BHP Iron Ore Pty Ltd (BHP)

Conceptual Exposure Model

Definition Phase Study, Jimblebar Beneficiation Project
7731-A-85248-VD-00020

January 2025

Question today
Imagine tomorrow
Create for the future

Conceptual Exposure Model Definition Phase Study, Jimblebar Beneficiation Project
7731-A-85248-VD-00020

BHP Iron Ore Pty Ltd (BHP)

[redacted]

wsp.com

Rev	Date	Details
1	3 November 2023	Issued for review, prepared by Madeleine Thomas, revised by Catherine Bingham
2	27 November 2024	Issued for review
3	5 December 2024	Issued for review
4	19 December 2024	Issued for approval
5	10 January 2025	Issued for approval

[redacted]

We recognise Aboriginal and Torres Strait Islander Peoples as the first scientists and engineers and pay our respects to Elders past and present.

Table of contents

List of tables

List of figures

List of appendices

Executive summary

Introduction

BHP Iron Ore Pty Ltd (BHP) is progressing the Definition Phase Study (DPS) design of the Orebody 17 (OB17) Swan and Orebody 18 (OB18) De Grey in-pit tailings storage facilities (IPTSFs) as part of the Jimblebar Beneficiation (JBB) Project.

This report presents a DPS Conceptual Exposure Model (DPS CEM), which is updated from the Selection Phase Study (SPS) CEM, and utilises information from geotechnical, hydrological, hydrogeological, geochemical and closure studies undertaken by WSP Australia Pty Ltd (WSP).

Objective and scope

The objective of the DPS CEM is the conduct of a risk assessment to assist BHP with management actions during the IPTSF operations and closure phases and to comply with legislative obligations. The DPS CEM risk assessment focuses on the source-pathway-receptor (SPR) linkages for emissions associated with the Swan and De Grey pits and potential human and ecological receptors for the operations phase (expected to be Financial Year (FY) 29 – FY 49) and closure phase (post 2050).

Operations comprises active tailings deposition from FY29 to FY31 as part of the first fill, and subsequent fill phases (“topping up” cycles) through to FY48 prior to closure implementation. The land use during operations is assumed to be an operational mine site.

The closure phase is expected to occur from FY51 once tailings deposition has ceased. A range of closure options were assessed in previous parts of the project, incorporating a number of factors including assessment of human health and environmental risks. The preferred closure option was assessed as Closure with Partial Backfill, which has been adopted in the CEM. The final land use at closure has not yet been confirmed but based on current information and for the purpose of the CEM, it is assumed to be native ecosystems and potentially some limited grazing[1].

The scope of the DPS CEM is limited to predicted conditions and emissions, particularly related to water quality, as presented in the reports of the various associated studies and does not consider current environmental conditions. The risk assessment focuses on ecological and human receptors, excluding occupational and safety risk[2]. This is consistent with the Western Australian Department of Water and Environmental Regulation (DWER) *Guideline: Risk Assessments*.

Risk assessment approach

The risk assessment component has been carried out according to the DWER *Guideline: Risk Assessments*, as the relevant regulatory risk framework. Risk ratings are calculated as a function of likelihood and consequence. The general method outlined in DWER guidelines is as follows:

- Identify the risk events through SPR analysis.
- Establish the consequence of each risk event.
- Establish the likelihood of each risk event.

---

[1] The stability of any pit voids and post-closure rehabilitation measures such as revegetation over tailings would need to be considered and assessed to ascertain suitability for grazing; however grazing has been included for completeness.

[2] It is expected that health and safety risks to workers during operations or physical safety risk to the community during closure will be assessed and managed via other mechanisms.

– Apply a risk rating using consequence criteria and likelihood criteria.

– Determine the risk rating via the risk rating matrix.

Uncertainties

The key uncertainties that impact on the CEM assessment are summarised below.

