Australian Government
Department of Agriculture, Water and the Environment
Supervising Scientist

Sulfate in Surface Water — Rehabilitation Standard for the Ranger uranium mine

Water and sediment theme

Preface

The Supervising Scientist developed this Rehabilitation Standard to describe the requirements to protect aquatic ecosystems outside of the Ranger Project Area in the Alligator Rivers Region of the Northern Territory from the effects of sulfate in surface water by preventing the formation of acid sulfate soils.

This document is part of a series of Rehabilitation Standards for the Ranger uranium mine. It may be updated as additional relevant knowledge becomes available.

This Standard should be cited as follows:

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1. General elements

Scope

1.1 The Rehabilitation Standards for the Ranger uranium mine have been developed in accordance with section 5c of the *Environment Protection (Alligator Rivers Region) Act 1978* and are advisory only.

1.2 The *Environmental requirements of the Commonwealth of Australia for the operation of the Ranger uranium mine* (Environmental Requirements) (Australian Government 1999) specify the environmental objectives for the rehabilitation of the Ranger uranium mine.

1.3 The Supervising Scientist's Rehabilitation Standards quantify the rehabilitation objectives and recommend specific values based on the best available science that will ensure a high level of environmental protection. These values can be used to assess the achievement of, or progress towards, the rehabilitation objectives, some of which may not be reached for a significant period of time.

1.4 Until it can be determined that the rehabilitation objectives have or will be reached, there will be an ongoing need to ensure environmental protection during and after rehabilitation through continued water quality monitoring, including the comparison of water quality data with relevant water quality limits.

Objective

1.5 There is currently no agreed acceptable level of effect to the environment surrounding the Ranger Project Area. In the absence of agreement, the rehabilitation standard for sulfate in surface water aims to prevent the formation of acid sulfate soils thereby protecting the biodiversity and health of aquatic ecosystems outside of the Ranger Project Area. This includes ecosystems upstream of the mine given that poor water quality associated with acid sulfate soil events within the Ranger Project Area could form a barrier to the movement of aquatic organisms. If an acceptable level of effect is agreed, this standard will be updated accordingly.

Application

1.6 This Rehabilitation Standard should be applied in Magela and Gulungul creeks at the boundary of the Ranger Project Area, downstream from the Ranger uranium mine.

1.7 Given the potentially long time frame between the completion of rehabilitation and the peak delivery of contaminants to surface water, this Rehabilitation Standard will most likely be used to assess predicted sulfate concentrations from modelled scenarios. Ongoing surface water, sediment and groundwater monitoring will be required after rehabilitation to continue to ensure the environment is being protected, and to validate and assess confidence in the models.

2. Relevant requirements

Environmental Requirements

2.1 The primary environmental objectives in the Environmental Requirements require that surface waters or groundwater arising from the Ranger uranium mine do not result in any detrimental change to biodiversity or impairment of ecosystem health outside of the Ranger Project Area, including during or following rehabilitation. This Rehabilitation Standard is relevant to the Environmental Requirements listed in Box 1.

Aspirations of Traditional Owners

2.2 The Mirrar Traditional Owners desire that operations at the Ranger uranium mine should not result in any change to the natural quality of surface waters outside of the Ranger Project Area (Iles 2004). Specifically, as stated in Garde (2013):

> ... the waters contained within all riparian corridors, (i.e. rivers and billabongs), must be of a quality that is commensurate with non-affected riverine systems and health standards. The principle of 'as low as reasonably achievable' should not apply to these areas. Instead, the standard of rehabilitation must be as high as is technically possible and level of contamination must be as low as technically possible.

Box 1: Ranger Environmental Requirements relevant to the Sulfate Rehabilitation Standard

1 Environmental protection

1.1 The company must ensure that operations at Ranger are undertaken in such a way as to be consistent with the following primary environmental objectives:

- (a) maintain the attributes for which Kakadu National Park was inscribed on the World Heritage list
- (b) maintain the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park)
- (d) maintain the natural biological diversity of aquatic and terrestrial ecosystems of the Alligator Rivers Region, including ecological processes.

1.2 In particular, the company must ensure that operations at Ranger do not result in:

- (a) damage to the attributes for which Kakadu National Park was inscribed on the World Heritage list
- (b) damage to the ecosystem health of the wetlands listed under the Ramsar Convention on Wetlands (i.e. the wetlands within Stages I and II of Kakadu National Park)
- (d) change to biodiversity, or impairment of ecosystem health, outside of the Ranger Project Area. Such change is to be different and detrimental from that expected from natural biophysical or biological processes operating in the Alligator Rivers Region.

3 Water quality

3.1 The company must not allow either surface or ground waters arising or discharged from the Ranger Project Area during its operation, or during or following rehabilitation, to compromise the achievement of the primary environmental objectives.

