Australian Government
Defence

PFAS INVESTIGATION AND MANAGEMENT PROGRAM

SERVICE
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# RAAF Base Tindal

# PFAS ONGOING MONITORING PLAN

April 2025

# ACKNOWLEDGEMENT OF COUNTRY

Defence acknowledges the Traditional Custodians of Country throughout Australia and the Traditional Owners of Country, the Jawoyn, Dagoman and Wardaman peoples of the Katherine region. Defence recognises their continuing connection to traditional lands and waters and would like to pay respect to their Elders both past and present. Defence would also like to pay respect to the Aboriginal and Torres Strait Islander peoples who have contributed to the defence of Australia in times of peace and war.

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# GLOSSARY

| | |
|---|---|
| **AFFF** | Aqueous Film Forming Foam |
| **AHD** | Australian Height Datum |
| **AS** | Australian Standard |
| **ASC NEPM** | National Environment Protection (Assessment of Site Contamination) Measure, as amended 2013 |
| **Base** | Royal Australian Air Force (RAAF) Base Tindal |
| **CFI** | Capital Facilities Infrastructure |
| **CSM** | Conceptual Site Model |
| **DO** | Dissolved Oxygen |
| **DQI** | Data Quality Indicators |
| **DQO** | Data Quality Objectives |
| **DSI** | Detailed Site Investigation |
| **EC** | Electrical Conductivity |
| **EPA** | Environment Protection Authority (or relevant state/territory jurisdiction) |
| **ERA** | Ecological Risk Assessment |
| **E&IG** | Estate and Infrastructure Group |
| **FSA** | Fire Station Area |
| **FTA** | Fire Training Area |
| **HEPA** | Heads of EPAs Australia and New Zealand |
| **HHRA** | Human Health Risk Assessment |
| **LOR** | Limit of Reporting |
| **Management Area** | The geographical area subject to Defence risk management actions. May include private or Defence owned detached properties beyond the boundaries of the base. |
| **MEOMS** | Mechanical Equipment Operations and Maintenance Section |
| **NATA** | National Association of Testing Authorities |
| **NT** | Northern Territory |
| **OMP** | Ongoing Monitoring Plan |
| **OMR** | Ongoing Monitoring Report |
| **PFAS** | Per- and poly-fluoroalkyl Substances |
| **PFAS NEMP** | PFAS National Environmental Management Plan |
| **PFHxS** | Perfluorohexane sulfonate |
| **PFOA** | Perfluorooctanoic acid |
| **PFOS** | Perfluorooctane sulfonate |
| **PMAP** | PFAS Management Area Plan |
| **QA** | Quality Assurance |
| **QC** | Quality Control |

| | |
|---|---|
| **RAAF** | Royal Australian Air Force |
| **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 Practicable |
| **Source** | A source can be primary or secondary. Primary sources are generally areas where AFFF was used or stored. Secondary sources may be an accumulation of contamination in the environment, such as in soil, sediments, or surface water bodies. |
| **STP** | Sewage Treatment Plant |
| **SW** | Surface water |
| **TDI** | Tolerable Daily Intake |
| **µg/L** | Micrograms per Litre |

# 1 INTRODUCTION

## 1.1 Background

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

This Ongoing Monitoring Plan (OMP) replaces the October 2021 revision.

## 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 previously identified risks to human and ecological receptors require review
- the influence that risk management activities performed at the Base, as outlined in the 2019 PMAP, have had on PFAS in the environment, and
- whether the identified changes trigger an action and/or review.

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

## 1.3 Supporting information

In developing the OMP, reference has been made to:

- PFAS National Environmental Management Plan (PFAS NEMP) (Heads of Environment Protection Agencies Australia and New Zealand (HEPA), 2020)
- National Environment Protection (Assessment of Site Contamination) Measure 2013 (ASC NEPM) (National Environment Protection Council (NEPC), 2013)
- Defence Estate, environmental and PFAS-specific strategies and guidance, and
- other information as provided in the References section of this document (**Appendix A**).

## 1.4 Constraints and assumptions

This OMP has been prepared based on information available at the time of writing and relies on the findings of the Detailed Site Investigation (DSI) (Coffey, 2018a) , risk assessments (Coffey, 2018b) (Coffey, 2018c), mass flux assessments, remediation activities, ongoing monitoring program data, and management of risks documented in the PMAP (Department of Defence, 2019a). Defence recognises that there may still be gaps in information, and if required these will be progressively addressed if considered necessary to inform or support the management of PFAS related risks, while impacted sites are being managed.

This document has been developed based on the following assumption: the OMP focusses on monitoring of general changes and variability in the nature and extent of PFAS contamination in the medium to long term. Specific sampling requirements to investigate or validate remediation actions over the short term are not addressed in this OMP.

# 2 SITE SETTING

## 2.1 Base description

RAAF Base Tindal (the base) is located approximately 13 km south-east of the township of Katherine in the Northern Territory (NT) (approximately 320 km south-east of Darwin). The base covers an area of approximately 122 square kilometres. The formal base facility forms a small portion of the overall land area, with the remaining area occupied by Eucalypt bushland and open forest.

## 2.2 Site and management area setting

The PFAS Management Area relates to on-base and off-base areas where management of land, waters or infrastructure is recommended in order to reduce control of people or environmental receptors to PFAS. The base management areas are described in three components: land and infrastructure management; groundwater management; and surface water management. The Management Area relevant to this OMP is presented in **Figure F1** in **Appendix B**.

The surface water component includes Tindal Creek down-stream of the base and a section of the Katherine River between Donkey Camp Weir and the connection to Daly River noting that PFAS concentrations have not been reported to exceed the drinking water guideline values downstream of Crystal Rapids.

The groundwater component extends from the operational part of the base, where the sources of PFAS impact to groundwater have been identified, through to Katherine River, where groundwater discharges. The Management Area includes a nominal extent on the Western side of the river to account for localised detections. The groundwater Management Area has been classified into five zones based on concentration ranges, which were related to potential exposure risks in the human health risk assessment (HHRA), these areas are shown on **Figure F1 Appendix B** and outlined below.

- Zone 1: Groundwater PFAS concentrations above drinking water and recreational water criteria.
- Zone 2: Groundwater PFAS concentrations above drinking water criteria.
- Zone 3: Katherine River water downstream of surface water monitoring location surface water (SW) location SW110.
- Zone 4: Town water supply (Power & Water): includes treated water from Katherine River.
- Zone 5: Groundwater PFAS concentrations below drinking water criteria. Each zone has tailored precautionary advice for residents to minimise exposure to PFAS.

The aquatic biota component includes Katherine River between Donkey Camp Weir and the connection to Daly River, where aquatic biota including fin fish and crustaceans, have reported concentrations above consumption guidelines. Aquatic biota sampling results are used to inform the Northern Territory (NT) Government's health advisory for consumption of fish and crustaceans from Katherine River within the Management Area.

All sampling locations relevant to this OMP are shown on **Figures F2** to **F5** in **Appendix B.**

### 2.2.1 Regional meteorology

The base and surrounding area fall within the Australian tropical savanna region which covers a substantial portion of northern Australia. The savanna is characterised by a Wet Season that begins in November and lasts through to April (with the heaviest rainfall typically experienced from December

through to March) and a Dry Season from about May through to October. The mean monthly rainfall (from 1969 to 2024) ranges between 0.7 mm in June and 260.6 mm in January. Mean daily evaporation ranges from 5.0 mm in June to 7.7 mm in October (station 014932, Bureau of Meteorology).

### 2.2.2 Topography, geology and hydrogeology

The base topography is relatively flat, sloping gently toward Tindal Creek (south-west orientation) with some small hills and limestone outcroppings, primarily in the northern and eastern portions of the base. Base elevations range from approximately 120 m Australian Height Datum (AHD) to 180 m AHD.

The base and off-base Management Area typically characterised by lateritic clays (red brown, high to medium plasticity) overlying weathered to competent karstic limestone. Outcrops of limestone and sandstone are present in some areas, and many sinkholes have been mapped throughout the karst limestone. Southern portions of the base have variable thickness of weathered siltstone and limestone (Cretaceous rock and Jinduckin formation) overlying the weathered to competent karstic limestone of the Tindall Limestone.

Hydrogeological units in the Groundwater Management Area comprise the:

- Antrim Plateau Volcanics (basalts forming the base of the Tindall Limestone aquifer).
- Tindall Limestone aquifer.
- Jinduckin Formation (southern edge of the management area).
- Cretaceous sediments (overlying the Tindall Limestone).

In the Katherine region, groundwater in the unconfined Tindall Limestone aquifer flows toward the Katherine River. The major springs on the river are the discharge points for the aquifer. Minor springs have also been observed within Tindal Creek.

### 2.2.3 Vegetation

The terrestrial environment at Tindal consists of large areas of bushland and open forest, with the majority characterised by Darwin box and/or bloodwoods woodland with sorghum, white grass, and tussock grasses. Many of the savanna grasses are shallow rooted annuals that grow in response to rainfall.

Patches of irrigated grass lawns are found in the landscaped areas of the base. To the west of the base, within the Management Area, are small scale farms, rural residential properties and a quarry.

### 2.2.4 Management Area drainage

Surface water run-off within the operational area of the base is collected via a series of concrete and earthen drains and is directed to two formalised channels presented on **Figure F4** (**Appendix B)**. The bulk of the surface run-off from the base is discharged to Tindal Creek at either a location upstream of the sewage irrigation paddock, or a location downstream of the northwest end of the airstrip.

Tindal Creek is an ephemeral tributary of Katherine River, and during the wet season is fed by surface water from base operational areas and bushland and scrubland in the upper portions. The creek is also groundwater fed in the Wet Season and part of the dry season, from Uralla through to the southern edge of Katherine.

### 2.2.5 Current and projected land uses (off-Base)

The Katherine township is the fourth largest urban area in the NT with a population of 11,000. The town is set on the banks of the Katherine River with residential areas spread up and down river of the Stuart Highway bridge, mostly on the eastern side of the river. Residential, educational, commercial and recreational areas dominate the Katherine township. The area between Katherine and the base includes rural residential properties, an industrial park, a quarry, the NT Government Research Farm and pastoral reserves.

With respect to water captured within and migrating through the Katherine River Catchment, the benefits associated with this water source include environmental, cultural, agricultural and industrial purposes as well as use as a public water supply.

The Katherine region is heavily reliant on its agricultural sector, which supports a variety of farming activities, including livestock production, horticulture and cropping. Thus, there is a great economic, social and environmental need for clean groundwater for irrigation, especially in the 6-month long dry season.