– The reliability of the water balance, hydrogeological, and geochemical modelling used to inform the CEM, including their inputs, assumptions, and outputs. In particular, the results of the high-level studies conducted for the closure phase, which were based on an alternative closure option, should be considered indicative and refinement may allow a more definitive risk assessment.

– Derivation of Hazard Quotients (HQ) based on national or international guidelines and screening criteria which may not reflect local ecosystems in the area, including their type, habitats and exposure durations; this likely overestimates the risk, which could be refined with more site-specific data on ecosystems likely to be present.

Further discussion on these and other uncertainties is provided in Section 7.

Conclusions

The CEM assessed potential risks to ecological and human receptors posed by chemical stressors associated with the Swan and De Grey IPTSFs using the DWER guideline methodology. The risk ratings of complete SPR linkages associated with operational and closure phases are summarised below.

Operations

No high-risk ratings were identified for Operations. Two medium risks were identified and are summarised below. The remaining risk ratings were low.

Medium Risk

– Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems (subterranean fauna and riparian vegetation), and the migration of seepage-impacted groundwater from the IPTSFs to the OB31 dewatering system and subsequent disposal of surplus water to the receiving environment resulting in impacts to surface water aquatic ecosystems and native terrestrial flora and fauna.

– Entry to IPTSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water by native terrestrial fauna.

Operations Risk Ratings are outlined **in Section 5.7** and Table 5.20.

Downstream water quality during operations

Downstream water quality modelling was also conducted to assess water quality parameters at OB31 during operations. It considered a mixture of pond seepage and natural groundwater in proportions indicated by the groundwater modelling as a time series (on a monthly basis). The screening assessment of downstream water quality indicates that TDS and barium exceed the screening criteria (see Section 5.6.4).

Of the exceedances, one high seepage scenario (during sustained seepage in the late stages of the operational period) showed Barium with a HQ >5. In summary, downstream water quality (at entry into the groundwater system) may have concentrations of PSOIs exceeding adopted screening levels. However, barium is noted to be naturally elevated in the groundwater, so the risk from JBB may be lower than indicated.

It's also important to note that - for barium as well as for other risks - hazard quotients are based on inherently conservative guidelines that generally assume long-term exposure, which is not necessarily the case in the JBB context (as discussed in **Section 4.2**) and a more detailed assessment may show a lower risk than indicated.

Closure with Partial Backfill

No high-risk ratings were identified for the partial backfill closure strategy. The medium risks for Closure are similar to those for Operations and are summarised below; the remaining risk ratings were low.

Medium Risk

- Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems (subterranean fauna and riparian vegetation communities).
- Entry to IPTSF containment and subsequent direct contact with or ingestion of waste fines and/or intermittent pond water by native terrestrial fauna within in-pit ponds.

The assessment of water quality at the receptors was not in the scope of this assessment and modelling has been conducted for operational downstream modelling at OB31 only. As such, medium risk is warranted which also considers incomplete understanding of the water quality at the receptors.

Closure Risk Ratings are outlined in **Section 6.7** and Table 6.2.

Recommendations

Reducing uncertainties

Additional assessment and modelling works are recommended to reduce uncertainties in the CEM risk ratings and refine the outcome, including:

Operations and Closure

- Collecting and/or assessing additional background environmental data to increase understanding of naturally elevated constituents in the area, and to increase confidence of the use of derived Site-Specific Trigger Values or modify where relevant.
  It may also establish baseline conditions to assist with understanding any significant impacts on the environment (such as pipeline spills) and the requirement for cleanup.

Closure

- Updating the geochemical studies and water balance and water quality modelling, to be more specific to Closure Option without Backfill. This could allow the seepage risk to groundwater to be refined, and the identification of potential receptors that may be impacted.
- The preferred Closure Option (original Option 2, with partial backfill) incorporates the tailings material being capped after the period of consolidation with a benign material (indicated to be waste rock covered by locally sourced surface soils). Assessment of the cover material is outside of the scope of this CEM. However, it is recommended that the suitability of the cover material in relation to chemical exposure risks of humans and wildlife is assessed prior to use.

