

Environmental Protection Order

This environmental protection order is issued by the administering authority pursuant to section 358 of the Environmental Protection Act 1994.

To: DGR Global Limited (ACN 052 354 837)
Level 27
111 Eagle Street
BRISBANE CITY QLD 4000

Cc: Brian Gerry Moller
Director
26 Jainba Street
INDOOROPILLY QLD 4068

Cc: Nicholas Mather
Director
Level 27, 111 Eagle Street
BRISBANE CITY QLD 4000

Cc: Peter Stanley Wright
Director
'Matisse Tower' Level 21, 110 Mary Street,
BRISBANE QLD 4000

Cc: Mr John Bierling
Group Operations Manager
DGR Global Limited
Email: jbierling@dgrglobal.com.au

Your reference: EPML00928813

Our reference: C-CPLPO-100049807 (101/0008732) STAT-E-100353709

21/04/2023

To whom it may concern,

Take notice: that under the *Environmental Protection Act 1994* (the Act) this environmental protection order (EPO) is issued to DGR Global Limited (ACN 052 354 837) (you) by the administering authority. The administering authority is the Chief Executive of the Department of Environment and Science (the department).

The EPO is issued with respect to the activities carried out by you at the Shamrock mine site located on mining lease (ML) ML50291, ML3749, ML3741, ML3678, ML3752 and ML3753, on land situated at Webb Road, BLACK SNAKE, QLD 4600 (the premises).



A. Grounds

This EPO is issued to you on the following grounds:

1. Section 358 of the Act prescribes *'the administering authority may issue an order (an environmental protection order) to a person -*
(d) to secure compliance by the person with -
(i) the general environmental duty; or...
(iii) a condition of an environmental authority.'
2. Pursuant to section 358(d)(i) of the Act, the department requires you to take reasonable measures to secure compliance with the general environmental duty (GED). The GED is detailed in s319 of the Act which states the following: *'A person must not carry out any activity that causes, or is likely to cause, environmental harm unless the person takes all reasonable and practicable measures to prevent or minimise the harm (the general environmental duty).'*
3. Pursuant to section 358(d)(iii) of the Act, the department requires you to take reasonable measures to secure compliance with condition A3-1 which states *'The holder of this environmental authority must:*
a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority; and
b) maintain such measures, plant and equipment in a proper condition; and
c) operate such measures, plant and equipment in a proper manner.'
4. Pursuant to section 358(d)(iii) of the Act, the department requires you to take reasonable measures to secure compliance with condition C1-1 which states *'Contaminants must not be release from the site to any **waters** of the bed and banks of any **waters**.'*
5. Pursuant to section 358(d)(iii) of the Act, the department requires you to take reasonable measures to secure compliance with condition C7-1 which states *'The design storage allowance on 1st November of each year for any dam containing **hazardous waste** constructed or operated within the operational **land** must comply with Table 4.*

Table 4 (Storage design* for dams containing hazardous waste)

Dam Name	Design Storage Allowance** Critical Wet Period	Spillway Critical Design Storm***	Mandatory**** Reporting Level
Shamrock Tailings Dam	502.7 mRL (2m freeboard)	150mm in 1 hour	503.4m RL (1.3m freeboard)

Note: AEP means annual exceedance probability

* Calculations are to be carried out in accordance with the "Site Water Management" guideline in the Technical Guidelines for Environmental Management of Exploration and Mining in Queensland – DME 1995.

** The design storage allowance on 1st November of each year for any dam containing hazardous waste constructed within the operational land must be equivalent to the run-off from the critical wet period plus process inputs for the period. Process inputs refers to hazardous mineral process waste and any water, which is being disposed of in the storage facility.

*** The critical storm has a duration that produces the peak discharge for the catchment.

**** The level below spillway crest that can accommodate runoff from a 72 hour ARI storm, or the ARI wave allowance whichever level is lower.'

The facts and circumstances forming the basis for these grounds are:

1. You are:
 - a. the holder of mining lease (ML) ML50291, ML3749, ML3741, ML3678, ML3752 and ML3753;
 - b. the holder of environmental authority EPML00928813 (the EA); and
 - c. the person with legal ownership and possession and control over the premises.

2. The EA authorises the environmentally relevant activity of resource activity, Schedule 3, 16: Mining gold ore at the premises, subject to conditions of the authority.
3. A tailings storage facility (TSF) is located on the premises.
4. In a report titled '*Shamrock Mine 2022 Annual Inspection of Regulated Structures – TSF 113337.13 November 2022*' (ATC Williams Pty Ltd, 2022) (the report), prepared for you as a requirement of condition F2-7 of the EA, it was reported that the TSF is a dam:
 - a. storing hazardous material (tailings solids and process liquor); and
 - b. containing approximately 770,000 tonnes of tailings material.
5. The EA definitions state that "*hazardous waste* means any substance, whether liquid, solid or gaseous, derived by or resulting from, the processing of minerals that tends to destroy life or impair or endanger health.'
6. Conditions F2-1 and F2-2 of the EA identify the TSF as a dam containing hazardous waste on the premises.
7. 'Contaminant' is defined in section 11 of the Act. 'A contaminant can be — (a) a gas, liquid or solid; or (b) an odour; or (c) an organism (whether alive or dead), including a virus; or (d) energy, including noise, heat, radioactivity and electromagnetic radiation; or (e) a combination of contaminants.'
8. Mine affected water (a liquid) stored in the TSF is considered a contaminant pursuant to section 11 of the Act.
9. Section 14 of the Act provides a definition of environmental harm:

'(1) Environmental harm is any adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on an environmental value, and includes environmental nuisance.

(2) Environmental harm may be caused by an activity— (a) whether the harm is a direct or indirect result of the activity; or (b) whether the harm results from the activity alone or from the combined effects of the activity and other activities or factors.'
10. Section 9 of the Act provides a definition of 'environmental value'. '*Environmental value is— (a) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or (b) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.*'
11. The environmental values and water quality objectives for the receiving waters are listed in Schedule 1 of the *Environmental Protection (Water) Policy 2009* see: Schedule 1 - Plan: WQ1381 Mary River environmental values and water quality objectives Basin No. 138, including all tributaries of the Mary River. Environmental values include aquatic ecosystems, irrigation, farm supply/use, stock water, aquaculture, human consumer, primary recreation, secondary recreation, visual recreation, drinking water, industrial use, cultural and spiritual values.
12. Section 440ZD of the Act provides a definition of 'prescribed water contaminant.' '*Prescribed water contaminant means — (a) earth; or (b) a contaminant prescribed under section 440ZF.*' Section 440ZF of the Act states that a regulation may prescribe a contaminant for part 3C when the Minister is satisfied the contaminant is likely to cause environmental harm if it enters waters. Prescribed water contaminants are defined in Schedule 10 of the *Environmental Protection Regulation 2019*. Contaminants including but not limited to chemicals and liquids containing suspended or dissolved solids are prescribed water contaminants and are considered likely to cause environmental harm if they enter waters. The department consider TSF water typically contains chemicals and suspended or dissolved solids likely to cause environmental harm if they enter waters.
13. There is potential for environmental harm associated with the release of contaminants from activities authorised by the EA on the premises including, but not limited to:
 - a. environmental risks associated with mobilisation of contaminants from disturbance to the land;
 - b. environmental risks associated with the entrainment of contaminants in rainfall runoff from disturbed areas; and
 - c. environmental risks associated with the release of contaminated mine wastes (e.g. residual process waters, tailings, contaminated soil, flue dust cell (FDC) material).

