

Site Audit Report 0503-2503 Singleton Military Area, NSW

Department of Defence





NSW Site Auditor Scheme

Site Audit Statement

A site audit statement summarises the findings of a site audit. For full details of the site auditor's findings, evaluations and conclusions, refer to the associated site audit report.

This form was approved under the *Contaminated Land Management Act 1997* on 12 October 2017.

For information about completing this form, go to Part IV.

Part I: Site audit identification

Site audit statement no. 0503-2503

This site audit is a:

☑ non-statutory audit

within the meaning of the Contaminated Land Management Act 1997.

Site auditor details

(As accredited under the Contaminated Land Management Act 1997)

Name	Andrew Lau		
Company	JBS&G Australia Pty Ltd		
Address	Level 8, 179 Elizabeth St, Sydney, NSW		
		Postcode	2000
Phone	02 8245 0300		
Email	alau@jbsg.com.au		

Site details

Address	Singleton Military Area			
	358 Range Road Whittingham NSW	Postcode	2330	

Prope	rty description		
(Attach	a separate list if se	veral properties are included in the site audit.)	
Part Lo	t 500 in DP 130225	5	
Local g	overnment area	Singleton	
Area of	site (include units,	e.g. hectares) 15 000 Hectares	
Current	zoning	SP2 Infrastructure	
Daniel	-4:	-4! o	
•	ation and notifica		
	best of my knowled	•	
	•	ct of a declaration, order, agreement, proposal or notice under the Management Act 1997 or the Environmentally Hazardous	
		as follows: (provide the no. if applicable)	
⊑	Declaration no	=	
€	l Order no.		
	Proposal no.		
	Notice no.		
	n e site is not the si	ubject of a declaration, order, proposal or notice under the	
	Contaminated Land Management Act 1997 or the Environmentally Hazardous		
	Chemicals Act 198	5.	
To the	best of my knowled	ge:	
	ne site has been no lanagement Act 19	tified to the EPA under section 60 of the <i>Contaminated Land</i> 9 7	
	ne site has not bee <i>Management Act 1</i>	n notified to the EPA under section 60 of the <i>Contaminated Land</i> 997.	
Site au	udit commission	ed by	
Name	Mr Richard	Lamont	
Compa	ny Department	of Defence	
Addres	s -		
		Postcode -	
Phone	0401 002 9 ⁻		
Email		ont1@defence.gov.au	

Con	tact details for contact person (if different from above)
Nam	e
Phon	е
Emai	I
Natu	re of statutory requirements (not applicable for non-statutory audits)
	Requirements under the Contaminated Land Management Act 1997 (e.g. management order; please specify, including date of issue)
━—	Requirements imposed by an environmental planning instrument (please specify, including date of issue)
	Development consent requirements under the Environmental Planning and Assessment Act 1979 (please specify consent authority and date of issue)
	Requirements under other legislation (please specify, including date of issue)

Purpose of site audit		
₽—	-A1 To determine land use suitability	
	Intended uses of the land:	
OR		
	A2 To determine land use suitability subject to compliance with either an active or passive environmental management plan	
	Intended uses of the land:	
OR		
(Tick	all that apply)	
₽—	B1 To determine the nature and extent of contamination	
$\overline{\checkmark}$	B2 To determine the appropriateness of:	
	☑ an investigation plan	
	□ a remediation plan	
	☑ a management plan	
₩	B3 To determine the appropriateness of a site testing plan to determine if groundwater is safe and suitable for its intended use as required by the Temporary Water Restrictions Order for the Botany Sands Groundwater Resource 2017	
₽—	B4 To determine the compliance with an approved:	
	☐ voluntary management proposal or	
	☐ management order under the Contaminated Land Management Act 1997	
	B5 To determine if the land can be made suitable for a particular use (or uses) if the site is remediated or managed in accordance with a specified plan.	
	Intended uses of the land:	
16		
	rmation sources for site audit	
	sultancies which conducted the site investigations and/or remediation:	
AEC	UM	

Titles of reports reviewed:

PFAS Management Area Plan (PMAP), Singleton Military Area, Department of Defence, December 2021 (Defence 2021).

Sampling Event Factual Report, January 2023, Singleton Lone Pine Barracks, Department of Defence, AECOM, April 2023 (AECOM 2023a).

Sampling Event Factual Report, July 2023, Singleton Lone Pine Barracks, Department of Defence, AECOM, January 2024 (AECOM 2024a).

Sampling Event Factual Report, January 2024, Singleton Lone Pine Barracks, Department of Defence, AECOM, May 2024 (AECOM 2024b).

Singleton Lone Pine Barracks – Former Cantonment Fire Station – Limited PFAS Soil Investigation, Department of Defence, AECOM, May 2024 (AECOM 2024c).

Singleton Lone Pine Barracks – Surface Water Mass Flux Sampling – April and May 2024, Department of Defence, AECOM, July 2024 (AECOM 2024d).

Ongoing Monitoring Report (OMR), (July 2022 – June 2023) PFAS OMP – Singleton Military Area, Ongoing Monitoring Program, Department of Defence, AECOM, July 2024, Rev 1 FINAL (AECOM 2024e).

Ongoing Monitoring Report, (July 2022 – June 2023), PFAS OMP – Singleton Military Area, Department of Defence, AECOM, January 2025, Rev B (AECOM 2025a).

Ongoing Monitoring Report, (July 2023 – June 2024), PFAS OMP – Singleton Military Area, Department of Defence, AECOM, February 2025, Rev C (AECOM 2025b).

PFAS Ongoing Monitoring Plan, Singleton Military Area, Department of Defence, 17 April 2025, Rev 1 (Defence 2025a).

Other information reviewed, including previous site audit reports and statements relating to the site:

Detailed Site Investigation, Singleton Military Area – PFAS Investigation, Department of Defence, AECOM, November 2019 (AECOM 2019a).

Singleton Military Area (Including Lone Pine Barracks), Singleton NSW, Non-Statutory Site Audit Report and Site Audit Statement, Department of Defence, Tony Scott of Coffey Environmental, December 2022 (Coffey 2022).

Singleton Military Area PFAS Site Transition Plan, Defence, December 2024 (Defence 2024).

Stakeholder and Community Engagement Plan, PFAS Investigation Management Program, Singleton Military Area, Department of Defence, 20 March 2025 (Defence 2025b).

PFAS Management Area Plan completion and next steps, PFAS Investigation and Management Program, Singleton Military Area, Department of Defence, April 2025 (Defence 2025c).

0356 SMA: Technical Memorandum 01, 30 Racecourse Lane, Department of Defence, AECOM, 17 April 2025 (AECOM 2025c).

Site audit report details

Title	Site Audit Report 0503-2503, Singleton Military Area, NSW	
Report no.	JBS&G 66617-164286	Date 30 April 2025

Part II: Auditor's findings

Please complete either Section A1, Section A2 or Section B, not more than one section. (Strike out the irrelevant sections.)

- Use Section A1 where site investigation and/or remediation has been completed and a
 conclusion can be drawn on the suitability of land uses without the implementation of
 an environmental management plan.
- Use **Section A2** where site investigation and/or remediation has been completed and a conclusion can be drawn on the suitability of land uses **with the implementation** of an active or passive environmental management plan.
- Use **Section B** where the audit is to determine:
 - o (B1) the nature and extent of contamination, and/or
 - (B2) the appropriateness of an investigation, remediation or management plan¹, and/or
 - (B3) the appropriateness of a site testing plan in accordance with the Temporary Water Restrictions Order for the Botany Sands Groundwater Source 2017, and/or
 - (B4) whether the terms of the approved voluntary management proposal or management order have been complied with, and/or
 - (B5) whether the site can be made suitable for a specified land use (or uses) if the site is remediated or managed in accordance with the implementation of a specified plan.

¹ For simplicity, this statement uses the term 'plan' to refer to both plans and reports.

Section A1

I cer	tify that, in my opinion:
The s	site is suitable for the following uses:
(Tick	all appropriate uses and strike out those not applicable.)
₽—	-Residential, including substantial vegetable garden and poultry
₽—	-Residential, including substantial vegetable garden, excluding poultry
	Residential with accessible soil, including garden (minimal home-grown produce contributing less than 10% fruit and vegetable intake), excluding poultry
₽—	Day care centre, preschool, primary school
₽—	Residential with minimal opportunity for soil access, including units
₽—	-Secondary school
₽—	-Park, recreational open space, playing field
₽—	-Commercial/industrial
	Other (please specify):
OR □ □	I certify that, in my opinion, the site is not suitable for any use due to the risk of harm from contamination. all comments:

Section A2

I certify that, in my opinion:

Subject to compliance with the <u>attached</u> environmental management plan² (EMP), the site is suitable for the following uses: (Tick all appropriate uses and strike out those not applicable.) — Residential, including substantial vegetable garden and poultry

₽—	Residential, including substantial vegetable garden and poultry
₽—	Residential, including substantial vegetable garden, excluding poultry
━—	Residential with accessible soil, including garden (minimal home-grown produce contributing less than 10% fruit and vegetable intake), excluding poultry
₽—	Day care centre, preschool, primary school
₽—	Residential with minimal opportunity for soil access, including units
₽—	Secondary school
₽—	Park, recreational open space, playing field
₽—	Commercial/industrial
₽	Other (please specify):
EMP	details
Title	

Author

EMP summary

Date

This EMP (attached) is required to be implemented to address residual contamination on the site.

No. of pages

The EMP: (Tick appropriate box and strike out the other option.)

- requires operation and/or maintenance of active control systems³
- □ requires maintenance of passive control systems only³.

² Refer to Part IV for an explanation of an environmental management plan.

³ Refer to Part IV for definitions of active and passive control systems.

Purpose of the EMP:
Description of the nature of the residual contamination:
Summary of the actions required by the EMP:
How the EMP can reasonably be made to be legally enforceable:
How there will be appropriate public notification:
Overall comments:

Section B

Purpose of the plan⁴ which is the subject of this audit:

The objectives of this Site Audit were to review and determine the appropriateness of the recommended reports arising from the PMAP actions (Defence 2021) and to review and determine the appropriateness of the updated OMP (Defence 2025) to provide the ongoing PFAS monitoring requirements for the management area.

The PMAP establishes a number of recommendations to manage PFAS at the base, as follows (Defence 2021):

- 1. Data Gap Investigation at the Former Cantonment Fire Station. The data gap investigation should consider the use of rainfall simulation and the installation of lysimeters to estimate the quantum and significance of contribution of this source to PFAS concentrations in surface water at the base boundary.
- 2. Review the works planned at the DNSDC as part of the SMA Mid Term Refresh. Part of the DNSDC compound is planned to be demolished during 2021 as part of the SMA Mid Term Refresh. As such, it is prudent this program of works is better understood before any remedial activities are planned. Appropriate guidance should be provided to the SMA Mid Term Refresh project on the appropriate management of PFAS.
- 3. Undertake a Mass Flux Study. A mass flux study should be undertaken to understand the ongoing contribution of PFAS from the SMA and its source areas to the environment via partitioning of PFAS from residual soil mass to water via surface water drainage and groundwater.
- 4. Implement the Ongoing Monitoring Plan (OMP) to monitor changes in PFAS concentrations within the Management Area, in groundwater, in wastewater discharge and in surface water bodies that ultimately drain to the Hunter River and regional groundwater.
- 5. Work with NSW Government and other stakeholders to evaluate the significance of current data gaps. This assessment would focus on previously identified groundwater impacts above the health-based guidance values in the north-eastern part of the Management Area and understand the contribution of PFAS from the Singleton STP.

I certify that, in my opinion:

(B1)	
₽—	The nature and extent of the contamination has been appropriately determined
₽—	The nature and extent of the contamination has not been appropriately determined
AND	OR (B2)
V	The investigation, remediation or management plan is appropriate for the purpose stated above
	The investigation, remediation or management plan is not appropriate for the purpose stated above
AND/	'OR (B3)

⁴ For simplicity, this statement uses the term 'plan' to refer to both plans and reports.

☐ The site testing plan:	
☐ is appropriate to determine	
☐ is not appropriate to determine	
if groundwater is safe and suitable for its intended use as required Water Restrictions Order for the Botany Sands Groundwater Resou	
AND/OR (B4)	
The terms of the approved voluntary management proposal* or management proposa	nagement order**
☐ have been complied with	
☐ have not been complied with.	
*voluntary management proposal no.	
**management order no.	
AND/OR (B5)	
☐ The site can be made suitable for the following uses:	
(Tick all appropriate uses and strike out those not applicable.)	
□ Residential, including substantial vegetable garden and poulti	r y
→ Residential, including substantial vegetable garden, excluding	j poultry
Residential with accessible soil, including garden (minimal ho contributing less than 10% fruit and vegetable intake), exclude	
□ Day care centre, preschool, primary school	
☐ Residential with minimal opportunity for soil access, including	-units
□ Secondary school	
□ Park, recreational open space, playing field	
□ Commercial/industrial	
☐ Other (please specify):	
IF the site is remediated/managed* in accordance with the following plan	(attached):
*Strike out as appropriate	
Plan title	
Plan author	
Plan date No. of pa	iges
SUBJECT to compliance with the following condition(s):	

Overall comments:

PMAP Response Action 1 – Data Gap Investigation at the Former Cantonment Fire Station

The former Cantonment Fire Station was demolished around 2022, after the PMAP (Defence 2021) was prepared. Due to the change in ground conditions in this part of the base arising from the demolition and removal off all above ground infrastructure, the Auditor considers that the previously recommended consideration of washdown tests and use of lysimeters to estimate the quantum and significance of this potential contamination source is no longer valid or appropriate, and that the surface soil investigations (AECOM 2024c), combined with the mass flux study undertaken (AECOM 2024d) and ongoing monitoring data provides much greater insights into this potential contamination source and its contribution to surface water PFAS concentrations at the base boundary.

The Auditor considers that the Limited PFAS Soil Investigation Report (AECOM 2024c) was prepared with appropriate consideration to relevant guidelines, and that the data quality was suitable to assess the contamination status of this part of the base. Furthermore, it is considered that sufficient data was obtained to confirm that the residual low-level PFAS in soils at the former Cantonment Fire Station pose a low risk to both human and ecological receptors. When considered in context with surface water data from both the previous investigations and the Ongoing Monitoring Program (OMP), the Auditor considers that this part of the base contributes only minor amounts of PFAS in surface water at the base boundary.

