

PFAS NEMP Supporting Document

Derivation of ecological guidelines for direct soil exposure to protect reptiles from perfluorooctanoic acid (PFOA)

National Chemicals Working Group of the Heads of EPAs Australia and New Zealand

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Acknowledgement of Country

We acknowledge the Traditional Custodians of Australia and their continuing connection to land and sea, waters, environment and community. We pay our respects to the Traditional Custodians of the lands we live and work on, their culture, and their Elders past and present.

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Introduction

Background and Purpose

This supporting document presents the background information on the derivation of the ecological criteria for direct soil toxicity of PFOA for protection of reptiles presented in Section 8.6 of the PFAS National Environmental Management Plan (NEMP) (NEMP 3.0).

At the request of Environment Ministers around Australia, the Heads of EPAs Australia and New Zealand (HEPA) and the Australian Government Department of Agriculture, Water and the Environment (DAWE) collaborated to develop and publish the PFAS National Environmental Management Plan (NEMP) (NEMP 1.0 in February 2018 and NEMP 2.0 in January 2020). The NEMP provides a nationally consistent approach to environmental management of PFAS, including environmental guideline values (GVs) intended to be protective of ecological and human health for a range of exposures.

Australia is a hotspot for reptile diversity, hosting the largest number of species of any country in the world and accounting for approximately 10% of all known species globally (Tingley et al. 2019). Australian reptile fauna is also very distinctive with around 90% of species being endemic (Chapman 2009).

There is a however paucity of ecotoxicological studies relevant to reptiles, particularly dietary intake ecotoxicological studies which are used to derive indirect soil guidance. The current PFAS National environmental management plan (NEMP) reflects this with no specific ecological guidance included for reptiles.

Currently only interim ecological guidance for PFOA is included in the NEMP, this being 10 mg/kg in Table 3 for direct toxicity only, based on the human health screening value for public open space. A draft indirect soil GV for PFOA has been developed for consideration by the NCWG. However, this is based on an end point (developmental toxicity to mammary gland development) that is irrelevant for reptiles.

Reptiles such as lizards and snakes have body plans and commonly exhibit behaviors and occupy niches that result in them spending significant time on the soil surface (Figure 1). There is a concern that a concentration of 10 mg/kg is not protective of reptiles from adverse effects due to direct contact with soil based on recent research findings. An alternative interim value considering this research has been developed.

Scope

The paper is restricted to developing potential guidance to be included in the forthcoming NEMP 3.0 for direct exposures to soil for reptilian ecological receptors via contact with contaminated soil. Indirect soil exposure and wildlife diet guidance for reptiles is out of scope due to a lack of toxicity studies measuring oral doses, needed to inform such guidance.

Figure 1: The Australian scrub python *Simalia kinghorni*, an example of a large reptilian predator



(photograph Neil Pritchard 2021)

1 Research findings on reptile exposure to soil

In a recent study, small lizards *Eremias argus* were exposed for 60 days in enclosures to soil spiked with nil and three concentrations (50µg/kg, 500µg/kg, 5000µg/kg) of perfluorooctanoic acid (PFOA). Measurements were made at intervals and throughout of bodyweight, survival rate, egg clutch characteristics and biochemical markers for immune response, lipid accumulation, sex steroid secretion, antioxidant level, and metabolomics (Zhang et al. 2020). This type of exposure is considered direct exposure (Schedule B5b NEPC 2013).

Strong sex differences were observed in responses. Males in all treatment groups showed significant differences compared to controls with reduced body weight and testes mass in all treatment concentrations and significantly greater deaths in the highest concentration. Other omics based observations in males included indications of dose dependent increase in markers of testis oxidative stress and increases in total cholesterol. Females were observed to devote an apparent greater proportion of energy reserves to maintenance over reproduction.

Growth reduction of 17% for male lizards in 50 µg/kg treatment group compared to controls and male survival reduction of 15% in the 5000 µg/kg treatment group was observed. These end points are considered ecologically relevant, particularly given the sub-chronic duration of the exposure. A No Observed Adverse Effect Level (NOAEL) could not be determined from the study.

2 Derivation of draft guideline for direct soil exposure

The Lowest Observed Adverse Effect Level (LOAEL) from the Zhang (et al. 2020) study is 50 µg/kg PFOA based on the growth reduction in male lizards.

The National Environment Protection (Assessment of Site Contamination) Measure 1999 (NEPC 2013) schedule B5b provides advice on uncertainty factor (UF) selection for deriving soil guideline values for direct toxicity. The NEPC (2013) recommend a minimum of 10 for extrapolation from field to laboratory settings for a chronic No Observed Effect Level (NOEL).

The critical study end point is a LOAEL rather than a NOEL and is of sub-chronic duration. An argument could thus be made for applying an additional UF for LOAEL to NOAEL conversion, for example UF in the range 2 to 5 (NEPC 2013).

As the guidance is designed to be applied broadly as well as on contaminated sites, there is a risk the minimum of UF of 10 adopted since based on an adverse effect concentration may not be sufficiently protective in the case of high ecological value sites or sites where endangered, threatened or vulnerable reptiles are resident. In those cases, or others where the regulator considers greater conservatism is warranted, application of an additional UF of at least 2 may be desirable.

A minimum interim soil direct toxicity concentration for reptiles of **5 µg/kg** is suggested. This is derived from the LOAEL of 50µg/kg divided by the minimum uncertainty factor of 10 to account for inter species differences (NEPC 2013). As PFOA is a synthetic organic contaminant, there is no need to consider natural ambient background concentration in derivation of a soil guidance value.

Draft amended text for the PFAS NEMP version 3.0 Table 3 is attached in [Appendix 1](#).

References

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Appendix A: Suggested amended PFAS NEMP Table 3. Ecological guideline values for soil to account for reptilian toxicity

Table A1 Ecological guideline values for soil (PFAS NEMP Table 3)

Exposure scenario	PFOS	PFOA	Land use	Comments and source
Ecological direct exposure	1 mg/kg	10 mg/kg	All land uses	<p>Future work may be undertaken to review available soil guideline values proposed by Australian research and industry organisations. For example, CRC CARE (2017).</p> <p>The human health screening value for public open space is used as an interim value (see Table 2), except where reptiles may be exposed directly to soil. For these sites, an interim screening value of 5 µg/kg is recommended. Based on a LOAEL of 50 µg/kg for reduced growth (Zhang et al. 2020), divided by an uncertainty factor of 10 for inter species differences (NEPC 2013). As this is based on a LOAEL, it may not be sufficiently protective of endangered, threatened or vulnerable reptiles and high ecological value site.</p>
Ecological indirect exposure	0.01 mg/kg		All land uses	<p>The guideline value is based on dietary exposure of a secondary consumer as the most sensitive exposure pathway assessed. This value may not be protective of specific animals relevant to Australia, including predatory animals such as quolls, antechinus and reptiles. For intensively developed sites with no secondary consumers and minimal potential for indirect ecological exposure, a higher criterion of up to 0.14 mg/kg may be appropriate as outlined in the accompanying text in section 8.2.1.</p>