Active ongoing management of these risks is required to mitigate the potential for environmental harm and demonstrate the GED.

14. Relevant water quality guidelines referenced in this EPO include *Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 2 Aquatic Ecosystems* and *Volume 3 Primary Industries* (ANZECC & ARMCANZ, 2000) and *Queensland Water Quality Guidelines 2009* (State of Queensland, 2013).
15. Relevant water quality guidelines use data to determine contaminant concentrations ('guideline values') that will protect a particular value (e.g. aquatic ecosystems and primary industries). Relevant water quality guideline values are referenced in Attachment A, Table 1.
16. The department holds water quality monitoring data for the premises. This data demonstrates the TSF (monitoring point S16) contains a range of water contaminants including total dissolved solids (TDS), dissolved salts expressed as electrical conductivity (EC), sulphate and metals, at levels typically exceeding relevant water quality guideline values.
17. A review of selected parameters TDS, EC, sulphate, aluminium, arsenic, cadmium, copper, lead, molybdenum, selenium and zinc sampled in the TSF by you from November 2013 to October 2022 and compared to relevant water quality guideline values (refer Attachment A, Table 1) indicates the following:
 - a. TDS (mg/L) results range between 379 mg/L (26/10/2021) and 5780 mg/L (21/10/2020). Mean value 1990 mg/L. TDS exceeding the guideline value (2000 mg/L) on 8 from 25 sampling occasions.
 - b. EC (µS/cm) results range between 561 µS/cm (26/10/2021) and 6810 µS/cm (21/10/2020). Mean value 2605 µS/cm. EC exceeded the guideline value (1200 µS/cm) on 24 from 25 sampling occasions.
 - c. Sulphate (mg/L) results range between 146 mg/L (26/10/2021) and 3320 mg/L (21/10/2020). Mean value 1071 mg/L. Sulphate exceeded the guideline value (1000 mg/L) on 8 from 25 sampling occasions.
 - d. Aluminium – dissolved (µg/L) results range between <10 µg/L on 22 from 25 sampling occasions to 90 µg/L (26/06/2014). Aluminium – dissolved was above the laboratory limit of reporting and exceeded the guideline (55 µg/L) on 3 occasions. Aluminium – total is not routinely sampled.
 - e. Arsenic – dissolved (µg/L) results range between 40.6 µg/L (19/01/2022) and 1000 µg/L (20/11/2019). Mean value 319.5 µg/L. Arsenic – total or speciated is not routinely sampled.
 - f. Cadmium - dissolved (µg/L) results range between 0.1 µg/L (20/04/2021) and 3 µg/L (23/11/2017). Mean value 0.86 µg/L. Cadmium – dissolved exceeded the guideline value (0.2 µg/L) on 24 from 25 sampling occasions. Cadmium – total is not routinely sampled.
 - g. Copper – dissolved (µg/L) results range between 5 µg/L (04/10/2016) and 43 µg/L (28/04/2015). Mean 19.8 µg/L. Copper – dissolved exceeded the guideline (1.4 µg/L) on all 25 sampling occasions. Copper – total is not routinely sampled.
 - h. Lead – dissolved (µg/L) results range between <1 µg/L on 20 from 25 sampling occasions to 36 µg/L (04/05/2022). Lead – dissolved exceeding the guideline (3.4 µg/L) on 4 occasions including May 2022 and October 2022. Lead – total is not routinely sampled.
 - i. Molybdenum - dissolved (ug/L) results range between 6 ug/L (04/06/2022) and 60 ug/L (14/06/2022). Mean value 18.28 ug/L. Molybdenum – dissolved exceeded the guideline (34 ug/L) on 4 from 25 sampling occasions, including in June 2022. Molybdenum – total is not routinely sampled.
 - j. Selenium – dissolved (µg/L) results range between 20 µg/L (04/10/2016) and 380 µg/L (26/10/2021). Mean value 76.8 µg/L. Selenium – total or speciated is not routinely sampled. *In addition, selenium – total (50.2 µg/L) sampled by the department on 04/07/2022 exceeded the guideline value (20 µg/L).*
 - k. Zinc – dissolved (µg/L) results range between <5 µg/L (17/05/2016 and 04/10/2016) and 59 µg/L (07/11/2013). Mean value 26.04 µg/L. Zinc – dissolved exceeded the guideline value (8 µg/L) on 22 from 25 sampling occasions, including 8 occasions in 2022. Zinc – total is not routinely sampled.
18. On 4 July 2022, authorised persons of the department conducted a compliance inspection of the premises and collected TSF surface water samples for analysis, including total metals. Select results are provided in Attachment A, Table 1.
19. Relevant water quality guidelines also identify when adverse effects may occur from elevated levels of contaminants in freshwater. Examples identified by ANZECC & ARMCANZ, 2000 guidelines on aquatic ecosystems (volume 2) and primary industries (volume 3) are provided in Attachment B, Table 2.

