuing with the mass flux assessment program is sufficient to provide an assessment of PFAS migration in terms of identifying source locations, event concentration ranges, and mass flux.*
Removal of MW223 from East and Southeast of SMA1	*Yes*	*Yes*	*Yes*	-	*No anticipated effect to OMP*	*This well appears to have been destroyed during recent development works at the base.*
Removal of MW257, MW258, and MW259 from East and Southeast of SMA1	*Yes*	*Yes*	*Yes*	-	*No anticipated effect to OMP*	*These three bores along with MW225 bores have consistently low PFAS. There is an opportunity to reduce the well group by retaining MW225 (as it has the longest data record and reports the highest of the low end PFAS for this well group).*
Removal of MW138 and MW250 from SMA2	*Yes*	*Yes*	*Yes*	-	*No anticipated effect to OMP*	*The listed groundwater well locations are a subset of two groups of nested wells in SMA-2.*

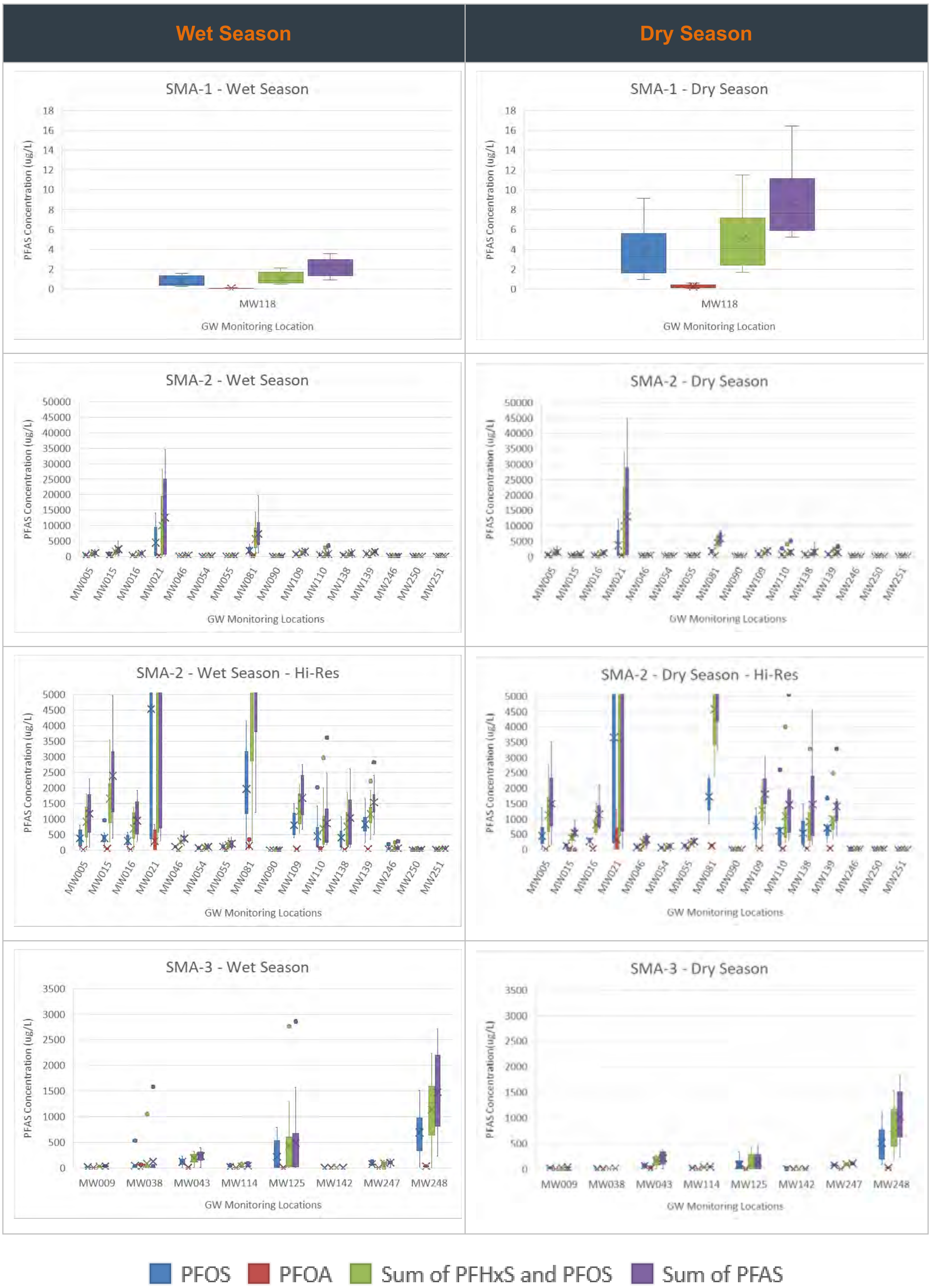
Location	***Does the location inform the nature of PFAS at the site***	***Does the location inform the extent of PFAS at the site***	***Does the location inform the risk profile at the site***	***Does the sampling frequency inform the risk profile***	***OMP Review Outcome***	***Reason***
Removal of MW043 and MW125 from SMA3	*Yes*	*Yes*	*Yes*	*-*	*No anticipated effect to OMP*	*These wells appear to have been destroyed or covered over during recent development works at the base.*
Removal of MW228 from External Defence Properties (South of Ingham Road)	*Yes*	*Yes*	*Yes*	*-*	*No anticipated effect to OMP*	*MW228 is a well located in an external Defence property immediately adjacent the base that consistently reports negligible PFAS concentrations; the remaining 3 locations in this set also report consistently low PFAS concentrations*
Removal of MW002, MW004, MW234 and MW235 from the balance of the base area	*Yes*	*Yes*	*Yes*	*-*	*No anticipated effect to OMP*	*These wells have consistent negligible to low PFAS concentrations and/or are adjacent to other well that consistently report similar negligible to low PFAS concentrations*
Removal of MW231, MW237, MW239, and MW254 from Bohle River and Bohle Industrial Estate	*Yes*	*Yes*	*Yes*	*-*	*No anticipated effect to OMP*	*These wells consistently report low PFAS and indicate limited influence from the base on PFAS contamination. MW262 will be retained from this area to assist with understanding of data range and groundwater regime (eg water level elevation understanding).*
Removal of MW233 and MW252 from Pallarenda, NE of base	*Yes*	*Yes*	*Yes*	*-*	*No anticipated effect to OMP*	*All three bores (including MW253) in Pallarenda have consistently low PFAS. MW253 will be retained for the OMP due to its closer proximity to base (and because it could be considered an early detection well).*