Risk control and mitigation measures

A number of engineering and management measures are recommended to protect the local environment and ecosystems, including human health. These include protection of air quality and soil, groundwater and surface water (from tailings delivery systems, decant water and tailings slurry deposition) and are outlined in the Risk Assessment tables for Operation (Appendix D) and Closure (Appendix E).

The recommended control measures for the two highest-risk scenarios identified for Operation and Closure (both classified as medium risks) are:

a Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems and to aquatic ecosystems and native terrestrial flora and fauna from migration of seepage-impacted groundwater to surface water.

Risk controls could include:

– Monitoring of groundwater and surface water quality and quantity (water level, flow).

– Continued operation of dewatering system to manage seepage.

b Entry to IPTSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water by native terrestrial fauna and aquatic ecosystems within in-pit ponds.

Risk controls could include:

– Exclusion bunding around pit to discourage access.

– Routine surveillance program, including regular fauna checks.

These recommendations are in addition to the management measures outlined in the IPTSF Closure Strategy (WSP, 2024j).

1 Introduction

BHP Iron Ore Pty Ltd (BHP) has commissioned WSP Australia Pty Ltd (WSP) to conduct geotechnical, hydrological, hydrogeological, geochemical, and closure studies for the Definition Phase Study (DPS) for the Jimblebar Beneficiation (JBB) De Grey and Swan In-pit storage facilities (IPTSFs). The existing pits are currently referred as orebody (OB)18 De Gey and OB17 Swan. The key purpose of the DPS is to pre-emptively secure a deposition location for tailings processed at a proposed beneficiation plant at Jimblebar.

As part of the DPS, this report presents the Conceptual Exposure Model (DPS CEM), an update to the SPS CEM (WSP, 2023a). At the direction of BHP, the DPS CEM incorporates a high level risk identification summary that considers the potential risks of the project on water resources and ecological and human receptors within the surrounding environment at a regional scale.

1.1 Purpose

This report presents the updated DPS CEM that includes a revised risk assessment of chronic exposures and effects to human and ecological receptors, using based on the outcomes of the associated studies listed below.

The following studies have been used to inform the development of the DPS CEM.

- Conceptual Exposure Model (Selection Phase Study) (WSP, 2023a).
- Slope stability assessment (WSP, 2024a).
- Water balance model (WSP, 2024b).
- Tailings deposition (WSP, 2024c).
- Consolidation modelling (WSP, 2024d).
- Water quality modelling (WSP, 2024e).
- Groundwater assessment (WSP, 2024f).

Specifically, the DPS CEM focuses on the complete source-pathway-receptor (SPR) linkages for exposures associated with the Swan and De Grey IPTSFs [3] and human and ecological receptors for both operations (pre-2051) and closure (post-2051). The DPS CEM incorporates the selection and design of a Preferred Investment Alternative (PIA) for closure which is understood to be partial backfill, as described in Section 7.1.1 (WSP, 2024g).

This work has been performed in accordance with the CEM objectives outlined in Section 3.2.3 of Proposal for Jimblebar In-Pit Tailings Storage Facility Definition Phase Study (reference number: PP135736-001-R-Rev2, dated 24 November 2022).

[3] Via air (dust), surface water and groundwater pathways.

