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Department of Defence

RAAF Base Darwin

Supplementary Detailed Site Investigation - Per- and Poly-fluoroalkyl Substances (PFAS) Executive Summary

2 November 2018

Results emerge
when local knowledge
intersects with
global expertise

RAAF Base Darwin

Prepared for
Department of Defence

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Introduction

The Department of Defence (Defence) has engaged Coffey Environments Australia Pty Ltd (Coffey) to undertake a Detailed Site Investigation (DSI) of per- and poly-fluoroalkyl substance (PFAS) site conditions at RAAF Base Darwin (the Base). A DSI report was completed in February 2018, based on investigation data collected to October 2017. A Supplementary DSI report has been prepared by Coffey to document data collected between October 2017 and April 2018 and describe observed seasonal differences in PFAS behaviour at and surrounding the Base.

The Investigation Area has not changed from the DSI report, and incorporates the Base, and surrounding off-Base areas relevant to characterise the nature and extent of PFAS contamination migrating from RAAF Base Darwin activities.

This document is a summary of the assessment and findings that are detailed in the Supplementary DSI Report (reference 754-MELEN199421_R10, dated 2 November 2018).

Background

RAAF Base Darwin is an operational joint civil-military airfield. The Base has administrative, accommodation, recreational and operational support facilities as well as technical workshops, aircraft hardstands and aircraft pavements. Darwin International Airport (DIA) lies to the immediate north of RAAF Base Darwin. The runway and taxiways are shared between Defence and DIA, with DIA classified as a Jointly Used Airport under the *Airports Act 1996* (Cth). Defence has historically used aqueous film forming foam (AFFF) that contained per-fluorooctane sulfonate (PFOS), per-fluorohexane sulfonate (PFHxS) and per-fluorooctanoic acid (PFOA) on the estate between approximately 1970 and 2009.

PFAS are a group of manufactured chemicals that are used in products that are resistant to heat, water and oil. Due to their heat resistant properties, and ability to form aqueous film forming foams, they have been used extensively in fire-fighting applications in Australia. These substances are understood to be highly persistent within the environment, readily mobile in water, and bio-accumulative. The potential health and ecological effects of these substances are not well defined, and given their environmental persistence, enHealth has issued a precautionary warning to limit exposure to humans from these compounds.

The DSI of RAAF Base Darwin has been conducted coincident to the development of the PFAS National Environment Management Plan, which aims to provide governments with a consistent, practical and risk based frameworks for evaluating and managing PFAS in the environment, as well as providing guidance for investigations and waste management measures for PFAS.

Objective and scope

Defence's primary project objective is to understand potential contamination both on the Defence property and to the surrounding areas, resulting from historical AFFF usage.

The environmental investigation of potential PFAS contamination is focussed on characterising sources of contamination as a result of the use, storage and waste management of historical potential AFFF products on RAAF Base Darwin. In accordance with the principles of the National Environment Protection (Assessment of Site Contamination) Measure, a conceptual site model is developed to identify possible connections between potential contamination and humans, the human food chain or ecology. Sampling of soils, waters and biota is then conducted to validate the model, and quantify the exposure pathways between the sources and receptors. These outcomes then guide the development and implementation of appropriate risk management actions associated with identified PFAS risks.

The objectives of the DSI were to:

- Identify known and potential sources of current and historical PFAS contamination and delineate extent of impact in source areas;
- Characterise the site setting sufficient to describe likely contaminant migration behaviour to inform preliminary risk assessment and contaminant transport models; and
- Identify receptors and the associated exposure concentrations.

The specific objectives of this Supplementary DSI report are to:

- Document the full year of investigation results, including seasonal analysis of PFAS concentrations and groundwater flow regime and interaction with surface waters;
- Evaluate the relationship between PFAS in surface water, soils and biota; and
- Estimate of the relative contribution of PFAS migration from each source area.