# 3 EXTENT OF PFAS CONTAMINATION

The extent of PFAS at the base (and in off-Base areas) has been defined in detail within the DSI (Coffey, 2018a), HHRA (Coffey, 2018b), Ecological Risk Assessment (ERA) (Coffey, 2018c) and Supplementary DSI (Coffey, 2018d) reports. Post-DSI data collected through the OMP and further Base assessments have built on the DSI information to monitor seasonal and long-term trends, or refine the level of detail, where relevant. A summary of the CSM is provided below.

## 3.1 Source areas

Source areas at the base relate to PFAS storage, distribution or use. Direct measurement of media such as soil, sediment and water, which was conducted as part of the DSI, identified the primary source areas on-base as being the following:

- Former Fire Training Area (FTA)
- Fire Station Area (FSA)
- Former Mechanical Equipment Operations Maintenance Sections (MEOMS)
- Fuel Farm 1
- Fuel Farm 2

The FTA and FSA were identified as key sources of PFAS impact to surface water and groundwater leaving the base. The other source areas had a relatively minor contribution or localised impact. **Table 1** presents the typical range of concentrations reported in groundwater within these source areas.

Additionally, reported concentrations around an on-base Sewage Treatment Plant (STP) were low and indicated that the plant and associated sludges were not a source of contamination to groundwater.

**Table 1. PFOS+PFHxS concentrations reported in groundwater in source areas**

| Source Areas | PFOS+PFHxS concentration ranges in groundwater in the source area* | Observed trends or variability *(AECOM, 2023)* |
|---|---|---|
| Fire Training Area | 0.02 to 8,100 micrograms per litre (µg/L) | Peak concentrations have been reported during Wet Season. Whilst no long-term statistically relevant trends are currently apparent, reductions in PFAS concentrations in both surface water and groundwater have been observed in proximity to the FTA and FSA, as well as within Tindal Creek following recent soil remediation works in both areas. |
| Fire Station Area | 0.01 to 3,100 µg/L | |
| Former Mechanical Equipment Operations Maintenance Sections | 5 to 20 µg/L | Concentrations in the area increase during the Wet Season and reduce over the Dry Season with the peak at the end of the Wet Season. No long-term trends are apparent. |
| Fuel Farm 1 | 0.40 to 45 µg/L | |
| Fuel Farm 2 | | |

* Concentration ranges cover monitoring results from 2018 to present.

## 3.2 Transport pathways

PFAS contamination within the primary source areas on the base is migrating off-base via:

- Leaching from impacted soil and infrastructure to groundwater (Tindall Aquifer) and subsequent flow with groundwater west toward the Katherine River, discharging to the river within the Management Area. This pathway has resulted in contamination of groundwater above the drinking water guideline values between the base and Katherine River, and in locations near and west of Katherine River in Emungalan and Cossack. The identified PFAS plume is estimated to be between 6 and 8 km wide.
- Surface water flow in Katherine River from the discharge zone (starting at Knott's Crossing) to the intersection with Daly River. Contamination is present above drinking water guideline values in the Dry Season, but dilution from runoff across the catchment leads to concentrations below the guideline values in the Wet Season (refer to Section 6.0 for a summary of PFAS screening criteria).
- Leaching from impacted sediment into surface water run-off via site drains and Tindal Creek, which flow through Uralla and discharges to the Katherine River in Katherine South during the Wet Season. Concentrations vary through the Wet Season but are typically above drinking water guideline values and above recreational guidance values in drains associated with source areas or in Tindal creek downstream from the base PFAS source areas.

**Table 2. Typical PFOS+PFHxS concentrations reported in migration pathways and potential exposure points**

| Pathway and exposure points | Typical PFOS+PFHxS concentration range* | Observed trends or variability *(AECOM, 2023)* |
|---|---|---|
| Groundwater migrating west across base boundary | 0.10 to 8 µg/L | Some fluctuations observed but no defined seasonal or long-term trends. |
| Groundwater beneath Uralla, Katherine East and Katherine | 0.03 to 3.50 µg/L | Subtle seasonal influence with lower concentrations during the Wet Season. |
| Groundwater west of Katherine River in Emungalan and Cossack | <0.01 to 1.55 µg/L | New high concentrations, new exceedances of the drinking water guideline values, and first-time detections of PFAS in locations where PFAS has not been previously detected have been reported within the Cossack area between 2021 and 2024. Changes in concentrations and where PFAS is detected west of Katherine River appear to be influenced by wet season conditions where higher concentrations and detections further west are reported during the wet season. |
| Katherine River down-stream of Knott's Crossing | <0.01 to 0.40 µg/L | Concentrations reduce to below detection limits in the Wet Season and peak at the end of the Dry Season. Peak concentrations are influenced by the duration of the Dry Season and magnitude of the previous Wet Season |

| | | |
|---|---|---|
| | | rainfall. The duration of concentrations below the detection limit is influenced by the duration and magnitude of the Wet Season. |
| Tindal Creek, down-stream of the base | 0.01 to 1.40 µg/L | The creek only flows in the Wet Season and concentrations peak at the end of the Wet Season. No long-term trends are apparent. However, recent sampling indicates the potential for an overall reduction in PFAS concentrations reported in Tindal Creek following the completion of soil remediation at the FSA and partial completion of soil remediation at the FTA. |

* Concentration ranges cover monitoring results from 2018 to present.

## 3.3 Receptors and risks

Based on the outcomes of the HHRA (Coffey, 2018b) and ERA (Coffey, 2018c), receptors that may be exposed to PFAS intake above tolerable daily intake (TDI) or ecological toxicity values include:

**Human Health**

- Consumers of impacted bore water (above drinking water guideline values [Refer to Section 6.0]) as a primary drinking water source.
- Consumers of home-grown produce (eggs and meat) irrigated using PFAS impacted bore water.
- Consumers of aquatic biota from Tindal Creek or Katherine River (downstream of Knott's Crossing).
- Base construction or maintenance workers in direct contact with impacted soils and effluent in source areas.

**Ecological**

- Aquatic invertebrates, amphibians and fish in impacted waters in source areas.
- Plants in direct contact with soils in source areas.
- Birds and mammals that eat fish from Tindal Creek.
- Birds and mammals that eat plants, invertebrates and reptiles from source areas.

Exposure point concentrations relevant to human and ecological receptors have been directly assessed through the DSI and key community exposure points continue to be monitored, including:

- The Katherine YMCA Pool, which has remained within recreational guidance values since 2018.
- The Katherine Hot Springs, which has remained within recreational guidance values since 2018.
- Aquatic Biota (Fish and cherabin) in Katherine River, which was identified as a potential exposure risk in the HHRA and continues to be monitored for changes in risk level.
- Groundwater bores on the western side of Katherine River, close to the river, where concentrations are potentially variable and may occasionally exceed drinking water values.

# 4 ONGOING MONITORING PLAN

This section sets out the data quality objectives, monitoring scope and assessment requirements. Changes made to the 2021 OMP are summarised in the following sections, and supporting rationale is provided in **Appendix D**.

## 4.1 Sampling, Analysis and Quality Plan

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

## 4.2 Data Quality Objectives

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

- clarifies the study objective.
- defines the most appropriate collection of data as relevant to the study objective.
- determines the conditions from which to collect data.
- 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 3**. They have been prepared in line with the DQO process outlined in the ASC NEPM (Schedule B2).

**Table 3. Data Quality Objectives**

| Process | Description |
|---|---|
| Step 1: State the problem | PFAS sources areas have been identified at the base that have led to the contamination of soil, groundwater and surface water, with PFAS measured within biota from Tindal Creek and the Katherine River.<br>Based on the data collected as part of investigations undertaken between April 2017 and May 2018, potential risks to human health and ecological receptors were identified.<br>It is important that the concentrations of PFAS within the environment continue to be monitored to review if the advice and management actions developed based on previous data and risk assessments. This ensures that OMP management actions continue to be appropriate and protective. |
| Step 2: Identify the decision/goal of the study | The purpose of the OMP is to collect adequate data to ensure that the concentrations of PFAS within groundwater, surface water and biota are monitored and assessed to evaluate spatial, and temporal (including seasonal) variability of PFAS and whether risks to human health and ecological receptors require review.<br>Though not a specific goal of the OMP, the data collected under the OMP can also provide supporting data to assess the performance of remediation actions. |

| Process | Description |
|---|---|
| Step 3: Identify the information inputs | • Existing data relevant to PFAS in soil, waters and biota<br>• Surface water and groundwater flow regimes (hydrogeology and drainage)<br>• Location and types of human and environmental receptors |
| Step 4: Define the boundaries of the study | Based on the understood extent of contaminated surface water or shallow groundwater at the base, the study area includes land, groundwater and waterways on RAAF Base Tindal, towards (and including) the receiving water bodies. The Management Area is shown in **Figure F1 Appendix B**.<br>Temporal boundaries of the study capture seasonal fluctuations across the year and the duration of the study will be reviewed regularly based on findings of the OMP and PMAP reviews. |
| Step 5: Develop the analytical approach/decision rules | Primary environmental samples are to be collected and analysed for the 28 PFAS compounds described in **Appendix E**. Perfluorooctane sulfonate (PFOS), Perfluorohexane sulfonate (PFHxS) and Perfluorooctanoic acid (PFOA) concentrations will be compared against screening levels relevant to the potential beneficial uses of water to identify changes to risk profile.<br>Where required, changes in screening levels will be reviewed and updated following finalisation.<br>The relative concentrations of all (analysed) PFAS compounds over time in groundwater, surface water and aquatic biota samples will be used to assess changes in the extent or magnitude of contamination. |
| Step 6: Specify performance or acceptance criteria | The ongoing monitoring program as a whole must reliably characterise the changes in PFAS contamination within surface water, groundwater and biota compared with the baseline conditions and describe the risk that the contamination may potentially pose to human or ecological receptors.<br>Trigger points and follow-up actions (if triggers are met) are provided in Section 7.0 of this OMP. |
| Step 7: Develop the plan for obtaining data | The methodology and rationale for obtaining relevant data for the OMP is described in Sections 4.3 and 4.4. |

## 4.3 Proposed monitoring intervals

Monitoring intervals of groundwater, surface water and biota are summarised in **Table 4**.