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***
Removal of MW202, MW204, MW207, MW212, MW214, MW219, MW236, MW238, MW240, MW260, MW261, and MW269 from the off-base monitoring area	*Yes*	*Yes*	*Yes*	*Yes*	*No anticipated effect to OMP*	*These wells have consistent negligible to low PFAS concentrations and/or are adjacent to other wells that consistently report similar negligible to low PFAS concentrations*
Inclusion of MW058, MW080, and MW083 (SMA-2)	*Yes*	*Yes*	*Yes*	*Yes*	*The addition of 3 new sampling locations for groundwater sampling during the wet season event*	*The inclusion of these groundwater locations to the OMP is a result of the post-remediation monitoring recommended in the RAP (WSP, 2023e; RAP Fuel Farm #2) to enhance the ability to track PFAS at locations within and downstream of areas that have been or are currently in remediation phases*
Removal of SD/SW121 from the on-base Mundy Creek Catchment locations	-	-	-	-	*No anticipated effect to OMP*	*SD/SW121 is one of a nested group of on-base sampling locations (that include SD/SW001 and SD/SW132).*

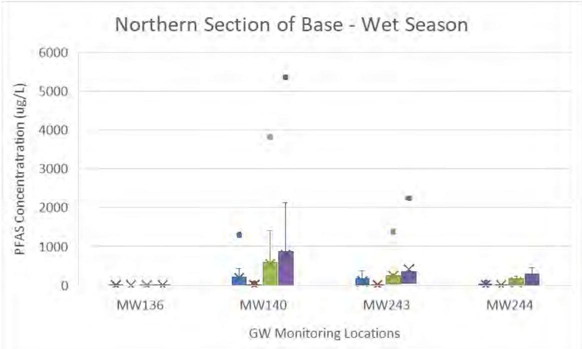
Location	***Does the location inform the nature of PFAS at the site***	***Does the location inform the extent of PFAS at the site***	***Does the location inform the risk profile at the site***	***Does the sampling frequency inform the risk profile***	***OMP Review Outcome***	***Reason***
Removal of SD/SW127 from the off-base Bohle River / Louisa Creek / Townsville Town Common locations	-	-	-	-	*No anticipated effect to OMP*	*SD/SW127 consistently reports negligible PFAS concentrations; the location of other sampling locations in proximity (ie SD/SW017 and SD/SW120) will reliably inform the OMP.*
Removal of SD/SW201, SD/SW120, and SD/SW129 *from the off-base Bohle River / Louisa Creek / Townsville Town Common locations*	-	-	-	-	*No anticipated effect to OMP*	*SD/SW201 is an upstream reference location that consistently reports negligible PFAS concentrations; the location of SD/SW129 downstream of SD/SW201 at the base boundary, which also reports consistently low PFAS concentrations, will reliably inform the OMP.* *SW120 along with SW017 are upgradient surface water monitoring locations, each of which have a history of measured low-level PFAS. Their value to the OMP is providing an indication of upstream reference data; however, having two of these locations in close proximity to each other is redundant. SW017 will be retained (it has a longer data record).* *SW129 along with SD/SW202 have consistently had very low-level PFAS and represent a few surface water sites within the Monitoring Area that have reported limited on-base impacts. The base ESM has identified the area around SD/SW202 as a highly valued and frequented fishing area. SW202 will be retained*

