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AECOM

Ongoing Monitoring Report (November 2021 - March 2023)

PFAS OMP - Robertson Barracks

28-Feb-2024
PFAS Ongoing Monitoring Program NT & SA
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Introduction

AECOM Australia Pty Ltd (AECOM) was engaged by the Department of Defence (Defence) to implement the per- and poly-fluoroalkyl substances (PFAS) Ongoing Monitoring Plan (OMP) outlined in the PFAS Management Area Plan (PMAP) (Defence, 2018) at Robertson Barracks (the Base) (Site ID 1200), Northern Territory (NT) (**Figure F1** in **Appendix A**).

Objective

The overarching objective of implementing the OMP is to provide information on changes in the location and concentrations of PFAS on-base and off-base within the Monitoring Area compared to conditions described in the Detailed Site Investigation (DSI) (Senversa, 2018a). The Monitoring Area comprises the Base (Robertson Barracks) and off-Base, within the southern drainage channel running along southern boundary of the Base and a portion of the Close Training Area (CTA).

The data is used to assist risk management decisions by Defence to protect human health and the environment, and to inform the understanding of the effectiveness of remedial actions.

Monitoring program

AECOM completed periodic monitoring of groundwater, surface water and sediment between November 2021 and March 2023 in general accordance with the Sampling and Analysis Quality Plan (SAQP) developed by AECOM (AECOM, 2022a).

The monitoring program targeted PFAS and included selected groundwater, surface water and sediment monitoring locations on-Base and off-Base within the Monitoring Area. Although outside the Monitoring Area, the monitoring also included groundwater bores within Shoal Bay Receiving Station (SBRS). Refer to **Figure F2** in **Appendix A**.

Groundwater results

Groundwater level monitoring data indicated that groundwater in the shallow groundwater aquifer[1] (upper portion of Bathurst Island Formation within the Monitoring Area generally flows north-east from the Base towards Milners Creek and Shoal Bay. Groundwater elevations appeared to vary between season at most monitoring locations (higher in wet season, lower in dry season). This is consistent with previous observations.

Overall, the groundwater monitoring results do not suggest a change in the understanding of contamination. The PFAS plume extents in groundwater were generally similar to that which was presented in the 2018 DSI (Senversa, 2018a). The following was observed:

- PFAS concentrations are highest on-Base in wells in the vicinity of Source Area 1 and Source Areas 2 and 3. The observed increased PFAS concentrations from Source Areas 2 and 3 (MW004), while notable, are not significant and do not change the overall site risk profile.
- The Sum of Perfluorooctane sulfonate and Perfluorohexane sulfonate (PFOS+PFHxS) concentrations in groundwater exceeded the adopted human health-based guidance value for drinking water in on-Base wells MW066 (Source Area 1), MW004 (Source Area 2), MW034 (northern monitoring well) and MW001 (southern monitoring well), and off-Base wells MW032 (northern monitoring well) and MW030 (southern monitoring well).
- PFAS concentrations in some locations (MW004, MW030, MW031) were reported above the historical range in the monitoring period, however PFAS concentrations were generally of the same order of magnitude as historical results. Subsequent monitoring events were completed (MW004 and MW030 only) reporting concentrations to be back within historical range.
- Concentrations of PFAS in groundwater indicated generally stable or inconclusive trends. Increasing trends were limited to two locations, namely northern monitoring wells MW034 and

[1] An aquifer is an underground layer of porous and permeable rock, gravel, sand or silt, which can contain or transmit groundwater that lies within the geology below the soil surface.

MW032, located on-Base and off-Base (respectively). However, concentrations at these two locations are close to the laboratory detection limits and marginally above the adopted human health-based guidance value for drinking water. Further data is required to understand temporal changes at these two locations.

Surface water results

PFAS concentrations in surface water at locations on-Base and off-Base were generally consistent with historical results. The following was observed:

- All surface water sample locations reported concentrations of PFOS+PFHxS below the adopted PFAS Recreational Water guidelines (HEPA, 2020).
- PFOS concentrations exceeding the 99% freshwater ecological criteria (HEPA, 2020) were detected in all on-Base and off-Base locations during the monitoring period, with the exception of SW023. The 99% protection level is applied to account for bioaccumulative effects that may manifest over time within the localised food chain. The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) recommends a conservative approach of applying lower guideline values for bioaccumulative toxicants such as PFOS.
- PFAS concentrations in some locations (SW007 and SW123) were reported above the historical range in the monitoring period, however PFAS concentrations were generally of the same order of magnitude as historical results, close to the laboratory detection limit and below the adopted PFAS Recreational Water guidelines (HEPA, 2020).
- Reported PFAS concentrations within on-Base and off-Base surface water sampling locations remained stable.

Sediment results

PFAS concentrations in sediment at all locations both on- and off-Base were primarily within historical ranges and were mostly close to or below the PFAS laboratory detection limit.

PFAS concentrations in SD059 and SD086 exceeded historical range, however PFAS concentrations were within the same order of magnitude as previous historical results.

Sediment sampling was removed from the OMP in the 2023 version (Defence, 2023) and subsequently removed from the sampling program. It was determined that sufficient sediment data was collected to determine that PFAS in sediment was not a significant contributor to PFAS movement from on-Base to off-Base areas.

Interpretive analysis

Data collected during the monitoring period were compared to historical (previous) data for the sampling locations.

PFAS concentrations within on-Base and off-Base groundwater were generally within the same order of magnitude as historical results and within the identified groundwater plume[2].

PFAS concentrations were generally lower at off-Base locations than PFAS concentrations observed at on-Base locations, consistent with previous results.

Statistical analysis of the monitoring results for groundwater locations suggests that PFAS concentrations were generally stable within the Monitoring Area.

What is an 'order of magnitude'?

This refers to a number decreasing or increasing by multiples of ten. For instance, an increase from 10 to 100 is an order of magnitude increase. When assessing changes in PFAS concentrations at an individual location, all concentrations are considered when determining trends, but order of magnitude changes are discussed separately as they represent a significant change in concentrations from what was reported in the previous event.

If a change is close to established health or environmental criteria, it will also be considered significant.

[2] PFAS contaminant plumes are areas of groundwater with elevated PFAS concentrations that are slowly moving from the source areas in the same direction that the groundwater flows.

Variation in PFAS concentrations were observed and likely due to the seasonal variability of Darwin's wet and dry seasons.

CSM and risk profile

The conceptual site model (CSM) was reviewed in light of the monitoring data collected during the current monitoring period between November 2021 and March 2023, and no changes were identified to sources, pathways or receptors at the base or within the Monitoring Area that would require an update to the CSM as described in the PMAP. The findings of the interpretive analysis conducted for the monitoring period are considered consistent with the risk profile for the Monitoring Area.

The results collected during the monitoring period were compared to screening criteria utilised in the Human Health and Ecological Risk Assessment (HHERA) (Senversa, 2018b). Locations in which results were outside the historical ranges were within the assessment criteria ranges in the HHERA (Senversa, 2018b), and therefore the data collected during the current monitoring period are considered consistent with the findings of the HHERA.

Conclusions

The following conclusions are based on the data collected during the monitoring period:

- The results for the monitoring period indicate that the nature and extent of PFAS in groundwater, surface water and sediment are consistent with previous findings.
- The CSM was reviewed, and based on the results presented within this report, no changes were identified to source, pathway or the type of receptors at the base and within the Monitoring Area.
- Based on the data collected during the monitoring period, no changes to the risk profile were identified within the Monitoring Area.
- The sampling conducted over the monitoring period is considered to have met the objectives of the OMP and was carried out in general accordance with the SAQP.

Given the remaining PFAS concentrations at the on-Base source areas, it is recommended that monitoring of groundwater and surface water is continued to understand the extent of PFAS, potential migration and any associated risk changes.

Abbreviations and acronyms

Abbreviation/ Acronym	Term
ADWG	Australian Drinking Water Guidelines
AECOM	AECOM Australia Pty Ltd
AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum
ASC NEPM	National Environment Protection (Assessment of Site Contamination) Measure
BOM	Bureau of Meteorology
CSM	Conceptual Site Model
CTA	Close Training Area
DO	Dissolved Oxygen
Defence	Department of Defence
DCMM	Defence Contamination Management Manual
DSI	Detailed Site Investigation
EC	Electrical Conductivity
ERS	Emergency Response Squadron
FSANZ	Food Standards Australia New Zealand
GWE	Groundwater Elevation
HEPA	Heads of Environment Protection Authority
HHERA	Human Health and Ecological Risk Assessment
LOR	Limit of Reporting
MK	Mann-Kendall
MTR	Marksmanship Training Range
MW	Monitoring Well
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NT	Northern Territory
NEMP	National Environmental Management Plan
OMP	Ongoing Monitoring Plan
ORP	Oxidation Reduction Potential
PFAS	Per- and poly-fluoroalkyl substances
PFOA	Perfluorooctanoic acid
PFOS	Perfluorooctane sulfonate
PFHxS	Perfluorohexane sulfonate
PMAP	PFAS Management Area Plan
QA/QC	Quality Assurance and Quality Control

Abbreviation/ Acronym	Term
SAQP	Sampling and Analysis Quality Plan
SBRS	Shoal Bay Receiving Station
SD	Sediment
SW	Surface Water
SWL	Surface Water Level

List of units

Unit	Definition
cm	centimetre
°C	degrees Celsius
g	grams
km	Kilometre
L	litre
ML	Megalitre
m	metre
mbtoc	metres below top of casing
m bgl	metres below ground level
µg	micrograms
µS	microsiemens
mg	milligrams
mV	millivolts
NTU	Nephelometric Turbidity Unit

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was engaged by the Department of Defence (Defence) to implement the per- and poly-fluoroalkyl substances (PFAS) Ongoing Monitoring Plan (OMP) at Robertson Barracks (the Base), Northern Territory (NT) (**Figure F1** in **Appendix A**).

The monitoring targeted PFAS and included selected locations within the Monitoring Area, comprising on-Base, southern drainage channel running along the southern boundary of the Base and a portion of the Close Training Area (CTA). The monitoring also included bores within Shoal Bay Receiving Station (SBRS). Refer to **Figure F2** in **Appendix A**. These locations were identified in the OMP (Defence, 2018).

In order to meet the objectives of the OMP, the monitoring was undertaken in accordance with the *Sampling and Analysis Quality Plan* (SAQP) (AECOM, 2022a). Note that the SAQP is generally updated prior to each monitoring event.

This report has been prepared in accordance with the Defence *PFAS OMP Annual Interpretive Report Guidance Version 0.4* (Defence, 2022) and summarises monitoring data collected between November 2021 and March 2023 (the 'monitoring period').

1.1 Purpose and objectives

The objective of the monitoring program set out in the OMP (Defence, 2018) is to provide information on changes in location and concentrations of PFAS within the Monitoring Area.

Assessing changes in the distribution, concentration, and transport (pathways and flow rates) of the contaminants against appropriate guideline values provides an:

- evidence-based approach for targeted and effective risk management decision making to protect human health and environmental receptors; and
- early warning that additional management of PFAS contamination may be warranted in areas not currently understood to be affected by PFAS.

The data will be evaluated to assess environmental variability and trends in PFAS concentrations and changes to the known risk profile as described in the DSI (Senversa, 2018a), and to inform recommendations for triggers to review the OMP (Defence, 2018) or the PFAS Management Area Plan (PMAP) (Defence, 2018) or any requirements to update the Human Health and Ecological Risk Assessment (HHERA) (Senversa, 2018b) documentation, if required.

1.2 Scope

The scope of works for this ongoing monitoring report included assessing changes to the nature and extent of PFAS during the monitoring period, in additional to interim monitoring data and historical OMP investigations and evaluating if these changes have implications for the understanding of the Conceptual Site Model (CSM) and the risk profile with respect to PFAS impacts at the base. This assessment included the evaluation of data reported in the following factual reports, as well as other data provided by Defence and ancillary external data sources:

- *Robertson Barracks – Sampling Event Factual Report, November 2021* (AECOM, 2022b).
- *Robertson Barracks – Wet Season Sampling Event Factual Report 2022* (AECOM, 2023a)
- *Robertson Barracks – Sampling Event Factual Report, End of Dry Season 2022* (AECOM, 2023b)
- *Robertson Barracks – Wet Season Sampling Event Factual Report 2023* (AECOM, 2023c)

In addition to the above reports pertaining to the monitoring period, the following historical documents were also considered:

- *Robertson Barracks – PFAS OMP Interpretive Report 2020* (AECOM, 2021a) (2020 AIR)
- *Robertson Barracks – PFAS OMP Interpretive Report 2021* (AECOM, 2022c) (2021 AIR)

- *Robertson Barracks – Ongoing Monitoring Report – October 2018 to May 2019* (Senversa, 2019)Robertson Barracks – Detailed Site Inspection 2018 ((Senversa, 2018a) (2018 DSI)

Ancillary external data sources included meteorological data (see **Section 6.4**).

2.0 Site setting

2.1 Site identification

The site identification and setting are summarised in **Table 1**, below as presented in the PMAP (Defence, 2018).

Table 1 Site identification and setting summary

Element	Description
Site ID	1200
Location	The Base is located approximately 17 km east of Darwin city centre. The area surrounding the Base contains predominantly semi-rural residential land uses, with open wetland and swamp areas as well as multiple quarrying areas including within the CTA located to the east of the Base as shown in **Figure F1** in **Appendix A**.
Regional climate	The base and surrounds lie within the monsoonal tropic area of northern Australia. The area experiences two distinct seasons, a warm dry season from approximately May to September and a hot, monsoon and tropical cyclone wet season from approximately October to April. Rainfall occurs predominantly during the wet season. Significant monsoon and tropical cyclone events during January to March are relatively common, occurring throughout the wet season and are likely to cause localised flooding. Darwin has an annual average rainfall of 1,725 millimetres (mm) (Bureau of Meteorology [BOM], 2023).
Topography, geology and hydrogeology	The Base and surrounds are slightly undulating and low lying with wetlands and swamps sloping towards the east, with the elevation ranging from approximately 37 metres Australian Height Datum (m AHD) in the north-west to 19 m AHD in the north-east. The surrounding area slopes to the north-east towards Shoal Bay. The area is generally underlain by the Bathurst Island Formation which overlies the Wildman Siltstone Formation with the exception of an outcrop of the Acacia Gap Quartzite Member located within the CTA. The nature of each of these formations is summarised below: • Bathurst Island Formation typically comprises radiolarian claystone, sandy claystone, clayey sandstone, quartz sandstone, glauconitic sandstone and basal conglomerate up to 50 m in thickness. • Wildman Siltstone Formation comprises siltstone, silty sandstone and minor quartzite encountered between 50 m to over 1,000 metres below ground level (m bgl). • Acacia Gap Quartzite Member comprises quartzite, commonly pyritic sandstone with interbedded siltstone. The geology encountered during the DSI generally comprised sandy silt or silty sand overlying siltstone. Fill material was observed at several locations within the CTA at locations previously mined and at several locations within the Base, generally associated with grass cover or below concrete and paving. The upper water table aquifers of the Bathurst Island Formation are discontinuous and unconfined, occurring as localised aquifers within the

Element	Description
	surface fluvial sand, silts and gravel beds of these predominantly fine sediment dominated units. Groundwater levels in the upper water table aquifer recorded during the DSI ranged between the ground surface during the wet season and approximately 10 m bgl during the dry season. The aquifer is recharged during the wet season by infiltration of rain and flood water and river leakage with seasonal variations of up to 9.3 m reported between the dry and wet seasons in the Marksmanship Training Range (MTR). In some areas, it is likely that the upper aquifer discharges to rivers, and the pattern of recharge and discharge relationships between the upper aquifers and rivers is in many areas, seasonal. Groundwater levels noted from monitoring wells installed within the lower aquifer of the Bathurst Island Formation ranged between approximately 27 and 30 m bgl, as well as approximately 1.4 and 7 m bgl suggesting a semi-confined aquifer system is also present. Vertical hydraulic gradient values between 'shallow' and 'deep' well pairs were minimal at two paired monitoring locations with a downward vertical gradient evident at one paired location which indicated that the two aquifers are likely to be hydraulically connected. Groundwater flow direction in the northern and central portions of the Base is inferred to the east-north-east. Groundwater flow direction in the southern portion of the Base is inferred to the south-south-east and is likely to be influenced by the southern drainage channel leading into Milners Creek. Groundwater hydraulic gradients reported for the wet season compared to the dry season were relatively similar, ranging between 0.011 and 0.014. This suggests that groundwater recharge to the underlying aquifers is relatively uniform across the Base and surrounds with no evidence of preferential recharge zones. The average calculated seepage velocities vary by an order of magnitude between the upper (silt) aquifer (from 46 m/year in the dry season to 77 m/year in the wet season) and the lower (siltstone) aquifer (approximately 2 m/year). As a result of the difference in surface topography between the Base and the CTA, groundwater was generally encountered at shallower depths within the CTA. In some areas of Milners Creek, including in the south of the CTA and immediately adjacent to the east of the Base, the creek channel is shallow and not likely to be in hydraulic continuity with groundwater during the dry season until further down-gradient closer to Milners Swamp. During the wet season, however, groundwater levels rose almost to the ground surface within the CTA in proximity of Milners Creek as well as above the drainage lines in some areas within the Base with groundwater and surface water both contributing to areas of high water flow and/or areas of inundation.

