EXECUTIVE SUMMARY

Background

The Royal Australian Air Force's (RAAF) Base in Williamtown, New South Wales (the Base), has been an active airbase since 1941. The Base is home to several aviation squadrons and support organisations conducting training and operational activities.

Aqueous film forming foam (AFFF) products are efficient fire suppressing foams that have been used at the Base for fire training activities and emergency response for at least 40 years. Through to 2007, the main AFFF product in use at the Base was 3M Lightwater which contains perfluoroalkyl and polyfluoroalkyl substances (PFAS), including perfluorooctane sulphonate (PFOS) and perfluorooctanoic acid (PFOA). 3M Lightwater was phased out in 2010 and replaced by Ansulite, which contains significantly lower concentations of PFOS and PFOA.

Concerns as to the potential for contamination associated with 3M Lightwater at the Base prompted a Stage 1 Environmental Investigation (EI), conducted by GHD in 2013. The investigation identified concentrations of PFAS in soil, sediment and in groundwater at several locations within and outside the Base. Due to the size of the investigation area, it was acknowledged that the full extent of AFFF-related impacts could not be established until a number of data gaps were addressed. Consequently, the Stage 1 EI recommended that a more comprehensive assessment, including further investigation of soil, sediment, surface water, groundwater and biota be undertaken to better understand migration pathways and the extent of impact.

On the basis of this recommendation for further investigation made in the Stage 1 EI, the Commonwealth Department of Defence (Defence) engaged URS Australia Pty Ltd (URS) to undertake a Stage 2 EI. This report presents the results of the Stage 2 EI conducted by URS from June 2014 to April 2015.

Objectives

The Statement of Requirement (SOR) issued by Defence stated that the purpose of the Stage 2 EI was to advise Defence on:

1 The nature and extent of contamination associated with the use of AFFF;
2 The risks posed by the contamination; and
3 Potential management and/or remediation options.

Further, the SOR stated that the ultimate objective of the investigation program was the management and, where necessary, remediation to address potential contamination risks found on the Base. Specifically, the objective was to assess the nature and extent of contamination and actions required to reduce the risk of exposure to contamination identified at the Base.

Conduct of the Stage 2 EI has resulted in: (a) an improved understanding of the nature and distribution of AFFF-related contamination; (b) an evolving understanding of the complex interactions of surface water and groundwater at and in the vicinity of the Base; and (c) recognition that additional site characterisation will be necessary to provide sufficient data to assess the risks posed by the contamination and identify potential management and/or

remediation options. Accordingly, this Report details URS's findings in relation to the nature and extent of contamination associated with use of AFFF.

Scope of Work

The Stage 2 EI included development of a Sampling and Analysis Quality Plan (SAQP) which presents the objectives, rationale, procedures and data quality objectives (DQOs) for the investigation work. Sampling of soil, groundwater, surface water, sediment and vegetation was undertaken at the six primary on-site source areas identified during the Stage 1 EI. This work included sampling of existing wells as well as groundwater well installation and in-situ profiling techniques. Surface water, sediment, aquatic and marine fauna and terrestrial vegetation were sampled at off-site locations including Fullerton Cove, Tilligerry Creek, Dawsons Drain, Moors Drain and Fourteen Foot Drain.

Contaminants of Potential Concern and Screening Criteria

The chemicals of potential concern (CoPC) for this investigation were:

- PFOS;
- PFOA; and
- 6:2 fluorotelomer sulphonate (6:2 FTS)

A range of additional PFAS were measured as part of the sampling program. Whilst screening criteria do not currently exist for these additional PFAS compounds, they were measured to help in the understanding of the nature and extent of PFAS contamination and whether potential CoPC precursors were present.

At the direction of Defence, the screening criteria against which the reported CoPC concentrations were compared were primarily sourced from the Defence-issued document '*Defence Contamination Directive 8 (DCD8) on Interim Screening Criteria*' dated 19 May 2015. Where screening criteria for specific applications were not presented within DCD8, URS selected supplementary interim screening criteria based on internationally published values. It should be noted that the presence of chemicals at concentrations higher than the adopted screening criteria a does not necessarily indicate an unacceptable risk. Rather, it indicates that potential exposures to these chemicals should be evaluated in greater detail, taking into account site-specific pathways of exposure.