The absence of additional sub surface soil analytical data collected during the additional soil investigations can be readily addressed through the normal Defence Construction and Maintenance Framework required for any future construction works in this part of the base.

PMAP Response Action 2 – Review of Works Planned at DNSDC as part of the SMA Mid Term Refresh

Based on the planned Mid Term Refresh project not proceeding, the Auditor accepts that a review of the works could not be undertaken to inform what/if any PFAS management actions may be required. Should this change in the future, then the Auditor considers it appropriate for the works to be managed under the Defence Construction and Maintenance Framework.

PMAP Response Action 3 – Undertake a Mass Flux Study

Based on data obtained as part of the DSI (AECOM 2021a) and further supported by ongoing monitoring data, the spatial distribution of PFAS detections in groundwater is limited and, in some cases isolated. As such, the Auditor considers that groundwater migration is not a significant transport mechanism off the Singleton Military Area. The primary PFAS migration pathway is via surface water and therefore the Auditor accepts that the mass flux study was appropriately focused on surface water, specifically at a location downstream/within the catchment of on-base PFAS source areas including the former Cantonment Fire Station.

For these reasons, the Auditor considers that the mass flux assessment undertaken was sufficient to gain an understanding of the ongoing contribution of PFAS from the identified source areas to the environment via partitioning of PFAS from soil to water via surface water drainage with a maximum estimated annual mean of 33 g of PFOS+PFHxS and 35 g of sum of PFAS across the rainfall events investigated. The Auditor reviewed the methodology and calculations and accepts the mass flux estimates as correct/appropriate, and notes that the findings indicate relatively low levels of PFAS migration are occurring from the base.

PMAP Response Action 4 – Implement the OMP

The various monitoring reports reviewed as part of this audit confirm that the Ongoing Monitoring Program (OMP) was undertaken to monitor changes in PFAS concentrations in accordance with the requirements of the PMAP (Defence 2021). Evidence of community consultation was also sighted by the Auditor, including additional water use surveys and publishing factsheets and monitoring reports and factsheets on Defence's website for the Singleton Military Area. As such, the Auditor considers that the OMP consultation requirement of the PMAP (Defence 2021) has been met.

PMAP Response Action 5 – Work with NSW Government and other Stakeholders

Based on the completion of the additional investigations at the former Cantonment Fire Station (AECOM 2024c), the mass flux investigation completed in the northern part of the base (AECOM 2024d) and undertaking periodic monitoring as part of the ongoing monitoring program (shared with NSW Government and other stakeholders), the Auditor considers that steps have been taken to addressing this action and that understanding the groundwater impacts in the north eastern part of the management area and the contribution of PFAS from the Singleton STP remains an ongoing endeavour appropriately captured in the ongoing monitoring program.

Updated Ongoing Monitoring Plan (Defence 2025)

The Auditor considers that, throughout the previous monitoring program, sufficient data has been collected to justify the proposed revisions to the updated OMP, specifically around the reduced monitoring frequency. This has been supplemented by the findings of the additional investigations around the former Cantonment Fire Station (AECOM 2024c) and the mass flux assessment (AECOM 2024d) which indicate low source concentrations within this potential source area and the relatively low levels of PFAS migration from the site, respectively.

Further to this, the Auditor considers that the updated OMP (Defence 2025) includes appropriate monitoring methodologies and assessment criteria; sufficiently clear delegated responsibilities; and the required triggers and response actions are appropriate.

Part III: Auditor's declaration

I am accredited as a site auditor by the NSW Environment Protection Authority (EPA) under the *Contaminated Land Management Act 1997*.

Accreditation no. 0503

I certify that:

- I have completed the site audit free of any conflicts of interest as defined in the Contaminated Land Management Act 1997, and
- with due regard to relevant laws and guidelines, I have examined and am familiar with the reports and information referred to in Part I of this site audit, and
- on the basis of inquiries I have made of those individuals immediately responsible for making those reports and obtaining the information referred to in this statement, those reports and that information are, to the best of my knowledge, true, accurate and complete, and
- this statement is, to the best of my knowledge, true, accurate and complete.

I am aware that there are penalties under the *Contaminated Land Management Act 1997* for wilfully making false or misleading statements.

Signed Market L.

30 April 2025

Part IV: Explanatory notes

To be complete, a site audit statement form must be issued with all four parts.

How to complete this form

Part I

Part I identifies the auditor, the site, the purpose of the audit and the information used by the auditor in making the site audit findings.

Part II

Part II contains the auditor's opinion of the suitability of the site for specified uses or of the appropriateness of an investigation, or remediation plan or management plan which may enable a particular use. It sets out succinct and definitive information to assist decision-making about the use or uses of the site or a plan or proposal to manage or remediate the site.

The auditor is to complete either Section A1 or Section A2 or Section B of Part II, **not** more than one section.

Section A1

In Section A1 the auditor may conclude that the land is *suitable* for a specified use or uses OR *not suitable* for any beneficial use due to the risk of harm from contamination.

By certifying that the site is *suitable*, an auditor declares that, at the time of completion of the site audit, no further investigation or remediation or management of the site was needed to render the site fit for the specified use(s). **Conditions must not be** imposed on a Section A1 site audit statement. Auditors may include **comments** which are key observations in light of the audit which are not directly related to the suitability of the site for the use(s). These observations may cover aspects relating to the broader environmental context to aid decision-making in relation to the site.

Section A2

In Section A2 the auditor may conclude that the land is *suitable* for a specified use(s) subject to a condition for implementation of an environmental management plan (EMP).

Environmental management plan

Within the context of contaminated sites management, an EMP (sometimes also called a 'site management plan') means a plan which addresses the integration of environmental mitigation and monitoring measures for soil, groundwater and/or hazardous ground gases throughout an existing or proposed land use. An EMP succinctly describes the nature and location of contamination remaining on site and states what the objectives of the plan are, how contaminants will be managed, who will be responsible for the plan's implementation and over what time frame actions specified in the plan will take place.

By certifying that the site is suitable subject to implementation of an EMP, an auditor declares that, at the time of completion of the site audit, there was sufficient information satisfying guidelines made or approved under the *Contaminated Land Management Act 1997*

(CLM Act) to determine that implementation of the EMP was feasible and would enable the specified use(s) of the site and no further investigation or remediation of the site was needed to render the site fit for the specified use(s).

Implementation of an EMP is required to ensure the site remains suitable for the specified use(s). The plan should be legally enforceable: for example, a requirement of a notice under the CLM Act or a development consent condition issued by a planning authority. There should also be appropriate public notification of the plan, e.g. on a certificate issued under s.149 of the Environmental Planning and Assessment Act 1979.

Active or passive control systems

Auditors must specify whether the EMP requires operation and/or maintenance of active control systems or requires maintenance of passive control systems only. Active management systems usually incorporate mechanical components and/or require monitoring and, because of this, regular maintenance and inspection are necessary. Most active management systems are applied at sites where if the systems are not implemented an unacceptable risk may occur. Passive management systems usually require minimal management and maintenance and do not usually incorporate mechanical components.

Auditor's comments

Auditors may also include **comments** which are key observations in light of the audit which are not directly related to the suitability of the site for the use(s). These observations may cover aspects relating to the broader environmental context to aid decision-making in relation to the site.

Section B

In Section B the auditor draws conclusions on the nature and extent of contamination, and/or suitability of plans relating to the investigation, remediation or management of the land, and/or the appropriateness of a site testing plan in accordance with the *Temporary Water Restrictions Order for the Botany Sands Groundwater Source 2017*, and/or whether the terms of an approved voluntary management proposal or management order made under the CLM Act have been complied with, and/or whether the site can be made suitable for a specified land use or uses if the site is remediated or managed in accordance with the implementation of a specified plan.

By certifying that a site *can be made suitable* for a use or uses if remediated or managed in accordance with a specified plan, the auditor declares that, at the time the audit was completed, there was sufficient information satisfying guidelines made or approved under the CLM Act to determine that implementation of the plan was feasible and would enable the specified use(s) of the site in the future.

For a site that *can be made suitable*, any **conditions** specified by the auditor in Section B should be limited to minor modifications or additions to the specified plan. However, if the auditor considers that further audits of the site (e.g. to validate remediation) are required, the auditor must note this as a condition in the site audit statement. The condition must not specify an individual auditor, only that further audits are required.

Auditors may also include **comments** which are observations in light of the audit which provide a more complete understanding of the environmental context to aid decision-making in relation to the site.

Part III

In **Part III** the auditor certifies their standing as an accredited auditor under the CLM Act and makes other relevant declarations.

Where to send completed forms

In addition to furnishing a copy of the audit statement to the person(s) who commissioned the site audit, statutory site audit statements must be sent to

- the NSW Environment Protection Authority: <u>nswauditors@epa.nsw.gov.au</u> or as specified by the EPA AND
- the local council for the land which is the subject of the audit.



We acknowledge the Traditional Custodians of Country throughout Australia and their connections to land, sea and community.

We pay respect to Elders past and present and in the spirit of reconciliation, we commit to working together for our shared future.





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Appendices

Appendix A Guidelines Made or Approved by the EPA

Appendix B Audit Correspondence

Appendix C Figures



Abbreviations

Term	Definition	
AFFF	Aqueous Film Forming Foam	
AHD	Australian Height Datum	
ALG	Alternate Landing Ground	
ANZECC	Australian & New Zealand Environment Conservation Council	
ВоМ	The Bureau of Meteorology	
CLM	Contaminated Land Management	
COC	Chain of Custody	
COPC	Contaminants of Potential Concern	
CSM	Conceptual Site Model	
DNSDC	Defence National Storage and Distribution Centre	
DP	Deposited Plan	
DQI	Data Quality Indicator	
DQO	Data Quality Objectives	
DSI	Detailed Site Investigation	
EPA	New South Wales Environment Protection Authority	
ESA	Environmental Site Assessment	
FCFS	Former Cantonment Fire Station	
HHERA	Human Health and Ecological Risk Assessment	
HIL	Health Based Investigation Level	
HLG	Helicopter Landing Ground	
LCS	Lab Control Sample	
LOR	Limit of Reporting	
m bgs	Metres below ground surface	
MS	Matrix Spike	
MW	Monitoring Well	
NATA	National Association of Testing Authorities, Australia	
NEMP	National Environmental Management Plan	
NEPC	National Environment Protection Council	
ОМР	Ongoing Monitoring Plan	
OMR	Ongoing Monitoring Report	
PARCC	Precision, Accuracy, Representativeness, Comparability and Completeness	
PFAS	Per and poly-fluoroalkyl substances	
PFASIM	PFAS Investigation and Management Program	
PMAP	PFAS Management Area Plan	
QA/QC	Quality Assurance/Quality Control	
RPD	Relative Percentage Difference	



SAQP	Sampling Analysis and Quality Plan
SAR	Site Audit Report
SAS	Site Audit Statement
SD	Sediment
SMA	Singleton Military Area
STA	Singleton Training Area
STP	Sewage Treatment Plant
SVOCs	Semi Volatile Organic Compounds
SW	Surface Water



1. Introduction

1.1 Introduction and Background

Andrew Lau, of JBS&G Australia Pty Ltd (JBS&G), was engaged by Department of Defence (Defence, the client) to conduct a Site Audit at the Singleton Military Area (SMA, the base) and neighbouring properties to the north, north-west and north-east which make up the Management Area. The base is located at Range Road, Singleton, NSW, approximately 3 km south-west of the Singleton township. The base covers an area of approximately 15,000 hectares (ha), legally identified as Part Lot 500 in DP 1302255 (**Figures 1** and **2**, **Appendix C**). The SMA was established in 1939 and is the location for the Australian Army School of Infantry and Special Forces Training Centre and comprises the Lone Pine Barracks (the Cantonment) and the Singleton Training Area (STA).

Andrew Lau is a Site Auditor accredited by the NSW Environment Protection Authority (EPA) under the *Contaminated Land Management Act 1997* (CLM Act 1997) (Accreditation Number 0503). The current audit was completed with the assistance of Dr Greg Dasey, JBS&G's Principal Hydrogeologist, and Katie Linz, a trained and experienced contaminated land audit assistant.

A number of environmental investigations, focused primarily on PFAS (Per and poly-fluoroalkyl substances), have been conducted since 2012. In 2022, a non-statutory Section B1 Site Audit Statement (SAS) and accompanying Site Audit Report (SAR) was completed by NSW EPA Site Auditor, Tony Scott, stating that the investigations were appropriate to assess the nature and extent of contamination and that the PFAS Management Action Plan (PMAP) (Defence 2021) was also appropriate for it's stated purpose, namely to manage PFAS on and emanating from the SMA (Coffey 2022).

The PMAP establishes a number of recommendations to manage PFAS at the base, as follows (Defence 2021):

- Data Gap Investigation at the Former Cantonment Fire Station. The data gap investigation should consider the use of rainfall simulation and the installation of lysimeters to estimate the quantum and significance of contribution of this source to PFAS concentrations in surface water at the base boundary.
- 2. Review the works planned at the DNSDC as part of the SMA Mid Term Refresh. Part of the DNSDC compound is planned to be demolished during 2021 as part of the SMA Mid Term Refresh. As such, it is prudent this program of works is better understood before any remedial activities are planned. Appropriate guidance should be provided to the SMA Mid Term Refresh project on the appropriate management of PFAS.
- 3. **Undertake a Mass Flux Study**. A mass flux study should be undertaken to understand the ongoing contribution of PFAS from the SMA and its source areas to the environment via partitioning of PFAS from residual soil mass to water via surface water drainage and groundwater.
- 4. **Implement the Ongoing Monitoring Plan (OMP)** to monitor changes in PFAS concentrations within the Management Area, in groundwater, in wastewater discharge and in surface water bodies that ultimately drain to the Hunter River and regional groundwater.
- 5. Work with NSW Government and other stakeholders to evaluate the significance of current data gaps. This assessment would focus on previously identified groundwater impacts above the health-based guidance values in the north-eastern part of the Management Area and understand the contribution of PFAS from the Singleton STP.



1.2 Objectives of Audit

The objectives of this Site Audit were to review and determine the appropriateness of the recommended reports arising from the PMAP actions (Defence 2021) and to review and determine the appropriateness of the updated OMP (Defence 2025) to provide the ongoing PFAS monitoring requirements for the management area.