**Table 4. Proposed monitoring intervals**

| Matrix | Monitoring frequency | Approximate monitoring period | **Rationale** |
|---|---|---|---|
| Groundwater monitoring well – on-base | Annual | Dry Season (September - October) | Monitor PFAS concentration along the northern boundary of the plume. |
| Groundwater – private bores in Cossack (on western side of Katherine River) * | Once in Dry Season and monthly in Wet Season | Once in Dry season (August)<br>Monthly in Wet season (November to April) | Monitoring frequency due to seasonal variance of historical results. |
| Groundwater - monitoring wells located on- and off-base throughout and adjacent to the Management Area. | Biannual | Dry Season (September - October)<br>Wet Season (April - May) | Monitor seasonality and groundwater concentrations up, down and cross-gradient of source areas.<br>Used to assess if groundwater PFAS concentrations change in response to management measures over time. |
| Surface water – Downstream Katherine River | Annual | Dry season (September - October) during biota sampling | Monitors downgradient PFAS concentrations of Katherine River. |
| Surface water – Katherine River locations, Hot Springs and YMCA pool | Biannual | Dry season (September - October),<br>Wet season (March - April) | Biannual events to occur at the end of the wet season and end of the dry season when groundwater and surface water condition reflect seasonal influences.<br>Monitors spatial and temporal variation of PFAS concentrations within Katherine River and monitors potential exposure risks associated to recreational use of surface water areas. |
| Surface Water – On-base drains and Tindal Creek (on- and off-base | Twice-during the Wet Season after a rainfall event | Wet season (November – December), ideally a first-flush event or closest event, and Wet season (February – | Assess and monitor PFAS within surface water runoff.<br>Monitor seasonal spatial and temporal |

| | | | |
|---|---|---|---|
| | | April). Depending on when water is observed in on-base drains and Tindal Creek | variations in PFAS concentration in surface water, and to provide data to contribute to surface water mass flux estimates. |
| Aquatic biota | Annual | Dry season (August to October) | Sampling based on the outcomes of the ecological risk assessments as an indicator for biota that may be exposed to PFAS intake above ecological toxicity value and support future review of human exposure risk to ingestion of biota containing PFAS.<br>Sample collection to be completed during the late dry season to ensure reliable boat ramp access as river access is limited and often unsafe during wet season conditions.<br>Factors that impact bioaccumulation and recorded PFAS concentrations within aquatic biota include individual species behaviours, diet and age rather than collection within a specific season. |

* New groundwater monitoring wells have been installed within the Cossack area to assist in understanding groundwater movement and associated PFAS concentrations across both wet and dry seasons.

## 4.4 Monitoring locations

The proposed monitoring locations are shown on **Figures F2** to **F5** (**Appendix B**). Sample media and the justification for monitoring locations is described in the following sections. Where there are changes to specific locations since the 2021 OMP, the specific locations and rationale for the change has been provided in **Appendix D**.

### 4.4.1 Groundwater monitoring locations

Groundwater monitoring wells identified for ongoing monitoring are presented on **Figures F2** and **F3** (**Appendix B**) and in listed **Table C-1** (**Appendix C)**.

Rationale for selection of groundwater wells for ongoing monitoring is based on:

- Monitoring plume extent through sentinel wells.

- Monitoring changes in concentrations through wells near source areas or within the plume.
- Monitoring changes in exposure risk by monitoring target areas with complete pathways.

It is noted that several groundwater bores selected for ongoing monitoring are private/residential bores. These have been selected to monitor exposure points in key areas. In order to obtain samples from private bores, a signed access agreement is required prior to sample collection. Off-site monitoring locations will require the agreement of the landholder/leaseholder. A stakeholder engagement plan will be prepared to manage this process.

Additional private/residential bores are proposed to be included in the monitoring network on the western side of Katherine River (within the Management Area and in an expanded area in Cossack). The rationale of expanding the network is to assess if other bores may be affected by exceedances, driven by either seasonal changes or ongoing westerly migration of the plume. The final number and locations of these bores is dependent on private bore owner approval and therefore these details have not been included in this OMP. Once approval has been granted, these bore IDs and locations will be included in the SAQP for OMP sampling.

Where a groundwater bore has been nominated for monitoring as a sentinel or plume well **(Table 1, Appendix C),** an alternative has been provided (where available) in the event that the original bore cannot be sampled. Where a nominated alternative bore is no longer suitable, well re-installation may be required if no other suitable bore exists.

### 4.4.2 Surface water monitoring locations

Surface water monitoring locations nominated for sampling are identified on **Figure F4 (Appendix B)** and **Appendix C.**

Off-base locations have been nominated to assess concentrations in each receiving waterway, at locations that are considered likely to represent relevant reaches of Tindal Creek and Katherine River. Additionally, the YMCA pool and Katherine Hot Springs has been included in order to monitor the concentrations of PFAS in the public locations for recreational use.

On-base locations have been nominated to assess concentrations and flow rates in drains that capture run-off from PFAS source areas or where significant discharge of water has been observed.

### 4.4.3 Biota monitoring locations

In addition to collection of groundwater and surface water samples, aquatic biota (fish and crustaceans) are to be sampled annually to supplement existing concentration data and monitor changes in potential human exposure risk.

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

- Sample collection methodologies should be selected based on the most suitable method for the location and target species. These methods may include the following:
  - Angling with a fishing rod, reel and braid fishing line.
  - Gill nets.
  - Electrofishing.
- Target species will be based on those that are recognised as frequently consumed, and from the following four groups:

**Table 5. Aquatic biota target samples**

| Group | Indicator/Target Species* | Relevant opportunistic catch |
|---|---|---|
| Low concentration Fish | Barramundi | Sleepy cod<br>Sooty grunter |
| Moderate concentration Fish | Bony Bream | Black or blue catfish<br>Butlers Grunter<br>Barred Grunter |
| High concentration Fish | Mullet | - |
| Crustaceans | Cherabin | - |

* Additional species (e.g. turtles, mussels, shrimp, etc.) may be included for sampling in the future pending consultation with local communities to ensure the right species are selected for inclusion.

- The number of samples collected will vary based on what is caught, however a target of at least three of each indicator species should be aimed for from each location.
- The two primary suitable locations identified for sample collection are in the vicinity of:
  - Stuart Highway boat ramp: Location code BIO088 (shown on **Figure F5** [**Appendix B**]).
  - Galloping Jacks boat ramp: Location code BIO078 (approximately 19 km downstream from Stuart Highway) (shown on **Figure F5** [**Appendix B**]).
- Captured target fish should be euthanised in line with ethics approval, which may involve ice slurry, Aqui-S solution anaesthesia, clubbing, pithing and/or cervical dislocation.
- For larger fish, complete tissue samples of edible flesh should be collected. Whole gutted fish samples should be taken for smaller fish.
- Samples of edible flesh, whole fish or gutted fish should retain the skin.
- A clean polypropylene cover should be used over a chopping board, and new sterilised scalpel blades or washed stainless steel blades used for sample preparation.
- A single surface water sample will be collected from Galloping Jacks (SW151) during the biota sample collection. The collected sample will be evaluated as part of the dry season Katherine River surface water monitoring. No other surface water sampling will be required by the biota sampling team as aquatic biota PFAS concentrations are not directly related to PFAS concentrations in surface water at the time of sampling.

## 4.5 Sample analysis

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

Laboratory levels of reporting (LORs) must be selected to achieve the OMP objectives (**Section 4.2**) and the DQO's. The rationale for selecting LORs below the standard LOR must be provided, however can occur if determined to meet PMAP objectives.

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

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

# 5 OTHER ASPECTS

To inform updates to the CSM and allow assessment of the risk profile and to meet OMP objectives, a review of other program elements will be undertaken including water use surveys, registered bore/well searches, changes in land use zoning, changes in land use on/off base.

Information included within the water use surveys undertaken by residential stakeholders will inform how much and for what purposes residents may use their bore water, informing potential exposure risk and subsequent exposure actions.

There is also a requirement for the OMP to consider works being undertaken or planned at the base. This additional information may also be considered as relevant to the CSM and/or assessment of the risk profile. This will be assessed as arises and includes:

- Directorate of Contamination Assessment Remediation and Management remediation or investigation projects including Water Quality Monitoring Programs.
- Estate and Infrastructure Group (E&IG) Projects.
- Capital Facilities Infrastructure Projects (CFI) and/or medium works projects.

It is noted that future infrastructure works may also provide potential for opportunistic sampling or access to previously inaccessible areas that may close any remaining data gaps and support remediation activity planning.

Noting that the PMAP and OMP documents function together, regular review and revision of the OMP is required to ensure that data collected is adequate to meet the objectives of the PMAP and ensure risk management actions remain appropriate.

# 6 PFAS SCREENING CRITERIA

PFAS screening values have been adopted for groundwater and surface water from the PFAS NEMP.

The adopted screening values are provided in the following tables (**Table 6** and **Table 7**) and should be reviewed and updated annually as and when changes to guidance occurs.

**Table 6. Groundwater and surface water screening levels**

| **Contaminant** | **Maintenance of Ecosystems (Modified Ecosystems) Freshwater** (µg/L) | **Recreation** (µg/L) | **Drinking water** (µg/L) |
|---|---|---|---|
| PFOS | 0.00023 (99%)<br>0.13 (95%) | 2 | 0.07 |
| PFHxS | - | | |
| PFOA | 19 (99%)<br>220 (95%) | 10 | 0.56 |

**Table 7. Biota screening levels**

| **Contaminant** | **Department of Health 2019 – Intake – Food – Fish** (mg/kg) | **Department of Health 2019 – Intake – Food – Crustaceans** (mg/kg) |
|---|---|---|
| PFOS | 0.0052 | 0.065 |
| PFHxS | 0.0052 | 0.065 |
| PFOA | 0.041 | 0.052 |
| Sum of PFOS + PFHxS | 0.0052 | 0.065 |

# 7 TRIGGERS FOR ACTION AND REVIEW

Trigger points, response actions and supporting rationale are outlined in **Table 8**. Triggers may prompt actions such as additional or modification to monitoring, additional assessment of risk, review of the PMAP or a reduction in monitoring. The response actions have been determined to ensure that they are relevant, actionable, commensurate with identified risks, and timely. Refer to Section 2.2 for a summary of the five zones that comprise the Management Area, related to potential exposure risks in the HHRA and referenced in **Table 8.**