Element	Description
Surface water drainage	The Base is located in the Kings Creek Catchment, which flows north out into Shoal Bay, located north-east of Darwin Harbour. The Base is situated partly on a wetland area which extends to the west of the Base and drains south along the western boundary into the southern drainage channel which discharges into Milners Creek, an intermittent creek which flows north into Milners Swamp. Flow from Milners Swamp then moves into Kings Creek which in part transitions through the Noogoo Swamp before entering Shoal Bay. There are two surface water features in low lying areas, present in the north-eastern and western portions of the Base that are likely to collect surface water run-off during high rainfall events. These features are likely to be associated with former water courses such as creeks and swamp systems. The swamp area along the western portion of the Base is predominantly inundated while the north-eastern area becomes inundated during high rainfall events. There are several lined and unlined drains located within the Base that generally follow the local topography and divert surface runoff through and off the Base. Generally, surface water diverts around the Base and runs around the perimeter in open channels before discharging along points on the eastern, western, and southern boundaries. The drainage lines in the southern portion of the Base discharge to the unlined southern drainage channel which is located outside of the Base and runs parallel to the southern boundary. This channel discharges into the southern tributary of Milners Creek which flows northwards through the CTA. The drainage lines in the central portion of the Base discharge to a drain that runs underneath Thorngate Road to the east and into the western tributary of Milners Creek. The two tributaries of the Milners Creek system converge within the CTA with the creek then flowing to the north-east and to the area known as Milners Swamp. These two tributaries of Milners Creek are ephemeral in places dependent on recent rainfall events and groundwater levels. Various man-made lakes are scattered across the CTA from historical quarrying activities. The water from these lakes is not used for any purpose by Defence, however, may be used by ecological receptors, particularly birds.
Vegetation	The Base and surrounds include both developed and undeveloped land areas that include fields, streams, wetlands, and forested areas.
Current land use	The Base is the home of Australia's 1st Brigade whose mission is to provide forces to conduct full-spectrum operations in order to defend Australia and its national interests. Over 2,600 staff work daily at the Base, with the addition of staff from the United States Marine Corp during the dry season. The current layout and key features include: • Helicopter airfield and infrastructure in the northern portion of the Base, including hangars, vehicle and aircraft maintenance areas, and fuel supply infrastructure. • Commercial/office buildings across the Base. • Residential housing for personnel, sports and recreational facilities and a childcare centre (used four days a week as a minimum by mothers and toddlers) in the central eastern section of the Base. • Four main catering kitchens and recreational facilities, including gyms, swimming pools, children's play parks, cafes and a chapel. • Training areas, including shooting ranges and revetments in the cleared open space to the north of the Base known as the MTR.

Element	Description
	• The CTA which is a former quarry area to the east of the Base has also recently been acquired by Defence and is currently being developed for the use of live fire range field training. As part of the proposed development of the CTA, fencing and gated access will be installed around the perimeter of the CTA to restrict access to the public who can currently access some areas of the CTA. • Sports fields, ovals and activity areas located along the south-eastern section of the Base. The surrounding land use is predominantly Commonwealth owned, with no privately-owned rural residential homes within a 1 km radius of the Base. Identified land uses in each direction from the Base are summarised below: • **North:** The SBRS is located to the north. This area predominantly comprises open woodlands, wetlands and swamps overlying an undulating topography. The littoral and marine zones of Shoal Bay lie immediately north of the SBRS. • **East:** To the east and north-east are former quarries that have been utilised for sand and gravel extraction and are now filled with water. Defence now manages the land which is Commonwealth owned and is in the process of transforming the area into a CTA. The CTA also includes Milners Creek which continues into Milners Swamp and Noogoo Swamp. Further to the east is the Darwin Correctional Facility. The flooded quarries and Milners Creek are located within the CTA with restricted access to the public, however, recreational fishing may occur in Milners Creek outside of the CTA and from the southern drainage channel which are accessible to the public. • **South:** Small woodland open reserve area, light industrial, commercial retail, office facilities and the Stuart Highway. • **West:** Open woodlands, tall shrubland, plains and swamps as well as an area managed by Airservices (not related to fire training exercises). Further west are semi-rural residential dwellings and Knuckey Lagoons Conservation Reserve.

2.2 Monitoring area

The location of the Base and the Monitoring Area is shown in **Figure F1** (**Appendix A**). The Monitoring Area comprises the following three areas:

- The Base
- The southern drainage channel running along the southern boundary of the Barracks which discharges to Milners Creek. Concentrations of PFAS above ecological screening levels have been identified in both the southern drainage channel and Milners Creek
- A portion of the western part of the CTA to monitor potential lateral migration of PFAS impacted groundwater and surface water from the Base.

Although outside the Monitoring Area, the monitoring also includes two groundwater abstraction bores used for potable purposes at the SBRS (refer to **Figure F2** in **Appendix A**). These two bores were tested as part of the DSI as the SBRS is operated by Defence and were included as part of ongoing monitoring despite no previous detections of PFAS.

2.3 Source areas

The PMAP (Defence, 2018) identified the following locations as PFAS source areas, illustrated in **Figure F1** (**Appendix A**):

- **Source Area 1**: The former Emergency Response Squadron (ERS) compound comprising Building 137 and immediate surrounds
- **Source Area 2**: 17 Combat Service Support Brigade Elements where the ERS parked their trucks prior to moving to Building 137
- **Source Area 3**: Wash down bays and refuelling within the southern portion of the Base. The drainage network also culminates in this area of the Base.

3.0 Sampling and analytical methodology

3.1 Sampling location rationale and methodology

The SAQP (AECOM, 2022a) (**Appendix C**) provides the sampling schedule and rationale, prescribing biannual groundwater sampling, biannual surface water sampling, and annual sediment sampling, during the monitoring period. This involved:

- A broad sampling and analysis event for the collection of groundwater samples occurring on a biannual basis, during the end of wet season (April/May), and end of dry season (September/October).
- A broad sampling and analysis event for the collection of surface water samples occurring on a biannual basis during the start of wet season (December/January), and at the end of the wet season (April/May).
- A broad sampling and analysis event for the collection of sediment samples occurring on an annual basis at the end of the wet season (April/May)

Details of the completed scope are provided in **Section 3.2**.

3.2 Summary of monitoring

A summary of the monitoring works implemented as part of the SAQP (AECOM, 2022a) between November 2021 and March 2023 is summarised in **Table 2**, below.

Table 2 Summary of monitoring works

Sampling Matrix	Sampling Event	Sampling Date	Scope
Groundwater	End of dry biannual event	2 and 3 November 2021	Sampling at 18 of 18 planned groundwater monitoring wells.
Surface water	Start of wet biannual event	20 January 2022	Sampling at 9 of 9 planned surface water monitoring locations.
Groundwater	End of wet biannual event	20, 21, 22 April 2022 and 30 May 2022	Sampling at 18 of 18 planned groundwater monitoring wells.
Surface water	End of wet biannual event	21 April 2022	Sampling at 7 of 9 planned surface water monitoring locations.
Sediment	End of wet annual event	20 and 21 April 2022	Sampling at 9 of 9 planned sediment monitoring locations
Groundwater	End of dry biannual event	19, 20, 21 September 2022	Sampling at 17 of 18 planned groundwater monitoring wells.
Surface water	Start of wet biannual event	24 and 28 November 2022	Sampling at 9 of 9 planned surface water monitoring locations.
Groundwater	End of wet biannual event	21, 22 and 23 March 2023	Sampling at 18 of 18 planned groundwater monitoring wells.

Sampling Matrix	Sampling Event	Sampling Date	Scope
Surface water	End of wet biannual event	21, 22 and 23 March 2023	Sampling at 8 of 9 planned surface water monitoring locations.

3.3 Deviations from the SAQP

The works undertaken over the monitoring period were completed in general accordance with the SAQP (AECOM, 2022a) and/or OMP (Defence, 2018) with few deviations which are identified in the associated Sampling Event Factual Reports (**Appendix B)** and summarised in **Table 3** below.

Table 3 Summary of SAQP deviations

SAQP requirement	Sampling event deviation	Impact of deviation on dataset
End of dry season groundwater sampling event (November 2021)		
Sampling of all OMP groundwater locations.	Monitoring location MW023 was dry and not able to be sampled. Monitoring location MW024 was sampled in lieu of MW023.	The alternative/contingency well MW024 was considered suitable to provide coverage for the assessment of PFAS impacts in the area. The overall dataset is not considered to have been impacted by this change.
Start of wet season surface water sampling event (January 2022)		
No deviations reported during this sampling event.		
End of wet season sampling event (April/May 2022)		
Sampling of all OMP groundwater locations.	Monitoring location MW023 was damaged and not able to be sampled. Monitoring location MW024 was sampled in lieu of MW023.	The alternative/contingency well MW024 was considered suitable to provide coverage for the assessment of PFAS impacts in the area. The overall dataset is not considered to have been impacted by this change. Note that MW023 was repaired prior to the subsequent sampling event.
Sampling of all OMP surface water locations.	Monitoring locations SW028 and SW023 were dry and not able to be sampled.	The gap in surface water data is not considered to impact the overall outcome of the assessment as both locations are on-Base. Downstream surface water locations were able to be sampled to assist in understating the impact to the receptors in the receiving environment.
Sediment samples to be collected from the sediment/water interface (0.0 to 0.1 m bgl). Where practicable, a grab sample will be collected wearing fresh disposable nitrile gloves. Where this sampling methodology is not possible, a hand trowel or shovel must be used.	Sediment samples were collected at the sediment/water interface between approximately 0.0 and 0.1 m bgl. At locations where water was present in creeks and drains, a laboratory-supplied high-density polyethylene-free soil jar was lowered into the water body using a stainless-steel sampling pole and nitrile gloves. The sediment was collected directly into the jars until sampling jar capacity was met.	The change to the sampling methodology is not considered to have a material impact on the monitoring results or interpretation, given samples were collected directly into laboratory provided sample containers.

End of dry season groundwater sampling event (September 2022)		
Sampling of all OMP groundwater locations.	Monitoring location MW004 was not sampled due to root growth preventing deployment of HydraSleeve™. No alternate location was available for this location during this sampling event.	The lack of data from MW004 has marginal impact on the understanding of concentration changes within the source area. However, given that the issue was resolved in the subsequent event and sampling was completed, the overall dataset is not considered to have been impacted by this change.
	Monitoring location MW023 was dry and not able to be sampled. Monitoring location MW024 was sampled in lieu of MW023.	The alternative/contingency well MW024 was considered suitable to provide coverage for the assessment of PFAS impacts in the area. The overall dataset is not considered to have been impacted by this change.
Start of wet season surface water sampling event (November 2022)		
In-situ field parameter collection for surface water.	Field parameter data was collected for surface water ex-situ.	Given that the collection of surface water field parameters ex-situ provides comparable results to in-situ parameters, when conducted immediately after the water is collected, this deviation is not considered to impact the dataset. Review of the in-situ results confirms that the results are comparable to the historic dataset.
Field observations	Observations of surface water body, specifically size of water body (stream width and depth), was not recorded.	This deviation limits interpretation of site conditions and may have a minor impact on future use of the historical data.
End of wet season sampling event (March 2023)		
Field parameter collection for groundwater.	Field parameters were not collected at the following locations: • Monitoring location MW023; insufficient water volume present. • Monitoring locations MW112 and MW113, field parameters not collected due to field staff being given limited time to collect samples by Base escort and not gaining access to return to collect field parameters.	Collection of field parameters from MW112 and MW113 is utilised primarily as reference data and not included for interpretation purposes as both locations are outside of the PFAS groundwater plume area. Monitoring locations MW112 and MW113 are sampled to ensure no PFAS is detected in water from these locations as the bores are used for potable water. Due to the distance between the bores and the identified PFAS groundwater plume it is not anticipated that PFAS would be detected in water from these bores.

		The loss of field parameters from this location is considered to have a minor impact on the dataset and does not impact the ability to interpret results.
Quality Assurance/Quality Control (QA/QC) samples. The SAQP requires the decontamination of field equipment (water level probe) between gauging locations using Liquinox and PFAS free water.	On 22 March 2023, a rinsate blank sample was inadvertently collected from equipment which had not been decontaminated.	The quality of the analytical data has still been assessed as acceptable, with any potential cross contamination considered unlikely based on the following: • Available rinsate and field blank samples reported results below the laboratory limit of reporting (LOR) . • Sampling equipment was either dedicated, disposable or decontaminated between each sample location. • Results obtained from locations sampled on 22 March 2023 were within historical concentration ranges, and do not suggest cross contamination had occurred.
Sampling of all OMP surface water locations.	Monitoring location SW023 was dry and not able to be sampled.	The gap in surface water data is not considered to impact the overall outcome of the assessment as SW023 is located on-Base. Downstream surface water locations were still sampled to assist in understating the impact to the receptors in the receiving environment.
Field parameter collection for surface water.	The field parameter data at locations SW028 and SW075 were lost due to electronic data collection fault, where the data was not saved and could not be retrieved.	Collection of field parameters for surface water locations is conducted to understand if there are changes in the physical or chemical properties of the water collected at each sample location, and to compare to groundwater physical and chemical properties to determine if groundwater contributes to surface water at specific sample locations. Surface water in the vicinity of SW028 is not anticipated to have groundwater interaction as it is located in a higher area on base outside of the groundwater influence zone. Field parameters were collected from locations both upgradient and down-gradient of SW075. The loss of field parameters from this location is considered to have a minor impact on the dataset and does not impact the ability to interpret results.
In-situ field parameter collection for surface water.	Field parameter data was collected ex-situ for surface water.	Given that the collection of surface water field parameters ex-situ provides comparable results to in-situ parameters, when conducted

		immediately after the water is collected, this deviation is not considered to impact the dataset.
Field observations	Observations of surface water body, specifically size of water body (stream width and depth), was not recorded.	This deviation limits interpretation of site conditions and may have a minor impact on future use of the historical data.
Sediment sampling	No sediment samples were collected.	Given that the concentrations of PFAS in sediment were consistently below LOR or at very low concentrations (i.e. close to the LOR), it has been considered sediment sampling is no longer required as part of the OMP. As such, this deviation has no impact on the dataset. Additionally, the requirement for sediment sampling has also been removed from the new revision of the OMP (completed in February 2023), to be implemented during the next monitoring period.