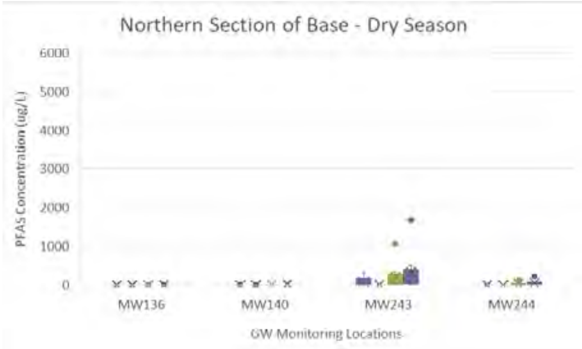
Location	***Does the location inform the nature of PFAS at the site***	***Does the location inform the extent of PFAS at the site***	***Does the location inform the risk profile at the site***	***Does the sampling frequency inform the risk profile***	***OMP Review Outcome***	***Reason***
Inclusion of SD/SW133, SD/SW145, SD/SW156 (SMA-1) and SD/SW012, SD/SW158, SD/SW160, SD/SW161, and SD/SW162 (SMA-2)	*Yes*	*Yes*	*Yes*	*Yes*	*The addition of 8 new sampling locations for sediment quality and surface water quality sampling during the wet season event*	*The inclusion of these surface water quality and sediment quality locations to the OMP is a result of the post-remediation monitoring recommended in the RAP (WSP, 2023c; RAP Fuel Farm #2) to enhance the ability to track PFAS at locations within and downstream of areas that have been or are currently in remediation phases.*
Inclusion of SD/SWNew1 and SD/SWNew2 to the on-base Bohle, Mt Louisa, and Town Common area	*Yes*	*Yes*	*Yes*	*Yes*	*The addition of 2 new sampling locations for sediment quality and surface water quality sampling during the wet season event*	*These 2 locations will increase the monitoring extent between SW123 and SW016. These are: one location immediately west of SW125 on Peewee Creek and one location on Peewee Creek immediately downstream of disused runway for wet season sampling.*

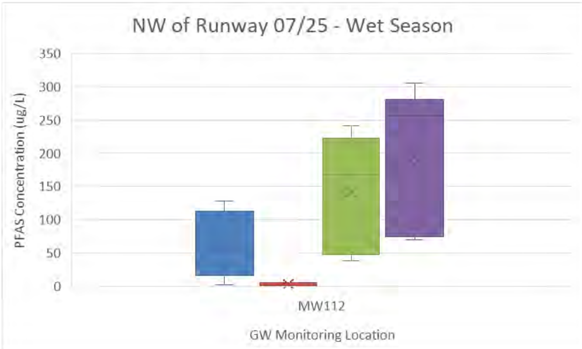
Figure D.1. Seasonal groundwater PFAS concentrations in on-base and off-base locations in the Monitoring Area (2017 to 2024)