1.2 Background

1.2.1 Extractive mining operations

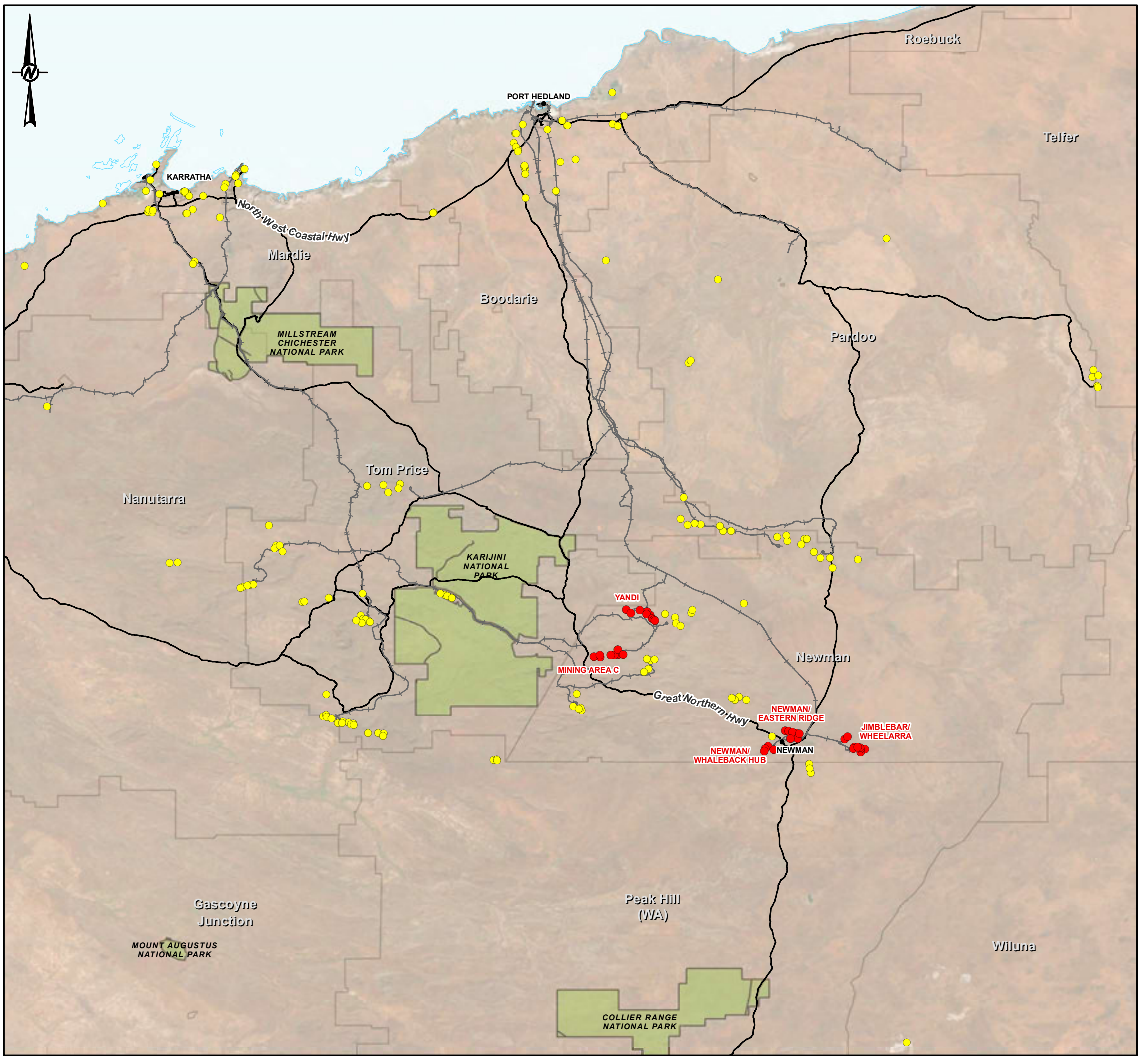
BHP Western Australian Iron Ore (WAIO) currently operates iron ore mining in the Pilbara region of northern Western Australia and processes the ore in four processing hubs (i.e., Newman, Jimblebar, Mining Area C, and Yandi). The Jimblebar Hub, located approximately 35 km east of the town of Newman, includes the following orebodies:

– Orebody 17 (Swan OB17) and Orebody 18 (De Grey OB18) – Extractive mining operations, concluded in 2020.

– Orebody 31 (OB31) – still operating.

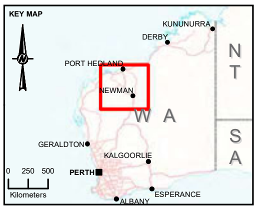
The activities conducted at the Jimblebar orebodies consisted of above and below water table open pit mining, with dewatering infrastructure utilised to abstract groundwater for access to below water table ore.