In reviewing the reports as part of this site audit, consideration was given to:

- The provisions of the CLM Act, Regulations and subsequent amendments;
- The provisions of any environmental planning instruments applying to the base; and
- Relevant guidelines made or approved by the EPA.

1.3 Type of Audit

The Site Audit was conducted as a Non-Statutory Site Audit, since the requirement for the audit did not arise as a result of any specific legal / regulatory requirement. The audit reference number is 0503-2503.

1.4 Documents Reviewed

The following documents were provided and reviewed as part of this Site Audit:

- PFAS Management Area Plan (PMAP), Singleton Military Area, Department of Defence, December 2021 (Defence 2021). This report was previously reviewed in detailed by Tony Scott in preparation of the previous SAR however was also provided to JBS&G to determine if the recommended PMAP response actions were adequately addressed.
- Sampling Event Factual Report, January 2023, Singleton Lone Pine Barracks, Department of Defence, AECOM, April 2023 (AECOM 2023a).
- Sampling Event Factual Report, July 2023, Singleton Lone Pine Barracks, Department of Defence, AECOM, January 2024 (AECOM 2024a).
- Sampling Event Factual Report, January 2024, Singleton Lone Pine Barracks, Department of Defence, AECOM, May 2024 (AECOM 2024b).
- Singleton Lone Pine Barracks Former Cantonment Fire Station Limited PFAS Soil Investigation, Department of Defence, AECOM, May 2024 (AECOM 2024c).
- Singleton Lone Pine Barracks Surface Water Mass Flux Sampling April and May 2024, Department of Defence, AECOM, July 2024 (AECOM 2024d).
- Ongoing Monitoring Report (OMR), (July 2022 June 2023) PFAS OMP Singleton Military Area, Ongoing Monitoring Program, Department of Defence, AECOM, July 2024, Rev 1 FINAL (AECOM 2024e).
- Ongoing Monitoring Report, (July 2022 June 2023), PFAS OMP Singleton Military Area, Department of Defence, AECOM, January 2025, Rev B (AECOM 2025a).
- Ongoing Monitoring Report, (July 2023 June 2024), PFAS OMP Singleton Military Area, Department of Defence, AECOM, 14 April 2025, Rev 0 (AECOM 2025b).
- PFAS Ongoing Monitoring Plan, Singleton Military Area, Department of Defence, 17 April 2025, Rev 1 (Defence 2025a).

Other information reviewed in preparation of this Site Audit Report is listed below:

• Detailed Site Investigation, Singleton Military Area – PFAS Investigation, Department of Defence, AECOM, November 2019 (AECOM 2019a).



- Singleton Military Area (Including Lone Pine Barracks), Singleton NSW, Non-Statutory Site Audit Report and Site Audit Statement, Department of Defence, Tony Scott of Coffey Environmental, December 2022 (Coffey 2022).
- Singleton Military Area PFAS Site Transition Plan, Defence, December 2024 (Defence 2024).
- Stakeholder and Community Engagement Plan, PFAS Investigation Management Program, Singleton Military Area, Department of Defence, 20 March 2025 (Defence 2025b).
- PFAS Management Area Plan completion and next steps, PFAS Investigation and Management Program, Singleton Military Area, Department of Defence, April 2025 (Defence 2025c).
- 0356 SMA: Technical Memorandum 01, 30 Racecourse Lane, Department of Defence, AECOM, 17 April 2025 (AECOM 2025c).

1.5 Base Inspections

The base was inspected on the date(s) shown in **Table 1.1**.

Table 1.1: Summary of Audit Inspections

Date	Attendance	Purpose
26 August 2024	Ben Sgherza – Defence	Base inspection to verify the condition/ surrounding environment.
	Stephen White – Contractor to Defence	
	Andrew Lau – Site Auditor (JBS&G)	
	Katie Linz – Site Audit Assistant (JBS&G)	

1.6 Chronology of Site Assessment and Audit Works

The process of the assessment and audits undertaken at the base has been chronologically listed in **Table 1.2** below.

Table 1.2: Summary of Investigation and Audit Works Undertaken at the Base

Date	Purpose
December 2021	Defence completed the PFAS Management Area Plan (PMAP) which was not reviewed as part of
	this Audit however was referenced to determine if all response actions listed within the plan had
	been addressed.
22 December	Based on review of the reports prepared prior, including the above mentioned PMAP, a non-
2022	statutory Section B1 Site Audit was completed by Tony Scott, stating that the investigation plan,
	remediation plan and management plan were appropriate (Coffey 2022).
19 April 2023	AECOM completed a Sampling Event Factual Report, January 2023 (AECOM 2023) which
	included the collection and analysis of groundwater, surface water, wastewater and sediment
	samples.
18 January 2024	AECOM completed a Sampling Event Factual Report, July 2023 (AECOM 2024a) which included
	the collection and analysis of groundwater, surface water, wastewater and sediment samples.
28 May 2024	AECOM completed a Sampling Event Factual Report, January 2024 (AECOM 2024b) which
	included the collection and analysis of groundwater, surface water, wastewater and sediment
	samples.
17 May 2024	AECOM completed a limited PFAS soil sampling investigation at the Lone Pine Barracks, Former
	Cantonment Fire Station site (AECOM 2024c).
12 July 2024	AECOM completed the Surface Water Mass Flux Sampling Report on the Lone Pine Barracks
	(AECOM 2024d).
26 July 2024	AECOM completed the Final June 2022 to July 2023 PFAS Ongoing Monitoring Report (AECOM
	2024e) which included two rounds of groundwater, surface water and sediment sampling in
	accordance with the requirements of the PMAP (Defence 2021).
26 August 2024	Andrew Lau (JBS&G) completed a base inspection to verify the base condition and surrounding
	environment.



Date	Purpose
9 December 2024	Defence hosted a Workshop to map out a Site Transition Plan and discuss each of the PMAP
	Actions and how they had been addressed. Defence and JBS&G were in attendance. Meeting
	minutes were provided by Defence as a record of the workshop (Defence 2024)
19 February 2025	AECOM issued Revision C of the OMR (July 2023 - June 2024) report (AECOM 2024f) which
	included two rounds of groundwater, surface water and sediment sampling in accordance with
	the requirements of the PMAP (Defence 2021).
21 February 2025	Defence issued Revision B of the PFAS Ongoing Monitoring Plan (OMP) (Defence 2025)
30 April 2025	Completion of Site Audit Statement and Site Audit Report (JBS&G 2025)

2. Base Description

2.1 Base Identification

The base details have been summarised in **Table 2.1** below and described in further detail in the following sections. The base location and layout are shown on **Figures 1** to **4**, **Appendix C**.

Table 2.1: Summary Base Details

Table 212. Gallinary Base Betans		
Street Address:	358 Range Rd, Whittingham, located approximately 8 km south of the township of	
	Singleton, NSW.	
Lot 1 DP	Part Lot 500 in DP 1302255 (previously defined as Lot 2 DP1207737 and Lot 1	
	DP547999, Coffey 2022).	
Local Government Area:	Singleton	
Property Size:	15,000 ha	
Zoning:	SP2 Infrastructure	
Previous Use	Military base, mixed use	
Current Use	Military base, mixed use	

2.2 Base Layout and Activities

The following description is based on the information provided in the PMAP (Defence 2021), as well as observations made by the Auditor during the base inspection on 26 August 2024. The base layout and surrounding environment are shown on **Figures 1** and **2** (**Appendix C**).

The SMA comprised of mostly open country with timber lined creek and scattered forests. The Broken Back Ranges rise steeply to the south of the base within the Pokolbin State Forest. The southernmost portion of the SMA extends to the south of Cessnock Road with the norther portion of the base (The Cantonment) extending to the north of Mitchell Line of Road (The Golden Highway). The SMA is divided into two areas, the Cantonment (Lone Pine Barracks) is the location of the on base accommodation, maintenance and training facilities, vehicle maintenance, storage and distribution of fuels, equipment wash-down and firefighting training with the Singleton Training Area (STA) the former location of active ranges for weapons firing, vehicle training and explosives testing. The STA occupies the majority (approximately 90%) of the SMA. The location of the main base features listed above are shown on **Figure 2**, **Appendix C**.

The Cantonment included a number of accommodation and training facilities, as well as the Former Cantonment Fire Station, as shown on **Figure 2**, **Appendix C**.

2.3 Topography and Hydrology

The consultant (AECOM 2019a) reported that the base was dominated by moderate to gently sloping inclines and hills, with the foothills of the Broken Back Ranges rising steeply at the southern extent of the base. The base and surrounding areas are located in the central lowlands along the Hunter River and characterised by undulating to rolling hills and inclines on weak sedimentary rocks.



The consultant reported that the base encompasses several drainage lines which drain north and east towards the Hunter River (located approximately 2 kilometres north of the base). The primary on-base drainage lines include:

- Mudies Creek and Emigrant Creek along the western and eastern boundaries of the Dochra Airfield.
- A number of small creeks originating from the southern area of the base.
- Doughboy Hollow Creek, which traverses the base and runs to the north.

A number of water bodies are located within the nearby offbase locations including private dams and smaller drainage lines located on residential properties.

The consultant (AECOM 2019a) reported that the Sewage Treatment Plant (STP) is located to the north of the base and receives wastewater from both the SMA and the Singleton township. The wetland east of the STP is understood to have hydraulic connectivity with groundwater present within the Hunter River alluvial floodplain at Whittingham. Therefore, surface water that migrates from Doughboy Hollow Creek to the wetland area east of the STP may provide recharge of groundwater present in the Hunter River alluvial floodplain. Previous investigations concluded that surface water bodies were ephemeral, and flow in response to rainfall, with no base flow component connected to the groundwater. Additionally, there was the potential for surface water to recharge groundwater in the area.

The DSI (AECOM 2019a) divided the catchments of the Cantonment into three sub-catchments as follows:

- Sub-Catchment A: Northern portion of the Cantonment. The primary drainage line is an un-named tributary of Doughboy Hollow Creek which flows in a northerly direction and discharges off-base at the northern Cantonment boundary. In addition to runoff via the un-named tributary of Dough Boy Hollow Creek, surface water runoff from the Cantonment during heavy rainfall events may occur via overland flow.
- Sub-Catchment B: Central portion of the Cantonment. The primary drainage line is an un-named tributary of Doughboy Hollow Creek which flows in a north-westerly direction and discharges off-base at the western Cantonment boundary down-gradient of the Helicopter Landing Ground (HLG).
- Sub-Catchment C: Southern portion of the Cantonment. The primary drainage line is the main watercourse of Doughboy Hollow Creek which flows in a north westerly direction and discharges off-base at the western Cantonment boundary in the vicinity of the landfill and former flame thrower range.

The catchments A, B and C are shown on Figure 4, Appendix C.

2.4 Regional Meteorology

As detailed in the AECOM DSI (2019a), the climate is characterised as temperate, with cool winters and warm summers. Winter months (May – October) are typically drier than summer months (November – April). The Bureau of Meteorology (BoM) at Singleton Military Defence Area (station number: 061430) has recorded the climate statistics on base since 2017, presenting a record of approximately 7 years. The following is a historic summary of temperature and rainfall data from this station:

- Mean monthly maximum temperatures have varied from 16.7°C in July to 28.6°C in January.
- Mean rainfall at the base is 713.6 mm per annum.
- Mean monthly rainfall is highest between October and March, averaging 87.92 mm per month, and lowest from May to July averaging 25.74 mm per month.
- The annual rainfall between January 2022 and January 2023 was 1154.2 mm*, wetter than the average for the base.



2.5 Hydrogeology

The consultant (AECOM 2019a) reported that the hydrogeology can be summarised into four notable subunits:

- The perched groundwater unit is an unconfined discontinuous perched zone within the sediments flanking creeks. Groundwater is present within the alluvium/colluvium flanking major water courses across the base. Recharge is mainly from rainfall and the zone periodically dries out following extended periods of low rainfall.
- The alluvial groundwater unit presents groundwater in the low-lying part of the base, within the alluvial sediments of the Hunter River floodplain. It is an unconfined aquifer and recharges predominantly from surface water. This zone has suitable yield used for irrigation, agriculture, and farming.
- In the weathered zone of the Permian bedrock lies the shallow groundwater unit where its presence is reliant on rainfall. The groundwater is perched above geological zones of low hydraulic conductivity such as clay or shale lenses within the bedrock. Groundwater quality within this unit is generally poor due to the leaching of salts from the Permian bedrock, which has been confirmed by the DSI (AECOM, 2019a) and sampling under the OMP.
- The deep groundwater unit forms the regional aquifer underlying the base. Rock porosity and the interconnection of void space highly dictates the flow of groundwater through this aquifer, followed by structural features in the rock.

The previous investigations and monitoring have indicated groundwater flows in a general northerly direction towards the Hunter River.

2.6 Soils and Geology

As outlined in the AECOM DSI (2019a), the base and its surrounding regions are situated in the northern part of the Sydney Basin, which is known for its Permian and Triassic-aged sedimentary rocks. The bedrock beneath the base belongs to the Narrabeen Group, consisting mainly of sandstone, with some conglomerate, claystone, and shale. Other less prominent rocks found in the area include quartzose sandstone from the Hawkesbury Sandstone, siltstone, and tuff. Extensive coal measures are also present, featuring black coal interbedded with sandstone, shale, mudstone, conglomerate, along with minor chert and tuff. The soils in the low-lying areas of the base are predominantly alluvial soils, along with yellow and red podzolic soils. In the southern part of the base, where the elevation is higher, the soil profiles are shallower and classified as shallow soils.

2.7 Management Areas

As defined in the PMAP (Defence 2021), the term 'Management Area' has been applied to two distinct areas:

- On-Base Management Area: which includes on- base areas where the PFAS sources were identified as follows:
 - Lone Pine Barracks:
 - o Former Cantonment Fire Station and surrounding area.
 - o Defence National Storage and Distribution Centre (DNSDC).
 - Alternate Landing Ground (ALG) and Associated Former Firefighting Training Area (FFTA).
 - o Helicopter landing ground (HLG).
 - Singleton Training Area (STA)
 - o Dochra Airfield.



2. <u>Off-base Management Area</u>: which includes private properties to the north, north-west and north-east of the base.

Management Areas are shown on Figure 3, Appendix C.