4.0 Quality assurance and quality control

Data validation pertaining to the data in this report has been completed and discussed within the factual reports listed in **Section 1.2**.

Data validation procedures employed in the assessment of the field and laboratory QA/QC data indicated that the reported analytical results are representative of the sample locations and that the overall quality of the analytical data produced is acceptably reliable for the purpose of the factual and ongoing monitoring reports.

The following key QA/QC anomaly was reported during the monitoring period:

- PFAS was detected in an inter-laboratory duplicate sample analysed from MW024 during the end of wet April 2022 groundwater sampling event (sampled as an alternate monitoring location for MW023). This location was resampled in May 2022 to confirm the results. Given the concentrations of PFAS were reported below LOR it was considered the original detection may be related to a laboratory error or potential cross contamination issue. Note that the analytical results from the resampling of MW024 were adopted for interpretive purposes, and the overall dataset was not considered to have been impacted by this issue.

AECOM considers the data obtained during the current monitoring period, along with the historical data assessed, to be representative of the conditions at the time of monitoring and to be suitable for the temporal assessment of the data in the Monitoring Area.

Additionally, all data collected during the monitoring events were reviewed and uploaded to the Defence ESdat database in accordance with Defence Contamination Management Manual (DCMM) (Defence, 2019) Annex L requirements.

5.0 Assessment criteria

The adopted screening criteria references the PFAS National Environmental Management Plan 2.0 (NEMP) (HEPA, 2020) Defence estate and environmental strategies, and Defence PFAS-specific strategies and guidance. At the time of preparing this report, the primary guidance document utilised is the *PFAS National Environmental Management Plan (version 2.0)* (NEMP) (HEPA, 2020).

The PFAS screening criteria adopted to assess the data generated from the monitoring are presented in **Table 4** and **Table 5**.

The adopted screening criteria included values for the following analytes:

- Perfluorooctane sulfonate (PFOS)
- Sum of Perfluorooctane sulfonate and Perfluorohexane sulfonate (PFOS+PFHxS)
- Perfluorooctanoic acid (PFOA).

Table 4 Summary of adopted water screening criteria: human health

Pathway	Compound	Criteria	Comment/Reference
Drinking water – groundwater	PFOS + PFHxS	0.07 µg/L	The values presented in the PFAS NEMP (HEPA, 2020). *All groundwater results were compared to these criteria.*
	PFOA	0.56 µg/L	
Recreational use – surface water	PFOS + PFHxS	2 µg/L	The values presented in the PFAS NEMP (HEPA, 2020) based on (NHMRC, 2019) guidance on the assessment of PFAS in recreational water released in August 2019. *All surface water results were compared to these criteria.*
	PFOA	10 µg/L	

Notes:
µg/L = micrograms per Litre

Table 5 Summary of adopted water screening criteria: ecological

Media	Compound	Criteria	Comment/Reference
Freshwater (99% species protection values) – groundwater and surface water	PFOS	0.00023 µg/L	The presented values are from the PFAS NEMP (HEPA, 2020). The 99% level of protection has been applied for slightly to moderately disturbed ecosystems. This approach is generally adopted for chemicals that bioaccumulate and biomagnify in wildlife. For the purposes of preliminary screening of analytical water results, the laboratory LOR will be adopted rather than sole use of the criteria value. *All groundwater and surface water results were compared to these criteria.*
	PFOA	19 µg/L	

Notes:
HEPA (2020) notes that the 99% species protection level for PFOS is close to the level of detection. Agencies may wish to apply a 'detect' threshold in such circumstances rather than a quantified measurement. The laboratory PFOS LOR adopted in this report is 0.001 µg/L.

It is noted that at the time this report was prepared no HEPA (2020) endorsed criteria was available for PFAS in sediments.

6.0 Contextual and ancillary information

6.1 Additional analytical data

AECOM is not aware of other PFAS related projects completed during the monitoring period within the Monitoring Area for inclusion in this report.

6.2 PFAS remediation projects

AECOM is not aware of any PFAS or other contamination remediation projects being completed or proposed to be completed at the Base which may have any impact on the identified PFAS source areas. Defence informed AECOM that there was no update on the status of remediation projects to be undertaken at the Base.

6.3 Infrastructure projects

Some development and refurbishment work at the Base have been completed since November 2018. All works have been managed with appropriate environmental management controls and approvals. AECOM is not aware of any practices or incidents which are likely to influence the nature or extent of PFAS at the Base.

6.4 Significant weather events

The monitoring period was characterised by a period of hot, humid and wet summers and hot and dry winters as recorded at Darwin Airport (Station 014015), located within RAAF Base Darwin (BOM, 2023).

The monthly rainfall during the monitoring period was generally consistent with the long-term average for the months of April to September, and well below average (~ 100 mm) for March (in all three years). Monthly total rainfall during the months of October to February varied across the monitoring period, whilst December in both 2021 and 2022 greatly exceeded (> 100 mm) the long-term average (**Plate 1)**.

Total rainfall for the period July 2021 to June 2022 was calculated as 1,606 mm, which is less than the mean annual rainfall of 1,724 mm (BOM, 2023). Whereas total rainfall for the period July 2022 to June 2023 was calculated as 1,985 mm, which is greater than the mean annual rainfall of 1,724 mm (BOM, 2023).

Temperatures exceeded the long-term average for the majority of 2021 and 2022, returning to the long-term average in 2023 (**Plate 2)**. This aligns with the drier first half of 2022 with below average rainfall for most of 2023.

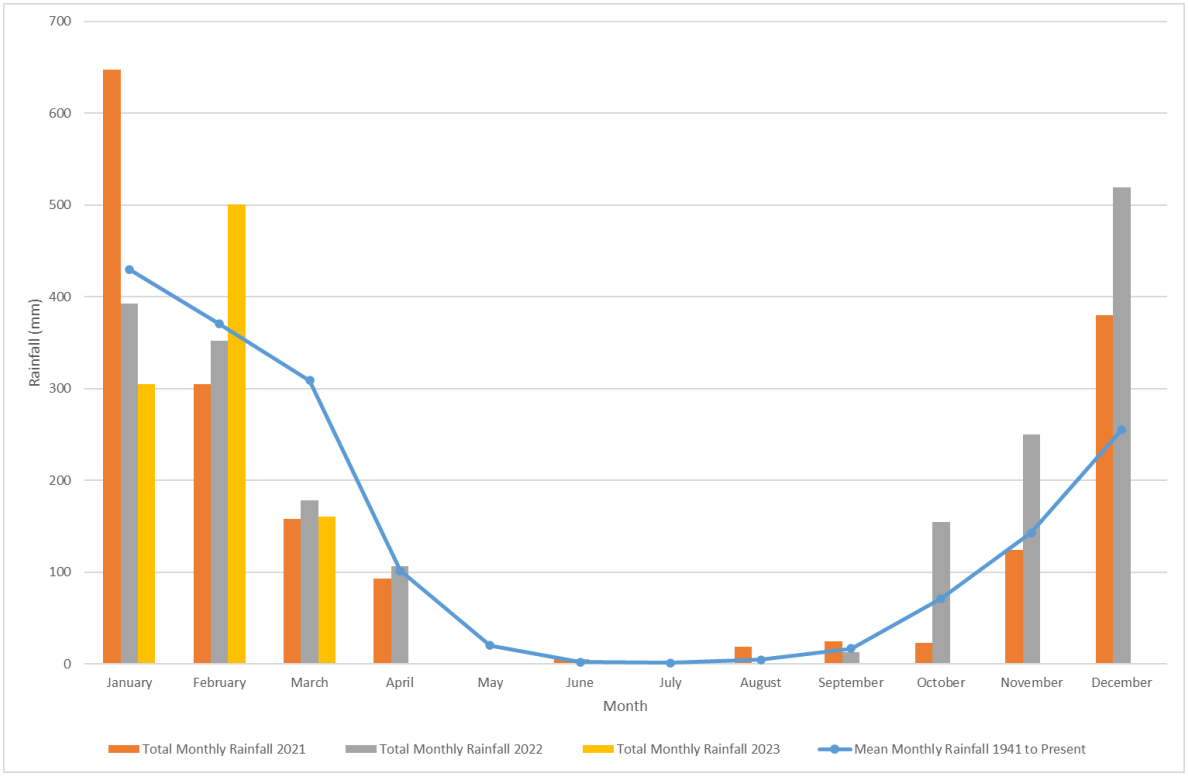

Plate 1 **Rainfall data – Monitoring period and mean monthly rainfall for Darwin Airport (1941 to present) (Station 014015) (BOM, 2023)**

Plate 2 **Temperature data – Monitoring period and mean monthly temperature for Darwin Airport (1941 - present) (Station 014015)** (BOM, 2023)

Groundwater Considerations

The OMP (Defence, 2018) requires groundwater sampling to be conducted at end of dry season (during September/October), however for the end of dry season 2021 sampling event, the groundwater samples were collected at the start of November 2021.

It is noted that, under normal climatic conditions, November is generally considered a transitional period between the dry and wet season, however considering the samples were collected at the start of the month, prior to the start of significant rainfalls (14 mm of rainfall recorded in November 2021 prior and during sampling, and 110 mm of rainfall recorded in November 2021 following sampling) groundwater levels are unlikely to be materially impacted by rain totals during this transitional period.

The 2021 period had lower volumes of precipitation leading up to the November 2021 event. Review of the gauging data from this round found groundwater elevations for the November 2021 to be within the expected range for the late dry season, and the impact on data quality and representativeness is likely to be negligible.

Surface Water Considerations

Surface water sampling occurs twice in the wet season, with:

- The first event typically occurs in December/January targeting as soon as practicable after the start of the higher rainfall periods, as the end of dry season/start of wet season is normally characterised by spikes in surface water concentrations (often referred to as “first-flush” sampling); and
- The second sampling event occurs at the end of the wet season.

Above average rainfall was recorded from October to December 2022, which would function as the first-flush event. This period was followed by a drier than average January 2023. As the first-flush rainfall events were earlier than anticipated and inconsistent with the long-term average, the targeted surface water sampling event for the start of the wet season 2022 was slightly later than intended and missed the first flush rainfall events in October.

The sampling undertaken in November 2022 was in line with the second instance of significant rainfall for the 2022 wet season. Whilst this should be noted when reviewing concentration trends in **Section 8.5**, the minor variance in timing does not seem to have significantly impacted the results obtained for the round (refer to **Table T4** in **Appendix B**), which were largely consistent with start of wet seasons results obtained historically.

Overall, the cyclical nature of the wet and dry seasons at the Monitoring Area may result in variability to the hydrogeological system and the data collected. This can include changes to water levels and other characteristics associated with groundwater and surface water such as flow rate, flow direction and gradient.

7.0 Monitoring data summary

As part of the OMP, as detailed in **Section 1.2** the following 8 sampling events were completed by AECOM across the monitoring period:

- November 2021 (AECOM, 2022b)
  - End of dry groundwater sampling between 2 and 3 November 2021
- January 2022 to April/May 2022 (AECOM, 2023a)
  - Start of wet surface water sampling on 20 January 2022.
  - End of wet groundwater sampling between 20 and 22 April 2022, and 30 May 2022
  - End of wet surface water sampling on 21 April 2022.
  - Annual sediment sampling on 20 and 21 April 2022.
- September 2022 (AECOM, 2023b)
  - End of dry groundwater sampling between 19 and 21 September 2022
- November 2022 to March 2023 (AECOM, 2023c)
  - Start of wet surface water sampling on 24 and 28 November2022
  - End of wet groundwater sampling between 21 and 23 March 2023
  - End of wet surface water sampling between 21 and 23 March 2023

The sample locations are shown on **Figure F2** (**Appendix A**). The results are summarised in following sections and on figure series **Figure F4**, **Figure F5** and **Figure F6** (**Appendix A**) and in **Table T1** to **Table T6** (**Appendix B**).

The groundwater elevations are shown on figure series **Figure F3** (**Appendix A**).

7.1 Groundwater results

7.1.1 Groundwater field observations

The field observations during groundwater sampling are provided in **Table T1** in **Appendix B** and key observations are summarised below.

Groundwater observations for the monitoring period were recorded to generally be clear to moderately turbid, colourless to light brown or orange/yellow/brown, and mostly without odour or sheens, with the exception of the following:

- An organic or hydrogen sulphide odour was observed during one or more monitoring events at MW004, MW004D, MW012D, MW021, MW021D, MW029, MW030 and MW034.
- A strong hydrocarbon odour was observed during at MW034 during one monitoring event (September 2022).
- High turbidity was observed during one or more monitoring events at MW004, MW029, MW030 and MW031.

7.1.2 Groundwater elevation and flow direction

The groundwater standing water level (SWL) was measured, where possible, across all identified wells included in the OMP to evaluate the groundwater elevations (m AHD) in the Monitoring Area. This was done biannually during the transitional periods between dry and wet seasons and between the wet and dry seasons.

The gauging results are presented on **Table T1** (**Appendix B)**. A summary of the SWLs recorded and groundwater elevations for on-Base and off-Base monitoring wells from the monitoring period are presented in **Table 6** below.

Table 6 Summary of groundwater elevations

GME	No. Wells	Min. SWL (m btoc)	Max. SWL (m btoc)	Min. GWE (m AHD)	Max. GWE (m AHD)
On-Base groundwater monitoring wells: MW001, MW004, MW004D, MW012, MW012D, MW034, MW066, MW080					
End of dry season November 2021	8	2.86 (MW001)	8.44 (MW012D)	14.291 (MW034)	24.49 (MW012)
End of wet season April 2022	8	1.17 (MW001)	5.08 (MW012D)	17.01 (MW034)	27.28 (MW012)
End of dry season September 2022	8	2.68 (MW001)	8.42 (MW012)	13.57 (MW034)	23.06 (MW012D)
End of wet season March 2023	8	1.11 (MW001)	4.78 (MW012D)	17.27 (MW034)	27.49 (MW012)
Off- Base groundwater monitoring wells: MW018, MW021, MW021D, MW023, MW024, MW029, MW030, MW031, MW032					
End of dry season November 2021	8*	2.49 (MW030)	5.68 (MW032)	2.92 (MW024)	22.44 (MW029)
End of wet season April 2022	8*	0.81 (MW030)	2.62 (MW018)	4.85 (MW024)	23.72 (MW029)
End of dry season September 2022	9	2.29 ((MW030)	6.71 ((MW023)	3.88 (MW024)	22.17 (MW029)
End of wet season March 2023	9^	0.59 (MW029)	5.87 (MW023)	16.03 (MW021)	24.85 (MW029)

Notes:

mbtoc = m below top of casing
SWL = Standing water level
mAHD = m Australian Height datum
GWE = Groundwater elevation

* = groundwater level monitoring at off-Base well MW023 was unable to be undertaken due to the location being dry (November 2021 and September 2022) or damaged (April 2022), MW024 was monitored as an alternate.

