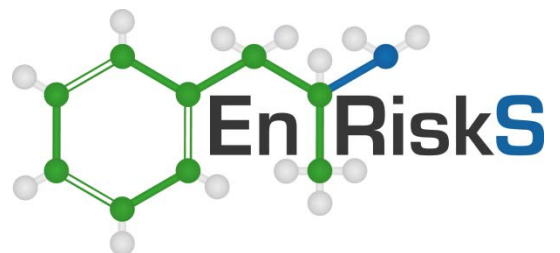


# Human Health and Ecological Risk Assessment for the RAAF Base Wagga PFAS Investigation – Executive Summary

*Prepared for: Jacobs Group (Australia) Pty Limited and the Australian Government Department of Defence*

6 November 2018





## Document History and Status

|                           |  |
|---------------------------|--|
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## Limitations

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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.

The methodology adopted, and sources of information used are outlined in this report. Environmental Risk Sciences Pty Ltd has made no independent verification of this information beyond the agreed scope of works and assumes no responsibility for any inaccuracies or omissions. No indications were found that information contained in the reports provided for use in this assessment was false.

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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   |
| AFFF                  | Aqueous Film-Forming Foams  |
| ANZECC                | Australia and New Zealand Environment and Conservation Council  |
| ASC NEPM              | National Environmental Protection Measure – Assessment of Site Contamination  |
| 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)   |
| CoPC                  | Chemicals of Potential Concern  |
| CSM                   | Conceptual Site Model   |
| 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   |
| 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  |
| GGPID            | Gumly Gumly Private Irrigation District   |
| 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. |
| HBGV             | Health-Based Guidance Value (see TRV).  |
| HHERA            | Human Health and Ecological Risk Assessment   |
| HI               | Hazard Index  |
| 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   |
| NEMP             | National Environmental Management Plan  |
| 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 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   |
| <b>PFAS</b>      | <b>Per- or Poly-fluoroalkyl Substances</b>  |
| <i>PFBA</i>      | <i>Perfluorobutanoate</i>   |
| <i>PFBS</i>      | <i>Perfluorobutane sulfonate</i>  |
| <i>PFPeA</i>     | <i>Perfluoropentanoate</i>  |
| <i>PFPeS</i>     | <i>Perfluoropentane sulfonate</i>   |
| <i>PFHxA</i>     | <i>Perfluorohexanoate</i>   |
| <i>PFHxS</i>     | <i>Perfluorohexane sulfonate</i>  |



|                     |  |
|---------------------|--|
| <i>PFHpA</i>        | <i>Perfluoroheptanoate</i>   |
| <i>PFHpS</i>        | <i>Perfluoroheptane sulfonate</i>  |
| <i>PFOA</i>         | <i>Perfluorooctanoate</i>  |
| <i>PFOS</i>         | <i>Perfluorooctane sulfonate</i>   |
| <i>PFNA</i>         | <i>Perfluorononanoate</i>  |
| <i>PFDA</i>         | <i>Perfluorodecanoate</i>  |
| <i>PFDS</i>         | <i>Perfluorodecane sulfonate</i>   |
| <i>PFUnDA</i>       | <i>Perfluoroundecanoate</i>  |
| <i>PFDoDA</i>       | <i>Perfluorododecanoate</i>  |
| <i>PFTTrDA</i>      | <i>Perfluorotridecanoate</i>   |
| <i>PFTeDA</i>       | <i>Perfluorotetradecanoate</i>   |
| <i>4:2 FtS</i>      | <i>4:2 Fluorotelomer sulfonate</i>   |
| <i>6:2 FtS</i>      | <i>6:2 Fluorotelomer sulfonate</i>   |
| <i>8:2 FtS</i>      | <i>8:2 Fluorotelomer sulfonate</i>   |
| <i>10:2 FtS</i>     | <i>10:2 Fluorotelomer sulfonate</i>  |
| <i>FOSA</i>         | <i>Perfluorooctane sulfonamide</i>   |
| <i>MeFOSA</i>       | <i>N-Methyl perfluorooctane sulfonamide</i>  |
| <i>EtFOSA</i>       | <i>N-Ethyl perfluorooctane sulfonamide</i>   |
| <i>MeFOSE</i>       | <i>N-Methyl perfluorooctane sulfonamidoethanol</i>   |
| <i>EtFOSE</i>       | <i>N-Ethyl perfluorooctane sulfonamidoethanol</i>  |
| <i>MeFOSAA</i>      | <i>N-Methyl perfluorooctane sulfonamidoacetic acid</i>   |
| <i>EtFOSAA</i>      | <i>N-Ethyl perfluorooctane sulfonamidoacetic acid</i>  |
| 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.   |
| PMAP                | PFAS Management Area Plan  |
| 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).   |
| RAAF                | Royal Australian Air Force   |
| Receptor Population | People who could come into contact with hazardous substances (see exposure pathway).   |
| Risk                | The probability that something will cause injury or harm.  |
| 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)  |
| RWCC                | Riverina Water County Council  |
| STP                 | Sewage Treatment Plant   |
| 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

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## **Introduction**

Environmental Risk Sciences Pty Ltd (enRiskS) has been engaged by Jacobs Group (Australia) Pty Limited (Jacobs), 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 in the vicinity of, Royal Australian Air Force (RAAF) Base Wagga, NSW (the “base”; refer to **Figure 1, Figure Set 1**). The study area is shown on **Figure 8, Figure Set 1**.