An Investigation Area was defined to reflect the extent of potential PFAS impact to focus the investigation, based on suspected release sites and contaminant migration pathways. The Investigation Area is shown in Figure A.

Figure A –Investigation Area

The Supplementary DSI involved:

- Surface water: Monthly surface water sampling from October 2017 to April 2018 (from up to 38 on-Base and 56 off-Base locations) and analysis for PFAS to observe seasonal trends;
- Groundwater: Installation of nine groundwater bores to improve spatial and vertical characterisation of PFAS extent, and sampling from nominated wells in the broad groundwater well network to monitor season trends in:
  - November 2017 (81 wells in the early Wet Season);
  - January 2018 (87 wells in mid Wet-Season); and

  - March 2018 (149 wells in the late Wet Season) and analysis for PFAS;
- Soil: Collection and analysis for PFAS of 56 shallow soil samples from off-Base areas to confirm extent of soil contamination, 6 soil samples from a stockpile within former Fire Training Area 2 to characterise residual contamination, and 33 samples from on-Base areas for waste characterisation or pairing with biota samples;
- Biota:
  - Vegetation: Sampling of vegetation from on-Base and off-Base locations for fruits, vegetables (41 samples) to inform human health risk assessment, and aquatic plants (18 samples) to inform ecological risk assessment (reported separately);
  - Aquatic biota: Sampling of fish, crustaceans and molluscs from freshwater, estuarine and marine environments in Rapid Creek (101 samples), Ludmilla Creek (117 Samples) and Darwin Harbour (100 samples) to inform human health risk assessment and ecological risk assessment (reported separately); and
  - Terrestrial biota: Sampling of terrestrial invertebrates (30 samples), mammals (17 samples), reptiles (17 samples) and amphibians (52 samples) to inform the ecological risk assessment (reported separately).

Nature and extent of PFAS contamination

The nature and extent of PFAS within most media (soil, groundwater, surface water and sediment) was well defined within the DSI report with regard to identifying potential receptor groups that may be exposed. The supplementary DSI works were conducted to assess seasonal fluctuations in surface water, groundwater and some biota. All relevant data presented in the Supplementary DSI report were used to guide the human health and ecological risk assessments. Therefore, the findings presented in this report do not change the interpretation of human health or ecological exposure.

Surface water

Seasonal surface water monitoring identified the following trends:

- Concentrations of PFOS+PFHxS in Rapid Creek increased over the Dry Season and then decreased by approximately half during the Wet Season. The extent of PFAS impact within estuarine Rapid Creek appeared to increase in the Wet Season as the flow of contaminated freshwater overcame the tidal flushing of seawater.
- PFAS concentrations in Ludmilla Creek at Dick Ward Drive increased steadily over the Wet Season, although increases were not observed further downstream due to tidal flushing. During the Dry Season discharge of PFAS to Ludmilla Creek, through stormwater drains or groundwater, was diluted at Dick Ward Drive by tidal flushing.
- There was no apparent trend in PFAS concentrations in Reichardt Creek and Sadgroves Creek during the Wet Season and Dry Season.
- Several stormwater drains that discharge into Rapid Creek were observed to continue flowing in the Dry Season. The main DIA drain that crosses Charles Eaton Drive contained water all year and PFAS concentrations were fairly consistent all year, with a small decrease during the Wet Season. The drain at the corner of Larkin Ave and Sir Norman Brearley Drive flowed for most of the year, and concentrations increased through the Wet Season, which is likely to be due to discharge of contaminated groundwater as water levels rose. Flows in this drain during the Dry Season were likely to be influenced by irrigation and wash water run-off from DIA, resulting in lower PFAS concentrations. The drain at the east end of Larkin Avenue did not flow for as long as other drains did during the Dry Season. PFAS concentrations in this drain increased during the Wet Season and are considered to be related to seepage of contaminated groundwater.