The locality of the project site is presented on Figure 1.1 on the following page.



LEGEND

- CURRENT OPERATING MINE PIT (BHP)
- CURRENT OPERATING MINE PIT (OTHER)
- FORTESCUE MARSH
- RAILWAY
- NATIONAL PARK / STATE FOREST
- POSTCODE BOUNDARY



0 50 100

1:2,000,000 KILOMETRES

NOTE:
1. COORDINATE SYSTEM: GCS GDA 1994

REFERENCES:
1. AERIAL IMAGE (DEC. 2016) PROVIDED BY CLIENT.
2. ROADS AND SUPPLEMENTARY AERIAL IMAGERY (2013) © WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2016)

CLIENT
BHP

PROJECT
JIMBLEBAR PIT TAILINGS

TITLE
LOCATION OF PROJECT SITE

CONSULTANT

YYYY-MM-DD	2024-11-27
DESIGNED	MJ
PREPARED	AM / JE
REVIEWED	CA
APPROVED	KB

PROJECT NO.	CONTROL	REV	FIGURE
PS134791	020 R	2	1.1

1.2.2 Context of the IPTSF

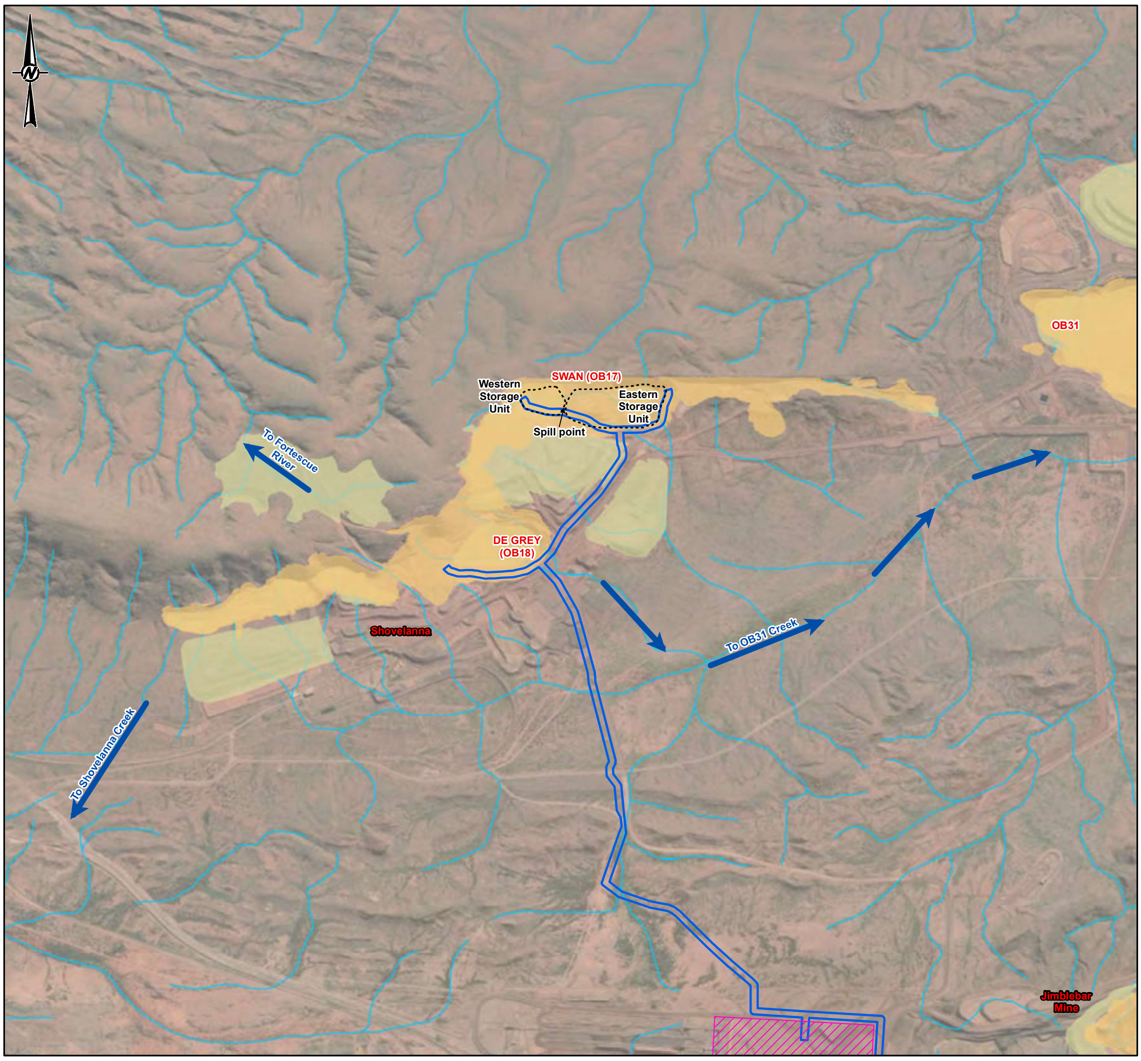
An Identification Phase Study (IPS) was undertaken in 2020 to consider the development of an in-pit strategy for the disposal of tailings produced at the Jimblebar operation (SKR, 2020). The IPS considered numerous pit options for the IPTSFs but recommended the De Grey Pit. The IPS presented the findings of the conceptual tailings deposition, hydrogeological, geochemical and environmental assessments. BHP undertook a trade-off study based on technical, safety, environmental, and economic risks, to compare several options for tailings disposal solutions. In-pit storage of short- and medium-term tailings was deemed the most appropriate option at the time, based on these considerations with the De Grey and Avon Pits considered as the most beneficial for this option. An SPS was therefore required to better understand the potential execution of this endeavour.