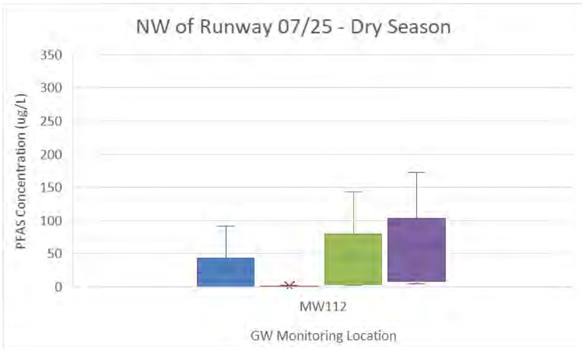


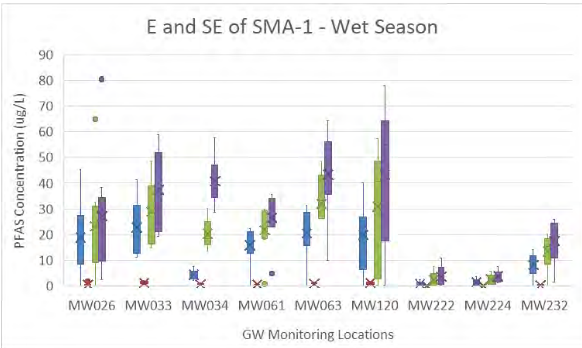
Wet Season	Dry Season

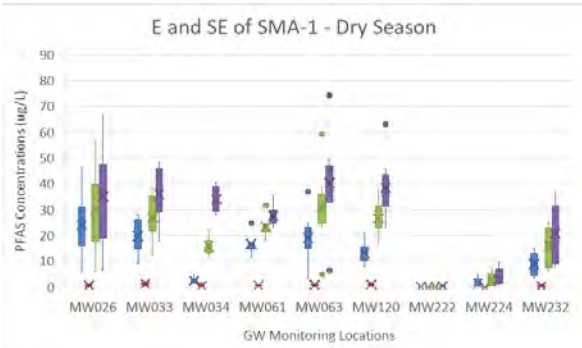


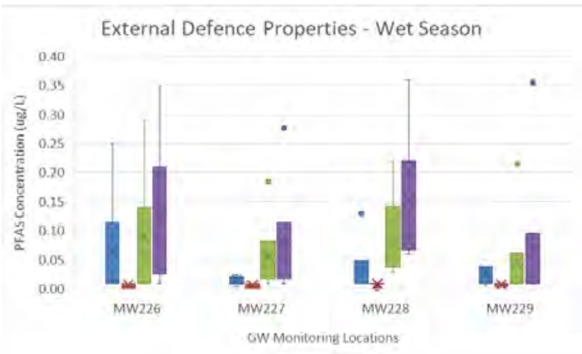


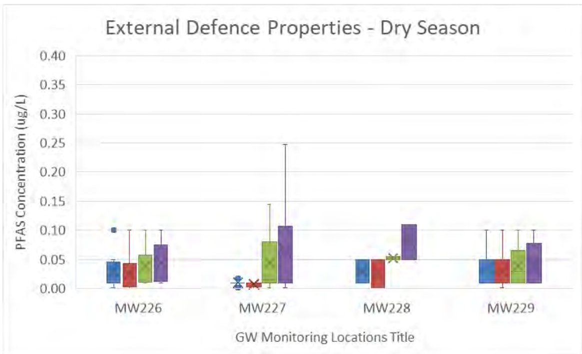






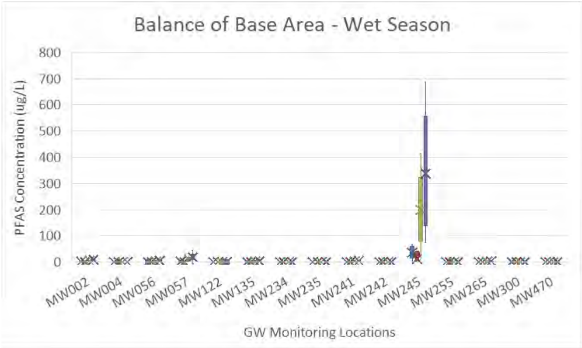


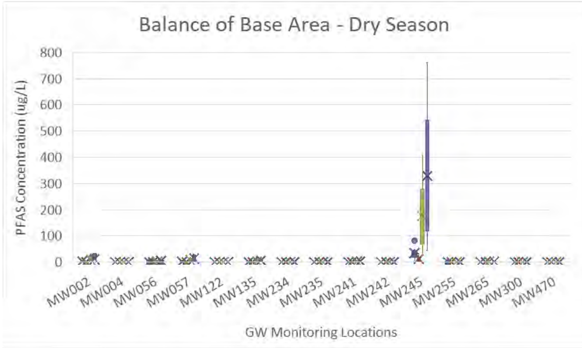


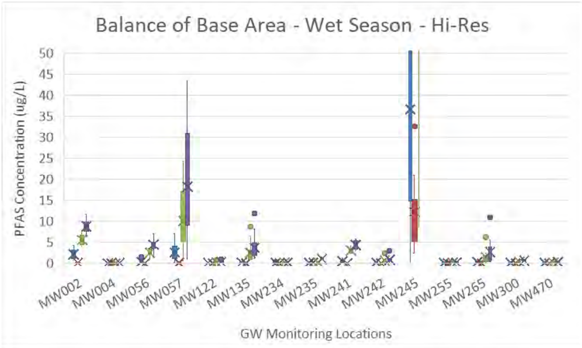


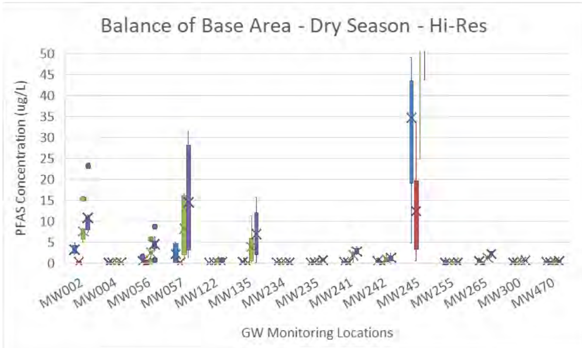
PFOS   PFOA   Sum of PFHxS and PFOS   Sum of PFAS