^ = groundwater elevation (mAHD) unable to be calculated at MW023 as top of casing elevation had not been surveyed since repair.

Groundwater elevations and interpreted contours for each event (presented in figure series **Figure F3** in **Appendix A**), indicate groundwater elevation is highest in the western portion of the Base, with groundwater flowing to the north-east towards the CTA from the northern portion of the Base, and in the southern end of the Base groundwater flows east towards the catchment of Milners Creek. This is generally consistent with previous investigations.

7.1.3 Groundwater geochemical parameters

During each sampling event, groundwater geochemical parameter field measurements were recorded prior to collecting groundwater samples, with the exception of MW023, MW112 and MW113 in March 2023 as detailed in **Table 3** (**Section 3.3**). All collected parameters are tabulated in **Table T1** (**Appendix B**).

The minimum and maximum recorded field parameters for the monitoring period are provided in **Table 7.** Overall, the field parameter readings from the monitoring period are considered consistent with previous investigations where sufficient data exists to evaluate parameter consistency.

Table 7 Groundwater quality parameter ranges (minimum – maximum)

Event	No. of samples	Dissolved oxygen (mg/L)	Electrical conductivity (µS/cm)	pH	Corrected redox* (mV)	Temperature (°C)
On-Base groundwater monitoring wells: MW001, MW004, MW004D, MW005, MW012, MW012D, MW034, MW066, MW080						
Historical (April 2019 to June 2021)	38	0.09 (MW034) – 19.00 (MW001). *Poor to well oxygenated conditions*	6.63 (MW004D) – 814 (MW004) *Freshwater conditions*	3.75 (MW034) – 6.99 (MW034) *Acidic - neutral conditions*	44.6 (MW004) – 655.8 (MW066) *Slightly oxidising - Oxidising conditions*	28.3 (MW034) – 33.7 (MW034)
End of dry season November 2021	8	0.44 (MW004) – 2.06 (MW066) *Poor to oxygenated conditions*	36.9 (MW012) - 489.3 (MW004) *Freshwater conditions*	4.03 (MW080) - 5.33 (MW034) *Acidic - slightly acidic conditions*	143.2 (MW004D) – 413.2 (MW012) *Oxidising conditions*	28.6 (MW034) – 32.1 (MW066)
End of wet season April 2022	8	0.78 (MW080) - 5.05 (MW012D) *Poor to oxygenated conditions*	73.4 (MW012) – 354.2 (MW004D) *Freshwater conditions*	4.20 (MW066) - 6.51 (MW004D) *Acidic - neutral conditions*	199.1 (MW004D) - 354.2 (MW066) *Oxidising conditions*	30.5 (MW001) – 32.9 (MW004)
End of dry season September 2022	7	1.34 (MW034) – 1.82 (MW080) *Poor to oxygenated conditions*	*32.3 (MW012)* – *341.4 (MW004D)* *Freshwater conditions*	4.38 (MW080) - 6.71 (MW004D) *Acidic - neutral conditions*	157.7 (MW004D) - 447.6 (MW012) *Oxidising conditions*	29.0 (MW001) – 32.7 (MW066)
End of wet season March 2023	8	0.55 (MW080) - 2.25 (MW012D) *Poor to oxygenated conditions*	36.6 (MW034) – 359 (MW004D) *Freshwater conditions*	4.38 (MW066) - 6.68 (MW004D) *Acidic - neutral conditions*	189 (MW004D) - 405.7 (MW066) *Oxidising conditions*	29.2 (MW001) – 32.2 (MW012)

Event	No. of samples	Dissolved Oxygen (mg/L)	Electrical Conductivity (µS/cm)	pH	Corrected Redox (mV)	Temperature (°C)
Off- Base groundwater monitoring wells: MW018, MW021, MW021D, MW023, MW024, MW029, MW030, MW031, MW032, MW112, MW113						
Historical (April 2017 to April 2021)	36	0.00 (MW029) – 36.40 (MW113). *Poor to well oxygenated conditions*	29.1 (MW032) – 404.6 (MW112) *Freshwater conditions*	4.71 (MW021) – 7.81 (MW021) *Acidic - neutral conditions*	121.1 (MW113) – 589.5 (MW032) *Oxidising conditions*	28.4 (MW034) – 33.2 (MW112)
End of dry season November 2021	10	0.70 (MW018) – 2.28 (MW021) *Poor to oxygenated conditions*	41.4 (MW018) - 1,902.0 (MW024)* *Freshwater to saline conditions* **All wells other than MW024 reported values below 400 µS/cm*	3.70 (MW031) - 5.90 (MW112/MW113) *Acidic - slightly acidic*	239.3 (MW112) – 418.2 (MW018) *Oxidising conditions*	24.8 (MW113) – 32.1 (MW024)
End of wet season April/May 2022	10	2.98 (MW112) - 8.34 (MW018) *Poor to oxygenated conditions*	78.2 (MW032) – 693.0 (MW024) *Freshwater conditions*	4.59 (MW031) – 6.82 (MW113) *Acidic - neutral conditions*	198.62 (MW029) – 312.4 (MW031) Oxidising conditions	28.9 (MW001) – 31.3 (MW031/MW113)
End of dry season September 2022	10	1.28 (MW029) - 3.16 (MW021) *Poor to oxygenated conditions*	33.7 (MW029) – 799.0 (MW112)* *Freshwater conditions*	*4.*89 (MW021) - 7.32 (MW112) *Acidic to slightly alkaline conditions*	147.2 (MW113) – 388.8 (MW021D) Oxidising conditions	29.0 (MW030) – 33 (MW113)
End of wet season March 2023	10 (7)[1]	0.88 (MW029) - 2.32 (MW021D) *Poor to oxygenated conditions*	5.5 (MW031) – 151.2 (MW021D) *Freshwater conditions*	5.00 (MW030) – 6.07 (MW021D) *Acidic – neutral conditions*	258 (MW029) – 275.7 (MW030) *Oxidising conditions*	28.4 (MW021D) – 30.8 (MW029)

Notes:

µS/cm: microSiemens per centimetre
mg/L: milligrams per Litre
mV: millivolts
°C: degrees Celsius
*Corrected Redox = redox potential relative to the standard hydrogen electrode (Eh = Er + 200mV)
[1] = 10 locations sampled; parameters only collected from seven locations (not collected from MW023, MW112, MW113).

7.1.4 Groundwater analytical results

All groundwater analytical results for each sampling event conducted in monitoring period are presented in historical groundwater analytical results **Table T2** (**Appendix B**).

Groundwater monitoring analytical results for both on- and off-Base wells for PFOS, PFOA and PFOS+PFHxS are summarised in **Table 8** and presented on concentration maps for PFOS+PFHxS in figure series **Figure F4** (**Appendix A**).

Deviations from historical groundwater dataset are also summarised **Table 8**. Concentrations of PFOS and PFOS+PFHxS exceeded historical ranges in MW004 (on-Base) and MW030 (off-Base) in November 2021 and MW031 (off-Base) in March 2023.

The groundwater analytical results for the monitoring in relation to source areas, cross gradient and down-gradient are summarised in **Section 8.2** and **Section 8.3**.

Table 8 Summary of PFOS, PFOA and PFOS+PFHxS concentrations in groundwater

Sampling event	No. of sample locations analysed	Compound	Concentration range (> LOR) (µg/L)	New maximum concentration reported (µg/L)	No. of sample locations with concentrations > LOR	No. of sample locations exceeding human health criteria	No. of sample locations exceeding ecological criteria*
On-Base monitoring well locations: MW001, MW004, MW004D, MW005, MW012, MW012D, MW034, MW066, MW080							
End of dry season November 2021	8	PFOS	0.02 (MW080) to 0.42 (MW066)	0.32 (MW004)	5	NA	5
		PFOA	0.01 (MW034) to 0.02 (MW066)	-	2	0	0
		PFOS+PFHxS	0.03 (MW080) to 0.54 (MW066)	0.44 (MW004)	5	4	NA
End of wet season April/\May 2022	8	PFOS	0.03 (MW004) to 0.34 (MW066)	-	4	NA	4
		PFOA	0.02 (MW066)	-	1	0	0
		PFOS+PFHxS	0.04 (MW004) to 0.42 (MW066)	-	4	3	NA
End of dry season September 2022	7	PFOS	0.07 (MW080) to 0.39 (MW066)	-	4	NA	4
		PFOA	0.02(MW066)	-	1	0	0
		PFOS+PFHxS	0.11 (MW034) to 0.53 (MW066)	-	4	3	NA
End of wet season March 2022	8	PFOS	0.08 (MW034) to 0.52 (MW066)	-	5	NA	4
		PFOA	0.03 (MW066)	-	1	0	0
		PFOS+PFHxS	0.01 (MW034) to 0.65 (MW066)	-	5	5	NA
Off-Base monitoring well locations: MW018, MW021, MW021D, MW023, MW024, MW029, MW030, MW031, MW032, MW112, MW113							
End of dry season November 2021	10	PFOS	0.05 (MW032) to 0.32 (MW030)	0.32 (MW030)	2	NA	2
		PFOA	0.01 (MW030)	-	1	0	0
		PFOS+PFHxS	0.08 (MW032) to 0.40 (MW030)	0.40 (MW030)	2	2	NA
End of wet season	10	PFOS	0.03 (MW004) to 0.10 (MW030)	-	3	NA	3
		PFOA	All <LOR	-	0	0	0

Sampling event	No. of sample locations analysed	Compound	Concentration range (> LOR) (µg/L)	New maximum concentration reported (µg/L)	No. of sample locations with concentrations > LOR	No. of sample locations exceeding human health criteria	No. of sample locations exceeding ecological criteria*
April/May 2022		PFOS+PFHxS	0.04 (MW004) to 0.14 (MW030)	-	3	2	NA
End of dry season September 2022	10	PFOS	0.05 (MW032) to 0.11 (MW030)	-	2	NA	2
		PFOA	All <LOR	-	0	0	0
		PFOS+PFHxS	0.08 (MW032) to 0.16 (MW030)	-	2	2	NA
End of wet season March 2022	9	PFOS	0.03 (MW031) to 0.08 (MW030)	0.03 (MW031)	3	NA	3
		PFOA	All <LOR	-	0	0	0
		PFOS+PFHxS	0.03 (MW031) to 0.11 (MW030)	0.03 (MW031)	3	2	NA

Notes:
***** Denotes that some samples may exceed the Freshwater 99% Species Protection Guideline (HEPA 2020) due to the Limit of Reporting being greater than the Guideline Criteria.
- Denotes no knew maximum concentrations reported
<LOR = below the laboratory limit of reporting
NA = Not applicable (no applicable guideline)
Human health criteria for groundwater denotes drinking water – groundwater PFAS NEMP (HEPA, 2020).
Ecological criteria for groundwater denotes Freshwater (99% species protection values) PFAS NEMP (HEPA, 2020).

7.2 Surface water results

7.2.1 Surface water field observations

The field observations during surface water sampling are provided in **Table T3** in **Appendix B**, and key observations are summarised below.

Surface water observations for the monitoring period were recorded to generally be clear/low turbidity, colourless, without odour or sheens, with the exception of the following:

- Organic odour was observed at:
  - SW007 and SW123 in November 2022
- Slight brown to yellow colouration was observed at:
  - SW023 and SW028 in January 2022
  - SW059, SW091 and SW123 in April 2022
  - SW007, SW059, SW075, SW086 and SW091 in November 2022
- Moderate to high visual turbidity was observed at:
  - SW023 and SW028 in January 2022
  - SW007 and SW075 in November 2022
  - SW007 and SW091 in March 2023

Surface water locations SW023 and SW028 were reported to be dry in April 2022, with pooled water (no flow) observed at SW023 and SW028 in November 2022. Surface water location SW023 was also reported to be dry in March 2023.

7.2.2 Surface water geochemical parameters

Surface water geochemical parameter field measurements were recorded at the time of collecting samples. The recorded water quality parameters are provided in full as **Table T3 (Appendix B)**.

The maximum and minimum recorded field parameters for the monitoring period are provided in **Table** 10. Overall, the field parameter readings from monitoring period are considered consistent with previous investigations where sufficient data exists to evaluate parameter consistency.

Table 9 Surface water quality parameter ranges (min – max)

Sampling event	No. of samples	Dissolved oxygen (mg/L)	Electrical conductivity (µS/cm)	pH	Corrected redox* (mV)	Temperature (°C)
On- Base surface water monitoring locations: SW001, SW007, SW023, SW028, SW059						
Historical (December 2019 to April 2021)	14	2.72 (SW007) – 73.40[1] (SW001) *Poor to well oxygenated conditions*	8.8 (SW028) – 83.6 (SW001) *Freshwater to saline conditions*	5.42 (SW007) – 7.92 (SW007) *Slightly acidic to slightly alkaline conditions*	297.4 (SW059) – 441.7 (SW007) *Oxidising conditions*	24.4 (SW007) – 35.6 (SW007)
Start of wet season January 2022	5	4.37 (SW001) - 7.38 (SW007) *Oxygenated conditions*	5.6 (SW028) – 45.3 (SW001) *Freshwater conditions*	5.58 (SW001) – 5.84 (SW0028) *Slightly acidic conditions*	374.5 (SW007) – 411.3 (SW059) *Oxidising conditions*	27.9 (SW123) - 32.3 (SW075)
End of wet season April 2022	3	2.53 (SW001) – 4.02 (SW059) *Oxygenated conditions*	53.6 (SW007) – 246.7 (SW001) *Freshwater conditions*	5.49 (SW001) – 6.82 (SW059) *Slightly acidic to neutral conditions*	272.3 (SW007) – 305.2 (SW059) *Oxidising conditions*	30.8 (SW001) – 34.2 (SW059)
Start of wet season November 2022	5	1.51 (SW001) – 2.81 (SW023) *Poor to oxygenated conditions*	13.5 (SW028) – 77.0 (SW001) *Freshwater conditions*	6.15 (SW007) – 6.97 (SW023) *Neutral conditions*	276.7 *(SW059)*- 475.8 *(SW023)* *Oxidising conditions*	27.3 (SW023) – 32.6 (SW001)
End of wet season March 2023	4(3)[2]	1.23 (SW001) – 1.94 (SW007) *Poor to oxygenated conditions*	23.3 (SW059) – 195.6 (SW007) *Freshwater conditions*	5.01 (SW059) – 5.45 (SW007) *Slightly acidic conditions*	231.6 (SW007) – 349.2 (SW059) *Oxidising conditions*	29.9 (SW001) – 30.4 (SW007)

Sampling event	No. of samples	Dissolved oxygen (mg/L)	Electrical conductivity (µS/cm)	pH	Corrected redox (mV)	Temperature (°C)
Off- Base surface water monitoring locations: SW075, SW086, SW091, SW123						
Historical (April 2017 to April 2021)	19	0.56 (SW123) – 55.50 (SW075). *Poor to well oxygenated conditions*	19.1 (SW123) – 176.1 (SW091) *Freshwater conditions*	5.31 (SW086) – 8.40 (SW091) *Slightly acidic to slightly alkaline conditions*	270.1 (SW091) – 461.0 (SW075) *Oxidising conditions*	25.0 (SW075) – 34.9 (SW086)
Start of wet season January 2022	4	2.92 (SW123) - 3.80 (SW075) *Oxygenated conditions*	21.5 (SW123) – 40.5 (SW086) *Freshwater conditions*	6.44 (SW091) – 6.85 (SW086) *Neutral conditions*	309 (SW086) – 344.5 (SW123) *Oxidising conditions*	29.1 (SW123) - 32.5 (SW075)
End of wet season April 2022	4	3.62 (SW075) – 4.47 (SW086) *Oxygenated conditions*	49.2 (SW123) – 64.5 (SW075) *Freshwater conditions*	5.43 (SW075) – 6.68 (SW086) *Slightly acidic to neutral conditions*	258.2 (SW086) – 280.5 (SW075) *Oxidising conditions*	28.2 (SW075) – 29.9 (SW091)
Start of wet season November 2022	4	3.19 (SW123) – 3.66 (SW075) *Oxygenated conditions*	17.4 (SW075) – 44.2 (SW086) *Freshwater conditions*	5.84 (SW086) – 6.57 (SW075) *Slightly acidic to neutral conditions*	280.4 *(SW123)*- 316.6 *(SW086)* *Oxidising conditions*	-
End of wet season March 2023	3	4.94 (SW123) – 5.62 (SW091) *Oxygenated conditions*	34.8 (SW123) – 44.3 (SW091) *Freshwater conditions*	5.82 (SW086) – 6.09 (SW091) *Slightly acidic to neutral conditions*	238.4 (SW091) – 248.2 (SW086) *Oxidising conditions*	29.7 (SW123) – 30.1 (SW091)

Corrected Redox = redox potential relative to the standard hydrogen electrode (Eh = Er + 200mV)

[1] = This value is likely a field reporting or equipment reporting error.