20. It is the departments assessment that contaminant levels in the TSF (refer paragraph 17 and Attachment A, Table 1 and Attachment B, Table 2) are likely to cause an adverse effect, or potential adverse effect (whether temporary or permanent and of whatever magnitude, duration or frequency) on the environmental values of Freshwater Dam, Collins Creek and surrounding groundwaters (environmental harm), in the event contaminants and hazardous waste present in TSF water were to enter Shamrock pit and/or Freshwater Dam and/or Collins Creek.
21. The EA does not authorise any release of contaminants to land or waters on or off the premises. Condition C1-1 of the EA states '*Contaminants must not be release from the site to any waters of (sic) the bed and banks of any waters.*' 'Release' is defined in Schedule 4 of the Act as '*Release, of a contaminant into the environment, includes— (a) to deposit, discharge, emit or disturb the contaminant; and (b) to cause or allow the contaminant to be deposited, discharged, emitted or disturbed; and (c) to fail to prevent the contaminant from being deposited, discharged, emitted or disturbed; and (d) to allow the contaminant to escape; and (e) to fail to prevent the contaminant from escaping.* The EA provides a definition of 'waters', which includes groundwater, Freshwater Dam and Collins Creek. '*Waters*' - *includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater runoff, and groundwater or any part-thereof.*'
22. The Environmental Management Overview Strategy prepared for the mining leases dated February 2005 (refer EA condition A1-1) states that since January 1999, any passive releases from the TSF have been designed to flow to Shamrock pit (section 6.8.9). Shamrock pit is considered a 'dam' and a 'residual void' as defined in the EA and condition F2-1 Note (2) of the EA.
23. The department considers Shamrock pit has potential to receive and contain contaminants and hazardous waste from the TSF. Condition F2-2 of the EA does not authorise Shamrock pit to contain hazardous waste.
24. You reported to the department that between approximately 9:45am 23 July 2022 and approximately 10am 29 July 2022 (6 days), there was an uncontrolled release from the TSF to Shamrock pit.
25. In the absence of an assessment of the risk of potential connection between surface water in Shamrock pit and groundwater you have not demonstrated compliance with the GED.
26. Any passive releases from Shamrock pit flow to the receiving waters of Freshwater Dam. Freshwater Dam flows to Collins Creek, a tributary for the upper catchment Wide Bay Creek, part of the Mary River basin.
27. The department considers Freshwater Dam and downstream waters have potential to receive and contain contaminants from Shamrock pit.
28. You applied to the department for a temporary emissions licence (TEL) and TEL A-TEL-NEW-100213898 was granted to you on 3 March 2022 for the period of 3 March 2022 to 24 March 2022, pursuant to Part 4A of the Act. The TEL temporarily overrode EA condition C1-1 of the EA and authorised the active release (pumping) of up to 73 ML water from the Shamrock pit into Freshwater Dam, and passive release from the TSF into the Shamrock pit. Your application demonstrated the Shamrock pit had lower contaminant levels than the TSF water. As such, the release to Freshwater Dam was authorised to increase the storage capacity in the pit and facilitate containment of TSF water to reduce risk of a subsequent release of higher contaminant levels into the Freshwater Dam, Collins Creek, Wide Bay Creek and ultimately the Mary River in the short term. The department does not consider any reliance on the provision of TEL's to be a suitable component of the water management strategy for the premises.
29. In a letter to the department dated 13 January 2023 you reported that Shamrock pit had a remaining available storage capacity of 94.554 ML. You do not currently implement any water reduction measures on Shamrock pit.
30. You have not provided the department with information to demonstrate the release of contaminants and hazardous waste from the TSF does not have potential to cause environmental harm on environmental values.
31. The intent of a design storage allowance (DSA) volume is to provide reasonable certainty that design performance criteria for containment will be met in any forthcoming wet season. Failure to operate a dam so that it meets the requirement to provide the DSA volume at the onset of each wet season (that is, on 1 November each year) infers that the dam is at risk of spillway discharge.

32. Condition C7-1 of the EA requires that the DSA on 1 November each year for any dam containing hazardous waste constructed or operated within the operational land must comply with Table 4 of the EA. Table 4 includes the TSF (only) as a dam containing hazardous waste and requires the following:

Dam name	DSA critical wet period	Spillway critical design storm	Mandatory Reporting Level (MRL)
Shamrock Tailings Dam	502.7 mRL (2m freeboard)	150mm in 1 hour	503.4m (1.3m freeboard)

33. The department considers that there is an increased risk of release from the TSF to Shamrock pit if you fail to take action to achieve DSA in the TSF by 1 November annually.
34. The report (refer paragraph 4) includes an assessment of containment and freeboard requirements. Reported water levels in the TSF and estimated capacities (inferred as at 1 Nov 2022) are summarised below:

TSF		DSA - no diverted catchments		MRL	
Water level	Available storage capacity	EA DSA	DSA	EA MRL	MRL
RL 504.55 m	10.4 ML	RL 502.7 m (2m freeboard)	145 ML	RL 503.4 m (1.3 m freeboard)	RL 504.2 m

35. The report indicated the TSF had 134.6 ML insufficient available storage entering into the 2022/2023 wet season (available storage capacity (10.4 ML) was less than the DSA requirement (145 ML)). The department has determined you have not complied with condition C7-1 of the EA.
36. On 6 January 2022 the department issued you with one (1) formal warning (WARN-E-100181781) for contravention of EA condition C7-1 whereby the TSF had 3.5 ML insufficient available storage entering into the 2021/2022 wet season.
37. The report indicated the DSA and MRL figures specified in the EA are not consistent with the *Manual for assessing consequence categories and hydraulic performance of structures* ESR/2016/1933 (Department of Environment and Science, 2016) (the manual). The report recommended that the EA is amended to reflect the requirements of the manual with regard to hydraulic performance. To date you have not submitted any applications to the department to amend the EA.
38. Condition A3-1 of the EA requires you to install, maintain and operate all measures, plant and equipment necessary to ensure compliance with the conditions of the EA. This includes measures, plant and equipment such as clean water diversion bunds and drains, evaporator fans, sprinklers, aerators and atomizers at the TSF that are necessary for you to comply with condition C7-1 of the EA, and at the Shamrock pit that are necessary for you to comply with condition C1-1 of the EA.
39. You have a current Tailings Dam Operation Plan (AusRocks, January 2022) (the TDOP) including standard operating procedures related to TSF overflow (SOP25) and MRL (SOP26). The primary ways by which the risks set out in paragraph 13 above are managed at the premises are outlined in the TDOP and the report. These measures include the following:
- use of transfer systems from the seepage pond to the TSF;
 - use of three (3) evaporator fans on the TSF for disposal of excess water quantities via aerial evaporation. Operation of these fans commenced on 15 December 2021;
 - daily and weekly site inspections including checking of water levels (TSF and seepage pond), with weekly reporting of current status to the department when the water level is above the MRL;
 - visual checks of diversion bunds and groundwater flow, in particular checking for any flows from the flue dust cell;
 - maintenance of roads, bunds, diversion drains, dam walls and earth work associated with the site infrastructure; and