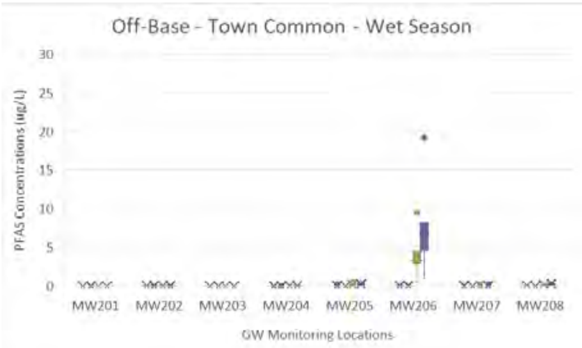
Wet Season	Dry Season

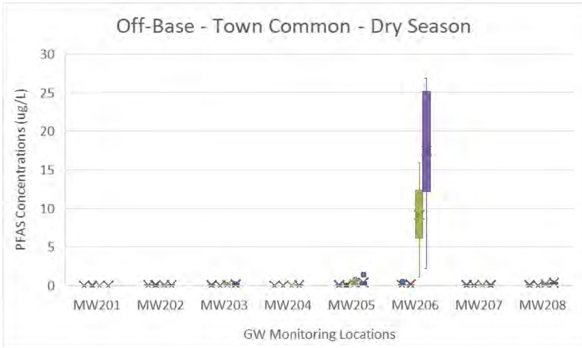


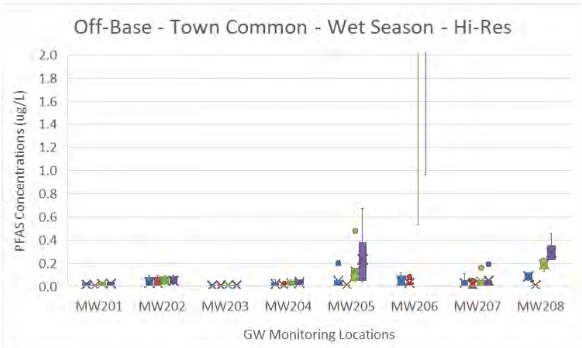


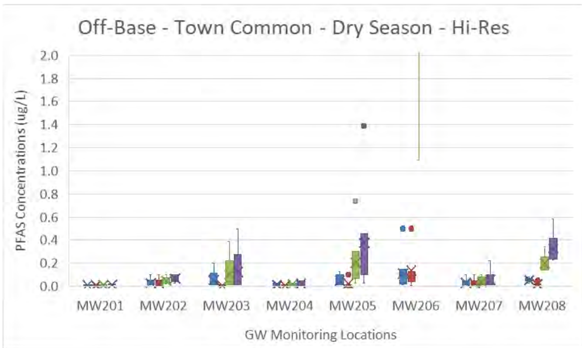




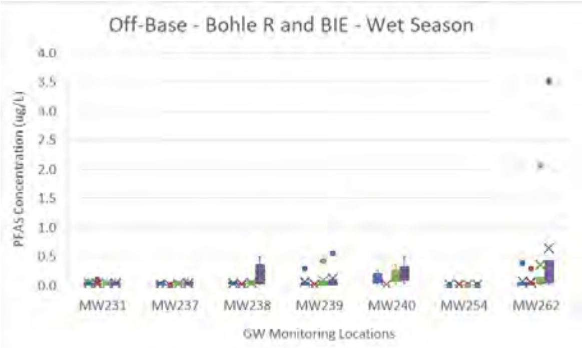
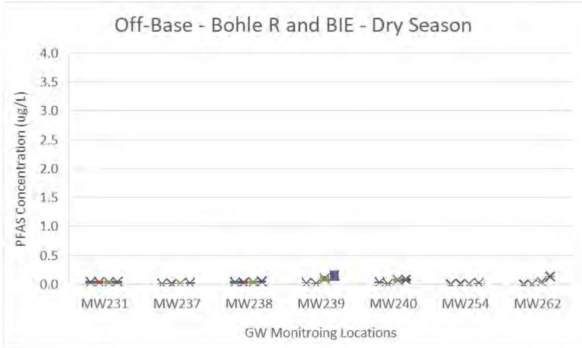
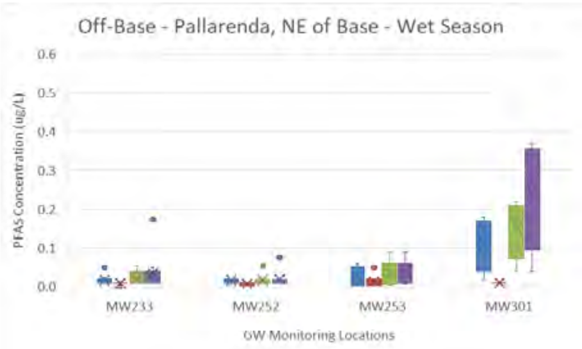
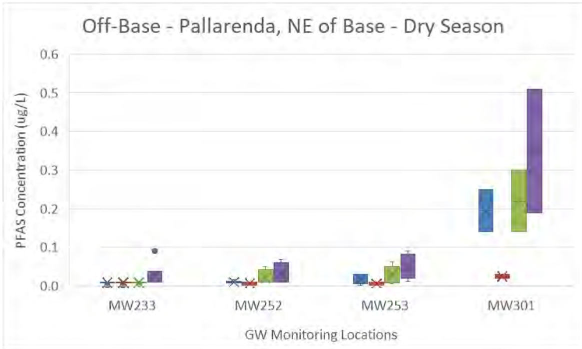
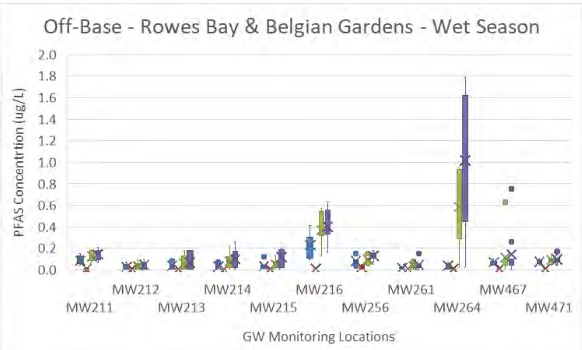
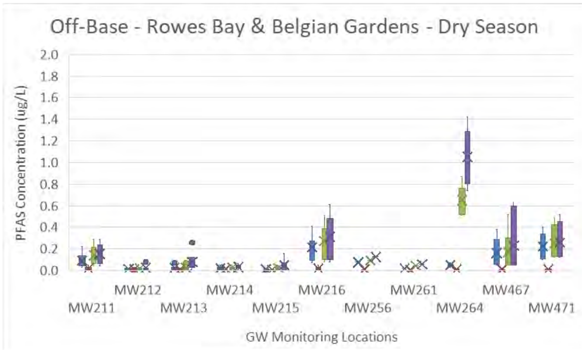
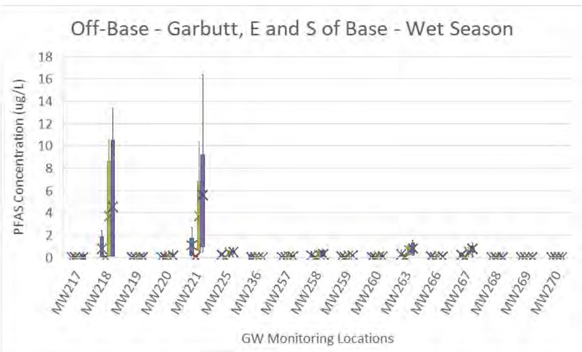
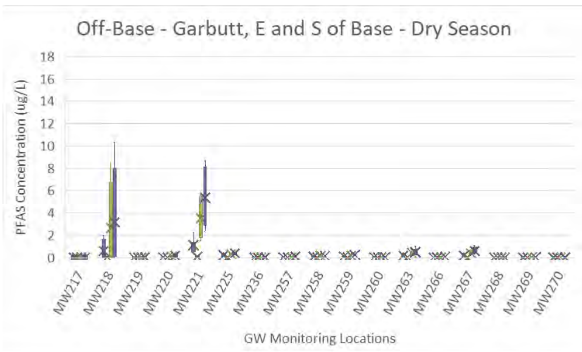