2.8 Surrounding Environment

As detailed in the PMAP (Defence 2021) the current land uses of the surrounding Off- base Management Areas are as follows:

- The grazing lands and floodplain areas of Whittingham and Glenridding, along with a Sewage Treatment Plant (STP) owned by Singleton Council, are situated to the north. The Whittingham Fire Station and airstrip are located 1 km and 1.3 km northeast, respectively.
- To the south of the base are the Pokolbin State Forest and the Broken Back Range, with Hunter Valley vineyards positioned further southeast.
- To the east, a combination of rural and semi-rural land holdings, including sparsely wooded open land and pasture, is found. The Hunter River, which irrigates the surrounding floodplain croplands, lies to the northeast.
- Immediately to the west of the base, grazing lands and irrigated croplands are situated within the floodplains of the Hunter River.

AECOM 2019a noted a number of potential offbase sources of PFAS as listed below:

- Hunter Valley Mines Rescue Facility, Singleton Heights;
- Singleton STP;
- Fire and Rescue NSW Singleton Station;
- Former Council sullage tip within the IA;
- Anecdotal reports of vehicle incidents on highways surrounding the SMA;
- Coal mine operators;
- Whittingham airstrip; and
- Whittingham Rural Fire Service

2.9 Audit Findings

The information provided by the consultants (AECOM 2019a) and in the PMAP (Defence 2021) in regards to the base condition and surrounding environment has been checked against, and adequately meets the requirements of EPA 2020¹. The information provided was also consistent with the observations made by the auditor during the base inspection conducted on the 26 August 2024.

Overall, the information provided in relation to base condition and the surrounding environment is considered adequate for the purposes of the investigation and monitoring works reviewed as part of this site audit.

¹ Consultants Reporting on Contaminated Land, NSW Environment Protection Authority, May 2020 (EPA 2020).



3. Conceptual Site Model

The National Environment Protection (Assessment of Site Contamination) Measure, NEPC, 1999 (as amended 2013, NEPC 2013) identifies a conceptual site model (CSM) as a representation of base related information regarding contamination sources, receptors, and exposure pathways between those sources and receptors. The development of a CSM is an essential part of all site assessments and remediation activities.

NEPC (2013) identified the essential elements of a CSM as including:

- Known and potential sources of contamination and contaminants of concern including the mechanism(s) of contamination;
- Potentially affected media (soil, sediment, groundwater, surface water, indoor and ambient air);
- Human and ecological receptors;
- Potential and complete exposure pathways; and
- Any potential preferential pathways for vapour migration (if potential for vapours identified).

The consultant presented a detailed CSM within the DSI (AECOM 2019a) which was used to inform the development of the PMAP and which is summarised below.

3.1 Sources of Contamination

Based on the base history review and base observations, the consultant identified a number of activities both on base and nearby that were the likely sources of the PFAS concentrations reported in soil, sediment, surface water and/or groundwater at the base.

Onbase sources included:

- AFFF use and storage/distribution associated with training at the former Cantonment Fire Station.
- AFFF use associated with maintenance activities, emergency response and ad hoc use at the Defence National Storage and Distribution Centre Compound.
- AFFF use associated with aircraft accidents and training emergency response activities at the Alternate Landing Ground (ALG).
- AFFF use associated with aircraft accidents and training emergency response activities at the Helicopter landing ground (HLG).
- AFFF use associated with aircraft accidents and training emergency response activities at Dochra Airfield.

Offbase sources included:

- Singleton Waste Water Treatment Plant, located 1 km north of the SMA.
- Former Council sullage tip, located adjacent to the north-eastern SMA boundary.
- Whittingham Fire Station, located 1 km north east of the SMA.
- Whittingham Airstrip, located 1.3k m north-east of the SMA.
- Anecdotal evidence of vehicle incidents on the highways surrounding the SMA.
- Fire and Rescue NSW, Singleton station, located 4 km north of the SMA.
- Hunter Valley Mines Rescue Facility, Singleton Heights, located 7 km north-west of the SMA.
- NSW Rural Fire Service, located in Bulga approximately 11 km west of the SMA.



• Coal Mine operations in Bulga and Mount Thorley, located adjacent to the western SMA boundary. Additionally, there are extensive coal mine operations in the Hunter Valley within the catchment of the Hunter River. There are also Power Stations within the catchment of the Hunter River.

The consultant also identified potential secondary sources as listed below:

- On base PFAS impacted shallow soil from surface runoff and or flooding.
- On base PFAS that have leached into concrete hardstand areas where AFFF was historically discharged or stored.
- Infiltration of surface water containing PFAS through fire training areas (e.g. pits or permeable hardstand/soft stand areas) other areas of historic AFFF discharge, and unlined swales/drains to groundwater.
- PFAS impacted sediments and surface water in on base drains.
- Off base surface water in creeks and swales containing PFAS.
- Off base groundwater containing PFAS.
- Sediments containing PFAS in off base drains and or creeks.
- Shallow soil with sorbed PFAS from surface run off and or flooding.
- Biota that have been exposed to PFAS resulting in bioaccumulation.
- Irrigation using surface water or groundwater with detectable concentrations of PFAS at off base locations.

3.2 Potentially Affected Media

The consultant (AECOM 2019a) identified that PFAS, where present, could occur in the following media:

- Fill materials;
- Underlying natural soils;
- Sediment;
- Groundwater; and
- Surface waters.

3.3 Potential Pathways for Migration

The consultant (AECOM 2019a) noted that enHealth (2019) states that ingestion of food and drinking water contaminated with PFAS are considered the major human exposure pathways, and that inhalation of dust and dermal contact with PFAS are considered minor exposure pathways for PFAS. The following potential exposure pathways have been identified:

- Ingestion (and dermal contact) with groundwater containing detectable concentrations of PFAS
 abstracted from privately owned bores for use as per the Water Use Survey results (domestic potable
 or non-potable purposes).
- Ingestion of home-grown produce and animal products (i.e. fruit and vegetables, poultry, livestock) irrigated with groundwater (or surface water) containing detectable concentrations of PFAS and grown and grown in soil containing detectable concentrations of PFAS.
- Ingestion of aquatic biota (fish, crustacea or plants) sourced from local waterways, including local ephemeral creeks containing detectable concentrations of PFAS.



- Incidental ingestion (and dermal contact) with surface water containing detectable concentrations of PFAS in dams that receive recharge from surface water runoff from the SMA or other off- base sources.
- Incidental ingestion (and dermal contact) with sediment containing detectable concentrations of PFAS
 in local waterbodies.
- Incidental ingestion (and dermal contact) with soil containing detectable concentrations of PFAS, including soils that have been irrigated with surface water and/or groundwater containing detectable concentrations of PFAS.
- Inhalation of soil derived dust (indoor and outdoor).
- Uptake and bioaccumulation of groundwater, surface water and/or pore water containing detectable concentrations of PFAS.
- Plant uptake of groundwater and/ or soil moisture containing detectable concentrations of PFAS.

The consultant also noted that as PFAS has the potential to bioaccumulate, human and ecological receptors can be exposed via multiple pathways.

3.4 Potential Risks

Based on human health and ecological risk assessments completed as part of the previous investigations, the following potential risks were identified who live off-base within the broader Study/Investigation Area (Defence 2021):

- Ingestion of home-grown red meat from sheep or cattle that have consumed water containing detectable PFAS, or have grazed in areas irrigated or flooded with water containing detectable PFAS
- Ingestion of home-grown milk from cows that have consumed water containing detectable PFAS, or have grazed in areas irrigated or flooded with water containing detectable PFAS
- Cumulative ingestion of home-grown red meat, of home-grown milk from cows from sheep or cattle
 and of eggs from home-grown backyard poultry that have consumed water containing detectable
 PFAS or have grazed / roamed in areas irrigated or flooded with water containing detectable PFAS.

In addition, a potential future risk (not known to occur at the time of the previous investigations) was identified in the form of possible future groundwater consumption.

The ecological risk assessment concluded low/minimal potential for direct or indirect risks to ecological receptors from exposure to PFAS.

As detailed in the AECOM 2025 Technical Memorandum, an updated water use survey at offsite location 30 Racecourse Lane, was requested by the EPA. It was found that PFAS concentrations in groundwater samples collected from bore MW056 at 30 Racecourse Lane, had increased compared to historical sampling events.

To understand current water usage at this site, several nearby stakeholders were contacted by AECOM in April 2025. Based on the most recent round of groundwater sampling, and the updated water use information obtained, AECOM revisited the 2021 HHERA and revised several hypothetical scenarios. It was concluded by AECOM, that despite the increased concentrations detected at groundwater bore location MW056, the risk profile for the typical scenarios remained unchanged, as low and acceptable.

3.5 Audit Findings

The CSM presented in the previous investigation report (AECOM 2019a) and which formed the basis of the PMAP (Defence 2021) is considered by the auditor to be adequately complete and addresses the relevant guideline requirements. The auditor notes that any CSM is based on the available information at the time it was presented, and the adequacy of the CSM and the risk profile posed by residual PFAS should be periodically reviewed as part of the ongoing monitoring program.



4. PMAP Response Actions

The PMAP (Defence 2021) identified five recommended Response Actions, which have been discussed in the following sections.

4.1 Response Action 1 - Data Gap Investigation at the Former Cantonment Fire Station

The PMAP stated that the data gap investigation should consider the use of rainfall simulation and the installation of lysimeters to estimate the quantum and significance of contribution of this source to PFAS concentrations in surface water at the base boundary.

To address the identified data gap at the former Cantonment Fire Station, the consultant undertook the following investigation.

4.1.1 Singleton Lone Pine Barracks – Former Cantonment Fire Station – Limited PFAS Soil Investigation (AECOM 2024c)

AECOM was engaged to undertake a limited PFAS Soil Investigation at the former Cantonment Fire Station (FCFS), at the Lone Pine Barracks.

The objectives of the investigation were to characterise PFAS impacts in shallow surface soils at the FCFS following the removal of hardstand and above ground structures, and to determine if additional stages of investigation at this location were necessary.

The scope of works comprised:

- Completion of a 20 x 20 m grid-based sampling across the footprint of the FCFS base area.
- Collection of 29 surface soil samples between 0.0-0.1 m bgs to provide high resolution lateral delineation of PFAS top-down impacts.
- Analysis of collected soil samples for total PFAS concentrations from National Association of Testing Authorities (NATA) accredited primary and secondary laboratories.
- Review of previous soil data collected during the Preliminary Site Investigation (AECOM 2019b²) and DSI (AECOM 2019a) against other source areas and shallow soil data to determine the relative significance of the impacts.
- Preparation of a technical memorandum to document the findings (AECOM 2024c).

Concentrations in all samples ranged from below laboratory limit of reporting (LOR) to 1.04 mg/kg. The highest concentrations were reported along the western extent of the investigation area.

All sample results were reported below the adopted human health screening criteria, with the exception of one sample (SS110), which exceeded the PFAS NEMP (2020) HIL C Public Open Space criteria for sum of PFOS and PFHxS (1.04 mg/kg). No exceedances of the PFAS NEMP 2020 ecological (direct exposure) criteria for PFOS or PFOA were reported. However, 11 sample exceeded the adopted ecological (indirect exposure) criteria for PFOS (0.14 mg/kg) ranging from 0.154 mg/kg to 0.911 mg/kg.

It was concluded that the single exceedance of the HIL C Public Open Space criteria presents a low risk to future users of the base. However, where possible, use of the land in areas for HIL C defined activities (e.g. recreational sport or field activities) should be avoided or appropriately controlled via on-base management practices.

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² Preliminary Site Investigation, Department of Defence, AECOM, 2019 (AECOM 2019b).



The consultant concluded that PFAS impacts in surface soils present a low risk to human and/or ecological receptors, noting that the FCFS footprint and surrounds were considerably disturbed soils and fill materials (following demolition of the facility) which were unlikely to support significant ecological value for secondary consumers.

4.1.2 Audit Comments

Data Usability Assessment

The auditor has undertaken a review of the QA/QC undertaken by the consultant (AECOM 2024c), which has been summarised in **Table 4.1 below** against the PARCC parameters (precision, accuracy, representativeness, comparability and completeness).

Table 4.1 Data Usability Assessment (AECOM 2024c)

Parameter	DQIs	Requirement	Auditor Assessment
Field and Lab QA/QC			
Precision	Intra- laboratory duplicates (blind)	Standard requirement of 1 per 20 samples, AECOM nominated a higher frequency of 1 per 10 primary samples. >5xLOR:30% RPD.	It was stated by the consultant that the elevated RPDs were likely attributable to heterogeneity of both analyte concentrations and soil particles within the sample matrix. In a number of instances analytical concentrations were reported close to the LOR. Elevated RPDs in these instances may be attributable to decreases in analytical precision as concentrations approach the LOR. The auditor concurs with the consultant's findings.
	Inter- laboratory duplicates (split)	Standard requirement of 1 per 20 samples, AECOM nominated a higher frequency of 1 per 10 primary samples. >5xLOR:30% RPD.	It was stated by the consultant that the elevated RPDs were likely attributable to heterogeneity of both analyte concentrations and soil particles within the sample matrix. In a number of instances analytical concentrations were reported close to the LOR. Elevated RPDs in these instances may be attributable to decreases in analytical precision as concentrations approach the LOR. The auditor concurs with the consultant's findings.
	Laboratory duplicates	1 per 20 samples. >5xLOR :30% RPD.	The consultant concluded that the requirement was met, and that the Relative Percentage Difference (RPD) were within acceptance limits. The auditor considers this acceptable.
	Laboratory method blanks	1 per 10 samples Results to be below laboratory LOR.	The consultant concluded that the requirement was met, and that the recoveries were within acceptance limits. The auditor considers this acceptable.
Accuracy	Laboratory matrix spikes (MS)	MS to be performed as required as NATA accreditation, generally one per 20 samples per batch. Recoveries to be within 70-130 % or 30-130 % (SVOCs).	It was stated by the consultant that matrix spike recoveries could not be determined as background level was ≥4 x spike level for numerous PFAS analytes grouped within methods EP231A - EP231D. The auditor considers this acceptable.
	Laboratory control samples (LCS)	LCS to be performed as required by NATA accreditation, generally one per 20 samples per batch. Recoveries to be within 70-130 % or 30-130 % (SVOCs).	No LCS recovery outliers were identified for the analysis completed. The auditor considers this acceptable.
Representativene ss	Sample storage and transport	Samples to be placed in an insulated container and chilled. Samples to be transported to laboratory under chain of custody conditions.	The temperature recorded on receipt of samples by the laboratory marginally exceeded the recommended temperature of 6 °C with a recorded result of 11.7 °C. It was noted that PFAS are non-volatile and therefore temperature is unlikely to influence analytical results. The auditor considers this acceptable.