- f. monthly checks of water management infrastructure, specifically the pumping capacity from the seepage pond.
- 40. Water balance modelling forms an integral component of the current TDOP and includes the following:
 - a. *'Tailings Dam Evaporation Modelling'* (AusRocks, 27 January 2022);
 - b. *'Shamrock Pit Evaporation Modelling'* (AusRocks, 27 January 2022); and
 - c. *'Seepage Pond Modelling as at January 2014'* (AusRocks, 2014).
- 41. The January 2022 evaporation modelling and water balance for the TSF indicated that with implementation of the current water management strategy, with preceding 5-year average rainfall inputs, the TSF would not achieve DSA by 1 November 2022, and you would be in contravention of condition C7-1 of the EA. The modelling also indicated that operation of 3 evaporators was not effective in reducing legacy water. For example, the February 2022 water level in the model was 503.8 mRL and assuming continued operation of 3 evaporators and 5-year average rainfall inputs, the estimated February 2023 water level was 503.72 mRL.
- 42. On 4 March 2022 the department sent you a letter regarding the water management strategy for the premises and requested an onsite storage compliance review.
- 43. The department has stated that it considers the revision of the water management strategy and updating the TDOP to include implementation of additional measures to manage risks associated with site water management, as reasonable and practicable measures necessary to prevent or minimise the harm (the GED).
- 44. The report includes information regarding upstream catchments reporting to the TSF and states area 3 (Rehabilitated Flue Dust Storage Area) '*... was used for storage of flue dust prior to it being encapsulated in the FDC. The area was rehabilitated as part of the FDC works. A diversion drain was constructed as part of the works, however modifications are required to divert the full catchment away from the tailings dam to the potable dam.*' This information has been included in the annual RPEQ reports prepared under condition F2-7 of the EA since 2017. It is apparent you have not implemented measures to divert the full clean water catchment away from the TSF.
- 45. On 13 January 2023 you reported that you have commenced solar heated pipe trials (black poly pipe) this 2022/2023 wet season in an effort to increase the effectiveness of the evaporator fans. You have not committed to the installation, maintenance and operation of any further measures or provided updated water balance modelling to the department.
- 46. In the weekly report dated 31 March 2023 you reported to the department that the TSF water level was at 503.760 mRL, 360 mm above MRL, 940 mm below the spillway, 440 mm below red alert level.
- 47. The Australian Bureau of Meteorology reported that southeast Queensland has been in a La Niña weather pattern. La Niña events increase the chances of above average rainfall and cloudiness for northern and eastern Australia.
- 48. The department has determined that you have not met your obligations associated with management of dams containing hazardous waste. You have not achieved DSA in the TSF by 1 November 2022 as required by condition C7-1 of the EA.
- 49. During the course of 2022, despite your efforts (refer paragraph 39 and 45), the premises has continued to accumulate water to the extent that the TSF on the premises was effectively full, leading into the 2022/2023 La Niña wet season. You have not demonstrated how you will achieve DSA in the TSF by 1 November 2023 and annually thereafter. Given long term historic climate data and in the absence of an effective water management strategy, it is the department's assessment that there is potential for additional release of contaminants and hazardous waste from the TSF to Shamrock pit and from Shamrock pit to waters particularly in the 2023/2024 wet season and future wet seasons, if additional water reduction measures are not implemented at the premises when required.
- 50. The department has determined that you have not installed, maintained and operated sufficient measures, plant and equipment necessary to effectively manage contaminated water and hazardous waste generated and stored in the TSF at the premises as required by condition A3-1 of the EA, to ensure compliance with condition C7-1 and condition C1-1 of the EA.
- 51. The department has determined that you have not demonstrated the GED by taking all reasonable and practicable measures necessary to prevent or minimise environmental harm associated with the potential

release of contaminated water and hazardous waste from the TSF, and subsequently Shamrock pit, which forms part of an activity authorised by the EA on the premises.

52. On the basis of the information set out in these facts and circumstances, the department has determined that it is reasonable to require you to take further action in order to secure compliance with conditions of the EA and the GED, such that you accelerate the reduction of the water inventory on the premises, develop an effective water management strategy for the premises and meet your obligations outlined in the EA.

B. Requirements

In accordance with this EPO, you are required to do the following (definitions in **bold** are provided in **Section 6 - Definitions** - below):

Section 1 - General

1. The duration of this EPO is from 21 April 2023 to 1 November 2023.
2. From 21 April 2023 you must not **release contaminants** and/or **hazardous waste**:
 - a. from the **Tailings Storage Facility** (TSF) to the Shamrock pit or **waters** or **land**, unless such a **release** is otherwise permitted under the Act; and
 - b. from the Shamrock pit to **waters** or **land**, unless such a **release** is otherwise permitted under the Act.
3. From 21 April 2023 you must ensure you always have available at the premises:
 - a. all measures, plant, equipment and resources installed, operational and maintained as necessary to ensure compliance with this EPO. This includes operation and maintenance of all installed clean water diversion measures;
 - b. fuel supplies and/or access to power to ensure the ongoing operation of required measures, plant, equipment and resources to ensure compliance with this EPO; and
 - c. sufficient security to ensure public safety and prevent theft or vandalism of the measures, plant, equipment and resources that are required to ensure compliance with this EPO.
4. From 21 April 2023 and at any time the water level in the TSF is greater than the DSA of 502.7 mRL (2m freeboard), you must operate a minimum of three (3), evaporator fans on the TSF on a continuous basis during daylight hours unless; it is raining, it is not safe to do so, or otherwise agreed in writing by the department. In the event unscheduled maintenance of evaporator fans and associated equipment is required, this is to be reported in writing to the department as soon as practicable and within 24 hours.
5. By 18 May 2023, you must engage a **suitably qualified and experienced person** (SQEP) to undertake relevant requirements in this EPO. Where any requirement of this EPO falls outside of the SQEP's expertise, the SQEP is required to nominate and work with an **appropriately qualified person** (AQP). You are required to ensure the SQEP nominates and works with an AQP to meet requirements of this EPO when necessary. You must notify the department in writing within 24 hours after engaging the SQEP and any AQP, including their qualifications and experience relevant to the requirements of this EPO.
6. By 1 November 2023 the water level in the TSF must be less than the design storage allowance critical wet period (DSA) of 502.7 mRL (2m freeboard), as defined in condition C7-1 of the EA.
7. By 1 November 2023 the SQEP engaged in EPO requirement 5 must design and oversee the installation of all measures (such as clean water diversion drains and bunds) necessary to effectively identify and divert any upstream clean water catchment of the TSF away from the TSF, in a safe and stable manner. Any measures must be designed and installed to manage greater than a 1:10 year, 72-hour duration Annual Exceedance Probability (AEP) rainfall event. Provide the design plan/s of such measures to the department.
8. Any written notification or submission to the department, as required by this EPO, must be provided via email to sunshinecoast.esr@des.qld.gov.au.

Section 2 - SQEP report

9. By 21 July 2023 the SQEP engaged in EPO requirement 5, must provide the department with a report that assesses the risk and / or probability of the TSF and the Shamrock pit overtopping in the 2023/2024 wet

season and future wet seasons, and which sets out a strategy (a water management strategy) to actively reduce the volume of water stored in the TSF and Shamrock pit to achieve compliance with the EA and the GED.