Previously, BHP commissioned Golder Associates (now WSP) to undertake the SPS tailings design, geotechnical, hydrological, hydrogeological, geochemical, CEM, and closure studies for the De Grey and Avon Pits. A decision was made to replace the Avon Pit with the Swan Pit primarily due to low capacity and high rate of rise in the Avon Pit. The SPS was completed by Golder Associates in 2021.

The operations phase of the IPTSF is projected to occur from Financial Year 2028 (FY28) to Financial Year 2051 (FY51). Operations comprises active tailings deposition from FY28 to FY31 as part of the first fill, and subsequent fill cycles through to FY47 prior to closure implementation (FY51) (WSP, 2024b). The tailings deposition process includes deposition cycling between De Grey and Swan IPTSFs (i.e., 2-week on and off rotations). Once maximum tailings elevation is achieved as part of the initial fill (FY28 to FY31), the in-pit TSFs will remain dormant to allow tailings to consolidate, upon which subsequent filling phases will commence again until FY47 (WSP, 2024b). Closure implementation (post FY51) will involve a period of tailings consolidation (consolidation rate <1m/yr for the tallest tailing column will be reached in 2086 for De Grey and 2072 for Swan), until the final landform can be achieved.

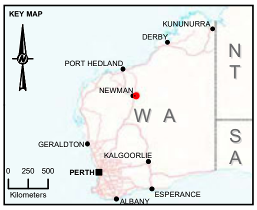
The available capacity in the pits is 13.78 Mm^3 at maximum tailings elevation for De Grey and 10.80 Mm^3 at maximum tailings elevation for Swan. The Swan Pit consists of two (east and west) individual storage units separated by an internal high point (also referred to as an internal spill point) (Figure 1.2). Above this high point, the pit acts as a single storage unit (WSP, 2024b). The Swan tailings deposition plan reflects this configuration whereby the east storage unit is filled initially until it reaches the internal spill point, after which the western storage unit is filled.

