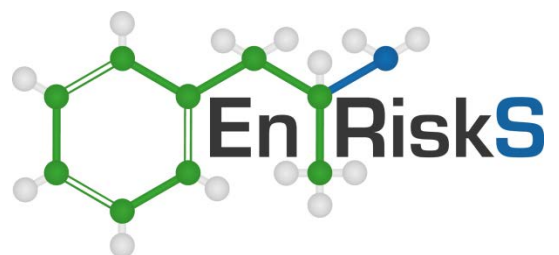


DEHP-ID-183-D1 Human Health and Ecological Risk Assessment for PFAS: HMAS Albatross

*Prepared for: Aurecon Australasia Pty Ltd and the Australian Government
Department of Defence*

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It is prepared in accordance with the scope of work and for the purpose outlined in the **Section 1** of this report.

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Glossary of Terms

Additive Effect	An additive effect is where two or more substances act together to produce a total effect that is the same as the sum of the individual effects
Adsorption	The process of taking in. For a person or an animal, absorption is the process of a substance getting into the body through the eyes, skin, stomach, intestines, or lungs.
Adverse Health Effect	A change in body function or cell structure that might lead to disease or health problems
ANZECC	Australia and New Zealand Environment and Conservation Council
ASC NEPM	National Environmental Protection Measure – Assessment of Site Contamination
ASLP	Australian Standard Leaching Procedure
AT	Averaging Time
Background Level	An average or expected amount of a substance or material in a specific environment, or typical amounts of substances that occur naturally in an environment.
BW	Body weight
Carcinogen	A substance that causes cancer.
CF	Unit Conversion Factor
Chronic Exposure	Contact with a substance that occurs over a long time (more than 1 year) (compare with acute exposure and intermediate duration exposure)
Dermal Contact	Contact with (touching) the skin (see route of exposure).
Detection Limit	The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.
Dose	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An “exposure dose” is how much of a substance is encountered in the environment. An “absorbed dose” is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
DSI	Detailed Site Investigation
ED	Exposure Duration
EF	Exposure Frequency
EFSA	European Food Safety Authority
ET	Exposure time
EPA Victoria	Victorian Environment Protection Authority
Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).
Exposure Assessment	The process of finding out how people come into contact with a hazardous substance, how often and for how long they are in contact with the substance, and how much of the substance they are in contact with.
Exposure Pathway	The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: a source of contamination (such as chemical leakage into the subsurface); an environmental media and transport mechanism (such as movement through groundwater); a point of exposure (such as a private well); a route of exposure (eating, drinking, breathing, or touching), and a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is termed a completed exposure pathway.