Parameter	DQIs	Requirement	Auditor Assessment
Laboratory sample receipt advice Holding times		Collected at a rate of 1 per piece of decontaminated sampling equipment. Analysed for primary contaminants of concern. Laboratory results below the laboratory limit of reporting (LOR).	NA – A rinsate blank sample was not collected or submitted for analysis at the completion of the sampling day. Dedicated disposable equipment was however used to collect soil samples presenting negligible potential for cross contamination. The auditor considers this acceptable.
		No damaged containers. No samples submitted in containers which have not been chilled. No samples to be submitted without sufficient times to comply with recommended holding times.	Laboratory sample receipt advice provided by the nominated laboratories confirmed that all samples were received in suitable condition (with the exception of the marginal temperature exceedance discussed above) with completed chain of custody documentation provided in the reports. The auditor considers this acceptable.
		Samples to be extracted and analysed within recommended holding times.	A review of the consultant's COC documentation and laboratory reports indicates that all samples were analysed within their holding times for all analyses undertaken. No holding time exceedances were reported for the investigation programs. The auditor considers this acceptable.
Comparability	Standard operating procedures used throughout the project.	All samples	The auditor considers the approach acceptable.
	Analytical Method	Samples to be analysed using NATA accredited methodology.	The laboratories NATA accredited for the analyses completed. The auditor considers the approach acceptable.
	Consistent field staff	All samples	The auditor considers the approach acceptable.
	Limits of reporting appropriate and accurate	All samples	The auditor considers the LORs appropriate and acceptable.
Completeness	Laboratory documentat ion	All relevant laboratory documentation to be collated, including chain of custody records, sample receipt advice and analytical reports.	The consultant provided all relevant COC documentation; laboratory sample receipt advice; and full laboratory certificates in the reports. The auditor considers this acceptable.
	Soil description and COCs complete/a ppropriate	All samples	Completed. The auditor considers this acceptable.
	Data set to be 95% complete after validation	All samples	The consultant reported that this was achieved. The auditor considers this acceptable.

The quality assurance/quality control measures employed by the consultant (AECOM 2024c) were checked and found, overall, to adequately comply with the requirements outlined in EPA 2017 and 2020, NEPC 2013 and NEMP 2020. The laboratory QA/QC results have been reviewed and the results indicate that the analytical laboratories were achieving adequate levels of precision and accuracy. As such, the Auditor accepts that the data were of a suitable quality for the purpose of assessing the contamination status of surface soils at the former Cantonment Fire Station.



Auditor Opinions on the Limited PFAS Soil Investigation

Review of the DSI data (AECOM 2019a) typically showed that the highest concentrations of PFAS were detected at 0.5 m bgs (metres below ground level), and not at the ground surface. These concentrations then decreased at 1 m bgs and deeper sample intervals. The only reported health-based exceedance in this part of the base in the DSI was at 0.5 m bgs, with the corresponding surface concentration around an order of magnitude lower.

The PMAP (Defence 2021) further described the previous activities as, "firefighting training involving the excavation of shallow pits up to 1 metre below ground surface (m bgs), followed by ignition of solid fuels which were extinguished using AFFF formulations." The limited PFAS data gap investigation involved surface samples only.

However, the former Cantonment Fire Station was demolished around 2022, after the PMAP (Defence 2021) was prepared but before the limited soil investigation (AECOM 2024a) was undertaken. This resulted in the demolition and removal off all above ground infrastructure and associated ground surface disturbances. Due to this base disturbance, the Auditor considers that the previously recommended consideration of washdown tests and use of lysimeters to estimate the quantum and significance of this potential contamination source to be no longer valid or appropriate in the context of the altered base condition, and that the surface soil investigations, combined with the mass flux study undertaken (AECOM 2024d) and ongoing monitoring data provides much greater insights into this potential contamination source and its contribution to surface water PFAS concentrations at the base boundary.

Additionally, on review of nearby surface water PFAS results collected at SW003, SW028 and SW032, the Auditor confirmed that the PFAS results were either below the adopted LOR (limit of reporting) of 0.01 μ g/L, or the adopted recreational criteria of 10 μ g/L (NEPM 2020) for PFOA, with maximum concentrations of 0.008 μ g/L.

The Auditor considers that the Limited PFAS Soil Investigation Report (AECOM 2024c) was prepared with appropriate consideration to relevant guidelines, and that the data quality was suitable to assess the contamination status of this part of the base. Furthermore, it is considered that sufficient data was obtained to confirm that the residual low-level PFAS in soils at the FCFS pose a low risk to both human and ecological receptors. When considered in context with surface water data from both the previous investigations and the ongoing monitoring program, the Auditor considers that this part of the base contributes only minor amounts of PFAS in surface water at the base boundary.

The absence of additional sub surface soil analytical data collected during the additional soil investigations can be readily addressed through the normal CEMP (Construction Environmental Management Plan) framework required for any future construction works in this part of the base.

4.2 Response Action 2 - Review the Works Planned at the DNSDC as part of the SMA Mid Term Refresh

At the time of preparation of the PMAP (Defence 2021), part of the DNSDC compound was planned to be demolished as part of the SMA Mid Term Refresh. As such, it was considered at the time that it would be prudent to better understand the program of works before any remedial activities were planned, and that appropriate guidance should be provided to the SMA Mid Term Refresh project on the appropriate management of PFAS.

A workshop was held by Defence on 9 December 2024 to discuss the status of the recommended actions detailed in the PMAP. Item 2 for discussion was to provide guidance to the Commonwealth on PFAS management, should the Base mid-term refresh proceed. Defence confirmed that, at the time of preparation of this audit report, that the project is not proceeding, and that if this was to change in the future, these works would be covered by the Defence Construction and Maintenance Framework as administered by the PFASIM Estate Management Team (**Appendix B**).



4.2.1 Audit Comments

Based on the planned Mid Term Refresh project not proceeding, the Auditor accepts that a review of the works could not be undertaken to inform what/if any PFAS management actions may be required. Should this change in the future, then the Auditor considers it appropriate for the works to be managed under the Defence Construction and Maintenance Framework.

4.3 Response Action 3 - Undertake a Mass Flux Study

The PMAP stated that a mass flux study should be undertaken to understand the ongoing contribution of PFAS from the SMA and its source areas to the environment via partitioning of PFAS from soil to water via surface water drainage and groundwater.

To address the requirement, the consultant undertook the following surface water mass flux investigation.

4.3.1 Singleton Lone Pine Barracks – Surface Water Mass Flux Sampling – April and May 2024 (AECOM 2024d)

AECOM was engaged to install a telemetric autosampler and undertake a series of rainfall sampling events at one location at the Singleton Lone Pine Barracks area of the base, during the months of April and May 2024.

The objective of the surface water monitoring and sampling was to calculate the dissolved phase PFAS mass discharge at one location, SW034, an on- base monitoring point located downstream of identified on- base source areas, including the Former Cantonment Fire Station.

To meet the project objective, the following scope of works was undertaken:

- Installation of flow monitoring and telemetry equipment (completed in February 2024) at surface water location SW034.
- Collection of time-series surface water samples at SW034 during run-off event flow conditions during six rainfall events.
- Laboratory analysis for the PFAS extended suite using standard levels of detection.
- Data management and reporting.

Six surface water monitoring events were completed between 9th April and 6th May 2024.

It was concluded by the consultant that the surface water data collected during the monitoring events was reliable and representative of the conditions assessed and sampled during the event.

It was concluded by the consultant that the cumulative flow volume and estimated PFAS mass discharge were highest at SW034 during the final event (event 6). This event occurred following the largest amount of rainfall within the 48 hrs prior to the sampling event, in comparison to the prior sampling events. An estimated mean of 33 g of PFAS+PFHxS and 35 g of sum of PFAS were calculated to be discharged at the downstream base boundary across the rainfall events investigated.

4.3.2 Audit Findings

Based on review of the AECOM 2024d Mass Flux report, 12 July 2024, the Auditor notes that the mass flux sampling undertaken was from a single location (SW034) in one of the identified sub-catchments.

Based on review of the surface water analytical data presented in the OMR (AECOM 2024f), PFAS analytical results from surface water samples collected at SW034, were one of the highest consistent set of results, with the sum of PFAS ranging from <0.01 up to 2.29 μ g/L. The exceptions were SW032 which recorded up to 4.85 μ g/L and SW002 which recorded only marginally higher concentrations, with results up to 2.61 μ g/L. While these locations recorded higher sums of PFAS results, both locations fall within the same catchment (Catchment A) as SW034, and are also anticipated to flow towards SW034.



Based on data obtained as part of the DSI (AECOM 2021a) and further supported by ongoing monitoring data, the spatial distribution of PFAS detections in groundwater is limited and, in some cases isolated. As such, the Auditor considers that groundwater migration is not a significant transport mechanism off the Singleton Military Area. The primary PFAS migration pathway is via surface water and therefore the Auditor accepts that the mass flux study was appropriately focused on surface water, specifically at a location downstream/within the catchment of on-base PFAS source areas including the FCFS.

For these reasons, the Auditor considers that the mass flux assessment undertaken was sufficient to gain an understanding of the ongoing contribution of PFAS from the identified source areas to the environment via partitioning of PFAS from soil to water via surface water drainage with a maximum estimated annual mean of 33 g of PFOS+PFHxS and 35 g of sum of PFAS across the rainfall events investigated. The Auditor reviewed the methodology and calculations and accepts the mass flux estimates as correct/appropriate, and notes that the findings indicate relatively low levels of PFAS migration are occurring from the base.

4.4 Response Action 4 - Implement the OMP

The PMAP also stated a requirement to monitor changes in PFAS concentrations within the Management Area both in groundwater, in wastewater discharge and in surface water bodies that ultimately drain to the Hunter River and reginal groundwater. It also states a requirement to undertake community consultation as part of the OMP.

4.4.1 Sampling Event Factual Report, January 2023 (AECOM 2023a)

A Sampling Event Factual Report was prepared to report the results of the January 2023 biannual sampling event, specifically highlighting first-time detections and/or new exceedances of human health or ecological screening criteria for PFAS compounds.

The scope of works was completed generally in accordance with the SAQP (Sampling Analysis and Quality Plan) (AECOM, 2023b³), as follows:

- obtain permission (where required) to conduct works at the base, off- base publicly accessible areas and at private properties;
- Gauging of groundwater level in monitoring wells prior to collection of samples;
- Groundwater sampling and collection of water quality parameters at 3 of 4 scheduled monitoring wells;
- Surface water sampling and collection of water quality parameters at 14 of 20 scheduled surface water locations:
- Sediment sampling at 19 of 20 scheduled sediment locations;
- Wastewater effluent sampling at one scheduled location;
- Collection of field intra-laboratory duplicate samples at a rate of 1 in 10 primary samples;
- Collection of field inter-laboratory duplicate samples at a rate of 1 in 10 primary samples;
- Analysis of samples for PFAS full suite (28 analytes) at the standard limit of reporting (LOR);
- Data management of the OMP field and laboratory data in Defence ESdat database; and
- Preparation of the Sampling Event Factual Report.

³ Note: the SAQP was not provided to JBS&G for review.



Sampling was conducted in general accordance with the Sampling Plan, with only minor deviations do to access restrictions and the absence of surface water at some sampling locations.

4.4.2 Sampling Event Factual Report, July 2023 (AECOM 2024a)

A Sampling Event Factual Report was prepared to report the results of the July 2023 biannual sampling event. The scope of works was completed generally consistent with the January sampling round as listed above and in accordance with the SAQP (AECOM, 2023d).

4.4.3 Sampling Event Factual Report, January 2024 (AECOM 2024b)

A Sampling Event Factual Report was prepared to report the results of the January 2024 biannual sampling event. The scope of works was completed generally consistent with the previous sampling round as listed above and in accordance with the SAQP (AECOM, 2023d).

4.4.4 Ongoing Monitoring Report from July 2022 to June 2023 (AECOM 2025a)

The consultant (AECOM) was engaged to implement the Ongoing Monitoring Plan (OMP) for monitoring of PFAS at the base. The objective of the OMP was to set out a program of monitoring to continue to assess the changes in the nature and extent of PFAS within the environment, where Defence's historical use of legacy Aqueous Film Forming Foam (AFFF) has led to an identified potentially elevated risk to a receptor(s), or potential future risk.

AECOM completed two monitoring events of groundwater, surface water and sediment between July 2022 and June 2023. This monitoring targeted PFAS and included selected locations on-base and in surrounding off-base areas.

Based on groundwater data collected during the targeted gauging round on 19 July 2022, AECOM inferred local groundwater flow direction was to the north northeast towards the Hunter River. The flow directions are consistent with previous observations during the DSI (AECOM, 2019a) and other OMP monitoring events.

Overall, the concentrations of PFAS in groundwater were found by AECOM to be generally consistent with previous results, with the highest PFAS concentrations detected at monitoring wells located near the identified PFAS source areas. New maximum concentrations of PFAS were reported in MW048 at Defence National Storage and Distribution Centre, in MW126 located off-base on the northern boundary, in MW124 located off-base to the north, and in MW132 located off-base to the north-east.

It was reported that the surface water results were consistent with the DSI (AECOM, 2019a) findings with the highest concentrations close to source areas. Elevated concentrations were also reported at down-gradient locations, off-base to the northwest, within Singleton Sewage Treatment Plant (STP) effluent and surface water locations near the STP. There were first-time detections of PFAS in six surface water locations located on-base. There was also a first-time detection of PFOA in the off-base waste-water location (OTH006). New maximum PFAS concentrations were reported in two surface water locations (SW002 and SW026) located on-base

AECOM found that the sediment results were consistent with the DSI findings (AECOM, 2019) with the highest concentrations near the source areas. There were first-time detections of PFAS in six on-base sediment locations (SD002, SD040, SD114, SD115, SD116 and SD555) and two off-base sediment locations (SD047 and SD540 at the off-base STP). New maximum PFAS concentrations were reported in seven on-base sediment locations (SD005, SD032, SD046, SD047, SD055, SD115 and SD555) and three off-base sediment locations (SD047, SD080 and SD539) to the north-west and at the off-base STP.