The De Grey Pit consists of a single uniform storage unit for tailings deposition, starting at 474 m RL (WSP, 2024b). Deposition within the Swan Pit has been considered into a dry pit whilst De Grey tailings deposition will be into an existing pond. Decant pumping in both De Grey and Swan IPTSFs is proposed to commence at the start of tailings deposition and maintains the pond within a specified operating range (1 m deep pond) (WSP, 2024b).



LEGEND

- PIT
- OVERBURDEN STORAGE AREA
- PROPOSED BENFICIATION PLANT
- APPROXIMATE DELIVERY AND DECANT PIPELINE CORRIDOR
- SURFACE WATER FLOW DIRECTION IN CATCHMENT
- BHP MINE (CURRENT)
- BHP MINE PIT (CURRENT)



1:30,000

NOTE:
1. COORDINATE SYSTEM: GCS GDA 1994

REFERENCES:
1. AERIAL IMAGE SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
2. ROADS, RAILWAY, MINES FROM WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2016)
3. RIVERS FROM DOW

CLIENT
BHP

PROJECT
JIMBLEBAR PIT TAILINGS

TITLE
SITE OVERVIEW AND SURFACE WATER FLOW DIRECTION

CONSULTANT

YYYY-MM-DD	2024-11-27
DESIGNED	MJ
PREPARED	AM / JE
REVIEWED	CA
APPROVED	KB

PROJECT NO.	CONTROL	REV.	FIGURE
PS134791	020 R	2	1.2

2 Environmental Setting

2.1 Geology, Hydrology and hydrogeology

The Jimblebar operations are situated within three adjacent bioregions, consisting of the eastern portion of the Hamersley and Fortescue subregions of the Pilbara, and the Augustus subregion of the Gascoyne.

The Hamersley Range and Fortescue Plains subregions (where Swan Pit and De Grey Pit are located) are typified by an arid and tropical climate, with hot wet summers and cool dry winters. Rainfall is intense, seasonal, and variable (DPIRD, 2021). Average annual rainfall is typically 300 mm, most of which falls during the summer as a result of rain depressions and cyclones (BOM, 2021). These intense weather events tend to cause high flow ephemeral creeks, which rapidly connect through drainage networks. Hot, dry, and sunny conditions in the Pilbara lead to very high evaporation rates. As a result of these high temperatures and seasonal rainfall events, surface flow in creek systems within the Pilbara region is generally brief and temporary, as a result of rainfall events. Recharge to the aquifers is typically via infiltration following rainfall events where the host rocks are exposed, or via intermediary alluvial systems associated with surface drainage.

The Swan and De Grey Pits are located on the south flank of Shovelanna Hill (Figure 2.1). The surface water catchment divide borders the north and southwest sides of the Swan and De Grey Pits. Runoff from the ridge flows mainly to the south and east towards OB31 Creek, an east flowing tributary of Jimblebar Creek. Runoff from the ridge also flows towards the western side of the catchment divide, draining into the Shovelanna creek catchment, and runoff towards the north, flows into the Fortescue River, catchment, and floodplain in the direction of Fortescue Marsh located approximately 100 km to the northwest of the IPTSFs.

The aquifers at Shovelanna area comprise **local orebody aquifers** and a **regional aquifer system**.

The **local orebody aquifers** are found within the Marra Mamba Iron Formation and the Brockman Iron Formation and are characterised by secondary permeability and porosity that have developed coeval with mineralisation. As is typical for aquifers defined by secondary permeability and porosity, they tend to be less continuous which limits both total aquifer storage and interconnectivity along strike. The spatial extents (and associated aquifer storage) are variable and correlate with the size and interconnectivity of fractures.

The **regional aquifer system**, made up of Wittenoom Formation dolomites (Paraburdoo Member) and Tertiary Detritals where present and saturated, extends from Ethel Gorge in the west (located about 18 km west of OB18) to OB31 in the east.