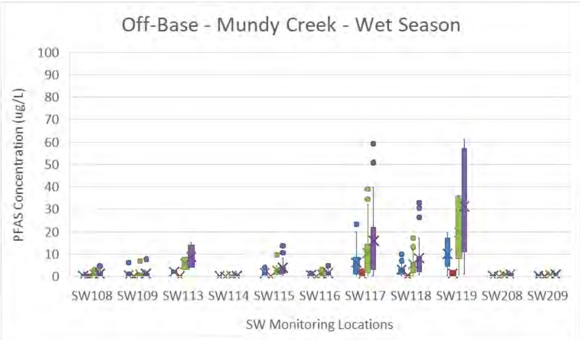
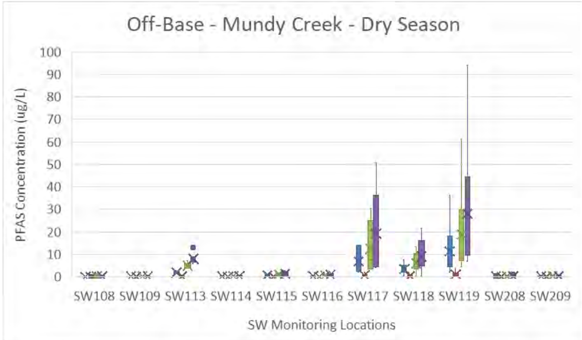
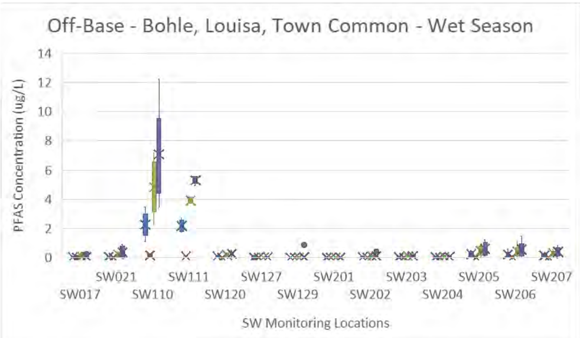
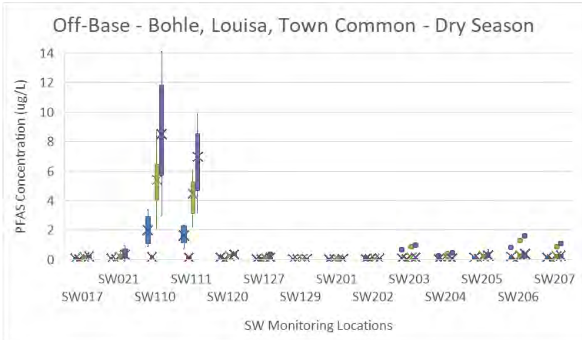
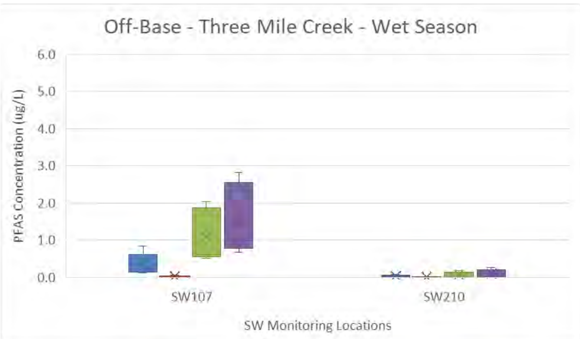
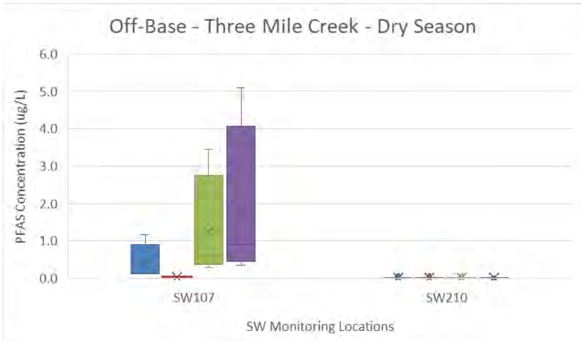


PFOS PFOA Sum of PFHxS and PFOS Sum of PFAS

Wet Season	Dry Season
	
	
	
	