FSANZ	Food Standards Australia New Zealand
Guideline Value	Guideline value is a concentration in soil, sediment, water, biota or air (established by relevant regulatory authorities such as the National Health and Medical Research Council (NHMRC), Australia and New Zealand Environment and Conservation Council (ANZECC) and World Health Organisation (WHO)), that is used to identify conditions below which no adverse effects, nuisance or indirect health effects are expected. The derivation of a guideline value utilises relevant studies on animals or humans and relevant factors to account for inter- and intra-species variations and uncertainty factors. Separate guidelines may be identified for protection of human health and the environment. Dependent on the source, guidelines will have different names, such as investigation level, trigger value, ambient guideline etc.
HHERA	Human Health and Ecological Risk Assessment
HI	Hazard Index
HIL	Health Investigation Level
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way (see route of exposure).
Inhalation	The act of breathing. A hazardous substance can enter the body this way (see route of exposure).
LOAEL	Lowest-observed-adverse-effect-level: The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals
LOR	Limit of Reporting
MDH	Minnesota Department of Health
No effect level	The tested dose of a substance that does not cause adverse effects in people or animals. See also NOAEL and LOAEL
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure
NHMRC	National Health and Medical Research Council
NNPAS	National Nutrition and Physical Activity Survey
NOAEL	No-observed-adverse-effect-level: The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects on people or animals
NSW DPI	New South Wales Department of Primary Industries
NSW EPA	New South Wales Environment Protection Authority
PEF	Particulate Emission Factor: The potential concentration of a chemical in dust that might be in air as a result of wind erosion
PFAS	Per- or Poly-fluoroalkyl Substances
<i>PFBA</i>	<i>Perfluorobutanoic Acid</i>
<i>PFBS</i>	<i>Perfluorobutanesulfonic Acid</i>
<i>PFPeA</i>	<i>Perfluoropentanoic Acid</i>
<i>PFHxA</i>	<i>Perfluorohexanoic Acid</i>
<i>PFHxS</i>	<i>Perfluorohexanesulfonic Acid</i>
<i>PFHpA</i>	<i>Perfluoroheptanoic Acid</i>
<i>PFOA</i>	<i>Perfluorooctanoic Acid</i>
<i>PFOS</i>	<i>Perfluorooctanesulfonic Acid</i>
<i>PFNA</i>	<i>Perfluorononanoic Acid</i>
<i>PFDA</i>	<i>Perfluorodecanoic Acid</i>
<i>PFDS</i>	<i>Perfluorodecanesulfonic Acid</i>
<i>PFUdA</i>	<i>Perfluoroundecanoic Acid</i>
<i>PFDoA</i>	<i>Perfluorododecanoic Acid</i>



PFTrDA	Perfluorotridecanoic acid
PFTeDA	Perfluorotetradecanoic acid
4:2 FtS	1H.1H.2H.2H-Perfluorohexanesulfonic Acid
6:2 FtS	1H.1H.2H.2H-Perfluorooctanesulfonic Acid
8:2 FtS	1H.1H.2H.2H-Perfluorodecane sulfonic Acid
PFOSA	Perfluorooctanesulfonamide
NEtFOSAA	N-ethyl-perfluorooctanesulfonamidoacetic acid
NMeFOSAA	N-methyl-perfluorooctanesulfonamidoacetic acid
pKa	The most widely used form of the acid dissociation constant (also known as the acidity constant) which is a quantitative measure of the strength of an acid. This value helps to predict what a molecule will do at a specific pH.
Point of Exposure	The place where someone can come into contact with a substance present in the environment (see exposure pathway).
Population	A group or number of people living within a specified area or sharing similar characteristics (such as occupation or age).
PSI	Preliminary Site Investigation
Receptor Population	People who could come into contact with hazardous substances (see exposure pathway).
Risk	The probability that something will cause injury or harm.
RME	Reasonable maximum exposure: The RME represents exposure scenario based on a set of exposure parameters that is representative of expected maximum exposure for that receptor and activity. The RME would not be expected to be exceeded except under highly specific and exceptional circumstances.
Route of Exposure	The way people come into contact with a hazardous substance. Three routes of exposure are breathing [inhalation], eating or drinking [ingestion], or contact with the skin (dermal contact)
SWL	Standing Water Level
TDS	Total Dissolved Solids
Toxicity	The degree of danger posed by a substance to human, animal or plant life.
Toxicity Data	Characterisation or quantitative value estimated (by recognised authorities) for each individual chemical for relevant exposure pathway (inhalation, oral or dermal), with special emphasis on dose-response characteristics. The data is based on available toxicity studies relevant to humans and/or animals and relevant safety factors.
Toxicological Profile	An assessment that examines, summarizes, and interprets information about a hazardous substance to determine harmful levels of exposure and associated health effects. A toxicological profile also identifies significant gaps in knowledge on the substance and describes areas where further research is needed.
Toxicology	The study of the harmful effects of substances on humans or animals.
TRV	Toxicity Reference Value, e.g. an RfD, ADI, TDI, or PTWI. A guideline toxicity value that incorporates uncertainty or safety factors to identify a safe dose assuming daily lifetime exposure to a substance that is unlikely to cause harm in humans.
Uncertainty Factor	Mathematical adjustments for reasons of safety when knowledge is incomplete. For example, factors used in the calculation of doses that are not harmful (adverse) to people. These factors are applied to the lowest-observed-adverse-effect-level (LOAEL) or the no-observed-adverse-effect-level (NOAEL) to derive a minimal risk level (MRL). Uncertainty factors are used to account for variations in people's sensitivity, for differences between animals and humans, and for differences between a LOAEL and a NOAEL. Scientists use uncertainty factors when they have some, but not all, the information from animal or human studies to decide whether an exposure will cause harm to people (also sometimes called a safety factor).