PFAS concentrations within the on-base and off-base groundwater, surface water and sediment were found by AECOM to be similar to historical results. There was no increasing or decreasing trends identified in PFAS concentrations in groundwater. Where there were new exceedances, new maximum or new minimum results of PFAS concentrations in groundwater or surface water, the results were within an order of magnitude of historical results.



Based on this data set, there was no discernible trend in sediment concentrations identified, with most locations with three or more results showing a fluctuating pattern. However, it is noted that an increase in the concentrations of PFOS+PFHxS were reported in four surface water locations (SW002, SW026, SW032 and SW034) on-base, when compared to previous monitoring events. It was recommended that further monitoring of these locations was required to assess whether there is an increasing trend or simply just fluctuations in concentrations, which may be attributable to seasonal rainfall.

It was noted that the Former Cantonment Fire Station and associated outbuildings were demolished prior to the July 2022 event which included PFAS impacted building material (concrete and asphalt hardstand). The insitu soils remaining at this location were sampled, concluding no further works were required due to the low levels of PFAS reported (AECOM 2024c).

Based on the data, AECOM considered that the conclusions made in the DSI (AECOM, 2019a) still applied and that the CSM and interpretive analysis supported the known risk profile. AECOM considered that the data collected during the monitoring period was representative of base conditions at the time of sampling and suitable for meeting the objectives of the OMP.

4.4.5 Ongoing Monitoring Report from July 2023 to June 2024 (AECOM 2025b)

AECOM completed an additional two monitoring events of groundwater, surface water and sediment sampling between July 2023 and June 2024 in accordance with the AECOM SAQP (2023d), consistent with the previous monitoring round discussed above.

PFAS concentrations in groundwater were consistent with previous results in the majority of locations sampled with the exception of two off-base well locations which reported new maximum concentrations. The reason for the new maximums was reported as unknown, and subsequent re-sampling has indicated that the concentrations may be anomalous. The highest PFAS concentrations detected during the monitoring period were reported on-base, along the northern boundary of the base.

The potential risk to off-base users of groundwater remained unchanged given that the concentrations of PFAS were below the adopted exposure point concentrations presented in the site-specific Human Health and Ecological Risk Assessment (HHERA) (AECOM, 2021⁴).

PFAS concentrations within the on-base and off-base surface water were similar to historical results.

PFAS concentrations in sediments both on and off the base fluctuated but remained within or the same order of magnitude of historical ranges or close to detection limits and present no further risks to people or the environment.

While there was localised changes in PFAS concentrations during the monitoring period (between July 2023 and June 2024), the CSM and overarching risk profile were considered to remain unchanged.

4.4.6 Audit Findings

The various monitoring reports reviewed as part of this audit confirm that the Ongoing Monitoring Program (OMP) was undertaken to monitor changes in PFAS concentrations in accordance with the requirements of the PMAP (Defence 2021). Evidence of community consultation was also sighted by the Auditor, including additional water use surveys and publishing factsheets and monitoring reports and factsheets on Defence's website for the Singleton Military Area⁵. As such, the Auditor considers that the OMP consultation requirement of the PMAP (Defence 2021) has been met.

⁴ Human Health and Ecological Risk Assessment, Singleton Military Area, Department of Defence, AECOM, December 2021 (AECOM 2021).

⁵ https://www.defence.gov.au/about/locations-property/pfas/pfas-management-sites/singleton-military-area, visited 21/3/2025



4.5 Response Action 5 - Work with NSW Government and other Stakeholders to Evaluate the Significance of Current Data Gaps

The PMAP (Defence 2021) mentions this assessment would focus on groundwater impacts above the health based guidance values in the north eastern part of the Management Area as identified during the DSI Addendum (AECOM 2021) and understand the contribution of PFAS from the Singleton STP.

Results from the ongoing monitoring program are shared with the NSW Government and are provided in an Ongoing Monitoring Report, available on the Defence Website for the Singleton Military Area (**Appendix B**). The OMP also contains triggers and actions required to be undertaken if certain results are obtained from the ongoing monitoring, including notification requirements to the EPA and other agencies.

4.5.1 Audit Findings

Based on the completion of the additional investigations at the former Cantonment Fire Station (AECOM 2024c), the mass flux investigation completed in the northern part of the base (AECOM 2024d) and undertaking periodic monitoring as part of the ongoing monitoring program (shared with NSW Government and other stakeholders), the Auditor considers that steps have been taken to addressing this action and that understanding the groundwater impacts in the north eastern part of the management area and the contribution of PFAS from the Singleton STP remains an ongoing endeavour appropriately captured in the ongoing monitoring program.

4.6 Updated PFAS Ongoing Monitoring Plan (Defence 2025)

The PMAP (Defence 2021) included an Ongoing Monitoring Plan (OMP) to document ongoing monitoring requirements for PFAS in the environment and to assess for changes in risks to human and ecological receptors from PFAS originating from the base.

Following the completion of the monitoring program over a 3 year period (2022 – 2025), an OMP (Defence 2025) was prepared to replace the previous OMP, having regard to the results, trends and conclusions obtained from the monitoring program.

The updated OMP (Defence 2025) sets out the requirements for collection of adequate data to identify and evaluate the following:

- Spatial, and temporal (including seasonal) variability of PFAS in the environment;
- Changes to sources, transport pathways and/or receptors, described as a conceptual site model for the base;
- Whether risks to human and ecological receptors require review;
- The influence that risk management activities at the base, as outlined in the PMAP (Defence, 2021) have had on PFAS in the environment; and
- Whether the identified changes trigger an action and/or review.

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

A excerpt of the summary of the monitoring changes presented in the updated OMP is provided in **Table 4.2** below, along with the associated groundwater monitoring rationale (**Table 4.3**), noting this remains an area of ongoing consultation with relevant NSW government stakeholders.



Table 4.2 Summary of Existing and Proposed Monitoring Intervals and Associated Rationale (Defence 2025)

Sample Media	Existing Monitoring Interval	Proposed Monitoring Interval Under this OMP	Rational for Change
Groundwater (selected monitoring wells and residential bores)	Bi-annual and biennial monitoring	Annual monitoring of all existing and accessible OMP locations	Concentrations of PFAS in groundwater, surface water and sediment at the base demonstrates limited variability in response to rainfall since monitoring commenced under the
Surface Water (including wastewater sampling)	Bi-annual monitoring		OMP. Monitoring of all media during Autumn is deemed appropriate based on the historical data, the CSM and the risk profile remains unchanged.
Sediment	Bi-annual monitoring		unchangeu.

Table 4.3 Rationale for Groundwater Monitoring (Defence 2025)

On-base (Cantonment)	Continue to monitor groundwater wells to develop temporal datasets to assist with better understanding of temporal patterns in PFAS concentrations Assess if PFAS concentrations in groundwater within and downgradient of the Cantonment source areas (former Cantonment Fire Station, ALG, DNSDC, and HLG) change in response to management measures, or other base activities, over time Provide early warning of PFAS concentrations migrating from the Cantonment to the Off-Base Management Area Assess if background conditions change over time
On-base (STA)	Continue to monitor groundwater wells to assist with understanding of temporal trends in PFAS concentrations
	Assess if PFAS concentrations in groundwater within and downgradient of Dochra Airfield change in response to management measures, or other base activities, over time Provide early warning of PFAS concentrations migrating from the STA to off-base areas to the north
Northern boundary of SMA, and off-base to the north	 Continue to monitor groundwater wells to understand potential changes in PFAS concentrations at the base boundary and at off-base locations to the north within the Off-Base Management Area (pastureland towards the STP) Sentinel wells along northern Cantonment boundary will provide early warning of PFAS concentrations migrating from the SMA boundary into the Off-Base Management Area.
West and northwest of the Cantonment (off- base)	Continue to monitor groundwater wells to assist with understanding of temporal trends in PFAS concentrations Provide early warning of PFAS concentrations migrating from the Cantonment boundary to the west and northwest portions of the Off-Base Management Area (towards Glenridding)
East and northeast of the Cantonment (off- base)	Continue to monitor groundwater wells to assist with understanding of temporal trends in PFAS concentrations Monitor groundwater wells on transects parallel and perpendicular to the Cantonment and off-base plume (Whittingham), to confirm that the Cantonment is not contributing to off-base PFAS impacts at Whittingham, or migration via groundwater



Key elements of the updated OMP are highlighted as follows:

- Defence would continue to consult with NSW Government and other stakeholder during the update and implementation of the OMP, and that the reports developed as part of the implementation would continue to be provided to NSW government for review and feedback, to address PMAP Response Action 5 above.
- Some minor changes to surface water sampling numbers were made, however, the total number of monitoring locations remain comparable, with additional samples collected at the northern cantonment boundary, the north eastern cantonment boundary and 2 less samples collected at the southern cantonment.
- Some minor changes were also made to the sediment sampling locations with the same number of samples collected overall.
- Reduction of the sampling rounds from biannual to annual, based on the trends established in the prior 4 year monitoring period.
- The OMP triggers and response actions were modified to more clearly define response actions including additional sampling, review of CSM and risk profile due to the potential future identification of drinking water sources.

4.6.1 Audit Findings

The most recent OMP (Defence 2025) provides substantial rationale as to why it is considered appropriate to reduce both the sampling frequency and the number of groundwater sampling locations from the previous sampling rounds. Up to 31 locations were previously sampled twice per year with a recent reduction down to 4 out of 5 scheduled locations, plus an additional 2 unscheduled locations – i.e., a total of 6 wells (AECOM 2024f).

The Auditor considers that, throughout the previous monitoring program, sufficient data has been collected to justify the proposed revisions to the updated OMP, specifically around the reduced monitoring frequency. This has been supplemented by the findings of the additional investigations around the former Cantonment Fire Station (AECOM 2024c) and the mass flux assessment (AECOM 2024d) which indicate low source concentrations within this potential source area and the relatively low levels of PFAS migration from the base, respectively.

Further to this, the Auditor considers that the updated OMP includes appropriate monitoring methodologies and assessment criteria; sufficiently clear delegated responsibilities; and the required triggers and response actions are appropriate.



5. Audit Summary Opinions

Based on the information reviewed as part of this Site Audit and subject to the limitations in **Section 6**, the following summary audit conclusions are made:

PMAP Response Action 1 – Data Gap Investigation at the Former Cantonment Fire Station

The former Cantonment Fire Station was demolished around 2022, after the PMAP (Defence 2021) was prepared. Due to the change in ground conditions in this part of the base arising from the demolition and removal off all above ground infrastructure, the Auditor considers that the previously recommended consideration of washdown tests and use of lysimeters to estimate the quantum and significance of this potential contamination source is no longer valid or appropriate, and that the surface soil investigations (AECOM 2024c), combined with the mass flux study undertaken (AECOM 2024d) and ongoing monitoring data provides much greater insights into this potential contamination source and its contribution to surface water PFAS concentrations at the base boundary.

The Auditor considers that the Limited PFAS Soil Investigation Report (AECOM 2024c) was prepared with appropriate consideration to relevant guidelines, and that the data quality was suitable to assess the contamination status of this part of the base. Furthermore, it is considered that sufficient data was obtained to confirm that the residual low-level PFAS in soils at the former Cantonment Fire Station pose a low risk to both human and ecological receptors. When considered in context with surface water data from both the previous investigations and the Ongoing Monitoring Program (OMP), the Auditor considers that this part of the base contributes only minor amounts of PFAS in surface water at the base boundary.

The absence of additional sub surface soil analytical data collected during the additional soil investigations can be readily addressed through the normal Defence Construction and Maintenance Framework required for any future construction works in this part of the base.

PMAP Response Action 2 - Review of Works Planned at DNSDC as part of the SMA Mid Term Refresh

Based on the planned Mid Term Refresh project not proceeding, the Auditor accepts that a review of the works could not be undertaken to inform what/if any PFAS management actions may be required. Should this change in the future, then the Auditor considers it appropriate for the works to be managed under the Defence Construction and Maintenance Framework.

PMAP Response Action 3 – Undertake a Mass Flux Study

Based on data obtained as part of the DSI (AECOM 2021a) and further supported by ongoing monitoring data, the spatial distribution of PFAS detections in groundwater is limited and, in some cases isolated. As such, the Auditor considers that groundwater migration is not a significant transport mechanism off the Singleton Military Area. The primary PFAS migration pathway is via surface water and therefore the Auditor accepts that the mass flux study was appropriately focused on surface water, specifically at a location downstream/within the catchment of on-base PFAS source areas including the former Cantonment Fire Station.

For these reasons, the Auditor considers that the mass flux assessment undertaken was sufficient to gain an understanding of the ongoing contribution of PFAS from the identified source areas to the environment via partitioning of PFAS from soil to water via surface water drainage with a maximum estimated annual mean of 33 g of PFOS+PFHxS and 35 g of sum of PFAS across the rainfall events investigated. The Auditor reviewed the methodology and calculations and accepts the mass flux estimates as correct/appropriate, and notes that the findings indicate relatively low levels of PFAS migration are occurring from the base.

PMAP Response Action 4 – Implement the OMP

The various monitoring reports reviewed as part of this audit confirm that the Ongoing Monitoring Program (OMP) was undertaken to monitor changes in PFAS concentrations in accordance with the requirements of the PMAP (Defence 2021). Evidence of community consultation was also sighted by the Auditor, including additional water use surveys and publishing factsheets and monitoring reports and factsheets on Defence's



website for the Singleton Military Area. As such, the Auditor considers that the OMP consultation requirement of the PMAP (Defence 2021) has been met.

PMAP Response Action 5 – Work with NSW Government and other Stakeholders

Based on the completion of the additional investigations at the former Cantonment Fire Station (AECOM 2024c), the mass flux investigation completed in the northern part of the base (AECOM 2024d) and undertaking periodic monitoring as part of the ongoing monitoring program (shared with NSW Government and other stakeholders), the Auditor considers that steps have been taken to addressing this action and that understanding the groundwater impacts in the north eastern part of the management area and the contribution of PFAS from the Singleton STP remains an ongoing endeavour appropriately captured in the ongoing monitoring program.

Updated Ongoing Monitoring Plan (Defence 2025)

The Auditor considers that, throughout the previous monitoring program, sufficient data has been collected to justify the proposed revisions to the updated OMP, specifically around the reduced monitoring frequency. This has been supplemented by the findings of the additional investigations around the former Cantonment Fire Station (AECOM 2024c) and the mass flux assessment (AECOM 2024d) which indicate low source concentrations within this potential source area and the relatively low levels of PFAS migration from the base, respectively.