[2] = Four locations sampled, however parameters only collected from three locations (not collected from SW028).

7.2.3 Surface water analytical results

Historical surface water analytical results for the monitoring period are presented in **Table T4** (**Appendix B**).

Surface water monitoring analytical results for both on- and off-Base wells for PFOS, PFOA and PFOS+PFHxS are summarised in **Table 10** and presented on concentration maps for PFOS+PFHxS in figure series **Figure F5 (Appendix A)**.

Deviations from historical surface water dataset are also summarised **Table 10** below. Concentrations of PFOA at SW123 (off-Base) in November 2022 and March 2023 and PFOS+PFHxS at SW007 (on-Base) and SW123 (off-Base) in March 2023 exceeded historical ranges.

The surface water analytical results for the monitoring of source areas and down-gradient areas are summarised in **Section 8.4** and **Section 8.5**.

Table 10 Summary of PFOS, PFOA and PFOS+PFHxS concentrations in surface water

Sampling event	No. of sample locations analysed	Compound	Concentration range (> LOR) (µg/L)	New maximum concentrations reported (µg/L)	No. of sample locations with concentrations > LOR	No. of sample locations exceeding human health criteria	No. of sample locations exceeding ecological criteria*
On-Base surface water monitoring locations: SW001, SW007, SW023, SW028, SW059							
Start of wet season January 2022	5	PFOS	0.02 (SW001)	-	1	NA	1
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.03 (SW001)	-	1	0	NA
End of wet season April 2022	3	PFOS	0.02 (SW001) to 0.18 (SW059)	-	2	NA	2
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.02 (SW001) to 0.25 (SW059)	-	2	0	NA
Start of wet season November 2022	5	PFOS	0.01 (SW001) to 0.03 (SW059)	-	2	NA	2
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.01 (SW001) to 0.03 (SW059)	-	2	0	NA
End of wet season March 2023	4	PFOS	0.01 (SW001) to 0.17 (SW059)	-	3	NA	3
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.05 (SW001) to 0.22 (SW059)	0.06 (SW007)	3	0	NA
Off-Base surface water monitoring locations: SW075, SW086, SW091, SW123							
Start of wet season January 2022	4	PFOS	0.02 (SW075, SW091 & SW123)	-	3	NA	3
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.02 (SW091) to 0.03 (SW075 & SW123)	-	3	-	NA
End of wet season April 2022	4	PFOS	0.02 (SW091 & SW123)	-	2	NA	2
		PFOA	All locations <LOR	-	0	0	0
		PFOS+PFHxS	0.03 (SW091) to 0.04 (SW123)	-	2	0	NA

Sampling event	No. of sample locations analysed	Compound	Concentration range (> LOR) (µg/L)	New maximum concentrations reported (µg/L)	No. of sample locations with concentrations > LOR	No. of sample locations exceeding human health criteria	No. of sample locations exceeding ecological criteria*
Start of wet season November 2022	4	PFOS	0.10 (SW075) to 0.20 (SW123)	-	3	NA	3
		PFOA	0.01 (SW123)	0.01 (SW123)	1	0	0
		PFOS+PFHxS	0.01 (SW091) to 0.25 (SW123)	-	3	0	NA
End of wet season March 2023	4	PFOS	0.01 (SW075, SW086 & SW123)	-	3	NA	3
		PFOA	0.15 (SW123)	0.15 (SW123)	1	0	0
		PFOS+PFHxS	0.01 (SW075, SW086 & SW091) to 0.35 (SW123)	0.35 (SW123)	4	0	NA

Notes:
***** Denotes that some samples may exceed the Freshwater 99% Species Protection Guideline (HEPA 2020) due to the Limit of Reporting being greater than the Guideline Criteria.
- Denotes no knew maximum concentrations reported
<LOR = below the laboratory limit of reporting
NA = Not applicable (no applicable guideline)
Human health criteria for surface water denotes recreational water – surface water PFAS NEMP (HEPA, 2020).
Ecological criteria for groundwater denotes Freshwater (99% species protection values) PFAS NEMP (HEPA, 2020).

7.3 Sediment results

7.3.1 Sediment sampling observations

Sediment sample observations recoded during the monitoring period are presented on **Table T5** in **Appendix B**.

The sediment encountered during the sampling event completed in April 2022 did not report any visible evidence of contamination, no odour was reported at the locations sampled.

The sediment matrix comprised mostly of red to brown with some grey coloured sand or silty sands, with clays observed at location SD028.

7.3.2 Sediment analytical results

Historical sediment analytical results for the monitoring period are presented in **Table T6** (**Appendix B)**.

Sediment monitoring analytical results for both on- and off-Base for PFOS, PFOA and PFOS+PFHxS are summarised in **Table 11** below and presented on concentration maps for PFOS+PFHxS in figure series **Figure F6 (Appendix A)**.

Deviations from historical groundwater dataset are also summarised **Table 11** below. Concentrations of PFOS and PFOS+PFHxS exceeded the historical ranges in SD059 (on-Base) and SD086 (off-Base) in April 2022.

The sediment analytical results for the monitoring of source areas and down-gradient areas are summarised in **Section 8.6**.

Table 11 Summary of PFOS, PFOA and PFOS+PFHxS concentrations in sediment

Sampling event	No. of sample locations analysed	Compound	New maximum concentration (mg/kg)	Concentration range (> LOR) (mg/kg)	No. of sample locations with concentrations > LOR
On-Base sediment monitoring locations					
April 2022	5	PFOS	0.0004 (SD059)	0.0003 (SD001) to 0.0004 (SD059)	2
		PFOA	-	All locations <LOR	0
		PFOS+PFHxS	0.0004 (SD059)	0.0003 (SD001) to 0.0004 (SD059)	2
Off-Base sediment monitoring locations					
April 2022	4	PFOS	0.0045 (SD086)	0.0007 (SD123) to 0.0045 (SD086)	3
		PFOA	-	All locations <LOR	0
		PFOS+PFHxS	0.0050 (SD086)	0.0007 (SD123) to 0.005 (SD086)	3

- Denotes no knew maximum concentrations reported
<LOR = below the laboratory limit of reporting

8.0 Interpretive analysis

In addition to the 2021/2023 OMP data, historical data from 2014 to 2021 was included in the assessment to analyse temporal trends, and the Base setting as outlined in **Section 1.2** was considered with regards to interpretation of the results. The historical data was obtained from the following reports:

- *Robertson Barracks – PFAS OMP Interpretive Report 2020* (AECOM, 2021a)
- *Robertson Barracks – PFAS OMP Interpretive Report 2021* (AECOM, 2022c)
- *Robertson Barracks – Ongoing Monitoring Report – October 2018 to May 2019* (Senversa, 2019)
- *Robertson Barracks – Detailed Site Inspection 2018* ((Senversa, 2018a)
- *Robertson Barracks – Human Health and Ecological Risk Assessment* (Senversa, 2018b).

For groundwater, where sufficient data is available, nominally eight or more like data points, Mann-Kendall (MK) statistical analysis has been utilised to determine the presence or non-presence of trends within individual monitoring locations. The smaller the sample set size available for statistical analysis the lower the potential accuracy of the statistical analysis results. As such, MK statistical analysis has only been applied to locations with a minimum of seven available data points. Additionally, where a location appears to be seasonally influenced with higher or lower concentrations reported during dry or wet seasons, the application of MK statistical analysis has been assessed to have limited benefit. In these instances, the assessment of results has been guided by temporal trend review instead. For surface water, temporal trend assessment of scatter plots presenting concentrations against daily rainfall averages were carried out.

8.1 Hydrogeology

The groundwater SWLs were measured in the groundwater monitoring wells biannually and converted to groundwater elevations (in mAHD). Depth to groundwater measurements are presented in **Table T1** (**Appendix B**) and the inferred potentiometric contours for the monitoring wells for the November 2021, April 2022, September 2022 and March 2023 monitoring events are presented in figure series **Figure F3** (**Appendix A**).

Groundwater levels fluctuate across the Monitoring Area over the wet and dry seasons, with higher groundwater levels recorded in the late wet season and lower groundwater levels recorded in the late dry season. Groundwater levels differ between one-metre and five-metres when compared to groundwater level monitoring between late wet and late dry season.

Inferred groundwater flow directions in the upper aquifer during the monitoring period was generally to the north-east from the Base towards Milners Creek and Shoal Bay, which is consistent with the flow presented in previous investigations.

8.2 Groundwater results overview

Groundwater results for PFOS+PFHxS compared to the assessment criteria are provided in figure series **Figure F4** (**Appendix A**), with PFAS concentrations presented in **Table T2** (**Appendix B**).

PFOS, PFOA or PFHxS concentrations were detected in monitoring wells down-hydraulic gradient from the identified PFAS source areas and suggest that the groundwater impacts are associated within the source areas. The maximum concentrations of PFOS+PFHxS reported during the monitoring period were as follows:

- **On-Base**: MW066 (Source Area 1), concentrations ranging between 0.36 to 0.65 µg/L (April 2022 and March 2023).
- **On-Base**: MW004 (Source Area 2), 0.04 to 0.44 µg/L (April 2022 and November 2021).
- **Off-Base**: MW030 (southern bore), 0.11 to 0.40 µg/L (March 2023 and November 2021).

The highest PFAS concentrations in the monitoring period were reported down-hydraulic gradient of Source Area 1.

The concentrations of PFOS and PFOS+PFHxS exceeded previous maximum concentrations at three locations during the monitoring period, as follows:

- **On-Base**: MW004 (November 2021) and MW031 (March 2023) (Source Area 2)
- **Off-Base**: MW030 (November 2022) (southern bore).

The new maximum concentrations of PFOS and PFOS+PFHxS reported at both MW004 and MW030 in November 2021 were of the same order of magnitude as historical range. Note that lower concentrations were reported within historical range at both locations in the subsequent monitoring events (April 2022 onwards).

Similarly, the new maximum concentrations of PFOS and PFOS+PFHxS reported at MW031 in March 2023 is within the same order of magnitude as historical range and remains close to the LOR.

The overall nature and extent of PFAS in groundwater within the Monitoring Area is generally consistent with the understanding presented in the 2021 AIR (AECOM, 2022c), with PFAS concentrations higher on-Base in the vicinity of known source areas, and lower in down-gradient locations. In general, the groundwater for the monitoring period and historically indicate that there is variability in concentrations of PFAS in groundwater within the Monitoring Area. The reported groundwater concentrations from the monitoring period and significance of any variation are discussed based on areas of interest in **Section 8.3** below.

8.3 Groundwater PFAS temporal trends

8.3.1 Approach to groundwater temporal trend analysis

A summary of PFOS+PFHxS and PFOA concentrations (including historical data) and temporal trend analysis for the five areas of interest specified in **Table 12** below are presented in tabular form and discussed in the following sub-sections (**Section 8.3.2** to **8.3.6**).

Table 12 Summary of groundwater monitoring areas

Area of interest	Groundwater monitoring well ID
Source Area 1	MW066, MW012, MW012D, MW021, MW021D
Northern bores	MW023[1], MW032 and MW034
Source Area 2 and 3	MW004[1], MW004D, MW018, MW031 and MW080
Southern bores	MW001, MW029 and MW030
Shoal Bay Receiving Station	MW112 and MW113

[1] Alternative location sample results used where indicated in lieu of primary location being unable to sample.

Temporal graphs and MK statistical analysis supporting the temporal trend analysis are presented in **Appendix D** and **Appendix E**, respectively.

The groundwater temporal graphs and MK statistical assessment only included locations which consistently reported concentrations of PFOS+PFHxS and/or PFOA greater than the LOR. Based on these criteria, **Table 13** below summarises the monitoring wells, and respective analytes, selected to be presented in temporal graphs and MK statistical assessment (separated into areas of interest). Where sample results were less than the LOR, half the LOR was adopted for the temporal graph and MK statistical analysis.

Table 13 Summary of locations Selected for groundwater temporal graphs and Mann-Kendall analysis

Area of interest	Graph ID	Analyte	Groundwater monitoring well ID
Source Area 1	G1	PFOA	MW066
	G2	PFOS+PFHxS	MW066
Northern monitoring wells	G3	PFOA	MW034
	G4	PFOS+PFHxS	MW032 and MW034

Area of interest	Graph ID	Analyte	Groundwater monitoring well ID
Source Area 2 and 3	G5	PFOS+PFHxS	MW004[1],MW031 and MW080
Southern monitoring wells	G6	PFOS+PFHxS	MW001 and MW030

[1] Alternative location sample results used where indicated in lieu of primary location being unable to sample.

The MK statistical analysis (using the historical and ongoing monitoring data) was used to assess whether concentrations in groundwater have a monotonic upward or downward trend. The significance of any identified trends is determined by the confidence factor, or p value, of the analysis, as follows:

- A confidence factor over 95% indicates that there is an increasing or decreasing trend.
- A confidence factor over 90% indicates the there is a 'probably increasing' or 'probably decreasing' trend.
- A confidence factor less than 90% indicates 'Stable' or 'No trend'.

Limitations of the MK statistical analysis is included in **Section 8.3.1.1**, which addresses data selection requirements and the impacts of seasonality on the statistical trends analysis.

8.3.1.1 Limitations of Mann-Kendall analysis

Statistical trend analysis was undertaken for the groundwater dataset where the historic monitoring dataset was sufficient to allow for insights to be made to an acceptable confidence level.

The MK statistical analysis has limited ability to accurately identify temporal changes when concentrations are close to the LOR. Hence, statistical trend analysis was only undertaken for select monitoring locations (presented in **Table 13**) where the historic monitoring dataset was sufficient to allow for insights to be made to an acceptable confidence level and which consistently reported greater than LOR for respective analytes.

MK statistical analysis has limited ability to detect temporal trends when seasonality is expected to be present in a dataset. Due to the seasonal variation of precipitation, corresponding fluctuations in groundwater levels, and seasonally influenced PFAS concentration variance, particularly noticeable at certain locations when examining temporal graphs (**Appendix E**), the results for each monitoring well for both late wet and late dry season conditions were evaluated separately where seasonal variation was observed.