The highest concentrations of PFAS in surface water reported in Base drains in the following areas:

- The south-east corner of the run way, near former Fire Training Area 1;
- North-east of the current Fire Training Ground, in the surface drains that run to Rapid Creek;
- The main DIA drain that crosses Charles Eaton Drive;
- South of the taxi-way adjacent to the former ARFF Fire Station; and
- North of Hangar 31, and along Bukatilla Road which collects run-off from the former RAAF Fire Station and formerly collected drainage from the foam discharge incidents at Hangar 31.

Groundwater

Seasonal groundwater monitoring identified the following trends:

- The extent of PFAS impact in groundwater did not change materially between the Dry and Wet Seasons.
- Groundwater levels rose over the Wet Season with the highest levels reported in March 2018. Water levels rose by up to 8 m in the centre of the Base, however groundwater levels rose less towards the boundary of the Base due to the proximity of surface water bodies.
- Saline influence in groundwater from seawater was observed in the south western corner of the Base, up-gradient of Ludmilla Creek.
- Outside of source areas, PFAS concentrations appeared to decrease in the Wet Season. However, vertical delineation sampling identified that this apparent trend was a result of dilution from rainfall recharge, or creation of a fresh layer of water at the top of the aquifer, or a combination of the two. Conversely, in a number of source areas, PFAS concentrations in shallow groundwater were higher in the Wet Season, indicating that PFAS was leaching from impacted soils in the unsaturated zone.

Mass estimates and mass flux estimates

The residual mass of total PFAS in soil and groundwater was estimated at each source area and dispersed across the Investigation Area. The annual flux of PFAS migrating from sources in groundwater flow was also estimated. Surface water mass flux was not quantified, however areas of high, moderate and low PFAS run-off potential were identified, based on the observed leachability of soils and depth of contaminated soils or infrastructure, and the proximity to drains. The values shown in Table A are estimates only and are intended to identify the main sources of impact to off-Base surface water bodies.

Table A: Estimates of residual PFAS mass and mass flux from source areas

Source Area	Mass of PFAS in Soil (kg)	Mass of PFAS in Groundwater (kg)	Total Estimated Mass of PFAS in Source Area (kg)	Mass Flux in GW (kg/year)	Surface water migration observation
Former Fire Training Ground 1	25.4	1.48	26.88	0.008	High leachability and high run off potential to drain SE of runway
Former Fuel Farm 5	1.08	0.66	1.74	0.0045	Low run-off potential
Former Fuel Farms 4 & 6	9.5	5.1	14.6	0.610	Low run-off potential

Source Area	Mass of PFAS in Soil (kg)	Mass of PFAS in Groundwater (kg)	Total Estimated Mass of PFAS in Source Area (kg)	Mass Flux in GW (kg/year)	Surface water migration observation
PFAS treated stockpiles	16	NA	16	NA	Low run-off potential in current state
Former ARFF fire station	18.5	32	50.5	0.560	Low run-off potential
Former Fuel Farm 1 & Hangar 31	16.8	2.7	19.5	0.05	Moderate run off potential from soils and infrastructure
Former RAAF fire station	2.5	0.3	2.8	0.04	Moderate run off potential from soils and infrastructure to Ludmilla Creek stormwater drain
Former Fire Training ground 2	19.7	0.29	19.99	0.02	Low run-off potential
Current Fire Training ground	15.1	5.9	21	0.1	High run off potential to drains towards Rapid Creek
Diffuse contamination	57.75	333.2	390.95		
Totals	**182.33**	**381.63**	**563.96**		

The mass estimates, groundwater mass flux and surface water run-off potential indicates that approximately 70% of the residual PFAS mass is spread beyond immediate source areas, and that former Fuel Farm 5 and the former RAAF Fire Station are the least significant source areas. Groundwater migration is most significant from the former Fuel Farms 4 and 6, former ARFF Fire Station and current Fire Training Ground, and surface water run-off from former Fire Training Area 1, Hangar 31, the former RAAF Fire Station and the current Fire Training Ground is most likely to be contributing to off-Base contamination.