Investigations conducted in the vicinity of the base by Jacobs have detected concentrations of some PFAS compounds in soil, sediment, groundwater, surface water, vegetation and biota (fish and crustaceans) in the off-base study area. 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 (also known as aqueous film-forming foams; AFFF). PFAS are not found in the environment from natural sources, only from anthropogenic sources (ATSDR 2018).

There is evidence to suggest that the base is a source of PFAS impacts in the off-base study area, and a number of activities that may lead to exposure to PFAS compounds have been identified in the off-base study area. The report presents a quantitative evaluation of potential health risks following off-base exposures and a qualitative assessment of risks to off-base environments.

## **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, surface water and edible produce (including fish products) in the off-base study area, in the context of the existing land uses;
- To undertake a qualitative evaluation of the potential risks to terrestrial and freshwater ecological receptors in the off-base study 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 in the off-base study area based on the information available up to 12 September 2018 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, or human health and environmental risk issues associated with any PFAS impacts and/or activities on-base.



## **Conclusions**

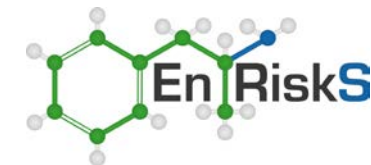
**Table ES-1** provides an overview of the ways in which off-base receptors (including members of the community and the terrestrial and aquatic environments) may be exposed to PFAS, derived from RAAF Base Wagga, and the conclusions and recommendations relevant to these areas. The conclusions and recommendations are made on the basis of the available data, and with consideration of the available information on the existing and potential future land use patterns in the off-base study area, and the uncertainties identified in this assessment. All recommendations should be considered and implemented in consultation with the relevant stakeholders, which includes the landowners.

It is noted that the risk issues identified in **Table ES-1** principally relate to PFAS derived from surface water discharged to the off-base study area, and the use of PFAS impacted groundwater at some properties including the Murray Cod Hatchery.

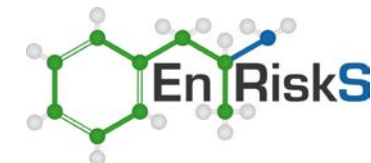


**Table ES-1: Conclusions and Recommendation, Off-Base Risks to Human Health and the Environment from PFAS**

| How the Community May be Exposed   | Potential Risks to Human Health and the Environment <sup>1</sup>   | Areas where Potential Risk Issues Identified <sup>1</sup>  | Recommendations <sup>1</sup>   |
|--|--|--|--|
| <b>Human Health – Current Exposures</b>  |  |  |  |
| Direct contact with PFAS in soil   | Low and acceptable. <sup>3</sup>   | NA   | NA   |
| Direct contact with PFAS in sediments (in dams, creeks and rivers)                           | Low and acceptable. <sup>3</sup>   | NA   | NA   |
| Ingestion of PFAS in the potable water including RWCC and GGPID water                        | Low and acceptable. <sup>3</sup>   | NA   | A groundwater model is being developed to assist in understanding potential future risks to drinking water supplies. This will be presented as part of the PMAP. An Ongoing Monitoring Plan will be required to validate the model and monitor the migration of PFAS in groundwater towards the groundwater users. |
| Non-potable and recreational use of water with PFAS where exposures occur via direct contact | Acceptable.  | NA   | NA   |
| Consumption of fish caught from local waterways  | <p>Murrumbidgee River and Marshalls Creek: risks are low and acceptable except for Carp. Where Carp that are caught and consumed comprise &lt;30% of the overall intake of fish per year, risks are expected to be low and acceptable. However, risks may be elevated for more regular consumption.</p> <p>Gregadoo Creek and Kyeamba Creek (Yabby in farm dams): risks are low and acceptable.</p> <p>Murray Cod Hatchery: there is the potential for elevated risks if fish are occasionally grown to full size and home-consumed.</p> | <p>Carp in the Murrumbidgee River and Marshalls Creek.</p> <p>Fish grown to full size in the Murray Cod Hatchery that are home-consumed.</p> | <p>The need for management measures in the Murrumbidgee River and Marshalls Creek should be considered by the NSW Government Agencies.</p> <p>Fish raised in the Murray Cod Hatchery ponds with the current water source should not be home-consumed.</p>  |