8.3.2 Source Area 1

There are five monitoring wells screened in the upper and lower Bathurst units located up-gradient, within and down-gradient of Source Area 1. The five monitoring wells are summarised as:

- MW012 and MW012D: located up the inferred groundwater hydraulic gradient from Source Area 1, screened in the upper and lower aquifer respectively.
- MW066: located at Source Area 1 and screened in the upper aquifer unit.
- MW021 and MW021D: located down the inferred groundwater hydraulic gradient from Source Area 1, screened in the upper and lower aquifer respectively.

Historical concentrations of PFOS+PFHxS and PFOA in groundwater from the above listed locations are summarised in **Table 14** below, and presented in full as **Table T2** (**Appendix B)**. Temporal graphs (**Graph G1** and **G2, Appendix D**) present reported concentrations of PFOS+PFHxS and PFOA overtime within monitoring well MW066. As presented in **Table 14** below, wells MW012, MW012D and MW021 have consistently reported PFAS concentrations below the LOR and hence are not presented in the temporal graphs.

Table 14 Source Area 1: PFAS summary results (µg/L)

Well ID	Analyte	Historical range*		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (November 2021 – March 2023)			
		Min	Max	Min	Max	Nov-21	Apr-22	Sep-22	Mar-23
MW066	PFOS+ PFHxS	0.40	1.71	0.33	0.55	0.54	0.42	0.53	0.65
	PFOA	<LOR	0.09	0.01	0.02	0.02	0.02	0.02	0.03
MW012	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW012D	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW021	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW021D	PFOS+ PFHxS	<LOR	0.02	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

<LOR = below the laboratory limit of reporting
* Historical data range since monitoring commenced in 2014 prior to OMP monitoring commencing.

Consistent with the historical results, monitoring well MW066 reported concentrations of PFHxS+PFOS above the NEMP (HEPA, 2020) Human Health Drinking Water guideline value (0.07 µg/L) and concentrations of PFOS above the 99% Freshwater Ecological criteria (0.00023 µg/L) in all groundwater monitoring events during the monitoring period.

The temporal graphs (**Graph G1** and **G2, Appendix D**) show that PFAS concentrations within MW066 have remained relatively stable since November 2018 with some minor seasonal fluctuations, however, this seasonal trend was not observed consistently on an annual basis with the change of each season.

A non-parametric MK statistical trend analysis was performed for MW066 and is presented in **Appendix E** and summarised in **Table 15** below. Monitoring wells MW012, MW012D and MW021 did not have sufficient data above the LOR to enable statistical analysis to be completed.

Table 15 Source Area 1: Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
MW066	PFOA	0.01–0.09	0.02-0.03	Stable	54.8%
	PFOS+PFHxS	0.33-1.71	0.42-0.65	Stable	82.1%

* Historical data range includes data since monitoring commenced in 2017 at MW066 and includes interim/OMP monitoring data.

Monitoring location MW066 presented a *stable trend* for PFOA and PFHxS+PFOS (with a relatively low confidence factor for PFOA).

As seasonal variability was not consistently observed with each change of season at MW066, no additional seasonally filtered MK statistical assessment was completed for this monitoring well.

8.3.3 Northern monitoring wells

Three monitoring wells are located to the north of the Base and north of Source Area 1. The wells are located on the Base and the CTA and screened in the upper aquifer. The three monitoring wells are summarised as:

- MW034: located cross gradient from Source Area 1 (located to the north).
- MW032: located east of MW034 on the north-west boundary of the CTA.
- MW023: located down the inferred hydraulic gradient from Source Area 1, within the CTA.

Historical concentrations of PFOS+PFHxS and PFOA in groundwater from the above listed locations are summarised in **Table 16** below, and presented in full as **Table T2** (**Appendix B)**. Temporal graphs (**Graph G3** and **G4, Appendix D**) present reported concentrations of PFOS+PFHxS and PFOA overtime within monitoring wells MW032 and MW034. As presented in **Table 14** below, MW023 (and contingency/alternative well MW024) has consistently reported PFAS concentrations below the LOR and hence is not presented in the temporal graphs.

Table 16 Northern monitoring wells: PFAS summary results (µg/L)

Well ID	Analyte	Historical range		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP Monitoring period (November 2021 – March 2023)			
		Min	Max	Min	Max	Nov-21	Apr/ May-22	Sep-22	Mar-23
MW032	PFOS+ PFHxS	<LOR	<LOR	0.01	0.09	0.08	0.09	0.08	0.09
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW034	PFOS+ PFHxS	0.04	0.10	0.02	0.21	0.12	0.09	0.11	0.10
	PFOA	<LOR	<LOR	<LOR	0.03	0.01	<LOR	<LOR	<LOR
MW023	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR[1]	<LOR[1]	<LOR[1]	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR[1]	<LOR[1]	<LOR[1]	<LOR

<LOR = below the laboratory limit of reporting
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.
[1] Results taken from MW024 as an alternate well to MW023

Monitoring wells MW032 and MW034 reported concentrations of PFHxS+PFOS above the NEMP (HEPA, 2020) Human Health Drinking Water guideline value (0.07 µg/L) and concentrations of PFOS above the 99% Freshwater Ecological criteria (0.00023 µg/L) in all groundwater monitoring events during the monitoring period.

Reported concentrations of PFOS+PFHxS and PFOS within MW034 have consistently been at or above the Human Health Drinking Water guideline value (0.07 µg/L) since May 2019. A spike in PFOS+PFHxS and PFOS concentrations were reported above historical range in November 2020 at this location, however returned and remained within historical range following on from this monitoring event (April 2021 onwards).

The temporal graphs (**Graphs G3** and **G4** (**Appendix D**) show that PFAS concentrations at both MW032 and MW034 experience seasonal fluctuations, notably an increase in PFAS concentrations during the dry season at MW034 and an increase following the wet season at MW032.

A non-parametric MK statistical analysis was performed for MW032 and MW034 and is presented in **Appendix E** and summarised in **Table 17**. Monitoring well MW023 did not have sufficient data above the LOR to enable statistical analysis to be completed. Further, MW032 PFOA results were excluded

from the statistical assessment as it did not have sufficient data above the LOR to enable statistical analysis.

Table 17 Northern monitoring wells: Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
All applicable data					
MW032	PFOA	<LOR	<LOR	NA	
	PFOS+PFHxS	<LOR-0.09	0.80-0.90	Increasing	96.4%
MW034	PFOA	<LOR-0.03	<LOR-0.01	No Trend	70.4%
	PFOS+PFHxS	0.02-0.21	0.09-0.12	Increasing	98.7%

Table 18 Northern monitoring wells: seasonal Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
Seasonally filtered data					
MW032 wet season	PFOA	<LOR	<LOR	NA	
	PFOS+PFHxS	<LOR-0.08	0.90	Increasing	99.2%
MW032 dry season	PFOA	<LOR	<LOR	NA	
	PFOS+PFHxS	0.01-0.09	0.80	No Trend	50.0%
MW034 wet season	PFOA	<LOR	<LOR-0.03	Stable	37.9%
	PFOS+PFHxS	0.07-0.10	0.09-0.10	No Trend	64.0%
MW034 dry season	PFOA	<LOR-0.03	<LOR-0.01	No Trend	64.0%
	PFOS+PFHxS	0.02-0.21	0.11-0.12	No Trend	86.4%

<LOR = below the laboratory limit of reporting
NA = Not analysed, insufficient data above the LOR to enable statistical analysis to be completed
* Historical data range includes data since monitoring commenced in 2017 and includes OMP monitoring data.

The MK statistical analysis trend for PFOS+PFHxS concentrations for both MW032 and MW034 were reported to be *increasing* (with a confidence factor of 96.4% and 98.7%, respectively). Given that the concentrations being assessed are near the LOR, the trends obtained are considered to be of limited consequence.

Given that there may be seasonal influence at both monitoring locations, additional MK analysis was completed by separating the data for dry and wet seasons (**Table 17**). It is noted that this seasonal assessment (**Table 18**) only considered data which conformed to the accepted end of wet and end of dry monitoring periods. With the identified dataset limitations, between five and six sampling points were considered by each of the seasonal MK assessments.

From the seasonally filtered dataset, the MK statistical analysis for MW032 held an *increasing* trend for PFOS+PFHxS in the wet season (with a confidence factor of 99.2%), with *no trend* observed in the dry season. Whereas the seasonally filtered analysis for PFOS+PFHxS concentrations at MW034 reported that both dry and wet seasons were holding *no trend*.

The seasonal filtered MK statistical analysis for MW032 further supports the seasonal trend observed in the temporal graphs (**Graph G4** in **Appendix D**) of increasing PFOS+PFHxS concentrations at MW032

following the wet season, indicating that there might be some vertical migration of contamination within the vicinity of this location driven by increased rainfall.

It is noted, due to the limitations of the dataset, the results obtained from seasonally filtered testing should be considered to be of low reliability until additional sampling data from future sampling events is collected.

8.3.4 Source Areas 2 and 3

There are five monitoring wells screened in the upper- and lower-Bathurst Island Formation units located up-gradient, within and down-gradient of Source Area 2 and 3. The five monitoring wells are summarised as:

- MW080: located up the inferred groundwater hydraulic gradient from Source Area 2 and 3, screened in the upper aquifer.
- MW004 and MW004D: located at Source Area 2 and screened in the upper and lower-aquifer unit, respectively.
- MW031 and MW018: located down the inferred groundwater hydraulic gradient from Source Area 2, screened in the upper aquifer.

Historical concentrations of PFOS+PFHxS and PFOA in groundwater from the above listed locations are summarised in **Table 19** below, and presented in full as **Table T2** (**Appendix B)**. A temporal graph (**Graph G5** in **Appendix D**) presents reported concentrations of PFOS+PFHxS overtime within monitoring wells MW031, MW080 and MW004. As presented in **Table 19** below, wells MW004D and MW018 have consistently reported PFOS+PFHxS concentrations below the LOR and hence are not presented in the temporal graph. Further, a temporal graph is not presented for PFOA as all wells in the vicinity of Source Area 2 and 3 have consistently reported concentrations below the LOR.

Table 19 Source Area 2 and 3: PFAS summary results (µg/L)

Well ID	Analyte	Historical range*		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Min	Max	Nov-21	Apr-22	Sep-22	Mar-23
MW004	PFOS+ PFHxS	<LOR[1]	0.19	0.07	0.28	0.44	0.05	NA	0.15
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	NA	<LOR
MW004D	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW080	PFOS+ PFHxS	<LOR	0.02	0.01	0.12	0.03	<LOR	0.07	0.02
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW018	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW031	PFOS+ PFHxS	<LOR	<LOR	<LOR	0.02	<LOR	<LOR	<LOR	0.03
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

NA = Not analysed,
<LOR = below the laboratory limit of reporting
Orange shading indicates results above the historical range.
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

[1] Historical result taken from MW005 as an alternate well to MW004

Monitoring well MW004 reported concentrations of PFOS+PFHxS above the PFAS NEMP (HEPA, 2020) Human Health Drinking Water guideline value (0.07 µg/L) in November 2021 and March 2023.

Monitoring wells MW004 and MW080 reported concentrations of PFOS above the 99% Freshwater ecological criteria (0.00023 µg/L) in all groundwater monitoring events during the monitoring period, with the exception of MW080 in April 2022.

The new maximum concentrations of PFOS and PFOS+PFHxS reported at MW004 in November 2021 (**Table 19)** were of the same order of magnitude as historical maximum results, and concentrations were reported lower and within historical ranges in the subsequent monitoring events (April 2022 onwards). It is also noted that the water level at MW004 during the November 2021 event was the lowest recorded historically at the location and may have contributed to the high concentration of PFAS.

Similarly, the new maximum concentrations of PFOS and PFOS+PFHxS reported at MW031 in March 2023 (**Table 19)** are within same order of magnitude as historical maximum results. It should also be noted that all concentrations reported at MW031 have been close to the LOR and therefore the new maximum is considered to be insignificant.

Monitoring well MW004D, screened within the lower aquifer unit within Source Area 2 reported concentrations of PFAS below the LOR, consistent with historical ranges, suggesting limited connectivity between aquifer units and that PFAS may be present primarily in the upper aquifer unit.

In general, the temporal trend analysis graphs (**Graph G5** in **Appendix D**) show that PFOS+PFHxS concentrations in MW004, MW031 and MW080 fluctuate with no clear observable trends. Notable spikes in concentrations have been observed at each location at various times, although no obvious trend is evident with the change of each season.

A non-parametric MK statistical analysis was performed for reported PFOS+PFHxS concentrations for MW004, MW031 and MW080 and is presented in **Appendix E** and summarised in **Table 20** below. Other locations in Source Area 2 (MW004D and MW018) did not have sufficient data above the LOR to enable statistical analysis to be completed.

Table 20 Source Area 2 and 3: Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
MW004	PFOS+PFHxS	<LOR[1]-0.28	0.05-0.44	No Trend	53.0%
MW031	PFOS+PFHxS	<LOR-0.02	<LOR-0.03	No Trend	50.0%
MW080	PFOS+PFHxS	<LOR-0.12	<LOR-0.07	No Trend	88.9%

<LOR = below the laboratory limit of reporting
* Historical data range includes data since monitoring commenced in 2017 and includes OMP monitoring data.
[1] Historical result taken from MW005 as an alternate well to MW004.

Monitoring locations MW004, MW031 and MW080 presented no statistical trend for PFOS+PFHxS. As variability was not observed with each season at MW004, MW031 and MW080, no additional seasonally filtered MK statistical assessments were completed for these datasets.

8.3.5 Southern monitoring wells

The Southern Drainage Channel is located in the southern-most extent of the Monitoring Area and comprises of two monitoring locations accessible from public land:

- MW001: located down the inferred groundwater hydraulic gradient of Source Area 2 and 3.
- MW029: located south of Milners Creek and up the inferred groundwater hydraulic gradient of Source Area 2 and 3.

- MW030: located north of Milners Creek approximately 2 metres from the southern boundary fence and down/ cross the inferred groundwater hydraulic gradient of Source Area 2 and 3.

Historical concentrations of PFOS+PFHxS and PFOA in groundwater from the above listed locations are summarised in **Table 21**, and presented in full as **Table T2** (**Appendix B)**.

A temporal graph (**Graph G6** in **Appendix D**) presents reported concentrations of PFOS+PFHxS overtime within monitoring well MW001 and MW030.

As presented in **Table 21** below, monitoring well MW029 has consistently reported PFOS+PFHxS concentrations below the LOR and hence not presented in the temporal graph. Further, a temporal graph is not presented for PFOA as all southern monitoring wells have in general consistently reported concentrations below or equal to the LOR.

Table 21 Southern monitoring wells: PFAS summary results (µg/L)

Well ID	Analyte	Historical range		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Min	Max	Nov-21	Apr-22	Sep-22	Mar-23
MW001	PFOS+ PFHxS	0.15	0.20	0.12	0.35	0.19	0.12	0.17	0.15
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW029	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW030	PFOS+ PFHxS	0.14	0.14	0.12	0.23	0.40	0.14	0.16	0.11
	PFOA	<LOR	<LOR	0.01	0.01	0.01	<LOR	<LOR	<LOR

<LOR = below the laboratory limit of reporting
Orange shading indicates results above the historical range.
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

Consistent with historical results, MW001 and MW030 reported concentrations of PFOS+PFHxS above the PFAS NEMP (HEPA, 2020) Human Health Drinking Water guideline value (0.07 µg/L) and PFOS above the 99% Freshwater ecological criteria (0.00023 µg/L) in all groundwater monitoring events during the monitoring period.