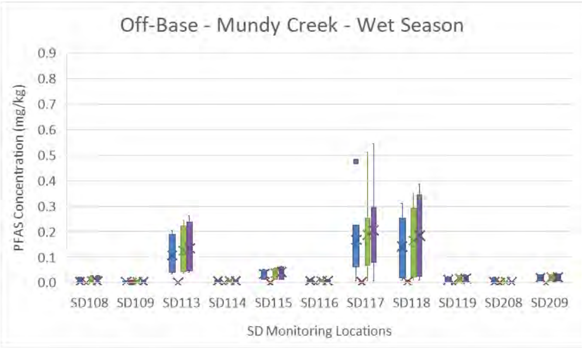
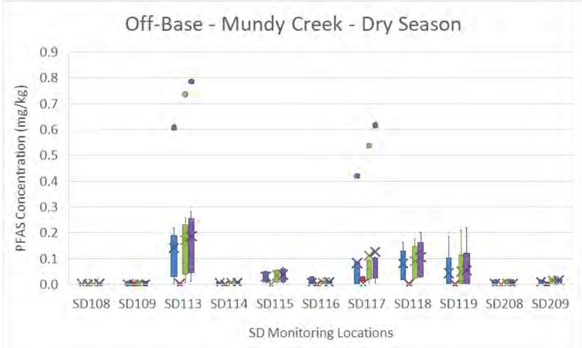
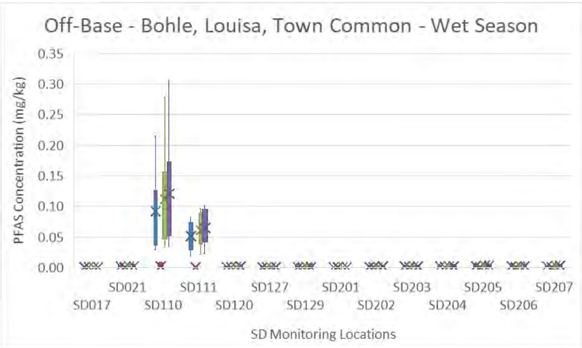
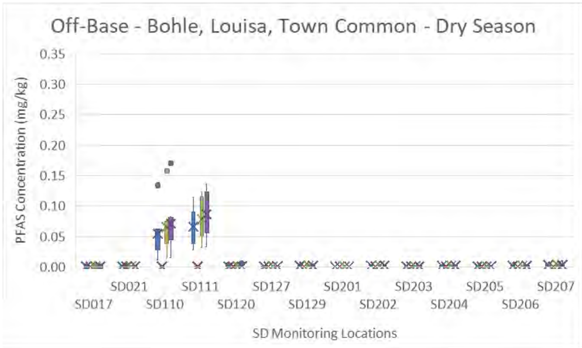
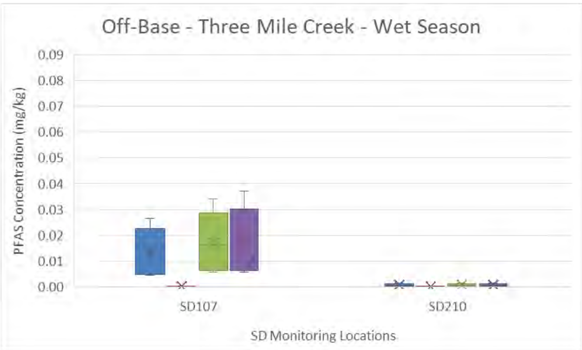
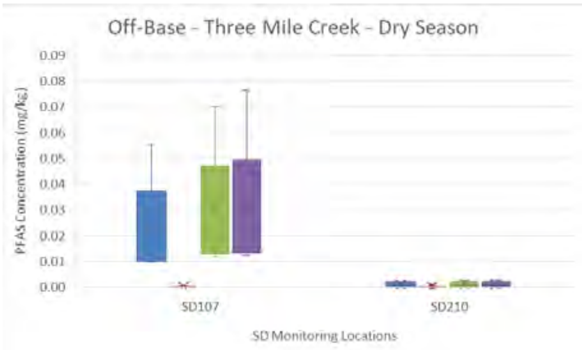
PFOS PFOA Sum of PFHxS and PFOS Sum of PFAS

Figure D.2. Seasonal surface water PFAS concentrations in on-base and off-base locations in the Monitoring Area (2017 to 2024)

Wet Season	Dry Season
	
	
	

PFOS PFOA Sum of PFHxS and PFOS Sum of PFAS

Figure D.3. Seasonal sediment PFAS concentrations in on-base and off-base locations in the Monitoring Area (2017 to 2024)

Wet Season	Dry Season
	
	
	

PFOS PFOA Sum of PFHxS and PFOS Sum of PFAS

APPENDIX E PFAS ANALYTICAL SUITE

Table E.1 – Limits of reporting for groundwater and surface water, and all sediment samples