**Table 8. OMP trigger points**

| Location | Trigger point | Action |
|---|---|---|
| Groundwater locations previously below laboratory LOR for PFAS | Detection of PFAS compounds | • Check and confirm with the laboratory that the concentration measured was not reported in error, or a quality assurance/quality control discrepancy.<br>• If concentration is confirmed by laboratory as correct and quality assurance (QA) / quality control (QC) review does not identify any discrepancies that may have led to the result<br>• If the presence of PFAS is determined, the HHRA should be reviewed with consideration to the new PFAS detection.<br>• Undertake a round of confirmation sampling of the affected well within six weeks, if required.<br>• Outcomes will inform a review of sampling frequency within the OMP and review of PMAP management actions (i.e. updating Northern Territory agencies and amending administrative controls). |
| Groundwater locations within specific management zones | PFAS concentrations reported above the designated management zone criteria or where there is an identified change in the risk profile resulting from the reported concentration. | • Check and confirm with the laboratory that the concentration measured was not reported in error, or a quality assurance/quality control discrepancy.<br>• If concentration is confirmed by laboratory as correct and QA/QC review does not identify any discrepancies that may have led to the result, undertake a round of confirmation sampling of the affected well within six weeks.<br>• If the additional sampling confirms the reported result, the HHRA should be reviewed in light of the identified PFAS change in groundwater.<br>• Outcomes will information a review of the PMAP depending on the potential risks arising from the change (which may include increased sampling frequencies, updating Territory Agencies, amending administrative controls). |
| Private bores in Cossack | New exceedances reported above the adopted drinking water health-based screening level**. | • Undertake QA/QC checks and review the change in the context of the overall concentrations of PFAS within the bore and surrounding bore network. |

| Location | Trigger point | Action |
|---|---|---|
| | | • Consider provision of alternative water supply (such as bottled water or rainwater tanks).<br>• Review the expansion of the monitoring network characterise the risk from the PFAS plume in this area.<br>• Consider revising the Management Area boundary with consideration to locations with new exceedances. |
| Private bore on Uralla Road (POT111) | Concentrations of PFAS are reported in POT111 which indicate an increase in plume size or concentrations above drinking water guidelines. | • Arrange retesting of the bore as soon as practicable to confirm the result. Conduct a second retest of the bore approximately one month after the first retest.<br>• If one or both of the retests report concentrations of PFAS above drinking water guidelines, consider provision of alternative water supply (such as bottled water or rainwater tanks) and conduct testing of nearby private bores to the south, as well as any other nearby properties which had previously reported PFAS <LOR and have not received a rainwater tank.<br>• For sampling of additional properties, follow the steps above in the event of detectable PFAS.<br>• Consider accessing or installing an additional bore in order to delineate the southern extent of the PFAS plume in Uralla. |
| (MW815) Northwestern sentinel well located on Gorge Road east of Katherine River | Detectable concentrations of PFAS are reported in MW815. | • Arrange retesting of the bore as soon as practicable to confirm the detection. Conduct a second retest of the bore approximately one month after the first retest.<br>• Consider requirements for additional investigation bores to delineate the northern extent east of Katherine River and testing of residential properties along Gorge Rd. |
| On-base location (MW133) | PFOS+PFHxS and/or sum of PFAS concentrations show an increasing trend (using statistical analysis) over two years of monitoring | • Arrange retesting of the bore as soon as practicable to confirm the result. Conduct a second retest of the bore approximately one month after the first retest.<br>• Consider requirements for additional investigation bores to delineate the northern extent of the PFAS plume in this area and testing of residential properties to the north of the base. |
| Off-base location on public land (MW136) | Detectable concentrations of PFAS are reported in MW136. | • Arrange retesting of the bore as soon as practicable to confirm the detection. Conduct a second retest of the bore approximately one month after the first retest.<br>• Consider accessing or installing an additional bore in order to delineate the extent of the PFAS plume in Lansdowne. |
| All groundwater and surface water locations | Changing PFAS drinking water guideline values | • Consider where analysis at a lower LOR may be required in locations where there is a complete or potential drinking water exposure pathway. |

| Location | Trigger point | Action |
|---|---|---|
| | | • Consider additional steps, such as water use surveys, further surface water and groundwater sampling to determine the defined extent of contamination with the lower LOR.<br>• Review all ambient groundwater and surface water sampling locations to advise where additional analysis of PFAS at a lower LOR may be required to understand ambient PFAS conditions. |

** The drinking water guidelines will be revised with the publication of the NHMRC Drinking Water Guidelines anticipated in early 2025. This will likely lower the laboratory LOR require additional analysis.

# 8 REPORTING REQUIREMENTS

## 8.1 Reporting

Monitoring event information, field and laboratory data and any changes to the SAQP will be documented in a factual report at the following frequency:

- After one dry season (any sampling conducted between May and October).
- Two wet season reports (November - January and February - May).

The reports will be provided one month after receipt of all sampling event(s) laboratory reports.

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

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

- Spatial, and temporal (including seasonal) variability of PFAS in the environment.
- Changes to sources, transport pathways or receptors, described as a CSM for the base.
- Changes in risks to human and environmental receptors.
- The influence that risk management activities at the base, as outlined in the 2024 PMAP, have had on PFAS in the environment.
- Whether the identified changes trigger a prescribed action and/or review (Section 7).

## 8.2 Stakeholder engagement

Engagement with a range of stakeholders, such as the Northern Territory Environment Protection Authority (EPA), Councils, other agencies, and the community will be undertaken. A stakeholder engagement plan has been prepared and will be maintained to manage the engagement process.

Where off-site monitoring is undertaken a separate letter will be provided to the stakeholder presenting the results of the monitoring event.

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

# APPENDIX A REFERENCES

AECOM. (2024). *Ongoing Monitoring Report, April 2021 to June 2024, PFAS Ongoing Monitoring Program, RAAF Base Tindal.*

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Coffey. (2018b). *RAAF Base Tindal Human Health Risk Assessment. 754-MELEN199420-R08.*

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Department of Defence. (2019a). *PFAS Management Area Plan - RAAF Base Tindal.*

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Department of Health. (2019). *Final Health based guidance values for PFAS for use in site investigations in Australia .*

Heads of Environment Protection Agencies Australia and New Zealand (HEPA). (2020). *PFAS National Environmental Management Plan 2.0.*

National Environment Protection Council (NEPC). (2013). *National Environment Protection (Assessment of Site Contamination) Measure Amendment 2013.*

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US EPA. (2000). *Guidance on Systematic Planning Using the Data Quality Objectives Process.*

US EPA. (2002). *Guidance on Environmental Data Verification and Data Validation.*

# APPENDIX B FIGURES

Figure F1 – PFAS Management Area

Figure F2 – On-base Groundwater Sample Locations

Figure F3 – Off-base Groundwater Sample Locations

Figure F4 – Surface Water Monitoring Locations

Figure F5 – Biota Monitoring Locations

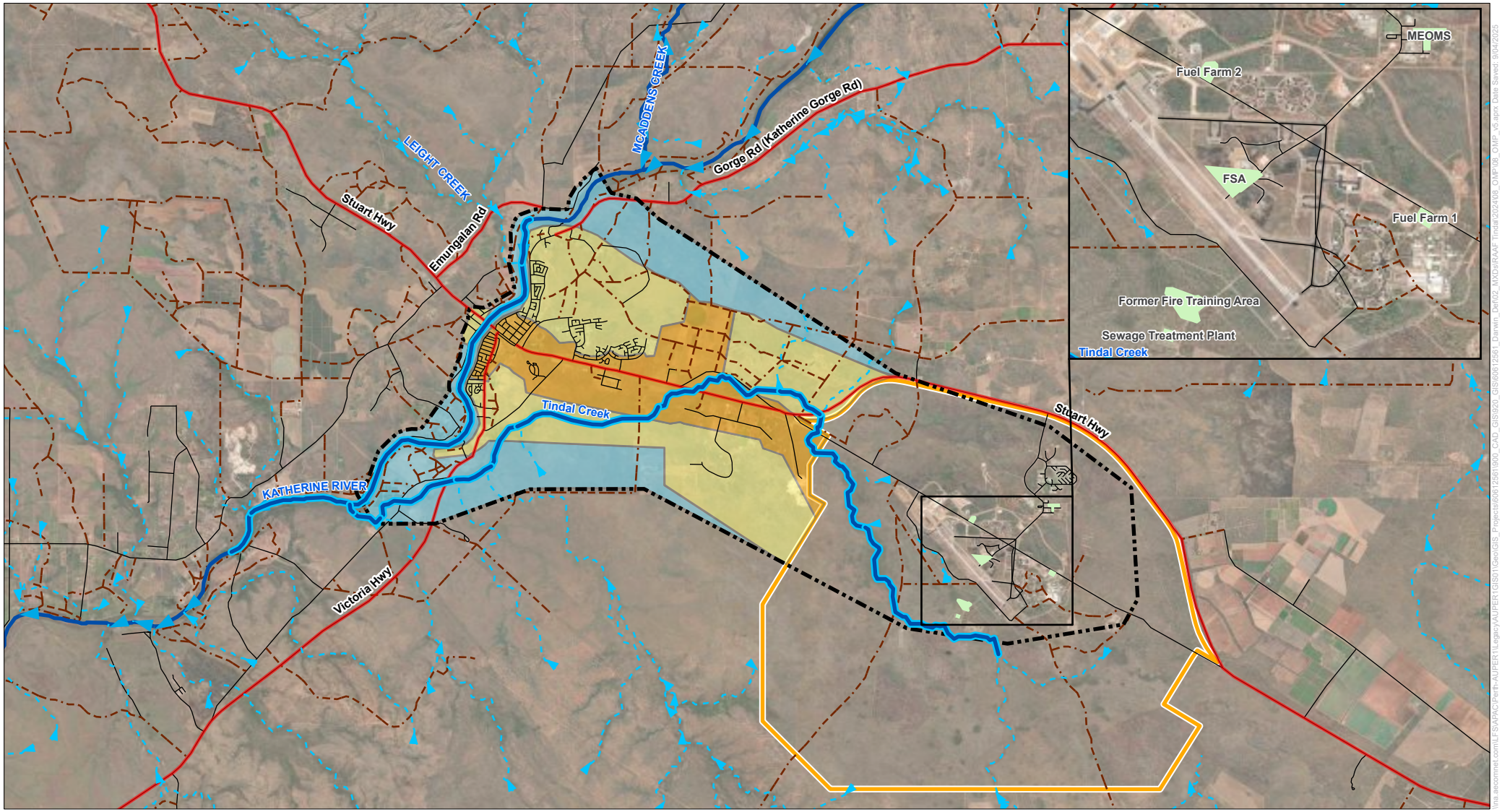


**FIGURE F1:** PFAS MANAGEMENT AREA

Legend

- RAAF Base Tindal
- Groundwater Management Area
- Zone 3 - Surface Water Management Area
- Highway
- Road
- Track
- Katherine River
- Drainage
- Zone 1 Groundwater > Recreational Water Criteria
- Zone 2 Groundwater > Drinking Water Criteria
- Zone 5 Groundwater < Criteria
- Source Areas