Monitoring well MW030 is located hydraulically down-gradient of Source Area 3 with comparable concentrations noted in adjacent/up-gradient location MW001, suggesting the concentrations at this location are due to up-gradient impacts. The new maximum concentrations of PFOS and PFOS+PFHxS reported at MW030 in November 2021 (**Table 21**) were of the same order of magnitude as historical results, and concentrations were reported lower and within historical range in the subsequent monitoring events (April 2022 onwards). The historically high PFOS+PFHxS concentration recorded in November 2021 may be the result of low groundwater elevations recorded during the sampling event where reduced water volumes in the aquifer may have a concentrating effect on some contaminants such as PFAS compounds in locations downgradient of source areas.

Variability in PFOS+PFHxS data since monitoring commenced in 2017 is evident in the temporal graph at MW001 and MW030 (**Graph G6** in **Appendix D**). A spike in PFOS+PFHxS concentrations were observed at MW001 in April 2020, and MW030 in late November 2021, however less variability has been observed at these locations since this time. In general, seasonal variation is evident at both locations, notably an increase in PFAS concentrations during the dry season possibly correlating with low groundwater levels.

A non-parametric MK statistical analysis was performed for reported PFOS+PFHxS concentration for monitoring locations MW001 and MW030 and is presented in **Appendix** E and summarised in **Table 22**

below. Monitoring well MW029 did not have sufficient data above the LOR to enable statistical analysis to be completed.

Table 22 Southern monitoring wells: Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
All applicable data					
MW001	PFOS+PFHxS	0.12-0.35	0.12-0.19	Stable	82.1%
MW030	PFOS+PFHxS	0.12-0.23	0.11-0.40	Stable	75.3%

Table 23 Southern monitoring wells: seasonal Mann-Kendall summary

Location ID	Analyte	Historical range*	Current monitoring period	Mann-Kendall trend	
		Min – Max (µg/L)	Min – Max (µg/L)	Trend	Confidence factor
Seasonally filtered data					
MW001 Wet season	PFOS+PFHxS	0.12-0.35	0.12-0.15	Stable	64.0%
MW001 Dry season	PFOS+PFHxS	0.20-0.23	0.17-0.19	Stable	75.8%
MW030 Wet season	PFOS+PFHxS	0.12-0.18	0.11-0.14	Stable	81.5%
MW030 Dry season	PFOS+PFHxS	0.15-0.23	0.16-0.40	Stable	40.8%

* Historical data range includes data since monitoring commenced in 2017 and includes OMP monitoring data.

Given that there may be seasonal influence at both monitoring locations MW001 and MW030, additional MK analysis was completed by separating the data for dry and wet seasons (as presented in **Table 22**). It is noted that this assessment only considered data which conformed to the accepted end of wet and end of dry monitoring periods. Within the dataset limitations, between five and six sampling points were considered by each of the seasonal MK assessments.

The MK statistical analysis trend of PFOS+PFHxS concentrations in MW001 and MW030 was reported to be *stable* (with a confidence factor of 82.1% and 75.4% respectively). Seasonal analysis (**Table 23**)

of PFOS+PFHxS concentrations reported that both dry and wet seasons were holding *stable* trends. Due to the limitations of the dataset, the results obtained from seasonally filtered testing should be considered to be of low reliability until additional sampling data from future sampling events is collected.

8.3.6 Shoal Bay Receiving Station

Two abstraction bores located within the SBRS, approximately 5.75 kms north of the Base, utilised for potable water purposes, are monitored as part of the OMP, MW112 and MW113.

The SBRS abstraction bores, MW112 and MW113, have not reported PFAS concentrations above LOR for any historical, interim, or OMP monitoring events as shown in **Table 24** below and presented on **Table T2** in **Appendix B**. No graphical representation or statistical analysis have been performed for these locations due to PFAS concentrations reporting below the LOR.

Table 24 On-Base Shoal Bay Receiving Station PFAS summary results (µg/L)

Well ID	Analyte	Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Nov-21	Apr-22	Sep-22	Mar-23
MW112	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
MW113	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

<LOR = below the laboratory limit of reporting

8.4 Surface water results overview

Surface water results for PFOS+PFHxS compared to assessment criteria are provided in figure series **Figure F5** (**Appendix A**), with PFAS concentrations presented in **Table T4** (**Appendix B**).

The highest concentrations of PFAS reported for the monitoring period were in SW059, located on-Base on the eastern boundary drainage line, and SW123, located off-Base (downstream of SW059) above the confluence of the northern drainage line with Milners Creek. The maximum concentrations of PFOS+PFHxS reported at these two locations during the monitoring period are listed below:

- **On-Base**: SW059, 0.22 µg/L (April 2022) and 0.25 µg/L (March 2023).
- **Off-Base**: SW123, 0.25 µg/L (November 2022) and 0.35 µg/L (March 2023).

New detections above LOR and/or maximum concentrations of PFOS+PFHxS and/or PFOA were reported at two locations during the monitoring period:

- **On-Base**: SW007 (located up-stream of the southern arm of the southern drainage channel), new maximum PFOS+PFHxS concentration reported in March 2023
- **Off-Base**: SW123 (located above the confluence of the northern drainage line with Milners Creek), new maximum PFOS+PFHxS concentration reported in March 2023
- **Off-Base**: SW123, new detection of PFOA concentration above LOR in November 2022 and new maximum PFOA concentration reported in March 2023.

The new maximum concentrations of PFOS+PFHxS reported at SW007 and SW123 in March 2023 were of the same order of magnitude as historical range. However, as no further monitoring has been conducted at these two locations within the monitoring period the significance (if any) of the new maximum concentrations observed cannot be assessed. Additionally, further monitoring is required to assess the significance (if any) of the new detection and maximum PFOA concentrations observed at SW123 in November 2022 and March 2023.

In general, the results indicate that there is variability in concentrations of PFAS in surface water; however, overall PFAS concentrations on-Base and off-Base have remained relatively stable. The overall nature and extent of PFAS in surface water within the Monitoring Area is generally consistent with the understanding presented in the 2021 AIR (AECOM, 2022c). The reported surface water concentrations from the monitoring period and significance of any variation are discussed based on areas of interest in **Section 8.5** below.

8.5 Surface water PFAS temporal trend

8.5.1 Approach to surface water temporal trend analysis

A summary of PFOS+PFHxS and PFOA concentrations (including historical data) and trend analysis results in surface water for the areas of interest specified in **Table 25** below are presented in tabular form and discussed in the following sub-sections (**Section 8.5.2** and **8.5.3**).

Table 25 Summary of surface water monitoring areas

Area of interest	Surface water sampling location ID
Base Drainage Lines	SW001, SW007, SW023, SW028, SW059 and SW075 (located off-Base)
Closed Training Area	SW086, SW091 and SW123

The temporal graphs only include locations which consistently report concentrations of PFOS+PFHxS greater than LOR. Based on this criterion, **Table 26** below summarises the monitoring locations and analytes selected for the temporal graphs for both monitoring areas. Where sample results were less than the LOR, half the LOR was adopted for the graph. Temporal graphs are not presented for PFOA as all location have in general consistently reported concentrations below the LOR.

Table 26 Summary of locations selected for surface water temporal graphs

Area of interest	Graph ID	Analyte	Surface water sampling location ID
Base Drainage Lines	G7	PFOS+PFHxS	SW001, SW007, SW028, SW059 and SW075
Closed Training Area	G8	PFOS+PFHxS	SW086, SW091 and SW123

Surface water temporal graphs are presented in **Appendix D**.

8.5.2 On-Base drainage lines; central, south-east, south-west and eastern boundaries

Five surface water monitoring locations are positioned throughout the Base in drainage lines, and one surface water monitoring location south of the Base boundary and west of Thorngate Road:

- SW001: located up-stream of the confluence with southern drainage channel and down-gradient of Source Area 2 and 3.
- SW007: located up-stream of the southern arm of the southern drainage channel.
- SW023: located at the central drainage line on the Base.
- SW028: located centrally up-stream of the southern drainage channel.
- SW059: located at the eastern boundary drainage line.
- SW075: located in the southern drainage channel and upstream of Milners Creek.

Historical concentrations of PFOS+PFHxS and PFOA in surface water from the above listed locations are summarised in **Table 27** below, and presented in full as **Table T2** (**Appendix B)**. A temporal graph (**Graph G7** in **Appendix D**) presents reported concentrations of PFOS+PFHxS overtime within the surface water monitoring locations, with the exception of SW023 which has consistently reported PFOS+PFHxS concentrations below the LOR. A temporal graph is not presented for PFOA as all location have consistently reported concentrations below the LOR.

Table 27 Base Drainage Lines: PFAS summary results (µg/L)

Location ID	Analyte	Historical range		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Min	Max	Jan-22	Apr-22	Nov-22	Mar-23
SW001	PFOS+PFHxS	0.05	0.09	<LOR	0.04	0.03	0.02	0.01	0.05
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
SW007	PFOS+PFHxS	<LOR	0.04	<LOR	<LOR	<LOR	<LOR	<LOR	0.06

Location ID	Analyte	Historical range		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Min	Max	Jan-22	Apr-22	Nov-22	Mar-23
	PFOA	<LOR	<LOR	<LOR	0.01	<LOR	<LOR	<LOR	<LOR
SW023	PFOS+ PFHxS	0.01	0.01	<LOR	<LOR	<LOR	NA[1]	<LOR	NA[1]
	PFOA	0.03	0.03	<LOR	<LOR	<LOR	NA[1]	<LOR	NA[1]
SW028	PFOS+ PFHxS	0.18	0.18	<LOR	<LOR	<LOR	NA[1]	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	NA[1]	<LOR	<LOR
SW059	PFOS+ PFHxS	0.67	0.67	0.01	0.12	<LOR	0.25	0.03	0.22
	PFOA	0.03	0.03	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
SW075	PFOS+ PFHxS	<LOR	0.13	<LOR	0.11	0.03	<LOR	0.01	0.01
	PFOA	<LOR	0.01	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR

NA = Not analysed,
<LOR = below the laboratory limit of reporting,
Orange shading indicates results above the historical range,
[1] Location dry
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

With the exception of SW023, all surface water monitoring locations within on-Base drainage lines and the southern drainage line reported concentrations of PFOS+PFHxS above laboratory LORs at least once during the monitoring period. Of note, SW023 and SW028 were reported as dry at least once during the monitoring period (SW023 in April 2022 and March 2023, and SW028 in April 2023).

The following locations reported concentrations of PFOS above the PFAS NEMP (HEPA, 2020) 99% Freshwater ecological criteria (0.00023 µg/L) during the monitoring period:

- SW001 in all monitoring events during the monitoring period
- SW059 in April2022, November 2022 and March 2023
- SW075 in January 2022, November 2022 and March 2023

All three of the above listed locations reported concentrations of PFOS+PFHxS above the LOR but below the adopted PFAS NEMP (HEPA, 2020) recreational criteria.

Surface water sample location SW007 reported a new maximum concentration of PFOS+PFHxS in March 2023 (0.06 µg/L). However, the concentration reported was of the same order of magnitude as historical results (previous maximum of 0.04 µg/L in July 2017). However, as no further monitoring has been conducted at this location within the monitoring period the significance (if any) of the new maximum concentration observed cannot be assessed.

In general, PFAS concentrations obtained during the monitoring period within on-Base drainage lines and the southern drainage channel remained within an order of magnitude of historical results. From review of the temporal trend graphs (**Graph G7** in **Appendix D**), concentrations generally fluctuated with no consistent pattern related to seasonal change, with the exception of SW059 (discussed further below). Overall, this indicates that the PFAS concentrations in surface water adjacent to on-Base source areas is variable.

Sample location SW059, located at the eastern boundary drainage line, has exhibited a slight seasonal variation evident over time, with the reported PFAS concentrations generally higher during end of wet season sampling (refer to **Graph G7** in **Appendix D**). Further, an increase in PFOS+PFHxS concentrations during the end of wet season sampling at this location has been observed since April 2022. While this change is noted, it is not considered significant as concentrations have remained below the historical maximum of 0.67 µg/L reported in February 2018.

Based on the monitoring data, the PFAS concentrations in these areas are variable, with no observable trend.

8.5.3 Closed Training Area

Three surface water monitoring locations are located in the CTA, down-gradient of the Base surface water catchment. The following summarises the locations:

- SW086: located in Milners Creek, downstream of the southern Base catchment.
- SW091: located down stream of SW123 and SW086 and is the most downstream location.
- SW123: located above the confluence of the northern drainage line with Milners Creek.

Historical concentrations of PFOS+PFHxS and PFOA in surface water from the above listed locations are summarised in **Table 28** below, and presented in full as **Table T2** (**Appendix B**). A temporal graph (**Graph G8** in **Appendix D**) presents reported concentrations of PFOS+PFHxS overtime within the surface water monitoring locations. A temporal graph is not presented for PFOA as all location have generally consistently reported concentrations below the LOR.

Table 28 Closed Training Area: PFAS Summary Results (µg/L)

Location ID	Analyte	Historical range		Interim/OMP monitoring (Nov 2018-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)			
		Min	Max	Min	Max	Jan-22	Apr-22	Nov-22	Mar-23
SW086	PFOS+ PFHxS	<LOR	<LOR	<LOR	0.01	<LOR	<LOR	<LOR	0.01
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
SW091	PFOS+ PFHxS	ND	0.08	0.01	0.08	0.02	0.03	0.06	0.01
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR
SW123	PFOS+ PFHxS	<LOR	0.21	0.01	0.34	0.03	0.04	0.25	0.35
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR	<LOR	0.01	0.15

<LOR = below the laboratory limit of reporting
Orange shading indicates results above the historical range.
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

Consistent with historical results, both SW091 and SW123, located within the northern portion of the CTA, reported concentrations of PFOS above the PFAS NEMP (HEPA, 2020) 99% Freshwater ecological criteria (0.00023 µg/L) during the monitoring period. Both locations reported concentrations of PFOS+PFHxS above the LOR but below the adopted PFAS NEMP (HEPA, 2020) recreational criteria.

Sample location SW086 reported concentrations of PFOS above the PFAS NEMP (HEPA, 2020) 99% Freshwater ecological criteria (0.00023 µg/L) in March 2023.

Sample location SW123, located above the confluence of the northern drainage line with Milners Creek, has reported a general increase in PFOS+PFHxS concentrations since January 2022, in comparison to

previous OMP monitoring events (since January 2020). The reported concentration of PFOS+PFHxS at SW123 reached a historical maximum of 0.35 ug/L in March 2023. Further, PFOA (0.01 ug/L) was detected for the first time at this location in November 2022 increasing to 0.15 ug/L in March 2023. Further monitoring is required to assess the significance (if any) of the new detection and/or maximums of PFOS+PFHxS and PFOA concentrations observed at this location.

Of note, in general the concentrations of PFOS+PFHxS at SW123 is in the same order of magnitude as PFOS+PFHxS concentrations reported at SW059 in recent monitoring events (**Graph G7** in **Appendix D**, and discussed in **Section 8.5.2** above), which is located upstream of SW123 within an on-Base eastern drainage line.

In general, the temporal data shows that the PFAS concentrations in surface water at CTA fluctuate with no consistent trend related to start of wet season “first flush” and end of wet seasons events. This is with the exception of SW123, which has historically reported occasional spikes in PFOS+PFHxS concentrations, notably during monitoring events in 2020, 2022, and 2023 (**Graph G8** in **Appendix D**). Further monitoring will provide greater understanding in the PFAS variability in surface water at these locations over time.