The annual flux of PFAS migrating off-Base was estimated using groundwater transport models and estimates of surface water flow and associated concentrations across the year. The estimates are summarised in Table B.

Table B: Estimated annual mass flux

	Estimated discharge through groundwater	Estimated discharge in surface water
Rapid Creek	0.36kg/year direct to creek 1kg/year including seepage to drainage network	10kg/year in main DIA drain at Charles Eaton Drive Approximately 28kg/year flows past McMillans Road
Ludmilla Creek	0.09kg/year from Hangar 31, FFF1 and former RAAF Fire Station through groundwater flow only	9kg/year through the Bukatilla Road drain
Reichardt Creek	0.23kg/year	~0.5kg/year

Estimated PFAS flux in surface water in the main DIA drain at Charles Eaton Drive, Rapid Creek at McMillans Road and in the open concrete drain that discharges to Ludmilla Creek from the Base, were larger values than the estimates of groundwater flux from source areas or across Base boundaries. Due to the large seasonal variation in groundwater levels, shallow groundwater, deep drains and multiple source areas, the contaminant transport pathways are likely to be complex and change through the seasons.

Biota

Biota testing of fish, molluscs, crustaceans, aquatic vegetation, terrestrial vegetation (including native plants, vegetables and fruits), terrestrial invertebrates and terrestrial vertebrates was conducted on-Base, in off-Base areas, and in freshwater and estuarine creeks surrounding the Base and Darwin Harbour. The testing characterised the distribution of PFAS through the environment and informed the site specific Human Health Risk Assessment (Coffey 2018b) and Ecological Risk Assessment (Coffey in progress).

This executive summary must be read in conjunction with the report proper and in the context of the limitations described in “Important information about your Coffey environmental report” attached.

Important information about your **Coffey** Environmental Report

Introduction

This report has been prepared by Coffey for you, as Coffey's client, in accordance with our agreed purpose, scope, schedule and budget.

The report has been prepared using accepted procedures and practices of the consulting profession at the time it was prepared, and the opinions, recommendations and conclusions set out in the report are made in accordance with generally accepted principles and practices of that profession.

The report is based on information gained from environmental conditions (including assessment of some or all of soil, groundwater, vapour and surface water) and supplemented by reported data of the local area and professional experience. Assessment has been scoped with consideration to industry standards, regulations, guidelines and your specific requirements, including budget and timing. The characterisation of site conditions is an interpretation of information collected during assessment, in accordance with industry practice,

This interpretation is not a complete description of all material on or in the vicinity of the site, due to the inherent variation in spatial and temporal patterns of contaminant presence and impact in the natural environment. Coffey may have also relied on data and other information provided by you and other qualified individuals in preparing this report. Coffey has not verified the accuracy or completeness of such data or information except as otherwise stated in the report. For these reasons the report must be regarded as interpretative, in accordance with industry standards and practice, rather than being a definitive record.

Your report has been written for a specific purpose

Your report has been developed for a specific purpose as agreed by us and applies only to the site or area investigated. Unless otherwise stated in the report, this report cannot be applied to an adjacent site or area, nor can it be used when the nature of the specific purpose changes from that which we agreed.

For each purpose, a tailored approach to the assessment of potential soil and groundwater contamination is required. In most cases, a key objective is to identify, and if possible quantify, risks that both recognised and potential contamination pose in the context of the agreed purpose. Such risks may be financial (for example, clean up costs or constraints on site use) and/or physical (for example, potential health risks to users of the site or the general public).

Limitations of the Report

The work was conducted, and the report has been prepared, in response to an agreed purpose and scope, within time and budgetary constraints, and in reliance on certain data and information made available to Coffey.

The analyses, evaluations, opinions and conclusions presented in this report are based on that purpose and scope, requirements, data or information, and they could change if such requirements or data are inaccurate or incomplete.