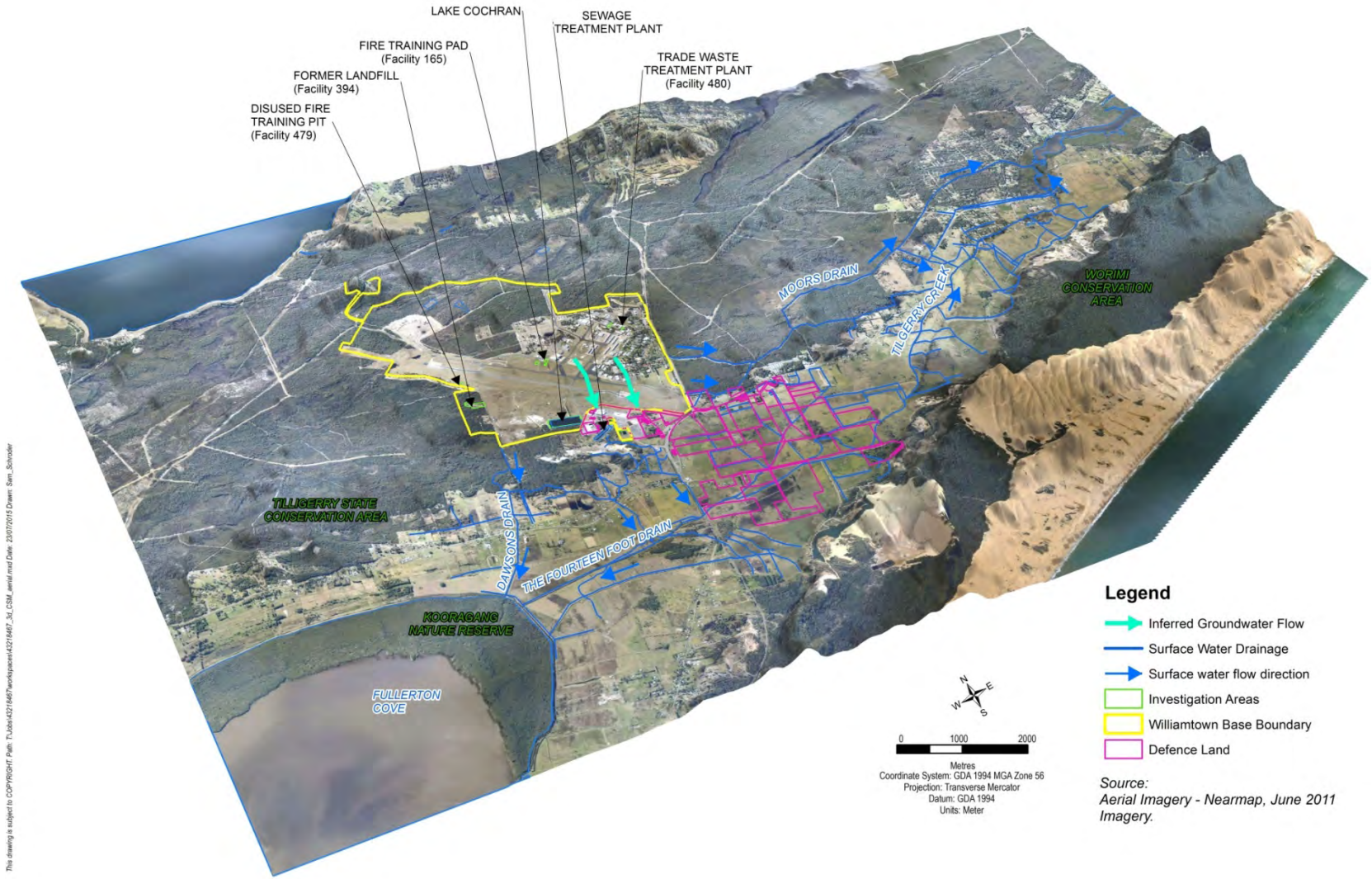
Source Areas, Migration Pathways and Results

Soil and groundwater sampling results indicate that there are six primary PFAS source areas:

- Fire Training Pad (Facility 165 or F165);
- Disused Fire Training Pit (Facility 479 or F479);
- Trade Waste Treatment Plant (TWTP) (Facility 480 or F480);
- Sewage Treatment Plant (STP) (Facility 410 or F410);
- Former Landfill (Facility 394 or F394); and
- Lake Cochran.

The six primary PFAS source areas are consistent with the historical site use of AFFF and consideration of surface water fate and transport within the Base. **Figure ES-1** below shows the source areas and groundwater and surface water flow in the surrounding area.

Figure ES-1: Site figure showing source areas, groundwater and surface water flow.



Soil Sample Results

The highest soil concentrations of PFOS and PFOA were reported in samples collected from the Fire Training Pad (up to 2.9 mg/kg PFOS and 0.062 mg/kg PFOA) and the Disused Fire Training Pit (up to 4.3 mg/kg PFOS and 0.006 mg/kg PFOA). These two facilities represent areas of direct application of AFFF to the ground surface. The investigation results indicate that former fire training activities in these areas represent the main mechanism of release of these compounds to the environment.