10. The SQEP report must:

- a. Include a water storage curve and table for the TSF and a water storage curve and table for the Shamrock pit, which characterises both the volume (ML) of water stored and available storage capacity (ML), related to mRL levels in both the TSF and Shamrock pit.
- b. Develop an accurate and calibrated water balance model for the TSF, associated seepage dam and Shamrock pit, as an input in the development and any review of the SQEP report.
 - i. The water balance model must include the use of available climate records from the premises in addition to long-term climate data (in excess of 100 years) sourced from the Queensland Government SILO (Scientific Information for Land Owners) system.
 - ii. The water balance model must include connections between the TSF and Shamrock pit, all contributing catchment areas, storage relationships, evaporation calculation and any other applicable inputs, outputs and transfers.
 - iii. The water balance model must include a comparison between climate records and modelled data. Where consistent differences between SILO data and climate records from the premises occurs, state the average differences and adjust the water balance accordingly, to align with the climate records from the premises. Complete a sensitivity analysis to characterise those parameters which influence model response and outcomes.
 - iv. The water balance model must be in electronic format; capable of being updated and run at any time.
- c. Use the water balance model to assess the risk and/ or establish the probability of the TSF and Shamrock pit overtopping in the 2023/2024 wet season, and characterise the corresponding scenarios.
- d. Give consideration to the outcome of the consequence category assessment for Shamrock pit (EPO requirement 11) and condition C1-1 of the EA and determine the minimum available volume required (the nominated storage allowance) in Shamrock pit at 1 November each year in order to achieve an appropriate probability of discharge from the pit e.g.1:100 AEP.
- e. Outline all of the water reduction measures available, that would result in the active removal of water:
 - i. in the TSF using lawful measures that minimise the potential for environmental harm and achieve compliance with the DSA as defined in condition C7-1 of the EA by 1 November 2023, and 1 November annually thereafter.
 - ii. in the Shamrock pit using lawful measures that minimise the potential for environmental harm, to maximise available storage capacity and ensure ongoing compliance with condition C1-1 of the EA.

Water reduction measures must include, but not be limited to; safe and stable diversion of clean water catchment flows away from the TSF, remediation of existing contaminated catchments to facilitate future diversion of these catchments away from the TSF and water evaporation measures (e.g. evaporators, sprinklers, aerators and atomizers).
- f. Identify the predicted timing of achieving the DSA volume in the TSF, and nominated storage capacity in the Shamrock pit, for each water reduction measure in isolation and in combination. The relevant data and any calculations or modelling used is to be presented, along with any assumptions and their justification.
- g. Estimate costs to implement each water reduction measure.
- h. Identify the actions, resources and responsibilities required to implement each water reduction measure.
- i. Identify any risks and controls associated with each water reduction measure.
- j. Identify any legislative approvals associated with each water reduction measure.
- k. Identify the calculated TSF and Shamrock pit catchment area associated with the water balance model.
- l. Nominate recommended water reduction measure/s which if implemented will, to the extent practicable, reduce the TSF water inventory and Shamrock pit water inventory in the shortest possible timeframe.

- m. Prepare a water management strategy which if implemented will, to the extent practicable:
 - i. reduce the TSF water inventory to achieve DSA by 1 November annually, and
 - ii. reduce the Shamrock pit water inventory to provide the nominated storage allowance by 1 November annually.

The water management strategy must include monthly iterations of the water balance model and provide clear water management decision thresholds (e.g. Trigger Action Response Plan (TARP), matrix or table) which summarises the water reduction measure/s to be implemented at the premises for a range of scenarios relating to water levels, rainfall forecasting and times during each year.

Section 3 – Shamrock pit

- 11. By 21 July 2023 the SQEP engaged in EPO requirement 5, must assess the consequence category of the Shamrock pit in accordance with the *Manual for assessing consequence categories and hydraulic performance of structures* (ESR/2016/19335) (the manual) and provide a report related to the assessment to the department, including SQEP certification in the form set out in the manual.
- 12. By 21 July 2023 you must install and maintain a marker post in the vicinity of Shamrock pit spillway which clearly indicates the water level (mRL) in the Shamrock pit.

Section 4 – Weekly report

- 13. From 24 April 2023, you must provide the department with a weekly report in writing. Each weekly report must be provided by 11:59 pm every Friday and include the following information for preceding 7-day period:
 - a. Daily rainfall totals received at the premises and expected rainfall in the next 7 days.
 - b. Rainfall (mm) required to reach TSF spillway and Shamrock pit spillway.
 - c. Water level in the TSF (mRL and distance to; spillway, MRL, DSA).
 - d. Water level in the Shamrock pit (mRL and distance to spillway).
 - e. Current remaining additional storage capacity (ML) in the TSF and Shamrock pit.
 - f. TSF seepage pumps (number and duration operated).
 - g. Summary of actions taken to reduce the TSF water inventory over the reporting period including, but not limited to, the number of evaporators in operation, their type, location and hours of use and the water reduction measure/s used.
 - h. Estimated daily volume of water removed from the TSF water inventory, listed for each day, separated by each water reduction measure, including details of the measurements, calculations and assumptions that the estimate is based.
 - i. The status of actions taken to comply with this EPO.

Section 5 – TSF and Shamrock pit release event

- 14. In the event of a release of water from the TSF and/or Shamrock pit, you must notify the department by contacting the 24/7 pollution hotline on 1300 130 372 (option 2) / pollutionhotline@des.qld.gov.au and sunshinecoast.esr.des.qld.gov.au as soon as practicable and within 24 hours of commencement of the release and daily thereafter. You must report the details of the release event (e.g. location, volume, duration, date, time, control measures).
- 15. In the event of a release of water from the TSF and/or Shamrock pit, you must undertake a surface water and ground water monitoring program. The program must include the following:
 - a. Surface water monitoring at the monitoring points prescribed in Table 3 (below) commencing the same day of release for 7 consecutive days (i.e. day 1 to day 7) and continuing weekly thereafter (i.e. day 14, day 21 etc) while the release/s are occurring. In the event of a TSF release only (i.e. when a Shamrock pit release has not occurred) it is not necessary to sample monitoring point S14 (Freshwater Dam).

- b. Weekly ground water monitoring at the monitoring locations prescribed in Table 3 (below) commencing in week 2 (i.e. between day 8 and day 14) and continuing weekly thereafter, while the release/s are occurring.
- c. In the event a release event ceases and then recommences, the surface water and ground water monitoring program recommences (i.e. from day 1).
- d. Analysis of surface water and ground water samples for the parameters prescribed in Table 3 (below) on all monitoring occasions.
- e. Analysis of surface water and ground water samples for the parameters; speciated arsenic (III), arsenic (V) and speciated selenium (Se (IV)) – dissolved (field filtered) on the first surface water and ground water monitoring occasion only.