| How the Community May be Exposed  | Potential Risks to Human Health and the Environment <sup>1</sup>   | Areas where Potential Risk Issues Identified <sup>1</sup>   | Recommendations <sup>1</sup>   |
|---|--|---|--|
| <b>Human Health – Potential Future Exposures</b>  |  |   |  |
| Consumption of home-slaughtered meat  | There is the potential for elevated risks in a number of off-base areas (noting that no home-slaughter and consumption of livestock has been identified within the off-base study area).   | Murray Cod Hatchery<br>Property adjacent to the Murray Cod Hatchery<br>Gumly Gumly Wetlands<br>Marshalls Creek<br>Gregadoo Creek <sup>2</sup><br>Kyeamba Creek <sup>2</sup><br>STP Irrigation Areas <sup>2</sup><br>OTH207 <sup>2</sup><br>MW223 <sup>2</sup><br>MW233 <sup>2</sup> | Consumption of home-slaughtered livestock is not recommended in these areas. If property owners may wish to home-consume livestock products in the future, livestock should be moved away from surface water and pasture where PFAS has been detected.   |
| Consumption of eggs   | There is the potential for elevated risks in a number of off-base areas (noting that no use of water containing PFAS has been identified for chickens producing home grown eggs within the off-base study area).   | Murray Cod Hatchery<br>Property adjacent to the Murray Cod Hatchery<br>Gumly Gumly Wetlands<br>Marshalls Creek<br>Gregadoo Creek <sup>2</sup><br>Kyeamba Creek <sup>2</sup><br>STP Irrigation Areas <sup>2</sup><br>OTH207 <sup>2</sup><br>MW223 <sup>2</sup><br>MW233 <sup>2</sup> | Consumption of eggs is not recommended in these areas. If property owners may wish to home-consume eggs in the future, an alternative water source that does not contain PFAS should be used for chickens. If eggs are produced on any properties where PFAS is present in stock water, the eggs should be tested, and risks re-evaluated. |
| Ingestion of homegrown fruit and vegetables on properties where PFAS is present in soil/sediment, or where water containing PFAS is used for irrigation | There is the potential for elevated risks where soil/sediment containing PFAS concentrations in excess of the residential guidelines is used to grow fruit/vegetables or where irrigation water with PFAS concentrations in excess of drinking water guidelines is used to water fruit/vegetables (noting that no home-grown fruit/vegetables are currently present in PFAS impacted areas). | All off-base areas where PFAS in soil/sediment exceeds the residential guidelines or PFAS in water used for irrigation exceeds the drinking water guidelines. The affected areas will be further defined as part of the development of the PMAP.                                    | If fruit/vegetables are produced on any properties where PFAS is present in soil, sediment or irrigation water above the relevant guidelines, the produce should be tested, and risks re-evaluated.  |



| How the Community May be Exposed                         | Potential Risks to Human Health and the Environment <sup>1</sup>                                   | Areas where Potential Risk Issues Identified <sup>1</sup>   | Recommendations <sup>1</sup>  |
|--|--|---|---|
| <b>Environment</b>                                       |  |   |   |
| <b>Terrestrial Environment</b>                           |  |   |   |
| Livestock health   | Low and acceptable. <sup>3</sup>   | NA  | NA  |
| Direct toxicity  | Low and acceptable. <sup>3</sup>   | NA  | NA  |
| Bioaccumulation and effects on higher order consumers    | Effects to higher order consumers cannot be excluded for a number of off-base areas.               | Murray Cod Hatchery<br>Property adjacent to the Murray Cod Hatchery<br>Gumly Gumly Wetlands<br>Marshalls Creek<br>Equex Exhibition Centre | Additional data and assessment may be required if these areas may be regularly accessed by birds and mammals. |
| <b>Aquatic Environment</b>                               |  |   |   |
| Livestock health (drinking water)                        | Low and acceptable. <sup>3</sup>   | NA  | NA  |
| Direct toxicity  | Potential for adverse effects to the environment cannot be excluded in a number of off-base areas. | Murray Cod Hatchery<br>Property adjacent to the Murray Cod Hatchery<br>Gumly Gumly Wetlands   | Management measures should be developed as part of the PMAP.  |
| Effects on higher order consumers due to bioaccumulation | Potential for adverse effects to the environment cannot be excluded                                | Murray Cod Hatchery<br>Murrumbidgee River<br>Marshalls Creek<br>Gregadoo Creek<br>Kyeamba Creek   | Management measures should be developed as part of the PMAP.  |

**Notes:**

PMAP = PFAS Management Area Plan

- 1 = The conclusions of the HHERA are based on the available sampling and analysis results. All recommendations should be considered and implemented in consultation with the relevant stakeholders, which includes the landowners.
- 2 = Exposures are not calculated to be elevated based on individual exposure pathways but may be elevated for worst-case exposures if multiple exposure pathways are present.
- 3 = Low is defined as concentrations of PFAS below the screening level guidelines.