**Note:**

Zone 4 - Treated Town Water Supply - Not shown

N

0 1 2 3 km

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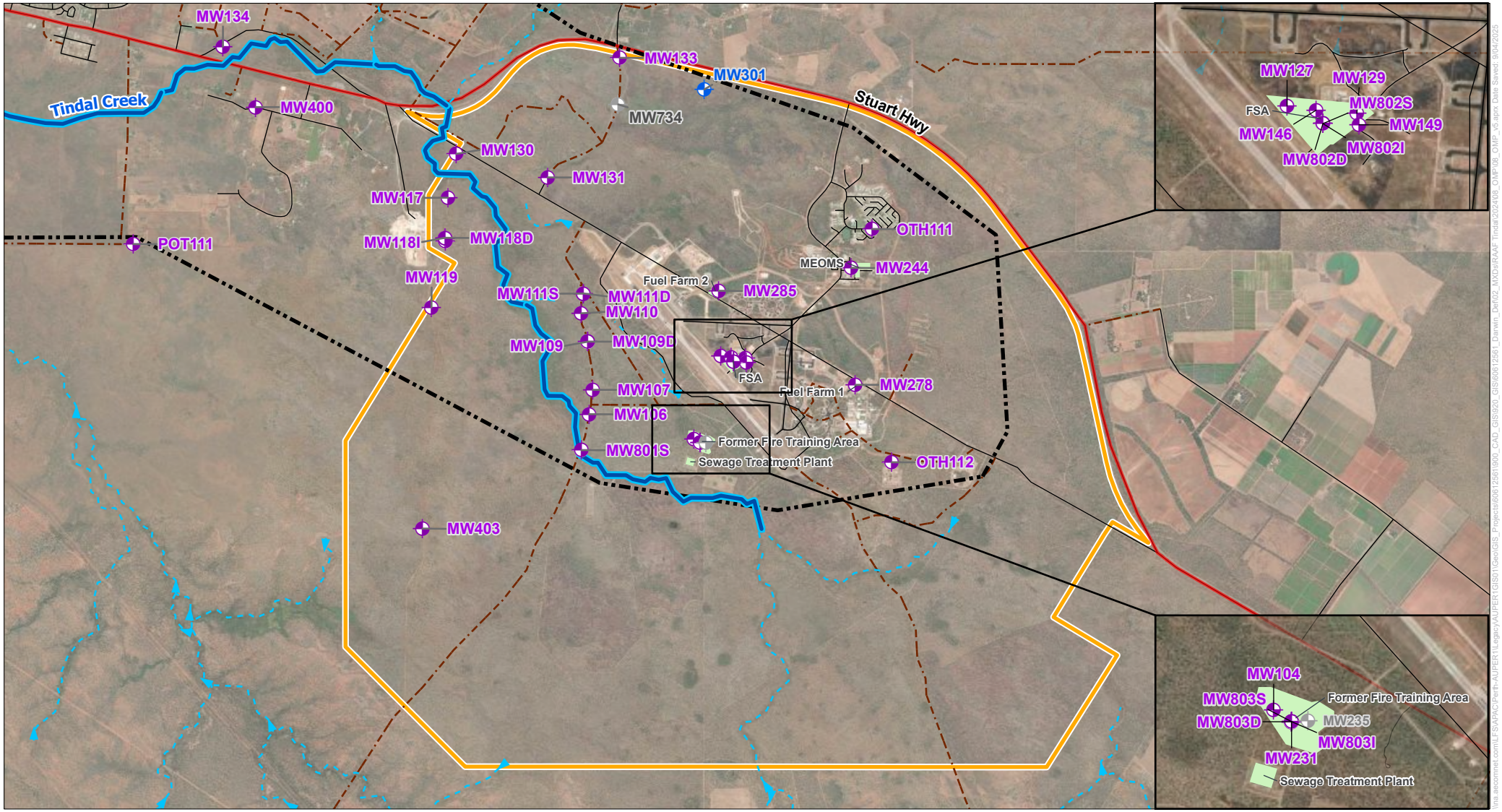


**FIGURE F2:** ON-BASE GROUNDWATER SAMPLE LOCATIONS

Legend

- RAAF Base Tindal
- Groundwater Management Area
- Zone 3 - Surface Water Management Area
- Highway
- Road
- Track
- Drainage
- Annual Groundwater Monitoring Location
- Biannual Groundwater Monitoring Location
- Removed from On-going Management Plan
- Source Areas

N

0 1 2 km

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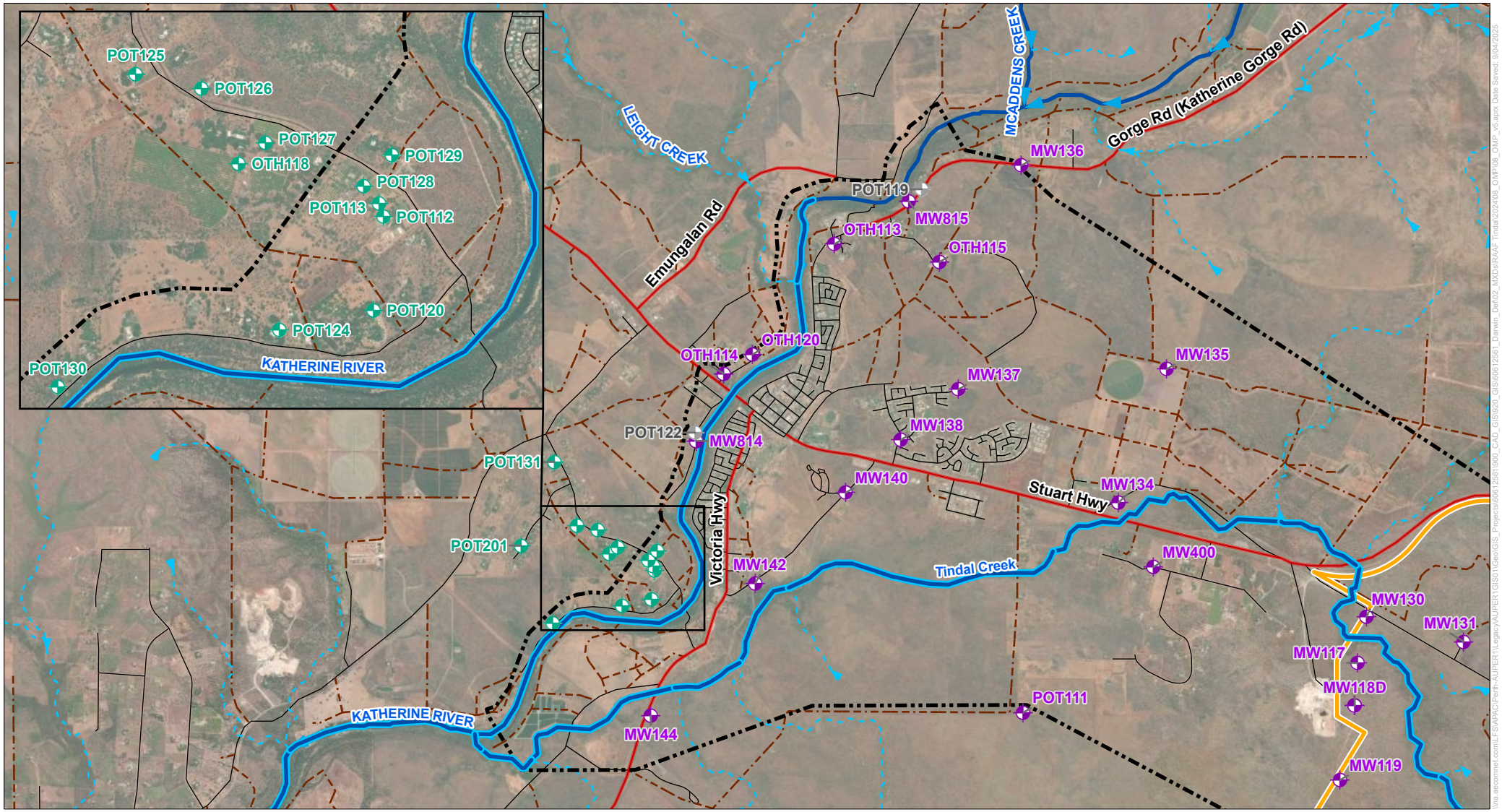


**FIGURE F3:** OFF-BASE GROUNDWATER SAMPLE LOCATIONS

Legend

- RAAF Base Tindal
- Groundwater Management Area
- Zone 3 - Surface Water Management Area
- Highway
- Road
- Track
- Katherine River
- Drainage
- Biannual Groundwater Monitoring Location
- Once in Dry Season and Monthly in Wet Season
- Removed from On-going Management Plan

**Note:**
OTH115 or alternative bore location as identified by Power and Water

OTH117, OTH119, POT114, POT121, POT198 not shown for privacy reasons.