The highest concentrations of 6:2 FTS in soil was found at the STP and the Fire Training Pad (0.94 mg/kg and 0.023 mg/kg respectively).

Lower concentrations of PFOS were detected in soil samples collected near the STP, the TWTP and the Former Landfill. PFOA was detected in soil samples collected near the STP as well as the Fire Training Pit and Fire Training Pad, but not from the other source areas.

Lake Cochran receives surface water runoff from across the Base and is considered in this sense as a secondary source of PFAS to the subsurface. However, there is anecdotal evidence of historic AFFF testing and possibly disposal near the lake which indicates that the area around the lake may also be a primary source of impacts to groundwater (personal communication, Horn, 2014). Soil and sediment samples collected near Lake Cochran were reported to contain PFOS (up to 2.3 mg/kg). PFOA was not detected at concentrations above the limit of reporting (LOR).

In total, 230 soil samples were collected in a Base-wide sampling approach that targeted primary source areas, other areas of suspected release and areas considered representative of background conditions. PFOA concentrations were reported above the LOR in 5 samples. PFOS concentrations were reported above the LOR in 74 of the 230 samples. While less significant potential source areas cannot be excluded, it is considered that the soil sampling program has identified the major source areas.

Surface Water and Sediment

PFOS and PFOA are water soluble and mobile. The main transport mechanisms are interpreted to be surface watercourses, infiltration to the subsurface and subsequent transport with groundwater. Both constructed surface water infrastructure and natural drainage systems may transport dissolved-phase PFAS.

Trade waste across the Base is pumped to a TWTP located on the north-eastern portion of the Base where solids separation occurs, but no chemical treatment. The trade waste is pumped from the TWTP to the STP located south of the Base. Research studies published in peer reviewed journals indicate that PFAS are resistant to biological decomposition and are not effectively treated in wastewater treatment plants. PFAS was confirmed to be present in the STP in 2015 based on analysis of influent and effluent samples (GHD, 2015).

Runoff from the central portion of the Base, including the location of the Fire Training Pad, is conveyed by surface drains to Lake Cochran. Runoff from the eastern portion of the Base drains to Moors Drain which discharges to the Tilligerry Creek. Runoff from the south-western portion of the Base drains to Dawsons Drain, which ultimately discharges to Fullerton Cove. Sediment samples collected from Moors Drain and Dawsons Drain were reported to contain relatively low PFOS concentrations (up to 0.24 mg/kg in Dawsons Drain) when compared to

sediment samples near source areas within the Base (up to 4.3 mg/kg was measured at the Fire Training Pit). However, the detection of PFOS in sediment and surface water samples (up to 0.36 µg/L) collected several kilometres east-northeast and south of the Base indicates that, if attributable to the use of AFFF at the Base, PFOS has spread longer distances and in different directions via surface watercourses than would be expected from advective transport with groundwater. PFOA was not detected above the LOR in any sediment sample collected from these drains but was detected in surface water samples at a maximum concentration of 0.61 µg/L in Dawsons Drain.

Groundwater

The subsurface beneath the Base and surrounding land is interpreted to consist primarily of sandy material, which is considered relatively permeable, interspersed with deposits of coffee rock (an indurated sand high in iron). In some areas, the sands are overlain by an estuarine deposit composed of fine grained material, which may locally limit infiltration. However, this unit is interpreted to be rather shallow and is not expected to affect the overall groundwater flow in the area, which is interpreted in a south-eastern direction. Groundwater is present at shallow depth, and is readily influenced by infiltration which is relatively high due to the typically sandy soil profile.

Groundwater sampling results indicate that PFOS, PFOA and other PFAS are present in groundwater near the interpreted primary source areas and at some locations along and down hydraulic gradient of surface water features. On-site groundwater concentrations of PFOS and PFOA were found to exceed the adopted drinking water screening criteria in proximity to, and/or down hydraulic gradient of all source areas. PFOS and PFOA concentrations in groundwater in off-site areas were generally lower than those within the Base, but in some instances also exceeded the adopted screening criteria. Off-site concentrations which exceeded the screening criteria were mostly confined to the land south of the Base and also to the east of the Base, in Tilligerry State Conservation Area. The reported concentration of 6:2 FTS in groundwater at the STP exceeded the screening criteria. All other on-site and off-site 6:2 FTS concentrations were reported to be below the screening criteria.

The highest PFOS and PFOA concentrations in samples collected from groundwater monitoring wells were reported near the Fire Training Pad (up to 38 µg/L PFOS), Disused Fire Training Pit (up to 170 µg/L PFOS), Former Landfill (up to 72 µg/L PFOS) and Lake Cochran (up to 70 µg/L PFOS). Samples from groundwater monitoring wells near the TWTP and STP were reported to contain up to nearly 10 µg/L PFOS. The reported concentrations of PFOA were typically more than one order of magnitude (20 to 30 times) lower than the PFOS concentrations.