Target analytes[1]	Groundwater and Surface Water		Sediment	
	Units	LOR	Units	LOR
Perfluoroalkyl Sulfonic Acids				
Perfluoropropane sulfonic acid (PFPrS)	µg/L	0.02	mg/kg	0.0005
Perfluorobutane sulfonic acid (PFBS)	µg/L	0.02	mg/kg	0.0002
Perfluoropentane sulfonic acid (PFPeS)	µg/L	0.02	mg/kg	0.0002
Perfluorohexane sulfonic acid (PFHxS)	µg/L	0.01	mg/kg	0.0002
Perfluoroheptane sulfonic acid (PFHpS)	µg/L	0.02	mg/kg	0.0002
Perfluorooctane sulfonic acid (PFOS)	µg/L	0.01	mg/kg	0.0002
Perfluorononane sulfonic acid (PFNS)	µg/L	0.02	mg/kg	0.0002
Perfluorodecane sulfonic acid (PFDS)	µg/L	0.02	mg/kg	0.0002
Perfluoroalkyl Carboxylic Acids				
Perfluorobutanoic acid (PFBA)	µg/L	0.1	mg/kg	0.001
Perfluoropentanoic acid (PFPeA)	µg/L	0.02	mg/kg	0.0002
Perfluorohexanoic acid (PFHxA)	µg/L	0.02	mg/kg	0.0002
Perfluoroheptanoic acid (PFHpA)	µg/L	0.02	mg/kg	0.0002
Perfluorooctanoic acid (PFOA)	µg/L	0.01	mg/kg	0.0002
Perfluorononanoic acid (PFNA)	µg/L	0.02	mg/kg	0.0002
Perfluorodecanoic acid (PFDA)	µg/L	0.02	mg/kg	0.0002
Perfluoroundecanoic acid (PFUnDA)	µg/L	0.02	mg/kg	0.0002
Perfluorododecanoic acid (PFDoDA)	µg/L	0.02	mg/kg	0.0002
Perfluorotridecanoic acid (PFTrDA)	µg/L	0.02	mg/kg	0.0002
Perfluorotetradecanoic acid (PFTeDA)	µg/L	0.05	mg/kg	0.0005
Perfluoroalkyl Sulfonamides				
Perfluorooctane sulfonamide (FOSA)	µg/L	0.02	mg/kg	0.0002
N-Methyl perfluorooctane sulfonamide (MeFOSA)	µg/L	0.05	mg/kg	0.0005
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	µg/L	0.05	mg/kg	0.0005
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	µg/L	0.05	mg/kg	0.0005
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	µg/L	0.05	mg/kg	0.0005
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	µg/L	0.02	mg/kg	0.0002
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	µg/L	0.02	mg/kg	0.0002
(n:2) Fluorotelomer Sulfonic Acids				
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.05	mg/kg	0.0005
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.05	mg/kg	0.0005
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.05	mg/kg	0.0005
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	µg/L	0.05	mg/kg	0.0005
PFAS Sums				
Sum of PFAS	µg/L	0.01	mg/kg	0.0002
Sum of PFHxS and PFOS	µg/L	0.01	mg/kg	0.0002
Sum of PFAS (WA DER List)	µg/L	0.01	mg/kg	0.0002

[1] - the suite of PFAS compounds analysed for the OMP may be revised if required to meet the OMP objective based on changes to screening criteria requirements or updates to the human and ecological risk profiles.

Table E.2 – Low-level limits of reporting for select off-base groundwater and surface water samples		
Target PFAS analytes[1]	Groundwater and Surface Water	
	Units	Low-level LOR
Perfluoroalkyl Sulfonic Acids		
Perfluoropropane sulfonic acid (PFPrS)	µg/L	0.01
Perfluorobutane sulfonic acid (PFBS)	µg/L	0.002
Perfluoropentane sulfonic acid (PFPeS)	µg/L	0.002
Perfluorohexane sulfonic acid (PFHxS)	µg/L	0.002
Perfluoroheptane sulfonic acid (PFHpS)	µg/L	0.002
Perfluorooctane sulfonic acid (PFOS)	µg/L	0.002
Perfluorononane sulfonic acid (PFNS)	µg/L	0.002
Perfluorodecane sulfonic acid (PFDS)	µg/L	0.002
Perfluoroalkyl Carboxylic Acids		
Perfluorobutanoic acid (PFBA)	µg/L	0.01
Perfluoropentanoic acid (PFPeA)	µg/L	0.002
Perfluorohexanoic acid (PFHxA)	µg/L	0.002
Perfluoroheptanoic acid (PFHpA)	µg/L	0.002
Perfluorooctanoic acid (PFOA)	µg/L	0.002
Perfluorononanoic acid (PFNA)	µg/L	0.002
Perfluorodecanoic acid (PFDA)	µg/L	0.002
Perfluoroundecanoic acid (PFUnDA)	µg/L	0.002
Perfluorododecanoic acid (PFDoDA)	µg/L	0.002
Perfluorotridecanoic acid (PFTrDA)	µg/L	0.002
Perfluorotetradecanoic acid (PFTeDA)	µg/L	0.005
Perfluoroalkyl Sulfonamides		
Perfluorooctane sulfonamide (FOSA)	µg/L	0.002
N-Methyl perfluorooctane sulfonamide (MeFOSA)	µg/L	0.005
N-Ethyl perfluorooctane sulfonamide (EtFOSA)	µg/L	0.005
N-Methyl perfluorooctane sulfonamidoethanol (MeFOSE)	µg/L	0.005
N-Ethyl perfluorooctane sulfonamidoethanol (EtFOSE)	µg/L	0.005
N-Methyl perfluorooctane sulfonamidoacetic acid (MeFOSAA)	µg/L	0.002
N-Ethyl perfluorooctane sulfonamidoacetic acid (EtFOSAA)	µg/L	0.002
(n:2) Fluorotelomer Sulfonic Acids		
4:2 Fluorotelomer sulfonic acid (4:2 FTS)	µg/L	0.005
6:2 Fluorotelomer sulfonic acid (6:2 FTS)	µg/L	0.005
8:2 Fluorotelomer sulfonic acid (8:2 FTS)	µg/L	0.005
10:2 Fluorotelomer sulfonic acid (10:2 FTS)	µg/L	0.005
PFAS Sums		
Sum of PFAS	µg/L	0.002
Sum of PFHxS and PFOS	µg/L	0.002
Sum of PFAS (WA DER List)	µg/L	0.002

[1] - the suite of PFAS compounds analysed for the OMP may be revised if required to meet the OMP objective based on changes to screening criteria requirements or updates to the human and ecological risk profiles.