N

0 1 2 km

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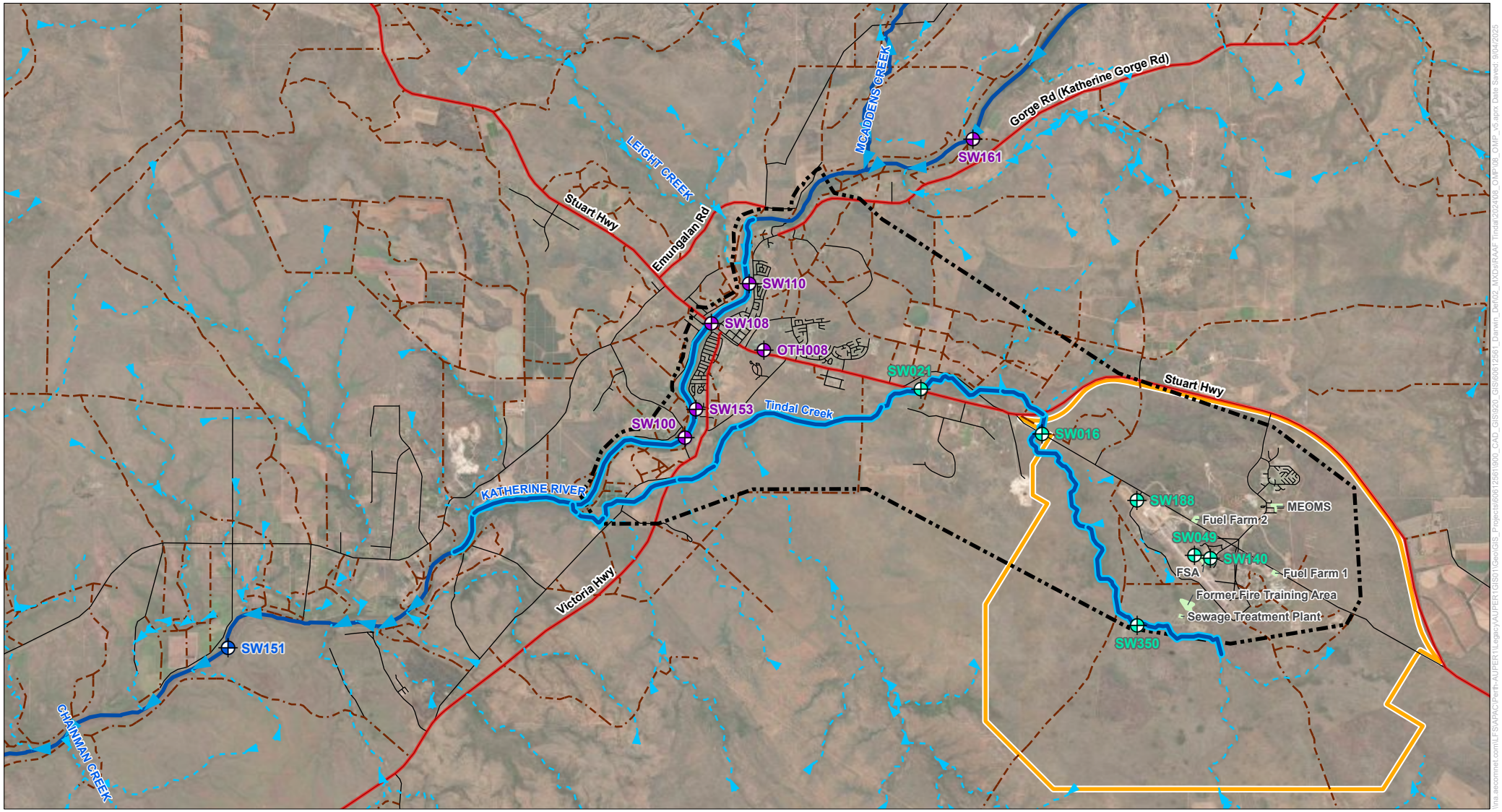


**FIGURE F4:** SURFACE WATER MONITORING LOCATIONS

Legend

- RAAF Base Tindal
- Groundwater Management Area
- Zone 3 - Surface Water Management Area
- Highway
- Road
- Track
- Katherine River
- Drainage
- Annual Surface Water Monitoring Location
- Biannual Surface Water Monitoring Locations
- Twice in Wet Season Surface Water Monitoring Locations
- Source Areas

**Note:**

SW151 is collected at the same time as biota sample collection.

N

0 1 2 3 km

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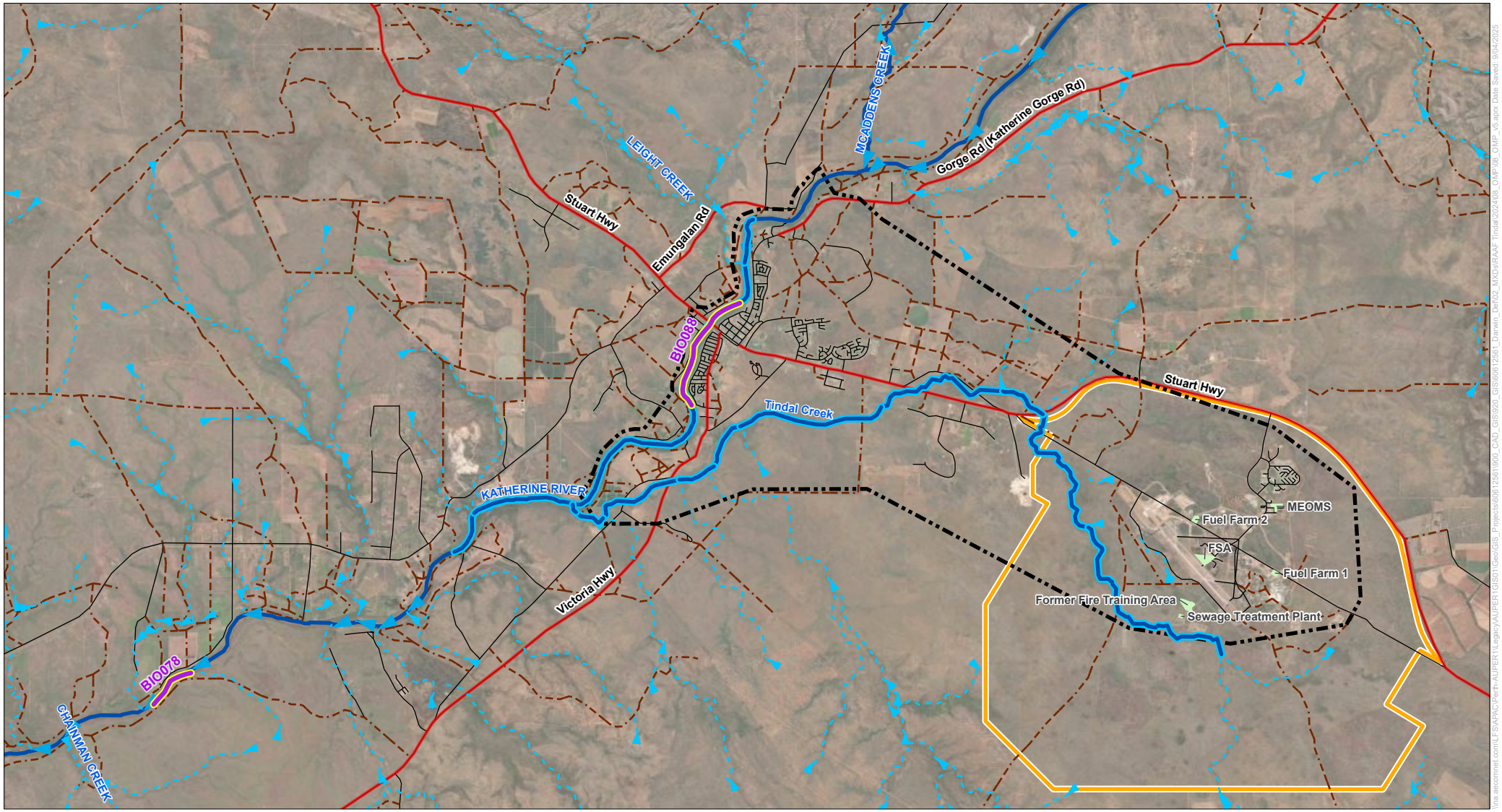


**FIGURE F5:** BIOTA MONITORING LOCATIONS

Legend

- RAAF Base Tindal
- Groundwater Management Area
- Zone 3 - Surface Water Management Area
- Highway
- Road
- Track
- Katherine River
- Drainage
- Biota Sampling Locations
- Source Areas

N

0 1 2 3 km

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# APPENDIX C SAMPLE LOCATION INFORMATION

# Table C-1 RAAF Base Tindal groundwater monitoring locations

| Frequency | Location Code | Historical location ID | On/Off Base | Location | Methodology | Easting | Northing | Screened Intervals (mbgl) | Well Depth (mbgl) | Alternative/Replacement | Rationale/Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Annual | MW301 | - | On-Base | Stuart Highway between Carson Dr and Tarakan Rd | Hydrasleeve | 217180.27 | 8397358.27 | 3 - 15 | 15 | None | Dry season GME location only due to wet season access concerns |
| Biannual | MW104 | - | On-Base | Fire Training Area | Hydrasleeve | 217083 | 8391953.544 | 2.5 - 20 | 20.65 | Replace | Approx. 200 m directly downgradient of Fire Training Area. Highest concentration in any of the wells installed along this transect. Would provide good understanding of PFAS leaving the Fire Training Area in groundwater. |
| Biannual | MW106 | - | On-Base | Central Transect | Hydrasleeve | 215500 | 8392314 | 2.4 - 18 | 18 | None | Central transect boundary road |
| Biannual | MW107 | - | On-Base | source area downgradient transect | Hydrasleeve | 215550 | 8392690.817 | 1.0 - 15 | 13.5 | MW106 | Provides data point ~2km downgradient of Fire Training Area |
| Biannual | MW109 | - | On-Base | Central Transect | Hydrasleeve | 215468 | 8393437 | - | - | None | Central transect boundary road |
| Biannual | MW109D | - | On-Base | Central Transect | Hydrasleeve | 215468 | 8393437 | 1 - 20 | 20 | None | Central transect boundary road |
| Biannual | MW110 | - | On-Base | source area downgradient transect | Hydrasleeve | 215361 | 8393873.912 | 1.2 - 13.2 | 12.06 | MW111 | Provides data point approx. 2 km downgradient of source areas |
| Biannual | MW111D | - | On-Base | Central Transect | Hydrasleeve | 215393 | 8394179 | 44.7 - 50.7 | 50.7 | None | Central transect boundary road |
| Biannual | MW111S | - | On-Base | Central Transect | Hydrasleeve | 215393 | 8394179 | 2 - 15 | 15 | None | Central transect boundary road |
| Biannual | MW117 | - | On Base | Western Base boundary | Hydrasleeve | 213333 | 8395638.664 | 0.5 - 14.5 | 14.5 | MW118 | Monitor PFAS concentrations in groundwater at the Base boundary |
| Biannual | MW118D | - | On-Base | Base Boundary | Hydrasleeve | 213299 | 8395019 | 45 - 51 | 51 | None | Base boundary road |
| Biannual | MW118I | - | On-Base | Base Boundary | Hydrasleeve | 213299 | 8395019 | 29.9 - 35.9 | 35.9 | None | Base boundary road |
| Biannual | MW118S | - | On-Base | Base Boundary | Hydrasleeve | 213299 | 8395019 | 4 - 20 | 20 | None | Base boundary road |
| Biannual | MW119 | - | On-Base | Base Boundary | Hydrasleeve | 213105 | 8393936 | 0.5 - 19.5 | 19.5 | None | Base boundary road |
| Biannual | MW127 | - | On-Base | Fire Station Area | Hydrasleeve | 217476 | 8393240.406 | 1.5 - 20 | 26.72 | MW126 or MW128 | Approx. 300m downgradient of Fire Station. Highest concentration in this transect of wells. Would provide good understanding of PFAS leaving the Fire Station in groundwater |
| Biannual | MW129 | - | On-Base | Fire Station Area | Hydrasleeve | 217848 | 8393205.031 | 2.0 - 20 | 19.6 | Replace | Adjacent to AFFF storage tank. Provide indication of groundwater impact at source area |
| Biannual | MW130 | - | On-Base | Base Boundary | Hydrasleeve | 213451 | 8396317 | 1 - 18 | 18 | None | Base boundary road |
| Biannual | MW131 | - | On-Base | Base Boundary | Hydrasleeve | 214834 | 8395969 | 1.1 - 15.1 | 15.1 | None | Base boundary road |
| Biannual | MW133 | - | On-Base | Northern Base boundary | Hydrasleeve | 215903.514 | 8397826.936 | 1.7 | 19.7 | - | Non-detect to minor detect well. This location can act as a point to monitor between source areas and receptors to the north of the base (Lansdowne) and monitor the northern extent of the plume. |
| Biannual | MW134 | - | Off-Base Private property | - | Hydrasleeve | - | - | 2.5 - 20 | 20 | MW732 (formerly RN002522) | Impacted well through the centre of the plume off-base |
| Biannual | MW135 | - | Off-Base Private property | - | Hydrasleeve | - | - | 2.5 - 19 | 19 | OTH123 (formerly RN033342 | Northern edge of the off-Base PFAS plume |
| Biannual | MW136 | - | Off-Base Public land | Gorge Rd - Landsdowne | Hydrasleeve | 208476.471 | 8402831.635 | 16.9 - 24.4 | 24.4 | None | Stickup well across road from discovery park |
| Biannual | MW137 | - | Off-Base Public land | Katherine East | Hydrasleeve | 207620 | 8399558.695 | 2.0 - 20 | 20.07 | OTH122 (formerly RN030662) | Impacted well through the centre of the plume off-Base |
| Biannual | MW138 | - | Off-Base Public land | Katherine East, centre of plume | Hydrasleeve | 206814 | 8398814.436 | 5.5 - 19.5 | 19.5 | OTH116 (formally RN007437) | Impacted well through the centre of the plume off-base |
| Biannual | MW140 | - | Off-Base Public land | Katherine East, centre of plume | Hydrasleeve | 206039 | 8398035.457 | 2.7 - 18.7 | 18.59 | RN002475 | provide data to estimate mass of PFAS entering Katherine River in the future and monitor any changes |
| Biannual | MW142 | - | Off-Base Public land | Adjacent to Katherine River | Hydrasleeve | 204773 | 8396702.963 | 3.0 - 18 | 10.95 | MW141 | provide data to estimate mass of PFAS entering Katherine River in the future and monitor any changes |
| Biannual | MW144 | - | Off-Base Public land | Adjacent to Katherine River | Hydrasleeve | 203314 | 8394753 | 3.0 – 20 | 20 | Replace | Concentrations historical reported <LOR or low detect. Ongoing monitoring to assess southern extent of plume |