Further to this, the Auditor considers that the updated OMP (Defence 2025) includes appropriate monitoring methodologies and assessment criteria; sufficiently clear delegated responsibilities; and the required triggers and response actions are appropriate.



6. Limitations

This audit was conducted with a reasonable level of scrutiny, care and diligence on behalf of the client for the purposes outlined in the *Contaminated Land Management Act 1997*. The data used to support the conclusions reached in this audit were obtained by other consultants and the limitations which apply to the consultant's report(s) apply equally to this audit report.

Every reasonable effort has been made to identify and obtain all relevant data, reports and other information that provide evidence about the condition of the base, and those that were held by the client and the client's consultants, or that were readily available. No liability can be accepted for unreported omissions, alterations or errors in the data collected and presented by other consultants. Accordingly, the data and information presented by others are taken and interpreted in good faith.

Sampling and chemical analysis of environmental media is based on appropriate guidance documents made and approved by the relevant regulatory authorities. Conclusions arising from the review and assessment of environmental data are based on the sampling and analysis considered appropriate based on the regulatory requirements.

Limited sampling and laboratory analyses were undertaken as part of the investigations reviewed, as described herein. Ground conditions between sampling locations and media may vary, and this should be considered when extrapolating between sampling points. Chemical analytes are based on the information detailed in the base history. Further chemicals or categories of chemicals may exist at the base, which were not identified in the base history and which may not be expected at the base.

Changes to the subsurface conditions may occur subsequent to the investigations described herein, through natural processes or through the intentional or accidental addition of contaminants. The conclusions and recommendations reached in this audit are based on the information obtained at the time of the investigations.

This report does not provide a complete assessment of the environmental status of the base, and it is limited to the scope defined herein. Should information become available regarding conditions at the base including previously unknown sources of contamination, JBS&G and the Site Auditor reserve the right to review the report in the context of the additional information, subject to meeting relevant guideline requirements imposed by the EPA.



Appendix A Guidelines Made or Approved by the EPA

Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Paper No 4, 2000 (ANZECC/ARMCANZ 2000)

Australian Drinking Water Guidelines 6 2011, National Health and Medical Research Council and National Resource Management Ministerial Council, Version 3.9, Updated December 2024 (NHMRC/NRMMC 2024)

Composite Sampling, Lock, W. H., National Environmental Health Forum Monographs, Soil Series No.3, 1996, SA Health Commission, (NEHF 1996)

Contaminated Land Guidelines: Sampling Design Part 1 - Application, NSW EPA, 2022 (EPA 2022)

Contaminated Sites: Guidelines for the Vertical Mixing of Soil on Former Broad-Acre Agricultural Land, NSW EPA, 1995 (EPA 1995)

Contaminated Sites: Guidelines for the Assessment and Clean Up of Cattle Tick Dip Sites for Residential Purposes, NSW Agriculture and CMPS&F Environmental, February 1996 (NSW Agr. 1996)

Contaminated Land Guidelines: Consultants Reporting on Contaminated Land, NSW EPA, 2020 (EPA 2020)

Contaminated Sites: Guidelines for Assessing Banana Plantation Sites, NSW EPA, 1997 (EPA 1997)

Contaminated Sites: Guidelines for Assessing Former Orchards and Market Gardens, NSW EPA, 2005 (EPA 2005)

Contaminated Land Management: Guidelines for the NSW Site Auditor Scheme (3nd Edition), NSW EPA, 2017 (EPA 2017)

Contaminated Sites: Guidelines for the Assessment and Management of Groundwater Contamination, NSW EPA, March 2007 (EPA 2007)

Contaminated Sites: Guidelines on the Duty to Report Contamination under the Contaminated Land Management Act 1997, NSW EPA, September 2015 (EPA 2015)

Environmental Health Risk Assessment: Guidelines for assessing human health risks from environmental hazards, Department of Health and Ageing and EnHealth Council, Commonwealth of Australia, June 2012 (EnHealth 2012)

National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended 2013, National Environment Protection Council (NEPC 2013)



Appendix B Audit Correspondence



Singleton Site Transition Plan

Table 1. Status of 2021 PMAP recommended actions

Action	Description	Status	Reason / timeframe
Data Gap Investigation at the Former Cantonment Fire Station.	The data gap investigation should consider the use of rainfall simulation and the installation of lysimeters to estimate the quantum and significance of contribution of this source to PFAS concentrations in surface water at the Base boundary.	Complete	Investigations undertaken at the Former Cantonment Fire Station (FCFS) as part of the Detailed Site Investigation (DSI) (AECOM, 2021a) identified low concentrations of PFAS in subsurface soils within the FCFS with the exception of one location (CNN0018_TP04) which reported one exceedance of the adopted human health criterion. The DSI considered some further investigation was warranted at the FCFS and this was identified as a recommended action in 2021 PMAP.
			In 2022, Defence demolished and removed all above ground surface infrastructure and hardstand surfaces at the FCFS.
			A soil sampling investigation was completed in early 2024 to characterise PFAS impacts in shallow surface soils at the FCFS following the removal of hardstand and above ground structures (AECOM, 2024a). The investigation demonstrated that PFAS impacts in surface soils present a low risk to human and the environment.
			Based on the limited mass of PFAS identified in surface soils at the FCFS, further investigation into PFAS runoff from this area was not considered warranted. Additionally, a mass flux study was being completed concurrently to understand PFAS mass leaving the Base boundary via surface water.
Review the works planned at the DNSDC as part of the SMA Mid Term Refresh.	Part of the DNSDC compound is planned to be demolished during 2021 as part of the Singleton Military Area Mid Term Refresh. As such, it is prudent this program of works is better understood before any remedial activities are planned. Appropriate guidance should be provided to the Singleton Military Area Mid Term	Reconsidered	The Mid Term Refresh project is no longer going ahead at the Singleton Military Area. If this project were to go ahead in the future, any PFAS impacted material can be managed by the Defence Construction and Maintenance Framework developed in general accordance with the PFAS National Environmental Management Plan (PFAS NEMP).

	Action	Description	Status	Reason / timeframe
		Refresh project on the appropriate management of PFAS.		
3.	Undertake a Mass Flux Study.	A mass flux study should be undertaken to understand the ongoing contribution of PFAS from the Singleton Military Area and its source areas to the environment via partitioning of PFAS from residual soil mass to water via surface water drainage and groundwater.	Complete	A mass flux study was completed between April and May 2024 to understand the ongoing contribution of PFAS from the Singleton Military Area to the surrounding environment. As identified during the DSI (AECOM, 2021a and 2021b) and further support from ongoing monitoring data, the spatial distribution of PFAS detections in groundwater is limited and, in some cases isolated. As such, it is considered unlikely that groundwater migration is a significant transport mechanism off the Singleton Military Area. The primary PFAS migration pathway is via surface water and therefore the mass flux study was focused on surface water, specifically at a location downstream/within the catchment of on-base PFAS source areas including the FCFS. This location was considered to be representative of PFAS mass discharging from the Singleton Military Area to the surrounding environment. The mass flux study estimated a mean of 33 g of PFOS+PFHxS and 35 g of sum of PFAS discharging at the downstream base boundary during a rainfall event.
4.	Implement the Ongoing Monitoring Plan (OMP)	To monitor changes in PFAS concentrations within the Management Area, in groundwater, in wastewater discharge and in surface water bodies that ultimately drain to the Hunter River and regional groundwater.	Ongoing	Defence continues to monitor PFAS concentrations in the environment at the Singleton Military Area through an ongoing monitoring program. This allows for the timely identification and management of emerging risks and informs Defence's approach to the management of PFAS. Monitoring requirements are outlined in an Ongoing Monitoring Plan (OMP). The OMP is reviewed regularly and, if required, amended to ensure it continues to provide the data needed to monitor important changes in PFAS concentrations and distribution.
5.	Work with NSW Government and other stakeholders to evaluate the significance of current data gaps.	This assessment would focus on groundwater impacts above the health-based guidance values in the north eastern part of the Management Area as identified during the DSI	Ongoing	The results from the ongoing monitoring program are shared with the NSW Government and are provided in an Ongoing Monitoring Report, available on the Defence website. The Ongoing Monitoring Report provides the PFAS data, and an analysis of what important changes in concentrations may mean to the profile of PFAS contamination set out in the Conceptual

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Action	Description	Status	Reason / timeframe
	Addendum (AECOM, 2021b) and understand the contribution of PFAS from the Singleton STP.		Site Model (CSM), or potential changes to risks to humans or the environment.
			Additionally, the OMP outlines triggers and actions that Defence will undertake if certain results or trends are reported from the ongoing monitoring program sampling. This includes actions to confirm the accuracy of results, notification to the NSW Environment Protection Authority and other agencies upon new PFAS detections or increasing trends, and implementing additional investigations and risk management actions if the monitoring data indicates changes to the current risk profile.

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Appendix C Figures

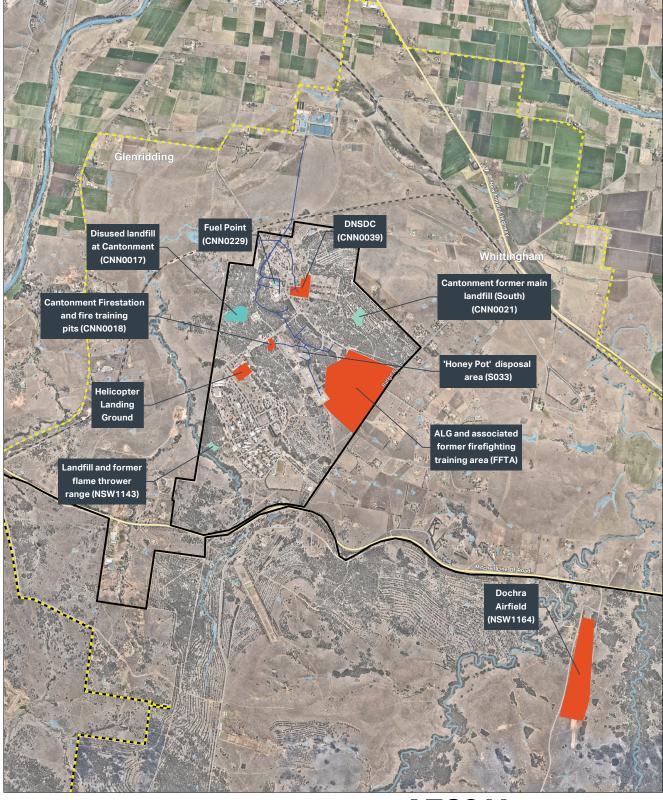


FIGURE 2: PMAP Source Areas

AECOM



Highways

■ PMAP Source

— Main Roads

Source Area

Local Roads - - Railway

Investigation Area

■ Property Boundary Watercourses

Waterbody

State Forest

Sewer

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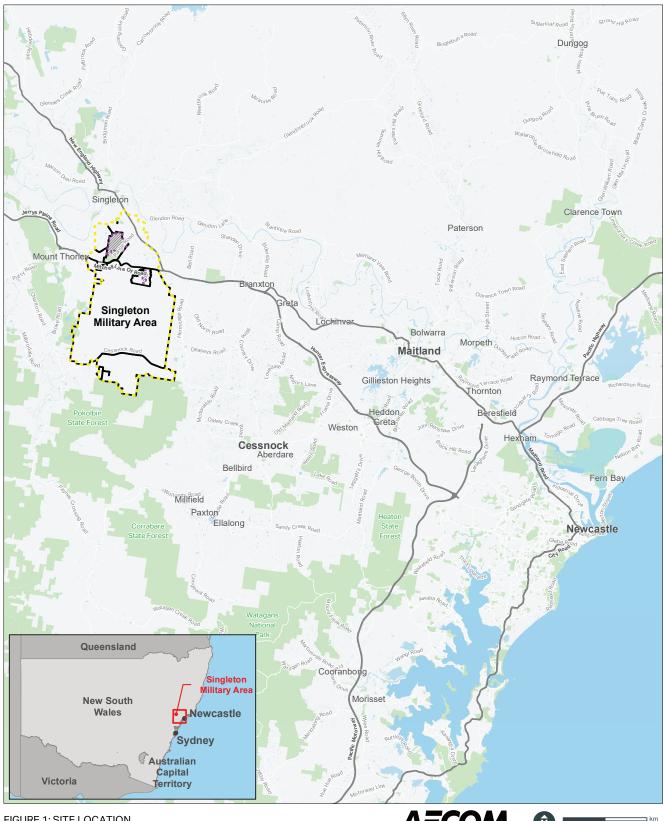


FIGURE 1: SITE LOCATION

AECOM 0 -



Legend ■ Property boundary Highways Former Investigation Area Main Roads Waterbody On-Site Management Area Parks, Forests and Parks, r o. Reserves