3. Recommended values for sulfate

3.1 To protect aquatic ecosystems outside the Ranger Project Area in accordance with the rehabilitation objectives, predicted water quality at the boundary of the Ranger Project Area, reported as seasonal averages, should not exceed the recommended values for the parameters shown in Table 1.

Table 1 Rehabilitation standard for sulfate in surface water

Parameter	Location	Rehabilitation standard
Dissolved sulfate	In Magela and Gulungul creeks at the boundary of the Ranger Project Area, downstream of the Ranger uranium mine	10 mg/L (seasonal average)

4. Scientific basis

Guidelines and standards used to develop the recommended values

4.1 The sulfate rehabilitation standard is based on national guidance for the management of acid sulfate soils in inland aquatic ecosystems (EPHC & NRMMC 2011). The recommended sediment sulfur standard set in other jurisdictions is 0.03% oxidisable sulfur, or net acidity of the sediments of 18 moles of H+ per tonne. This sediment sulfur standard can be achieved by maintaining an average annual concentration of sulfate in surface water below 10 mg/L (Ahearn et al. 1998ab, Tulau 2000, Dear et al. 2002, Ahearn et al. 2004, EPHC & NRMMC 2011).

4.5 During wetting and drying cycles that occur in tropical water bodies, acid sulfate soils can induce acidification events, where accumulated reduced sulfur in the sediment oxidises to form sulfuric acid, which reduces the pH of the sediment pore water and water column (EPHC & NRMMC 2011). The occurrence and severity of acid sulfate soils induced acidification events depends on the acid-neutralising capacity of both the overlying surface water and the underlying sediments (EPHC & NRMMC 2011). Significant decreases in pH can mobilise other contaminants bound to the sediment and deoxygenate surface waters.

4.6 The effects of sulfate in local surface waters around the Ranger uranium mine, and the associated formation of acid sulfate soils, have been the subject of some investigation (Jones et al. 1999, Esslemont & Iles 2015, Esslemont 2016).

4.6.1 Acid sulfate soils were present in Ranger Retention Pond 1 (RP1) from at least the 1990s (Batterham & Overall 2000, Overall et al. 2002 cited in Esslemont & Iles 2015) when the mean concentration of sulfate in the water body was 13 mg/L. Jones et al. (1999) reported that a long-term (from 1980 to 1991) average sulfate concentration of 15 mg/L led to an acid sulfate soils event in RP1 during the 1990s. The findings of these investigations were that an elevated loading of sulfate to the system and the maintenance of high water levels led to the formation of acid sulfate soils.

4.6.2 Occasional instances of acid sulfate soils induced acidification events in Coonjimba Billabong were observed in the early 1990s, with increasing prevalence from 2002 after a decade of increasing sulfate concentrations in surface waters. The mean surface water concentration over the 1989–2001 period, before the first significant acid sulfate soils induced acidification event in Coonjimba Billabong, was 13 mg/L sulfate (Baldwin 2017). Since 2002, acidification events have frequently occurred in Coonjimba Billabong at the start of the wet season, after oxidation of sulfides in sediments during the dry season. These events have been characterised by very low surface water pH (< 4) and high concentrations of some metals, particularly manganese and uranium (> 300 µg/L for manganese and > 7 µg/L for uranium, which is 10 times the median concentration) (ERA weekly water quality monitoring data).

4.7 The data from both RP1 and Coonjimba Billabong indicate the formation of acid sulfate soils in local water bodies after long-term exposure to surface waters with sulfate concentrations of less than 15 mg/L. This supports the nationally recommended guideline value of 10 mg/L to prevent the formation of acid sulfate soils. Additional site-specific knowledge may lead to further refinement of this standard.

5. Future Knowledge Needs

5.1 Rehabilitation planning can only be based on the best available information at a given time, but this should not preclude the continual improvement of the knowledge base and its subsequent application where directly relevant and possible.

5.2 The Supervising Scientist, through its Key Knowledge Needs, has identified the knowledge required to ensure appropriate management of the key risks to the environment from the rehabilitation of the Ranger uranium mine. For sulfate, these knowledge needs are shown in Table 2.

Table 2 Key Knowledge Needs for Sulfate in surface water

ER Link	Key Knowledge Need	Questions
Biodiversity and human health	WS5. Determining the impact of contaminated sediments on aquatic biodiversity and ecosystem health	WS5A. To what extent will contaminants accumulate in sediments over time, including the development of acid sulfate sediments?
	WS7. Determining the impact of chemical contaminants on aquatic biodiversity and ecosystem health	WS7F. Can a contaminant plume in creek channels form a barrier that inhibits organism migration and connectivity (e.g. fish migration, invertebrate drift, gene flow)?

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