# Table C-1 RAAF Base Tindal groundwater monitoring locations

| Frequency | Location Code | Historical location ID | On/Off Base | Location | Methodology | Easting | Northing | Screened Intervals (mbgl) | Well Depth (mbgl) | Alternative/Replacement | Rationale/Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Biannual | MW146 | - | On-Base | FSA | Hydrasleeve | 217631.497 | 8393220.258 | 6 - 18 | 18 | None | FSA approximately 40m southwest of ECT2 plant |
| Biannual | MW149 | - | On-Base | Fire Station Area | Hydrasleeve | 217860 | 8393142 | 10.0 - 16.0 | 16 | MW406 | Adjacent to Fire Station Area to the west. Location in the area where surface runoff from the Fire Station Area flows to. Provide indication of groundwater impact at source area. |
| Biannual | MW231 | - | On-Base | Fire Training Area | Hydrasleeve | 217180 | 8391890 | 3.0 - 24 | 24 | MW121 | Adjacent to evaporation ponds on the downgradient (western) side. Provide indication of groundwater impact at source area. |
| Biannual | MW244 | - | On-Base | Former Mechanical Equipment Operations Maintenance Sections (MEOMS) | Hydrasleeve | 219423 | 8394622 | 1.0 - 21.0 | 21 | MW306 | Consistently highest reported concentrations in Former MEOMS area. Provide indication of groundwater impact at minor source area. |
| Biannual | MW278 | - | On-Base | Fuel Farm 1 | Hydrasleeve | 219505 | 8392814 | 3.0 - 24 | 24 | MW115 | Adjacent to fuel farm - highest concentration reported at FF1. Provide indication of groundwater impact at minor source area. |
| Biannual | MW285 | - | On-Base | Fuel Farm 2 | Hydrasleeve | 217432 | 8394245 | 3.0 - 18.0 | 18 | MW286 | Adjacent to fuel farm - highest concentration reported at FF2. Provide indication of groundwater impact at minor source area. |
| Biannual | MW400 | - | Off-Base Public land | Collins Road | Hydrasleeve | 210418 | 8397006 | 30.6 - 36.0, 51.6 - 57.6, 78.6 - 84.6 | 84.6 | Replace | Impacted well through the centre of the plume off-Base |
| Biannual | MW403 | 064MW08 | On-Base | source area downgradient transect | Hydrasleeve | 213008 | 8390513.033 | 6.5 - 10.5 | 10.5 | MW735 (formerly RN029430) | Southern Edge of Base |
| Biannual | MW801S | - | On-Base | Central Transect | Hydrasleeve | 215391 | 8391756 | 5.4 - 11.4 | 11.4 | None | Central transect boundary road |
| Biannual | MW802D | - | On-Base | FSA | Hydrasleeve | 217668 | 8393147 | 16 - 19 | 19 | None | Southwest of the capped FSA area, grouped silver wells |
| Biannual | MW802I | - | On-Base | FSA | Hydrasleeve | 217668 | 8393147 | 12.2 - 15.2 | 15.2 | None | Southwest of the capped FSA area, grouped silver wells |
| Biannual | MW802S | - | On-Base | FSA | Hydrasleeve | 217668 | 8393147 | 8.5 - 10.2 | 10.2 | None | Southwest of the capped FSA area, grouped silver wells |
| Biannual | MW803D | - | On-Base | FTA | Hydrasleeve | 217180.23 | 8391890.25 | 18.8 - 24.8 | 24.8 | None | 3 silver grouped wells northwest of ECT2 and behind EPS Excavation |
| Biannual | MW803I | - | On-Base | FTA | Hydrasleeve | 217180.23 | 8391890.25 | 12.9 - 15.9 | 15.9 | None | 3 silver grouped wells northwest of ECT2 and behind EPS Excavation |
| Biannual | MW803S | - | On-Base | FTA | Hydrasleeve | 217180.23 | 8391890.25 | 7.8 - 10.9 | 10.9 | None | 3 silver grouped wells northwest of ECT2 and behind EPS Excavation |
| Biannual | MW814 | - | Off-Base | Ardnt Road | Hydrasleeve | 203912.478 | 8398775.704 | 28-31 | 31 | None | Monitor PFAS concentrations along the western plume on the west of Katherine River |
| Biannual | MW815 | - | Off-Base | Gorge Rd - Landsdowne | Hydrasleeve | 206896.826 | 8402293.577 | 28-31 | 31 | None | Monitoring PFAS concentrations to the northern extent east of Katherine River. |
| Biannual | OTH111 | RN028782, MW244, MW520 | On-Base | Married Quarters | Hydrasleeve | 219732 | 8395225.993 | 45 - 60 | >30 | - | Bore is (or has previously been) used for on-Base irrigation |
| Biannual | OTH112 | RN025650 | On-Base | 75 Squadron | Tap | 220069 | 8391621.993 | Not Known Base 64m | 64 | - | Bore is (or has previously been) used for on-Base construction works |
| Biannual | OTH113 | RN021099 | Off-Base Public land | Katherine Town Council - Museum | Tap | 205836 | 8401651.993 | 18 - 30 | 30 | RN022025 | To provide data to estimate mass of PFAS entering Katherine River in the future and monitor any changes |
| Biannual | OTH114 | RN033019 | Off-Base Private property | Katherine Town Council | Tap | - | - | Not Known Base 98m | NA | - | This bore has previously reported detectable concentrations of PFAS. Ongoing monitoring to assess PFAS impacts on the western side of Katherine River. Collected from trough outlet on western boundary of property. |
| Biannual | OTH115 | RN7807 | Off-Base Government Property | Morris Road | Tap | 207334 | 8401412 | 41 - 68 | NA | As guided by PWC | Power & Water bore originally installed as a town water production bore |

**Table C-1 RAAF Base Tindal groundwater monitoring locations**

| Frequency | Location Code | Historical location ID | On/Off Base | Location | Methodology | Easting | Northing | Screened Intervals (mbgl) | Well Depth (mbgl) | Alternative/Replacement | Rationale/Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Biannual | OTH120 | RN033559 | Off-Base Private property | Kalano Community | Tap | - | - | NA | 40 | None | Detect west of Katherine River. Sample collected from a tap adjacent to bore. Info to be provided after well |
| Biannual | POT111 | PB077 | Off-Base Private property | Uralla | Hydrasleeve | - | - | 23 - 29 | NA | MW478 (PB050) | Closest non-detect private bore to the southern extent of the plume in Uralla. This and 3 other properties to the south are <LOR and have not received a rainwater tank. Need to monitor this bore and reconsider tanks if a detect is reported. Collection from headworks in gated field at entrance of property |
| Once in dry season and Monthly in wet season. | OTH117 | - | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Collected from port adjacent to headworks. |
| Once in dry season and Monthly in wet season. | OTH118 | RN024868 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from port adjacent to headworks near card reader sign. |
| Once in dry season and Monthly in wet season. | OTH119 | RN025769 | Off-Base Private property | Cossack | Tap | - | - | 20 - 27 | NA | None | Detect west of Katherine River. Collected from port adjacent to headworks next to control panel. |
| Once in dry season and Monthly in wet season. | POT112 | PB141 | Off-Base Private property | Cossack | Tap | - | - | 33 - 39 | NA | None | Detect west of Katherine River. No town water supply or rainwater tank. Collected from tapped outlet of bore headworks |
| Once in dry season and Monthly in wet season. | POT114 | PB232 | Off-Base Private property | Cossack | Tap | - | - | 43 - 50 | NA | None | Detect west of Katherine River. No town water supply or rainwater tank. Collected from tapped port of permanent sprinkler system 5 m south of bore headworks. |
| Once in dry season and Monthly in wet season. | POT120 | PB092 | Off-Base Private property | Cossack | Tap | - | - | 50 - 56 | NA | None | Detect west of Katherine River. No town water supply or rainwater tank. Collected from water intake within large water tank located approximately 10 m north of the bore and control panel. |
| Once in dry season and Monthly in wet season. | POT121 | PB187 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. No town water supply or rainwater tank. Collection from pump outlet prior to tank. Requires removing hose attachment to sample. |
| Once in dry season and Monthly in wet season. | POT124 | - | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected between storage tank and bore headworks. |
| Once in dry season and Monthly in wet season. | POT125 | RN026086 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from port adjacent to headworks next to control panel. Bore feeds into a tank, |
| Once in dry season and Monthly in wet season. | POT126 | RN041870 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from port adjacent to headworks and next to storage tank. Bore feeds into tanks, |
| Once in dry season and Monthly in wet season. | POT127 | RN021096 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from a tap on side of pumphouse that is fed by the bore. |
| Once in dry season and Monthly in wet season. | POT128 | RN021098 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Collected from port adjacent to headworks along south side of property access road |