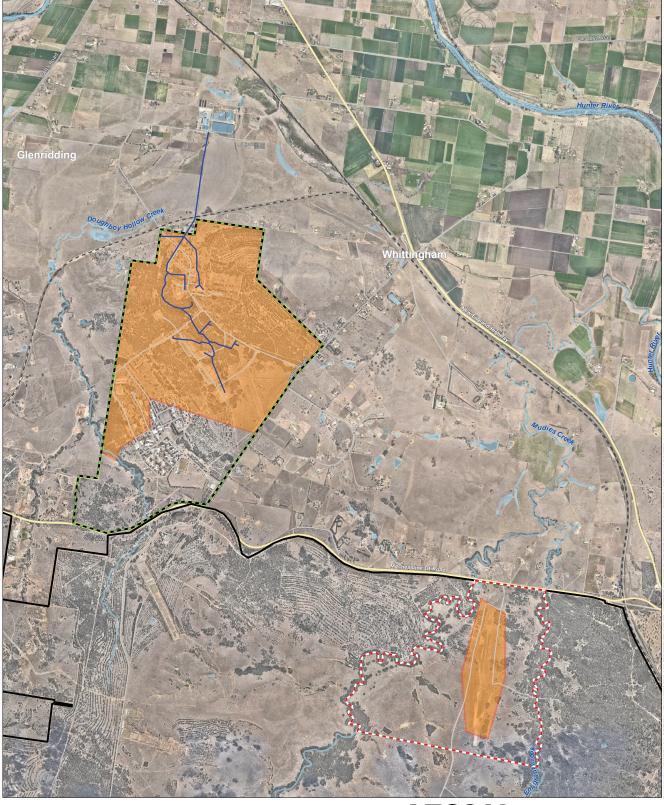


FIGURE 3: MANAGEMENT AREA

AECOM



Highways

— Main Roads

Local Roads

- - Railway

Waterbody

 Watercourses - Sewer

■ Property Boundary

- Dochra Airfield Investigation
- Boundary

Cantonment Boundary

On-Site Management Area

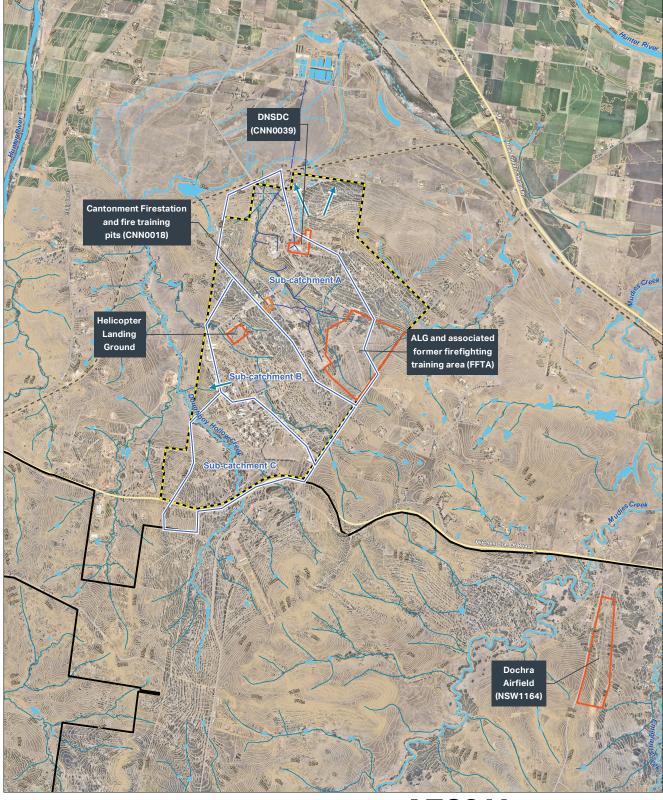


FIGURE 4: CANTONMENT CATCHMENTS

AECOM



Cantonment Boundary

☐ Property Boundary

CSR boundaries

State Forest

Contours (1m)

→ Overland flow

Waterbody

— Drainage line

Watercourses

-- Undefined Drainage Lines

- Catchment Boundaries

_ Sewer

- - Railway

Highways

Main Roads

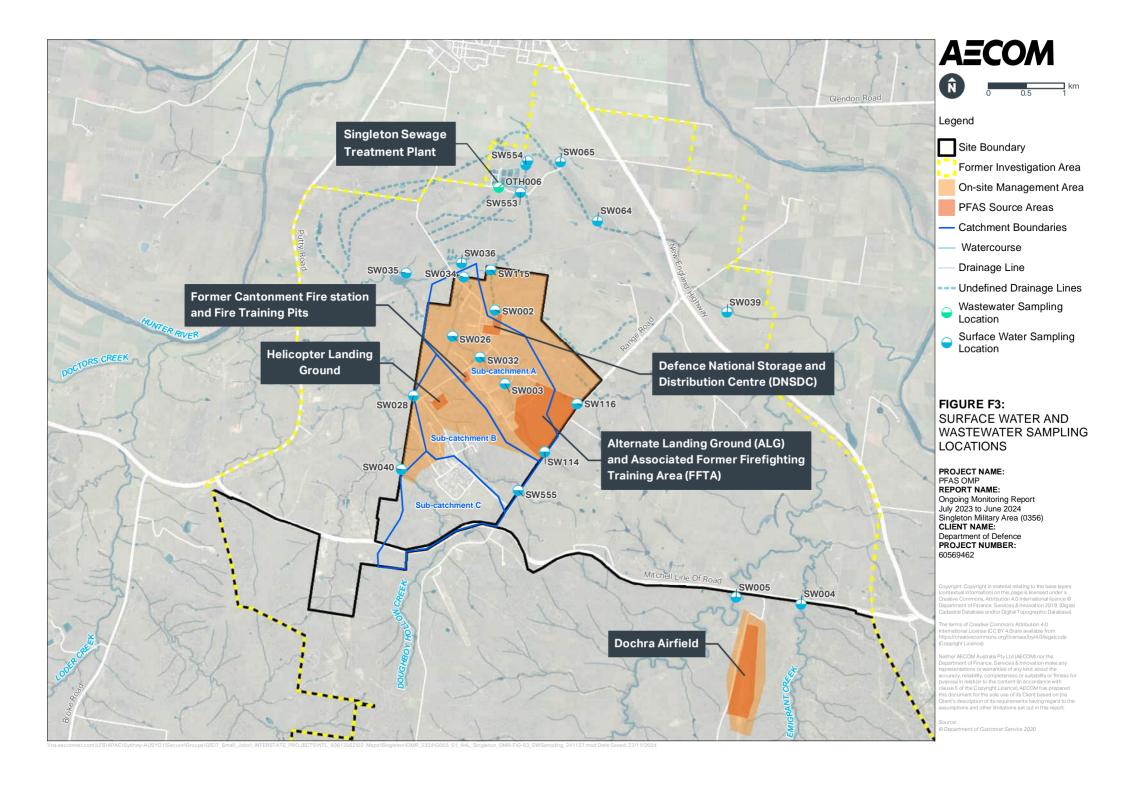
— Local Roads

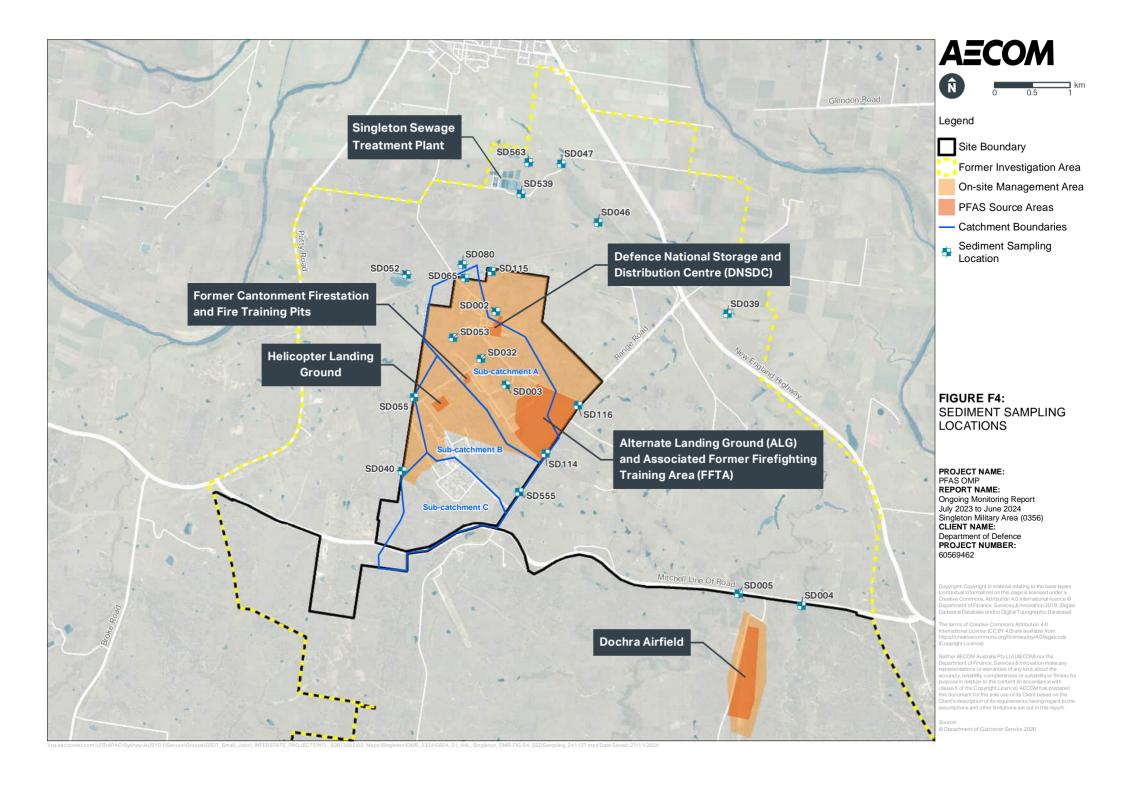
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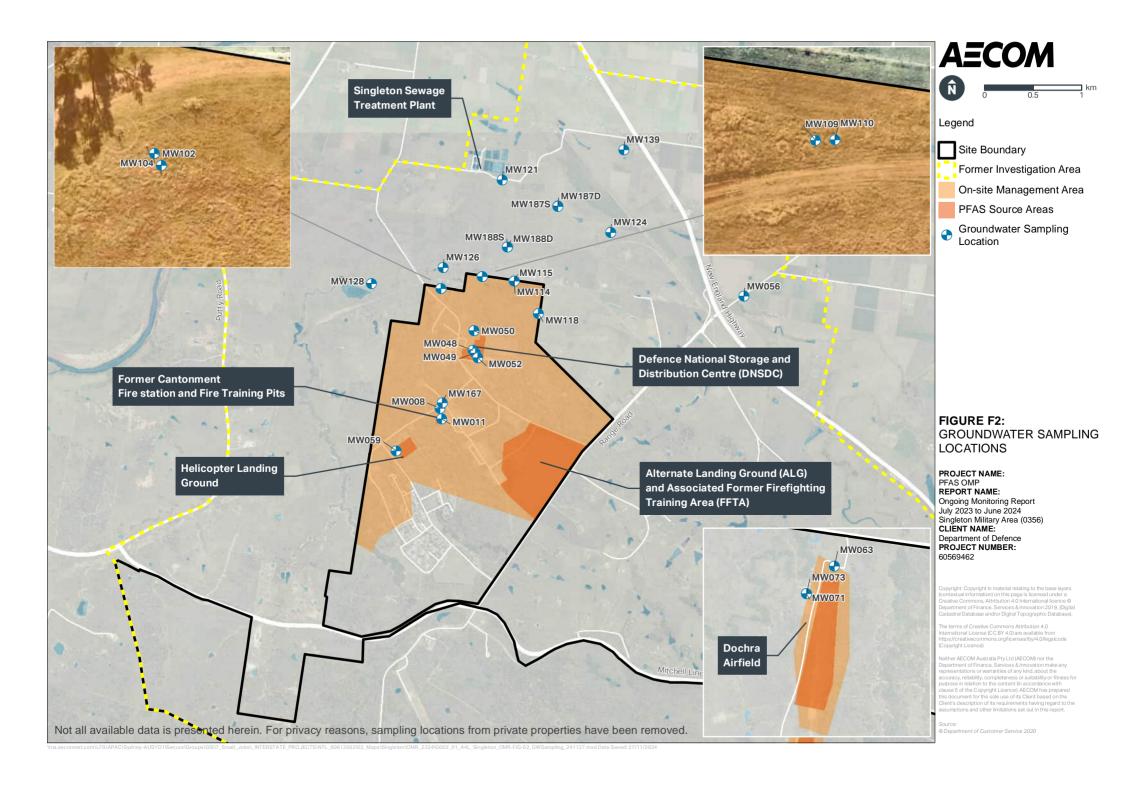
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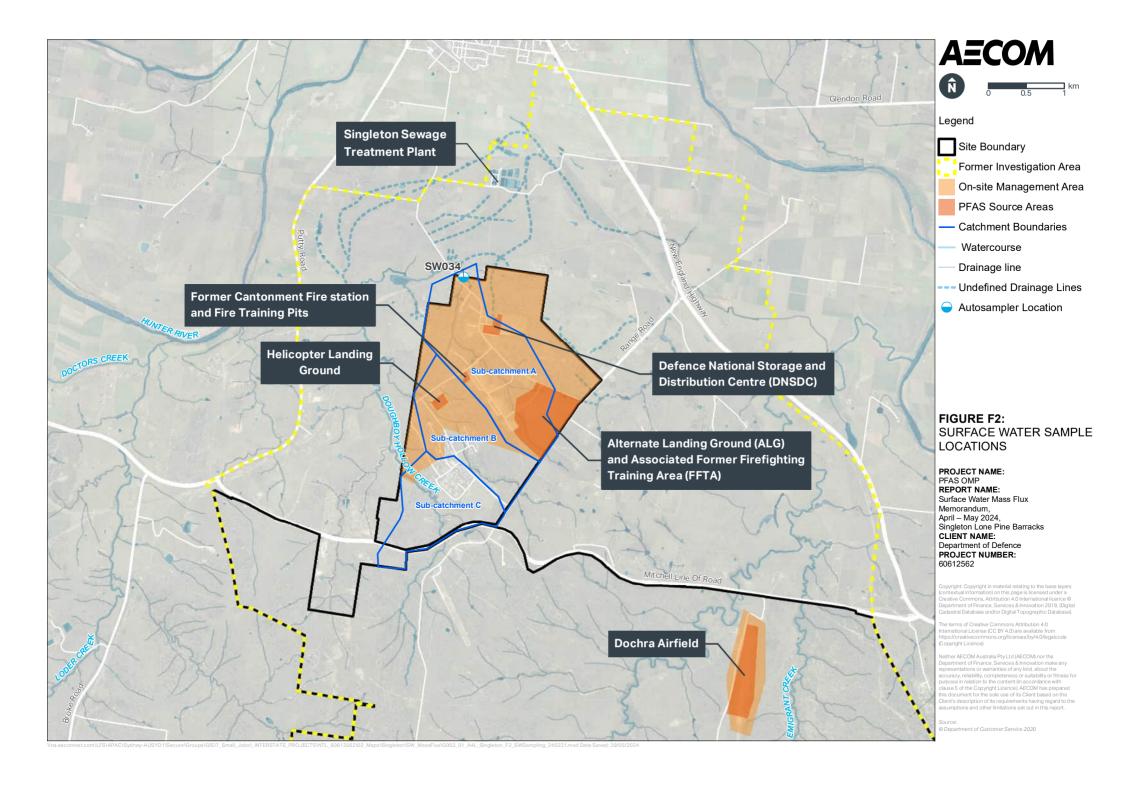
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		Consultant to Defence	
		Richard.lamont1@defence.gov.au	
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		Regional Coordinator NSW/ACT	
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		Richard.lamont1@defence.gov.au	

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