USEPA	United States Environmental Protection Agency
WHO	World Health Organisation

Executive Summary

Introduction

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Aurecon Australasia Pty Ltd (Aurecon), on behalf of the Australian Government Department of Defence (Defence), to review available data and undertake a human health and ecological risk assessment (HHERA) in relation to the presence of per- and polyfluoroalkyl substances (PFAS) located at, and in the vicinity of, HMAS Albatross (0026), Nowra, NSW (the “base”; refer to **Figure 1** for the HMAS Albatross site boundary and the investigation area). It is noted that the base is located on Commonwealth Land.

Investigations conducted at the site by Aurecon have detected concentrations of some PFAS compounds in soil, sediment, groundwater and surface water at the base. PFAS are a family of fluorine-containing compounds with unique properties to make materials stain- and stick-resistant. PFAS are often described as being “ubiquitous in the environment”. They have been widely used in man-made products such as paints, roof treatments, hardwood floor protectant, surface protection products (e.g. carpet and clothing treatments) and coatings for cardboard and packaging. Some PFAS are, or were also historically used in fire-fighting foams. These compounds are not found in the environment from natural sources, only from anthropogenic sources (ATSDR 2015).

A number of site activities that may lead to exposure to PFAS compounds have been identified and this report presents an assessment of potential health risks following these exposures. In addition, there is evidence to suggest that PFAS impacts at the site may have migrated off-base. An evaluation of potential human health risks following off-base exposures and a qualitative assessment of risks to on- and off-base environments has also been undertaken.

Objectives

The objectives of the assessment presented in this report are:

- To undertake a quantitative evaluation of the potential risks to human health associated with potential direct contact exposures with PFAS compounds in soil, sediment, groundwater and surface water in the on-base area, in the context of its ongoing operation as a Defence base. This includes the following receptor populations that have been identified to date:
 - Defence personnel including contractors (adults only; no families or children are present at the base)
- To undertake a quantitative evaluation of the potential risks to human health associated with potential direct contact exposures with PFAS compounds in soil, sediment, groundwater, surface water and edible produce (including fish products) in the off-base area, in the context of the existing land uses. This includes the following receptor populations that have been identified to date:
 - Residents in properties adjacent to the base
 - Public users of off-base waterways downstream of the base
- To undertake a qualitative evaluation of the potential risks to terrestrial and aquatic (freshwater) ecological receptors in the on-base area;
- To undertake a qualitative evaluation of the potential risks to terrestrial, freshwater and (if applicable) marine ecological receptors in the off-base area; and



- Based on the HHERA, identify any additional data that may be required to assist in refining the assessment of risk or in considering additional risk management measures that may be needed.

This assessment has been undertaken to evaluate potential risks to human health and ecosystems at in the on-base and off-base area based on the information available up to 22 August 2017 and as described in **Section 1.4**. The HHERA has addressed human health and environmental risk issues relevant to PFAS in the investigated environmental media (including food products). The assessment has not addressed human health or environmental risk issues associated with other chemicals.

Conclusions

On the basis of the available data, and with consideration of the available information on the use groundwater and surface water on and off the base, and the uncertainties identified in this assessment, the following conclusions and recommendations relate to potential risks to human health and the environment, associated with PFAS, on and off the base.

The approach taken for the assessment of human health and environmental risks is in accordance with guidelines / protocols endorsed by Australian regulators and is expected to be conservative from an overall point of view.