Table 3 – Surface water and ground water monitoring points and parameters

Sample Type	Parameter	Units	Monitoring Points
Surface water	pH	pH units	TSF (S16)
	Electrical Conductivity	µS/cm	Shamrock pit (S15)
	Total Dissolved Solids	mg/L	Freshwater dam (S14)
	Major cations (Ca, Mg, Na, K)	mg/L	'X' (blind field duplicate)
	Major anions (Cl, SO ₄ , Alkalinity) and Fluoride	mg/L	'XX' (blind field blank)
	Cyanide (Total and Weak Acid Dissociable)	mg/L	
	Ultra-trace ORC Metal Suite (Sb, As, Be, B, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Sn, Zn) – dissolved metals (field filtered)	µg/L	
	Aluminium – dissolved (field filtered)	µg/L	
	Ultra-trace ORC Metals Suite (Sb, As, Be, B, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, Ag, Sn, Zn) – total metals	µg/L	
	Aluminium – total metals	µg/L	
Ground water	All surface water parameters (refer above)	-	GM3 / MB3 (Freshwater Dam borehole) FC1 (flue dust cell 1) FC2 (flue dust cell 2)

- f. For quality control purposes each water monitoring event must include one (1) complete set of blind field duplicate samples, labelled 'X'; and one (1) complete set of blind field blank samples using water supplied by the testing laboratory, labelled 'XX'.
 - g. The laboratory chain of custody (COC) for each monitoring event is to include a copy of all email reports to be provided to the department to sunshinecoast.esr@des.qld.gov.au at the same time all email reports are provided to you.
 - h. Use of the latest version of the department's guideline '*Using Monitoring Data to Assess Groundwater Quality and Potential Environmental Impacts*' (State of Queensland, 2021) to derive the trigger and limit concentrations for groundwater.
16. Within 28 calendar days of receipt of the sampling results of each monitoring event undertaken in accordance with EPO requirement 15, you must provide a monitoring report to the department in writing. Reporting must include:

- a. A review of surface water results against relevant guideline values (including *Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 2 Aquatic Ecosystems* and *Volume 3 Primary Industries* (ANZECC & ARMCANZ, 2000) and *Queensland Water Quality Guidelines 2009* (State of Queensland, 2013). Use applicable dissolved metal values, total metal values and metals speciation when comparing results with guideline values.
 - b. A review of the ground water results against relevant trigger and limit contaminant concentrations for groundwater (refer EPO requirement 15.h.).
 - c. Tabular or graphical representation and analysis of trends in available monitoring data.
 - d. Field records and measurements, including the groundwater standing water level (SWL) and surface water flow rates.
 - e. Laboratory certificates of analysis (COA), and associated field records for all water quality monitoring undertaken as a requirement of this EPO from 21 April 2023 and for the duration of this EPO. Any COA results must be provided in the format requested by the department, within 7 days of the request, and be uploaded to the department's WaTERS database.
17. All surface water samples, groundwater samples and other samples:
- a. Must be collected by an SQEP (or an AQP nominated by the SQEP under EPO requirement 5).
 - b. Must be analysed by a laboratory which holds National Association of Testing Authorities (NATA) accreditation for the analysis performed. All sample container(s), sample preservation and holding times are to be in accordance with laboratory requirements for the analysis performed, as demonstrated on the associated laboratory sample receipt notification (SRN).
18. All determinations of the quality of contaminants in waters, including quality control sampling, must be made in accordance with methods prescribed in the latest edition of the *'Monitoring and Sampling Manual Environmental Protection (Water) Policy 2009'* (Department of Environment and Science, 2018) and carried out on samples that are representative.

Section 6 - Definitions

'Appropriately qualified person' (AQP) is defined as a person who has professional qualifications, training, skills and experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relating to the subject matter using the relevant protocols, standards, methods or literature.

'Contaminant' is defined in section 11 of the Act. *'A contaminant can be — (a) a gas, liquid or solid; or (b) an odour; or (c) an organism (whether alive or dead), including a virus; or (d) energy, including noise, heat, radioactivity and electromagnetic radiation; or (e) a combination of contaminants.'*

'Hazardous waste' is defined in EA EPML00928813 and means *'any substance, whether liquid, solid or gaseous, derived by or resulting from, the processing of minerals that tends to destroy life or impair or endanger health.'*

'Land' means land excluding waters and the atmosphere.

'Release' is defined in Schedule 4 of the Act. *'Release, of a contaminant into the environment, includes— (a) to deposit, discharge, emit or disturb the contaminant; and (b) to cause or allow the contaminant to be deposited, discharged, emitted or disturbed; and (c) to fail to prevent the contaminant from being deposited, discharged, emitted or disturbed; and (d) to allow the contaminant to escape; and (e) to fail to prevent the contaminant from escaping.'*

'Suitably qualified and experienced person' (SQEP) is defined in the guideline ['Structures which are dams or levees constructed as part of environmentally relevant activities ESR/2016/1934'](https://des.qld.gov.au/structures-which-are-dams-or-levees-constructed-as-part-of-environmentally-relevant-activities-ESR/2016/1934) (des.qld.gov.au) as 'in relation to regulated structures means a person who is a RPEQ under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience:

- for regulated dams, an RPEQ who is a civil engineer with the required qualifications in dam safety and dam design.
- for regulated levees, an RPEQ who is a civil engineer with the required qualifications in the design of flood protection embankments.

Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology.'

'Tailings storage facility' (TSF) is defined as the DGR Global Ltd Shamrock mine site tailing storage facility and associated seepage dam; a dam containing hazardous waste in environmental authority EPML00928813.

'Waters' includes river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and bank of any waters, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater runoff, and groundwater or any part thereof.

C. Obligations

If you propose to dispose of the place or business to which the EPO relates, you **must** advise the buyer of the existence of this EPO.

If you cease to carry out the activity to which this EPO relates, you **must** give written notice of ceasing to carry out the activity to the department within 10 days of ceasing the activity.

Take notice:

- the requirements of this order take effect immediately upon service of the order;
- failure to comply with this order is an offence under the EP Act;
- this order remains in force until further notice from the administering authority.

D. Penalty

It is important that you know the impact to you personally as an individual or as a corporation for not meeting your obligations.

Failure to comply with an EPO is an offence.