**Table C-1 RAAF Base Tindal groundwater monitoring locations**

| Frequency | Location Code | Historical location ID | On/Off Base | Location | Methodology | Easting | Northing | Screened Intervals (mbgl) | Well Depth (mbgl) | Alternative/Replacement | Rationale/Description |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Once in dry season and Monthly in wet season. | POT129 | RN030864 | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from tap approximately 20 metres NE of bore location |
| Once in dry season and Monthly in wet season. | POT130 | - | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Owner's request to be included in OMP. |
| Once in dry season and Monthly in wet season. | POT131 | N/A | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Detect west of Katherine River. Sample collected from tap to the right of the house. |
| Once in dry season and Monthly in wet season. | POT198 | - | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Owner's request to be included in OMP. |
| Once in dry season and Monthly in wet season. | POT201 | - | Off-Base Private property | Cossack | Tap | - | - | NA | NA | None | Owner's request to be included in OMP. |
| Once in dry season and Monthly in wet season. | POT113 | PB193 | Off-Base Private property | Cossack | Tap | - | - | 35 - 42 | NA | None | Detect west of Katherine River. Sample collected directly from tapped bore. Bore is located across from water tank. |

## Table C-2 RAAF Base Tindal Surface Water Monitoring Locations

| Frequency | Location Code | On/Off Base | Location | Easting | Northing | Longitude | Latitude | Former name | Rationale/Description |
|---|---|---|---|---|---|---|---|---|---|
| Annual | SW151 | Off-Base Public land | Katherine River - Galloping Jacks | 191700 | 8390422 | 132.139347 | -14.541763 | None | Monitor concentrations of PFAS in Katherine River |
| Biannual | OTH008 | Off-Base Private property | YMCA Pool | 205856 | 8398730 | 132.271504 | -14.468295 | PB043 | Monitor concentrations of PFAS in the Katherine YMCA pool. |
| Biannual | SW100 | Off-Base Public land | Katherine River - Low-level crossing | 203786 | 8396312 | 132.252054 | -14.489915 | KR3_SW001 | Monitor concentrations of PFAS in Katherine River |
| Biannual | SW108 | Off-Base Public land | Katherine River - Stuart Hwy | 204453 | 8399446 | 132.258584 | -14.461678 | SW109, KR1_SW001, SW077, SW173, SW172 | Monitor concentrations of PFAS in Katherine River |
| Biannual | SW110 | Off-Base Public land | Katherine River - Knotts Crossing | 205444 | 8400547 | 132.267888 | -14.451841 | None | Monitor concentrations of PFAS in Katherine River |
| Biannual | SW153 | Off-Base Public land | Katherine Hot Springs | 204069 | 8397100 | 132.254768 | -14.482826 | None | Monitor concentrations of PFAS in Katherine Hot Springs |
| Biannual | SW161 | Off-Base Public land | Katherine River – Donkey Camp | 211349. 1519 | 8404565. 292 | 132.323049 | -14.416184 | SW167 | Monitor upgradient concentrations of PFAS in Katherine River |
| Twice in wet Season | SW016 | On-Base | Tindal Creek – Base boundary | 213286 | 8396526 | 132.340139 | -14.488989 | TDL WAT 3, SW121 | Tindal Creek base boundary |
| Twice in wet Season | SW021 | Off-Base Public land | Tindal Creek - off-Base | 210044 | 8397724 | 132.310219 | -14.477827 | SW114, SW115 | Tindal creek off-base in Uralla. Adjacent to Stuart Highway |
| Twice in wet Season | SW049 | On-Base | FSA - Runway drain | 217380 | 8393267 | 132.37774 | -14.518859 | None | Monitor concentrations within runway drain adjacent to Fire Station Area |
| Twice in wet Season | SW140 | On-Base | FSA - Drain off Fire Station hardstand | 215877 | 8391329 | 132.38162 | -14.5196 | None | Monitor concentrations of runoff directly from Fire Station |
| Twice in wet Season | SW188 | On-Base | Western end of runway drain | 215832 | 8394742 | 132.363547 | -14.505368 | TDL WAT 2 | Capture runoff from runway drains |
| Twice in wet Season | SW350 | On-Base | Tindal Creek - near Fire Training Area | 215877 | 8391329 | 132.3636 | -14.5362 | TDL WAT 5 | Capture potential PFAS runoff from Fire Training Area into TC. |

# APPENDIX D OMP REVIEW

**Table D1 OMP monitoring location and frequency review**

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| POT119 | Yes | Yes | Yes | Yes | Remove location from OMP and replace with newly installed MW815 that is on nearby accessible land. | All reported results from this location are below the laboratory limit of reporting (LOR) for all PFAS analytes. Field technicians have not been able to gain access to the property since April 2021. Newly installed monitoring well, MW815 is a replacement location for POT119 as a substitute data collection point.<br><br>This location (POT119) is currently sampled on an annual basis, however, the substitute new |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| | | | | | | location (MW814) is to be sampled biannually to capture season fluctuations and associated changes in risk profile. |
| MW815 | Yes | Yes | Yes | Yes | Add location into OMP as a replacement location for POT119. | This location is a replacement well for inaccessible POT119.<br>This location tracks the potential changes in PFAS concentrations within the northern boundary of the plume, near Katherine River.<br>Sample frequency is biannually to capture season fluctuations and associated changes in risk profile. |
| POT122 | Yes | Yes | Yes | No | Remove location from OMP and replace with newly installed MW814 that is on nearby in accessible land | Some PFAS analytes reported results are above the LOR. Field technicians have not |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| | | | | | | been able to gain access to the property since January 2022. Newly installed monitoring well, MW814 is a replacement location for POT122 as a substitute data collection point. |
| MW814 | Yes | Yes | Yes | Yes | Add location to the OMP as a replacement location for inaccessible POT122. | This location is a replacement well for inaccessible POT122.<br>This location tracks the potential changes in PFAS concentrations within the northern boundary of the plume, near Katherine River.<br>Sample frequency is biannually to capture season fluctuations and associated changes in risk profile. |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| MW734 | Yes | Yes | Yes | Yes | Remove location from OMP and replace with MW133, located further north along the northern transect road. | All reported results from this location are below the laboratory LOR for all PFAS analytes. Field technicians have not been able to gain access to the well since April 2023 and last reports of site visits have noted that this well is locked. This location was used to track the northern boundary of the PFAS plume. North location MW133 will be a suitable replacement of this location. |
| MW133 | Yes | Yes | Yes | Yes | Include in OMP as a replacement location for MW734 that has consistently been blocked. | To monitor changes of PFAS concentrations within the plume to the northern boundary of the Base. A replacement location for MW734. |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| MW104<br>MW107<br>MW110<br>MW117<br>MW127<br>MW129<br>MW134<br>MW135<br>MW137<br>MW138<br>MW140<br>MW142<br>MW144<br>MW149<br>MW231<br>MW235<br>MW244<br>MW278<br>MW285<br>MW400<br>MW403<br>OTH111<br>OTH112 | Yes | Yes | Yes | No | Change sample frequency to Biannual | These locations are currently sampled on an annual basis and the frequency will be increased to biannual in order to capture seasonal fluctuations between the wet and dry season periods. |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| OTH113<br>OTH115<br>POT111 | | | | | | |
| MW301 | Yes | Yes | Yes | Yes | Include location in OMP | Location on the northern Base boundary near Stuart Highway. Adding to increase resolution of the sentinel well network tracking the northern plume edge in areas where plume migration would impact communities. This location will be an annual dry season sampling event due to restricted wet season access. |
| MW136 | Yes | Yes | Yes | Yes | Include location in OMP | Adding to increase resolution of the sentinel well network tracking the northern plume edge in areas where plume migration would impact communities. Sampled biannually. |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| MW118S<br>MW118I<br>MW118D<br>MW119<br>MW130<br>MW131 | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of mass flux across the Base boundary. Wells are on the plume centreline. Sampled biannually. |
| MW106<br>MW801S | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of mass flux downgradient of the FTA. Wells are on the FTA plume centreline. Sampled biannually. |
| MW109<br>MW109D<br>MW111S<br>MW111D | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of mass flux downgradient of the FSA.<br>Wells are on the FSA plume centreline. Sampled biannually. |
| MW146<br>MW802S<br>MW802I<br>MW802D | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of the PFAS mass flux in the FSA source area. Sampled biannually. |
| MW149 | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of the PFAS mass |

| Location | Does the location inform the nature of PFAS in the Management Area | Does the location inform the extent of PFAS in the Management Area | Does the location inform the risk profile in the Management Area | Does the sampling frequency inform the risk profile | OMP Review Outcome | Reason |
|---|---|---|---|---|---|---|
| | | | | | | flux in the FSA source area extension (i.e. downgradient of MFS forecourt). Sampled biannually. |
| MW803S<br>MW803I<br>MW803D | Yes | Yes | Yes | Yes | Include location in OMP | Ongoing monitoring of the PFAS mass flux in the FTA source area. Sampled biannually. |
| MW235 | Yes | Yes | Yes | Yes | Remove location from OMP | Well has been decommissioned. This location will be replaced upon completion of soil remediation at FTA. Sampled biannually. |
| OTH008<br>SW108<br>SW153 | Yes | Yes | Yes | Yes | Frequency from quarterly to biannual | The locations have not shown sufficient seasonal variation to warrant quarterly sampling. Biannual sampling provides sufficient frequency to observe potential seasonal variance. |

# APPENDIX E PFAS ANALYTICAL SUITE

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