All recommendations should be considered and implemented in consultation with the relevant stakeholders, which includes the landowners.

On-Base Areas

Human health: Defence personnel, contractors and visitors to the base have the potential to be exposed to PFAS that has been identified in soil, sediments and surface water. PFAS has also been identified in groundwater however there are no pathways of exposure for workers, contractors and visitors. On the basis of the assessment undertaken no risks to the health of these workers has been identified

Terrestrial environment: No direct toxicity effects to the terrestrial environment are expected to occur. However, in areas close to and within the Lowland Rainforest endangered ecological community located on-base the potential for bioaccumulative effects cannot be excluded. Additional sampling of soil, and further assessment of terrestrial risk issues in these areas is recommended. The presence of PFAS in and soil, specifically leachable levels of PFAS remains an ongoing source of PFAS to the off-base environment.

Aquatic environment: There are no aquatic environments located on the base that warrant protection. However, the presence of PFAS in surface water and soil leachate remain and an ongoing source of PFAS to the off-base environment.

Off-Base Areas

PFAS has been reported in groundwater, surface water, soil, sediments and biota within a number of properties and waterways in the off-base areas. PFAS, and more specifically PFOS, bioaccumulate in the environment and have the potential to be present in edible produce on

properties where PFAS is present in stock or irrigation water, and also bioaccumulate through the terrestrial and aquatic food chain. Exposures that may occur through direct contact with PFAS in the off-base environment has been evaluated along with exposures to PFAS that has bioaccumulated, or may bioaccumulate to produce (and consumed) or the environment

The following table provides an overview of the ways in which off-base receptors (including members of the community and the terrestrial and aquatic environments) may be exposed to PFAS, derived from the HMAS Albatross Base and the conclusions and recommendations relevant to these areas. It is noted that the risk issues identified in **Table E1** principally relate to PFAS derived from former spills and surface water discharged to the off-base areas.

Table E1: Conclusions of off-base risks to human health and the environment: PFAS

How the community may be exposed?	Potential risks to human health	Area where potential risk issues identified	Recommendations
Human health			
Direct contact with PFAS in soil	Low and acceptable, with the exception of one property.	Braidwood Road drain sub-catchment	Further soil assessment is required to better understand health risks.
Direct contact with PFAS in sediments (in dams and creeks)	Low and acceptable.	NA	NA
Ingestion of homegrown fruit and vegetables on properties where PFAS is present in soil	Low and acceptable, with the exception of one property and three additional locations (BH28, BH33 and BH34).	Braidwood Road drain sub-catchment and locations BH28 (Nowra Creek sub-catchment) and BH33 and BH34 (Upper Currambene Creek sub-catchment) (noting that homegrown fruit and vegetables currently not grown).	Soil at these locations is not suitable for growing fruit and vegetable produce, without further assessment.
Use of groundwater for drinking/potable water	Shoalhaven River Basin* – low and acceptable except for the Braidwood Road drain sub-catchment. Clyde River Basin* – low and acceptable except in the area of BH26 (Upper Currambene Creek sub-catchment).	Shoalhaven River Basin* – Braidwood Road drain sub-catchment. Clyde River Basin* – not defined.	Groundwater at these locations is not suitable for potable water, stock watering and irrigation.
Use of surface water for stock watering and irrigation			
Consumption of home-slaughtered meat and offal (worst-case, RME and average intakes)	Where 100% of meat intakes are from home-consumption (worst-case) there is the potential for elevated risks for a number of properties. Where reasonable maximum and average intakes of meat from home-consumption are considered there is the potential for elevated risks at SW-POU-1 & SW-POU-12 (Braidwood Road drain sub-catchment). Risks for other properties considered to be low.	SW-POU-1, SW-POU-2, SW-POU-3 & SW-POU-12 (Braidwood Road drain sub-catchment) SW-POU-16 (Upper Currambene Creek sub-catchment) SW-POU-05 (Upper Currambene Creek sub-catchment) SW-POU-13 (Cabbage Tree Creek sub-catchment) SW-POU-14S & SW-POU-21 (Nowra Creek sub-catchment)	Where possible cattle should be moved away from surface water drains and pasture where PFAS has been detected. Consumption of home-slaughtered livestock not suitable for these properties.