- The maximum penalty for an individual for wilfully contravening an EPO is 6,250 penalty units, totalling \$898,437.5 or five years imprisonment.
- The maximum penalty for a corporation for wilfully contravening an EPO is 31,250 penalty units, totalling \$ 4,492,187.50.
- The maximum penalty for an individual for contravening an EPO is 4,500 penalty units, totalling \$646,875.
- The maximum penalty for a corporation for contravening an EPO is 22,500 penalty units, totalling \$3,234,375 for a corporation.

Failure to provide written notice to the buyer of the existence of the order is an offence.

- The maximum penalty for an individual is 50 penalty units, totalling \$ 7,187.50.
- The maximum penalty for a corporation is 250 penalty units, totalling \$35,937.50.

Failure to provide written notice to the department within 10 business days of ceasing the activity to which an environmental protection order relates is an offence.

- The maximum penalty for an individual is 50 penalty units, totalling \$7,187.50.
- The maximum penalty for a corporation is 250 penalty units, totalling \$35,937.50.

Section 3 of the *Penalties and Sentences Regulation 2015* prescribes the monetary value of a penalty unit.

E. Reviews and appeals

The provisions regarding reviews of decisions and appeals are found in sections 519 to 539 of the EP Act.

A person who is dissatisfied with an original decision made by the Department of Environment and Science (the department) may apply to have that decision internally reviewed.

Information about initiating an appeal in relation to this notice is contained within the [Internal Reviews and Appeals Information Sheet](#) (available at www.qld.gov.au using the publication number ESR /2015/1742 as a search term)

A request for review or appeal is to be made using the approved form '[Application for review of original decision](#)' (available at www.qld.gov.au using the publication number ESR/2015/1573 as a search term).

Applications for reviews are to be sent to Permit and Licence Management, Department of Environment and Science: via email at palm@des.qld.gov.au , or by mail to the following address: GPO. Box 2454, Brisbane, QLD, 4001.

Where an application has been made for a decision to be reviewed, the applicant may also apply to the relevant court for a stay of the decision to secure the effectiveness of the review.

Once the original decision has been reviewed, a person who is dissatisfied with the review decision may be able to appeal against that decision to the relevant court within 22 business days after receiving notice of the review decision.

A person whose interests are or would be adversely affected by a decision of the department may be able to request a statement of reasons for a decision or a statutory order review under the *Judicial Review Act 1991*.

You may have other legal rights or obligations and should seek your own legal advice.

Pursuant to section 540 of the Act, the department is required to maintain a register of certain documents and information authorised under the Act. A copy of this document will be kept on the public register. The register is available for inspection by members of the public who are able take extracts, or copies of the documents from the register. Documents that are required to be kept on the register are published in their entirety, unless alteration is required by the Act. There is no general discretion allowing the department to withhold documents or information required to be kept on the public register. For more information on the department's public register, search 'public register' at www.qld.gov.au. For queries about privacy matters please email privacy@des.qld.gov.au or telephone 13 74 68.

Should you have any queries in relation to the notice, please contact Jacinta Thrower on 07 5459 6141.



Signature

21/04/2023

Date

Ben Grant

Compliance Delivery Manager

Delegate of the Chief Executive

Department of Environment and Science

Environmental Protection Act 1994

Enquiries: Jacinta Thrower

COMPLIANCE CENTRE: Sunshine Coast

Ph: (07) 5459 6141

Email: sunshinecoast.esr@des.qld.gov.au

Attachment A

Table 1 – Summary of select TSF (S16) water quality analysis results and relevant guideline values.

Parameter	Guideline - Aquatic ecosystems ¹ (Freshwater) 95% species protection	Guideline - Primary Industries ²	Queensland Water Quality Guideline ³	04/07/2022
TDS (mg/L)	-	2000 ⁴	-	1060
EC (µS/cm)	1500 ⁵		1200 (80 th percentile)	1400
sulphate (mg/L)	-	1000 ⁶	-	558
aluminium – dissolved (µg/L)	55 ⁷	-	-	<5
aluminium – total (µg/L)	-	5000 ⁸	-	24
arsenic - dissolved (µg/L)	13 (AsV) and 24 (AsIII) ⁹	-	<50 µg/L ¹⁰	264 ²⁰
arsenic - total (µg/L)	-	500 ¹¹	-	242
cadmium – dissolved (µg/L)	0.2 ¹²	-	-	0.97
cadmium – total (µg/L)	-	10 ¹³	3 ¹⁴	1.02
copper – dissolved (µg/L)	1.4	-	-	12.5
copper – total (µg/L)	-	500 ¹⁵	6 soft water	13.7
lead – dissolved (µg/L)	3.4	-	-	<0.1
lead – total (µg/L)	-	100 ¹⁶	30	<0.1
molybdenum - dissolved (ug/L)	34 ¹⁷	-	-	6.7
molybdenum - total (ug/L)	-	150 ¹⁸	-	7.1
selenium - dissolved (µg/L)	11 (Se (IV)) ¹⁹	-	-	45 ²⁰
selenium - total (µg/L)	5 ²¹	20 ²²	-	50.2
zinc – dissolved (µg/L)	8 ²³	-	-	37
zinc – total (µg/L)	-	20,000 ²⁴	30-60 soft water; 1000-2000 hard water ²⁵	42

¹ Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 2 Aquatic Ecosystems — Rationale and Background Information (ANZECC & ARMCANZ, 2000).

² Australian and New Zealand Guidelines for Fresh and Marine Water Quality – Volume 3 Primary Industries — Rationale and Background Information (ANZECC & ARMCANZ, 2000).

³ Queensland Water Quality Guidelines 2009 (State of Queensland, 2013).

⁴ ANZECC & ARMCANZ, 2000. Volume 3, section 9.3.4.5 Table 9.3.3 The conservative value has been applied.

⁵ ANZECC & ARMCANZ, 2000 Volume 3, section 8.2.3.3 Hart et al. (1990, 1991).

⁶ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.4.4.

⁷ ANZECC & ARMCANZ, 2000. Volume 2, section 8.3.7.

⁸ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.1.

⁹ ANZECC & ARMCANZ, 2000. Volume 2, section 8.3.7.1.

¹⁰ State of Queensland, 2013. Table 7.1.1.

¹¹ ANZECC & ARMCANZ, 2000. Volume 3, section 9.3.5.2.

¹² ANZECC & ARMCANZ, 2000. Volume 2, section 8.7.7.1.

¹³ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.5.

¹⁴ State of Queensland, 2013. Table 7.1.1.

¹⁵ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.8. The conservative value has been applied.

¹⁶ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.11.

¹⁷ ANZECC & ARMCANZ, 2000 Volume 2 section 8.3.7.1 low reliability

¹⁸ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.14

¹⁹ ANZECC & ARMCANZ, 2000. Volume 2, section 8.3.7.1.