8.6 Sediment PFAS temporal trend

8.6.1 Approach to surface water temporal trend analysis

A summary of sediment PFOS+PFHxS and PFOA concentrations (including historical data collected) and trend analysis results for the two areas of interest specified in **Table 29** below are presented in tabular form and discussed in the following sub-sections (**Section 8.6.2** and **8.6.3**).

Table 29 Summary of sediment monitoring areas

Monitoring area	Groundwater monitoring well ID
On-Base and Southern Drainage Channel	SD001, SD007, SD023, SD028, SD059 and SD075 (located off-Base)
Closed Training Area	SD086, SD091 and SD123

Temporal graphs for the monitoring areas outlined in **Table 29** are presented in **Appendix D**.

The temporal graphs only include locations which consistently report concentrations of PFOS+PFHxS greater than LOR. Based on this criterion, **Table 30** summarises the monitoring locations and analytes selected for the temporal graphs for both monitoring areas. Where sample results were less than the LOR, half the LOR was adopted for the graph. Temporal graphs are not presented for PFOA as all location have in general consistently reported concentrations below the LOR.

Table 30 Summary of locations selected for sediment temporal graphs

Monitoring area	Graph ID	Analyte	Groundwater monitoring well ID
Base Drainage Lines	G9	PFOS+PFHxS	SD001, SD028, SD059 and SD075
Closed Training Area	G10	PFOS+PFHxS	SD086, SD091 and SD123

8.6.2 Base drainage lines; central, south-east, south-west and eastern boundaries

Sediment samples have been collected within the on-Base surface water drainage network at 5 key drainage locations where corresponding surface water locations have also been monitored, summarised as:

- SD001: located up-stream of the confluence with the southern drainage channel and down-gradient of Source Area 2 and 3
- SD007: located up-stream of the southern drainage channel.
- SD023: located at the central drainage line on the Base.
- SD028: located centrally up-stream of the southern drainage channel.

- SD059: located at the eastern boundary drainage line.
- SD075: located in the southern drainage channel and upstream of Milners Creek.

Historical concentrations of PFOS+PFHxS and PFOA in sediment from the above listed locations are summarised in **Table 31** below, and presented in full as **Table T2** (**Appendix B)**. A temporal graph for concentrations of PFOS+PFHxS within the sediment monitoring locations is presented in **Graph G7** (**Appendix D**). The temporal graphs do not present results for well SD007 and SD023 as these locations has consistently reported PFOS+PFHxS concentrations below the LOR. A temporal graph is not presented for PFOA as all location have consistently reported concentrations below the LOR.

Table 31 Base drainage lines: PFAS summary results (mg/kg)

Location ID	Analyte	Historical range*		Interim/OMP monitoring (Apr 2019-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)
		Min	Max	Min	Max	Apr 2022
SD001	PFOS+ PFHxS	0.0032	0.0072	<LOR	0.0015	0.0003
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD007	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD023	PFOS+ PFHxS	<LOR	<LOR	<LOR	<LOR	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD028	PFOS+ PFHxS	0.0003	0.0015	0.0004	0.0009	<LOR
	PFOA	<LOR	0.0002	<LOR	<LOR	<LOR
SD059	PFOS+ PFHxS	<LOR	0.0002	<LOR	0.0002	0.0004
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD075	PFOS+ PFHxS	0.0003	0.0014	<LOR	0.0007	0.0013
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR

<LOR = below the laboratory limit of reporting
Orange shading indicates results above the historical range.
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

Sample locations SD007, SD023 and SD028 reported concentrations of PFOS+PFHxS below the LOR during the monitoring period, consistent with historical results (with the exception of SD028). Sample location SD028 reported concentrations of PFOS+PFHxS below the LOR for the first time since sediment monitoring commenced in 2018.

Sample locations SD001, SD059 and SD075 reported concentrations of PFOS+PFHxS above the LOR during the monitoring period. Concentrations at these locations were within historical range with the exception of SD059 which reported a new maximum concentration of PFOS+PFHxS in April 2022, however the result is marginally higher than the historic maximum, within the same order of magnitude as historical results.

Temporal graphs indicate limited variability in PFOS+PFHxS concentrations in sediment since the commencement of monitoring.

8.6.3 Close Training Area

Three sediment sample locations are located in the CTA, down-gradient of the Base surface water catchment, where corresponding surface water locations have also been monitored, summarised as:

- SD086: located in Milners Creek, downstream of the southern Base catchment.
- SD091: located down stream of SW123 and SW086 and is the most downstream location.
- SD123: located above the confluence of the northern drainage line with Milners Creek.

Historical concentrations of PFOS+PFHxS and PFOA in sediment from the above listed locations are summarised in **Table 32** below, and presented in full as **Table T2** (**Appendix B)**. A temporal graph for concentrations of PFOS+PFHxS within the sediment monitoring locations is presented in **Graph G8** (**Appendix D**). A temporal graph is not presented for PFOA as all location have consistently reported concentrations below the LOR.

Table 32 Close Training Area: PFAS summary results (mg/kg)

Location ID	Analyte	Historical range		Interim/OMP monitoring (Apr 2019-Apr 2021)		OMP monitoring period (Nov 2021 – Mar 2023)
		Min	Max	Min	Max	Apr 2022
SD086	PFOS+ PFHxS	0.0008	0.0008	<LOR	<LOR	0.005
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD091	PFOS+ PFHxS	0.0012	0.0017	<LOR	0.0002	<LOR
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR
SD123	PFOS+ PFHxS	0.0022	0.0072	ND	0.0004	0.0007
	PFOA	<LOR	<LOR	<LOR	<LOR	<LOR

<LOR = below the laboratory limit of reporting
Orange shading indicates results above the historical range.
* Historical data range since monitoring commenced in 2017 prior to OMP monitoring commencing.

Monitoring locations SD086 and SD123 reported concentrations of PFOS+PFHxS marginally above LORs, within historical range (with the exception of SD086). Sample location SD086 reported a new maximum concentration of PFOS+PFHxS in April 2023, however within the same order of magnitude as historical results.

9.0 Conceptual site model

The CSM was developed during the investigation stages (Senversa, 2018a) and summarised in the PMAP (Defence, 2018). The CSM summarises the linkages between sources, exposure pathways and receptors.

The OMP monitoring between November 2021 and March 2023 as discussed in this report has provided additional data to further understand the nature and magnitude of PFAS concentrations in groundwater, surface water and sediment. Key observations included:

- PFAS concentration in groundwater exceed the adopted human health criteria in on-Base wells MW066 (Source Area 1), MW004 (Source Area 2), MW034 (northern monitoring well) and MW001 (southern monitoring well).
- PFAS concentrations were generally within historical range within groundwater, surface water and sediment. It is noted, whilst PFAS concentrations were reported greater than historical maximums at MW004, MW030, MW031, SW007, SW123, SD059 and SD086 within the monitoring period, they were within the same order of magnitude as the historical dataset. Further, subsequent monitoring completed at MW004 and MW030 reported concentrations back within historical ranges. Overall, the new maximum PFAS concentrations reported at MW004, MW030, MW031, SW007, SW123, SD059 and SD086 do not currently change the understanding of the CSM as described in the DSI.
- MK trend analysis of groundwater monitoring data from different locations indicated generally stable or inconclusive trends. Increasing trends were limited to two locations, MW034 (located on-Base cross gradient from Source Area 1) and MW032 (located off-Base east of MW034 on the north-west boundary of the CTA). It is noted, PFAS concentrations at these two locations are close to the LOR and marginally above the adopted human health assessment criteria. Further data is required to understand temporal changes at these two locations.
- PFAS concentrations detected in groundwater in the vicinity of Source Areas 2 and 3 (in particular at MW030), remained relatively low and do not currently change the understanding of the CSM as described in the DSI.
- PFAS concentrations are present in groundwater in five of ten off-Base locations (MW024, MW029, MW030, MW031 and MW032). The concentrations reported are above the adopted human health drinking water criteria at two of the five locations (MW030 and MW032) however generally within historical range.
- PFAS concentrations in surface water both on- and off-Base in general have appeared to remained stable, below the adopted human health recreational criteria and generally close to the LOR.

The PFAS concentration ranges (presented for PFOS+PFHxS) for groundwater and surface water/sediment monitoring locations, reported during the OMP monitoring period are shown in Figure series **Figure F4** to **Figure F6** (**Appendix A**).

The pathways for PFAS exposure and risks to human health as presented in the HHRA (Senversa, 2018b) are considered to be remained relevant, and data presented in this report does not suggest any significant changes to the exposure pathways or risks.

When compared to the available historical dataset, data indicates that the magnitude of PFAS impacts in groundwater and surface water is relatively unchanged since the CSM was developed in the DSI (Senversa, 2018a).

The data presented in this report do not change the understanding of the CSM sources, pathways and/or receptors as described during the investigation stages (Senversa, 2018a; Senversa, 2018b) and summarised in the PMAP (Defence, 2018).

10.0 Discussion

10.1 Risk profile

10.1.1 Risk assessment summary

The DSI (Senversa, 2018a) and the HHERA (Senversa, 2018b) concluded that the risks associated with the majority of exposure pathways relating to PFAS originating from Robertson Barracks to human and ecological receptors was low and acceptable, with potentially elevated exposure scenarios identified for aquatic ecosystems from bioaccumulation and human consumption of recreationally caught fish and molluscs. Risk sources associated with the following pathways from the CSM that require monitoring or management as summarised in the PMAP (Defence, 2018) are as follows:

- Shallow groundwater (upper portion of Bathurst Island Formation) impacts within Robertson Barracks. Concentrations of PFAS in shallow groundwater were reported above the drinking water and recreational water human health guidelines at and around the identified Source Areas. The nature and extent of shallow groundwater impacts and whether impacted groundwater is migrating outside of Robertson Barracks is understood.
- Shallow groundwater (upper portion of Bathurst Island Formation) impacts migrating outside of Robertson Barracks. Concentrations of PFAS exceeding the screening values has been identified to the south of Robertson Barracks near to the southern drainage channel at MW030. Groundwater flow direction in this part of the Monitoring Area has been inferred to the south-southeast and no concentrations of PFAS have been detected at MW029 to the south, Should the nature or intensity of land use change and groundwater abstraction occur near to this area, there is the potential for a future risk to off-site users of shallow groundwater. There is also a potential that discharge of groundwater from the upper portion of Bathurst Island Formation could occur to Milners Creek and the southern drainage channel due to high groundwater levels in the Wet season at concentrations exceeding the adopted ecosystem screening values.
- Migration pathways from soil sources at Robertson Barracks. Legacy AFFF was only stored and used in limited areas of Robertson Barracks with higher concentrations generally recorded at and in proximity Source Areas 1 to 3. Given the reported PFAS concentrations in soil and the nature and behaviour of PFAS in the broader environment, soil impacts are likely to present an ongoing source of impacts to groundwater and surface water from infiltration and overland flow, respectively.

10.1.2 Risk profile evaluation

The data collected during OMP monitoring between November 2021 and March 2023 when combined with the 2014-2018 historic data, 2018 – 2019 interim monitoring and 2019-2021 OMP monitoring suggest that the risk profile to human health and ecological receptors within the Monitoring Area is overall unchanged since the publication of the HHERA (Senversa, 2018b). This is based on the following assessment of the OMP data:

Groundwater

- **Nature and extent of groundwater PFAS impacts:** The groundwater plume extents are generally similar to that which was presented in the DSI (Senversa, 2018a). PFAS concentrations are generally highest on-Base in wells in the vicinity of Source Area 1 and Source Areas 2 and 3. The observed increased PFAS concentrations from Source Areas 2 and 3 (MW004), is not considered to be significant and does not change the overall risk profile. Off-Base monitoring wells have PFAS concentrations below the PFAS NEMP (HEPA, 2020) Human Health Drinking Water guideline value of 0.07 µg/L for PFOS+PFHxS with the exception of MW030 and MW032 in the southern and northern boundary areas, respectively.
- **Areas of groundwater PFAS concentration change:** The changes in PFAS concentrations in groundwater for the monitoring period are limited and do not constitute a change in risk profile for the Base or the surrounding Monitoring Area. The fundamentals of the previously derived CSM (Senversa, 2018a) are generally supported by the data collected over the monitoring period, as discussed in **Section 9.0**. Where new maximums have been observed during the monitoring period, PFAS concentrations are noted to be in regions where concentrations of the same order of

magnitude are already present, as such the reported concentrations do not constitute a change in risk profile.

Surface water

- **Nature and extent of surface water PFAS impacts:** PFAS concentrations in surface water bodies were generally similar to previous (historical) results. Monitoring location SW123 reported a first-time detection of PFOA, however it is noted this location has reported PFOS+PFHxS previously. All surface water monitoring locations, with the exception of SW023, reported PFOS concentrations above the PFAS NEMP (HEPA, 2020) 99% species protection guideline value of 0.00023 µg/L. The 99% protection level is applied to account for bioaccumulative effects that may manifest over time within the localised food chain. Actual impacts on aquatic biota are not currently understood and utilisation of the 99% protection level functions as a conservative approach to measuring ecological risk. All surface water monitoring locations reported PFOS+PFHxS concentrations below the Recreational Water guideline (HEPA, 2020) value of 2.0 µg/L.
- **Areas of surface water PFAS concentration change:** In general, PFAS concentrations remained within and generally below historical PFAS concentrations for the monitoring period, suggesting no material change in the risk profile for surface water.

Sediment

- **Sediment PFAS impacts:** PFAS concentrations in sediment were generally similar or lower than previous (historical) results.

10.2 Assessment of current OMP

Based on the above review of the data collected during the current monitoring period, there are no significant changes to the understanding of the nature, extent or risks associated with PFAS within the Monitoring Area, or the need for monitoring of additional media.

It is noted that the 2018 OMP was revised in February 2023 for implementation in subsequent monitoring events following the monitoring period reported in this OMR.

11.0 Conclusions

Groundwater, surface water and sediment monitoring were completed between November 2021 and March 2023 in accordance with the SAQP (AECOM, 2022a).

The results for the monitoring period indicate that the nature and extent of PFAS in groundwater, surface water and sediment are consistent with previous findings.

Variation in PFAS concentrations were observed and likely due to the seasonal variability of Darwin's wet and dry seasons. In general, PFAS concentrations were within historical ranges within groundwater, surface water and sediment. Concentrations of PFAS in groundwater indicated generally stable or inconclusive trends, with increasing trends limited to two locations (namely MW034 and MW032), however concentrations at these two locations are close to the LOR and marginally above the adopted human health drinking water criteria. Further data collected from both locations under the OMP is required to understand temporal changes at these two locations.

The CSM was reviewed, and based on the results presented within this report, no changes were identified to source, pathway or receptors at the base and within the Monitoring Area.

Based on the data collected during the monitoring period, the risk profile has not changed within the Monitoring Area.

The monitoring conducted over the monitoring period is considered to have met the objectives of the SAQP and the OMP. The groundwater monitoring network is considered generally appropriate and sufficient for the program objectives.

12.0 References

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Appendix A

Figures

Appendix B

Tables

Appendix B Tables

Appendix C

SAQP and Factual Reports

Appendix C SAQP and Factual Reports

Appendix D

Graphs

Appendix D Graphs

Appendix E

Mann-Kendall Analysis

Appendix E Mann-Kendall Analysis