This report is valid as of the date of preparation. The condition of the site (including subsurface conditions) and extent or nature of contamination or other environmental hazards can change over time, as a result of either natural processes or human influence. Coffey should be kept appraised of any such events and should be consulted for further investigations if any changes are noted, particularly during construction activities where excavations often reveal subsurface conditions.

In addition, advancements in professional practice regarding contaminated land and changes in applicable statues and/or guidelines may affect the validity of this report. Consequently, the currency of conclusions and recommendations in this report should be verified if you propose to use this report more than 6 months after its date of issue.

The report does not include the evaluation or assessment of potential geotechnical engineering constraints of the site.

Interpretation of factual data

Environmental site assessments identify actual conditions only at those points where samples are taken and on the date collected. Data derived from indirect field measurements, and sometimes other reports on the site, are interpreted by geologists, engineers or scientists to provide an opinion about overall site conditions, their likely impact with respect to the report purpose and recommended actions.

Variations in soil and groundwater conditions may occur between test or sample locations and actual conditions may differ from those inferred to exist. No environmental assessment program, no matter how comprehensive, can reveal all subsurface details and anomalies. Similarly, no professional, no matter how well qualified, can reveal what is hidden by earth, rock or changed through time.

The actual interface between different materials may be far more gradual or abrupt than assumed based on the facts obtained. Nothing can be done to change the actual site conditions which exist, but

steps can be taken to reduce the impact of unexpected conditions.

For this reason, parties involved with land acquisition, management and/or redevelopment should retain the services of a suitably qualified and experienced environmental consultant through the development and use of the site to identify variances, conduct additional tests if required, and recommend solutions to unexpected conditions or other unrecognised features encountered on site. Coffey would be pleased to assist with any investigation or advice in such circumstances.

Recommendations in this report

This report assumes, in accordance with industry practice, that the site conditions recognised through discrete sampling are representative of actual conditions throughout the investigation area. Recommendations are based on the resulting interpretation.

Should further data be obtained that differs from the data on which the report recommendations are based (such as through excavation or other additional assessment), then the recommendations would need to be reviewed and may need to be revised.

Report for benefit of client

Unless otherwise agreed between us, the report has been prepared for your benefit and no other party. Other parties should not rely upon the report or the accuracy or completeness of any recommendation and should make their own enquiries and obtain independent advice in relation to such matters.

Coffey assumes no responsibility and will not be liable to any other person or organisation for, or in relation to, any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report.

To avoid misuse of the information presented in your report, we recommend that Coffey be consulted before the report is provided to another party who may not be familiar with the background and the purpose of the report. In particular, an environmental disclosure report for a property vendor may not be suitable for satisfying the needs of that property's purchaser. This report should not be applied for any purpose other than that stated in the report.

Interpretation by other professionals

Costly problems can occur when other professionals develop their plans based on misinterpretations of a report. To help avoid misinterpretations, a suitably qualified and experienced environmental consultant should be retained to explain the implications of the report to other professionals referring to the report and then review plans and specifications produced to see how other professionals have incorporated the report findings.

Given Coffey prepared the report and has familiarity with the site, Coffey is well placed to provide such assistance. If another party is engaged to interpret the recommendations of the report, there is a risk that the contents of the report may be misinterpreted and Coffey disowns any responsibility for such misinterpretation.

Data should not be separated from the report

The report as a whole presents the findings of the site assessment and the report should not be copied in part or altered in any way. Logs, figures, laboratory data, drawings, etc. are customarily included in our reports and are developed by scientists or engineers based on their interpretation of field logs, field testing and laboratory evaluation of samples. This information should not under any circumstances be redrawn for inclusion in other documents or separated from the report in any way.

This report should be reproduced in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties.

Responsibility

Environmental reporting relies on interpretation of factual information using professional judgement and opinion and has a level of uncertainty attached to it, which is much less exact than other design disciplines. This has often resulted in claims being lodged against consultants, which are unfounded. As noted earlier, the recommendations and findings set out in this report should only be regarded as interpretive and should not be taken as accurate and complete information about all environmental media at all depths and locations across the site.