²⁰ speciation required

²¹ ANZECC & ARMCANZ, 2000. Volume 2, section 8.3.7.1.

²² ANZECC & ARMCANZ, 2000. Volume 3, section 9.3.5.16

²³ ANZECC & ARMCANZ, 2000. Volume 2, section 8.3.7..

²⁴ ANZECC & ARMCANZ, 2000 Volume 3, section 9.3.5.19

²⁵ State of Queensland, 2013. Table 7.1.1

Attachment B

Table 2 – Examples of adverse effects from elevated levels of contaminants in freshwater. Sourced from ANZECC & ARMCANZ, 2000 guidelines on aquatic ecosystems (volume 2) and primary industries (volume 3).

Parameter	Adverse effects
Salinity / EC	Adverse biological effects (loss of native biota) would be expected in aquatic ecosystems if salinity or EC was allowed to increase to around 1,000 mg/L (or approximately 1,500 µS/cm) (Hart et al).
Sulphate	Adverse effects may occur at sulphate (SO ₄) concentrations between 1,000 and 2,000 mg/L (ANZECC & ARMCANZ, 2000 section 9.3.4.4) especially in young or lactating animals or in dry, hot weather when water intake is high. Levels of SO ₄ greater than 2,000 mg/L may cause chronic or acute health problems in stock.
Arsenic	The Australian diatom <i>Nitzschia closterium</i> is highly sensitive to arsenic (III), with a 72-h EC ₅₀ for growth inhibition of 7 µg/L (Florence & Stauber 1991), compared to >2000 µg/L for arsenic (V). Acute toxicity of arsenic (III) to freshwater invertebrates occurred at concentrations as low as 812 µg/L (Sanders & Cope 1968, Call et al. 1983, Lima et al. 1984). The lowest concentration of arsenic (V) causing acute toxicity was 850 µg/L for a cladoceran <i>Bosmina longirostris</i> (Passino & Novak 1984).
Cadmium	Acute toxicity of cadmium to freshwater animal species in 44 genera ranged from 1 µg/L for rainbow trout to 28 000 µg/L for mayfly (USEPA 1986). For Australian freshwater guideline derivation, ANZECC & ARMCANZ, 2000 section 8.3.7 states chronic data points included fish: 9 spp, geometric means ranged from 0.49 µg/L (<i>O. tshawytscha</i> ; adjusted from LC ₅₀) to 767 µg/L for <i>Salmo salar</i> . The lowest measured chronic figure (hardness-corrected) was 0.5 µg/L for <i>O. mykiss</i> (LOEC). Crustaceans: 6 spp, geometric means for species and end-points ranged from 0.08 µg/L for <i>D. magna</i> to 3.2 µg/L for <i>Asellus aquaticus</i> , although the crayfish <i>Orconectes virillis</i> , had a NOEC (geometric mean) of 122 µg/L. Insects: 2 spp, means for NOECs of 0.52–0.82 µg/L.
Copper	Acute toxicity of copper in freshwater animal species included fish: 10 species, 2.6 µg/L (<i>Ptylocheilus oregonensis</i> , from 7-day LC ₅₀) to 131 µg/L (<i>Pimephales promelas</i> , 7-day LC ₅₀); seven species had geometric means <25 µg/L. Crustaceans: five species, 1.7 µg/L (<i>D. pulex</i> and <i>G. pulex</i> , NOEC, reproduction & mortality) to 12.1 µg/L (<i>Hyaella azteca</i> , from 10 to 14-day LC ₅₀). Insects: three species, 2.2 µg/L (<i>Tanytarsus dissimilis</i> , from 10-day LC ₅₀) to 11 µg/L (<i>Chironomus tentans</i> , 10 to 20-day LC ₅₀). Molluscs: three species, 1.64 µg/L (<i>Flumicola virens</i> , from 14-day LC ₅₀) to 56.2 (<i>Corbicula manilensis</i> , from 7 to 42-day LC ₅₀). The latter figure was not included in calculations as it was outside the pH range.
Lead	Aquatic toxicity data included fish: four species, 5.65 µg/L (<i>Lepidomeda vittata</i>) from maximum acceptable toxicant concentration (MATC) reproduction to 43 µg/L (<i>Salmo salar</i> , from chronic LC ₅₀). Crustaceans: two species, 5.1 µg/L (<i>Gammarus pseudolimnaeus</i> , from LC ₅₀ and LOEC) to 19.5 µg/L (<i>D. magna</i> , from EC ₅₀ and NOEC reproduction). Insects: one species, <i>Tanytarsus dissimilis</i> , 28 µg/L, from LC ₅₀ . Molluscs: one species, <i>Dreissena polymorpha</i> , 28 µg/L, from LC ₅₀ (ANZECC & ARMCANZ, 2000 section 8.3.7.1).
Selenium	For selenium, food chain uptake leading to secondary poisoning is more significant than water uptake. Sediments can be a significant source of selenium in fish and invertebrates. Toxic effect threshold levels for selenium in freshwater have been reported as 2 µg/L (Lemly 1993). Acute toxicity data for total selenium included crustacean: two species, 14-day no observed effect concentration (NOEC), 14 to 86 µg/L (from lethal concentration 50 (LC ₅₀)); 21-day NOEC, growth, 85 µg/L. Insect: one species, <i>Chironomus riparius</i> , 30-day NOEC emergence, 252 to 303 µg/L. (volume 2, page 8.3-139). Concentrations of total selenium in drinking water for livestock exceeding 0.02 mg/L may be hazardous to stock health (ANZECC & ARMCANZ, 2000 section 9.3.5.16).
Zinc	For freshwater guideline derivation, the NOEC values (adjusted) for zinc included fish: 11 species, 24 µg/L (<i>Oncorhynchus tshawytscha</i> ; from LC ₅₀) to 1316 µg/L (<i>Ptylocheilus oregonensis</i> ; from LC ₅₀); seven species had geometric means < 250 µg/L and a measured NOEC of 38 µg/L was reported for <i>Pimephales promelas</i> . Crustaceans: three species, 5.5 µg/L (<i>C. dubia</i> ; from LC ₅₀) to 25.3 µg/L (<i>C. dubia</i>), plus a figure of 18,480 for the crayfish <i>Orconectes virillis</i> . Insect: one species, <i>Tanytarsus dissimilis</i> , 5 µg/L (NOEC). Molluscs: three species, 54 µg/L (<i>Dreissena polymorpha</i>) to 11,200 µg/L (<i>Velesunio ambigua</i>), a NOEC of 487 µg/L was measured for <i>Physa gyrina</i> (ANZECC & ARMCANZ, 2000 section 8.3.7).