Groundwater samples collected using a hydraulic profiling tool (referred to herein as “in-situ samples”), reported greater variability in PFAS concentrations than those collected from monitoring wells. The results for these samples indicate that the concentrations of PFAS may vary significantly over a relatively small distance and that high concentrations are present close to source areas. The highest reported PFOS and PFOA concentrations for in-situ samples were 2,900 µg/L and 16,000 µg/L, respectively, in samples collected on the southwest side of Lake Cochran.

Groundwater impacts near the surface drains, remote from the source areas, are interpreted to be localised in nature. The impacts are not considered to result from migration of

groundwater beneath the source areas, but are interpreted to result from infiltration through the bottom of the surface water features.

The migration of groundwater and interaction with surface water in the vicinity of the Base is complex. It is apparent that surface water bodies may be 'gaining' through groundwater discharge to the surface water network at some locations, and 'losing' through infiltration to the ground or a combination of the two, dependent on relative levels of groundwater and surface water at any given point in time.

Biota Sampling

A biota sampling program was also undertaken which comprised the collection of on-Base and off-Base vegetation and aquatic organism samples. The highest concentrations of PFAS were reported in on-Base vegetation samples in the vicinity of known source areas. For example, the highest CoPC concentrations in vegetation were reported at the Fire Training Pad (PFOS: 1,000 µg/kg, PFOA: 21 µg/kg and 6:2 FTS: 3.6 µg/kg).

Off-Base vegetation samples reported low concentrations of PFAS, with PFOA and 6:2 FTS not reported above the LOR. The highest off-Base CoPC concentration in vegetation (PFOS: 8.9 µg/kg) was found close to the southeast corner of the Base.

Aquatic organisms were also sampled from Dawsons Drain, Moors Drain, Tilligerry Creek and Fullerton Cove. The highest PFAS concentrations were reported in samples from Dawsons Drain (PFOS: 6,700 µg/kg), which was below the ecological screening criteria. The lowest concentrations were reported for samples from Tilligerry Creek and Fullerton Cove. The maximum PFOA concentration in aquatic fauna of 110 µg/kg was reported for a sample from Dawsons Drain. 6:2 FTS was reported above the LOR for only one sample (3.5 µg/kg).

Data Gaps

The results of the investigation: (a) confirmed the presence of six on-Base source areas; (b) identified the likely migration pathways for PFAS originating from the Base; and (c) provided an improved understanding of the extent of off-site impacts. Notwithstanding, there are several data gaps present:

- The nature and extent of PFAS impacts in the identified main source areas has not been fully delineated;
- Previously unidentified PFAS impacts were detected in the northeast and southwest corners of the Base. The source of these impacts has not yet been established ;
- The nature and extent of off-site groundwater dissolved-phase PFAS impacts requires further assessment;
- The hydrogeological pathways between the Base and potential off-site human and ecological receptors require more detailed investigation. Specifically, the characteristics of the local aquifer, including seasonal variability in groundwater/surface water interactions, the interaction between groundwater and surface water in drainage lines, Hunter Water Corporation (HWC) pumping regimes and geology contributing to the source area persistence and off-site migration require further investigation; and
- The nature and extent of off-site surface water, sediment and aquatic fauna impacts from the Base boundary to Fullerton Cove and Tilligerry Creek requires further assessment.

Conclusions

The investigation showed that PFAS are present in the environment both within the Base and in several off-site areas. The most likely primary source of the identified impact is the historical use of AFFF products containing PFAS. PFAS concentrations in groundwater exceeding the adopted drinking water screening criteria were found in all Base areas investigated and in several off-site areas. PFAS were also found in on-Base and off-site surface water, sediment, vegetation and aquatic fauna.

On-Base and off-site surface water investigations indicate that surface water is a prominent off-site migration pathway, In particular, PFAS were found in the drain adjacent to the Fire Training Pad, Lake Cochran, Dawsons Drain, Moors Drain and Tilligerry Creek. Off-site migration of dissolved-phase PFAS in surface water appears to have led to impacted sediments at various locations downstream from the Base. However, aquatic fauna sampled in off-site areas reported PFAS concentrations below the adopted ecological screening criteria.

The investigation results indicate that dissolved-phase PFAS is migrating off-site to the south, east and west of the Base in groundwater. In particular, concentrations of PFAS exceeding the adopted drinking water screening criteria were reported to the south and east of the Base. The extent of off-site groundwater migration remains to be delineated.