How the community may be exposed?	Potential risks to human health	Area where potential risk issues identified	Recommendations
Home consumption of milk at dairy farm (worst-case, RME and average intakes)	Where 100% of milk intakes are from home-consumption (worst-case) there is the potential for elevated risks for a number of properties. Where reasonable maximum and average intakes of milk from home-consumption are considered there is the potential for elevated risks at SW-POU-1 & SW-POU-12 (Braidwood Road drain sub-catchment). Risks for other properties considered to be low.	SW-POU-1, SW-POU-2, SW-POU-3 & SW-POU-12 (Braidwood Road drain sub-catchment) SW-POU-16 (Upper Currumbene Creek sub-catchment) SW-POU-05 (Upper Currumbene Creek sub-catchment)	No properties currently used as dairy farms. Home consumption of raw milk should not occur on these properties.
Consumption of eggs	Potential for elevated risks, where stock water with PFAS concentrations in excess of drinking water guidelines is used to water chickens.	All properties where PFAS in water used for stock water exceeds the drinking water guidelines	If eggs are produced on any properties where PFAS is present in stock water, the eggs should be tested and risks re-evaluated
Consumption of fruit and vegetable produce (including crops)	Potential for elevated risks, where irrigation water with PFAS concentrations in excess of drinking water guidelines is used to water fruit/vegetables.	All properties where PFAS in water used for irrigation exceeds the drinking water guidelines	If fruit/vegetables (or crops) are produced on any properties where PFAS is present in irrigation water, the produce should be tested and risks re-evaluated
Consumption of honey	Low and acceptable	NA	NA
Recreational exposures			
Recreational use of surface water	Low and acceptable	NA	NA
Consumption of fish caught from local waterways	Shoalhaven River Basin*: based on the limited data collected, risks are low and acceptable Clyde River Basin*: The available data indicates the potential for elevated exposures from fish intakes. Further work is required to better understand these exposures.	NA	Additional data needs to be collected from the lower reaches of the Currumbene Creek where more regular recreational fish is likely to occur. Potential risks associated with the consumption of fish and crustaceans can then be further evaluated. A water use survey should also be undertaken to establish the type and frequency of recreational fishing activities at downstream locations.
Environment			
Terrestrial environment			
Livestock health	Risks are low and acceptable	NA	NA
Direct toxicity	No risk issues identified	NA	NA
Bioaccumulation and effects on higher order consumers	Risks are low, with the exception of SW-POU-1 & SW-POU-12 (Braidwood Road drain sub-catchment) where effects to higher order consumers cannot be excluded.	SW-POU-1 & SW-POU-12 (Braidwood Road drain sub-catchment)	Where this property may be regularly accessed by birds and mammals, addition data and assessment may be required.



How the community may be exposed?	Potential risks to human health	Area where potential risk issues identified	Recommendations
Aquatic environment			
Livestock health	Risks are low and acceptable	NA	NA
Direct toxicity	Potential for adverse effects considered to be low.	NA	NA
Bioaccumulation and higher order consumers	Shoalhaven River Basin* and Clyde River Basin*: potential for bioaccumulation identified. Potential for adverse effects to the environment cannot be excluded.	Shoalhaven River Basin and Clyde River Basin	Further sampling and assessment recommended to supplement the data collected from the initial investigation.

Note: All recommendations should be considered and implemented in consultation with the relevant stakeholders, which includes the landowners.

* The Shoalhaven River Basin and Clyde River Basin areas referenced in this table is limited to the waterways where sampling was undertaken, and the extent of sampling within these waterways.