Tertiary valley-fill sediments are developed along an east–west trending valley to the south of OB18, these are approximately 50 m thick in this area and consist of an alternating sequence of alluvial, colluvial, aeolian sediments and calcrete. Where saturated, the valley-fill aquifer is expected to have a higher specific yield than the surrounding bedrock aquifers. However, the monitoring data indicates, in general, unsaturated detritals occur around the OB18 pits.

The regional aquifers are the major pathways for groundwater flow in the region and under natural conditions groundwater flow is westerly. No discharge areas or associated groundwater dependent ecosystems (GDE) have been directly associated with orebody aquifers in the Shovelanna area.

2.2 Environmental receptors

The key environmental receptors identified are listed below followed by a summary of related details.

- The Ethel Gorge Threatened Ecological Community (TEC) with respect to groundwater.
- The ecological systems of the surface water bodies in the vicinity of the pits, including riparian vegetation.

The dominant land uses in the region are grazing, native pastures, ecological conservation, mining and urban. Unallocated Crown Land (UCL) and the Sylvania Pastoral Lease are the underlying land tenures occupying the Swan and De Grey areas. Table 2.1 presents an overview of the surrounding land uses based on a 30 km search radius for ecological receptors and wider for human receptors, including their location and relation to the proposed Swan and De Grey IPTSF.

With respect to groundwater, the key environmental receptor is the Ethel Gorge TEC. While OB31 dewatering is occurring, the seepage from the De Grey and Swan IPTSFs is not predicted to flow towards the TEC. However, seepage from the IPTSFs is expected to flow towards the OB31 dewatering system and surplus abstracted groundwater from this system is discharged to the Ophthalmia Dam Managed Aquifer Recharge (MAR) facility, which is adjacent to the Ethel Gorge TEC.

The MAR facility consists of the dam, four recharge ponds, two infiltration basins, and an open earth canal. Excess water from dewatering can be returned to the Ethel Gorge aquifer system via the Ophthalmia Dam MAR. The MAR maintains groundwater levels within the Ethel Gorge aquifer system, which hosts the stygofauna TEC, maintaining water levels on the TEC and the downstream Newman town potable water supply.

In addition, abstracted groundwater will also be injected into the Ninga MAR, which is approx. 1 km from the Warrawandu water supply and mining camp.

Other environmental receptors include the ecological systems, including riparian vegetation, of the surface water bodies in the vicinity of the pits, including creeks and minor drainage lines to the east downstream of OB31.

For the purposes of the CEM, it is assumed that the current land uses will persist beyond the life of the Swan or De Grey IPTSF.

Table 2.1 Surrounding land Uses

Direction from site	Land Use Activity/Features[1]
North	— Lake Macdonald (19 km north) — Kalgan Creek (19.5 km northwest) — Sandy Creek (21 km northwest)
East	— Jimblebar Creek (13 km downgradient) — Jigalong Aboriginal Community[2] (60 km east) — Carramulla Creek (23 km east) — Coobina Chromite Mine (28 km southeast)
South	— **OB31 Creek (<1km south)** — Innawally Pool (16 km southeast) — Sylvania Creek (22 km southwest)
West	— Shovelanna Creek (<7 km downgradient) — BHP Warrawandu Mining Camp (11.5 km west) — BHP Warrawandu Water Supply Borefield (as above) — **Newman Water Reserve[3] (~1 to 2 km west)** — Ninga MAR (~10 km west) — Town of Newman and associated facilities and infrastructure[4] (31 km west) — Parnpajinya Aboriginal Community[5] (31.5 km west) — Major roads, such as Marble Bar Road (~18 km west) — Ethel Gorge TEC (17 km west) — Ophthalmia Dam (17 km west) — Ashburton River (18 km west) — Upper Fortescue River[6] (23.5 km northwest) — Newman Airport (29 km southwest) — Sylvania Station (28 km southwest) — Southern reaches of the Fortescue River[6] (22 km southwest) — Trugallenden Pool (18 km southwest)

Notes:

1) Sensitive human health and ecological receptors down hydraulic gradient and within 10 km of Swan (OB17) and De Grey (OB18) are bold.

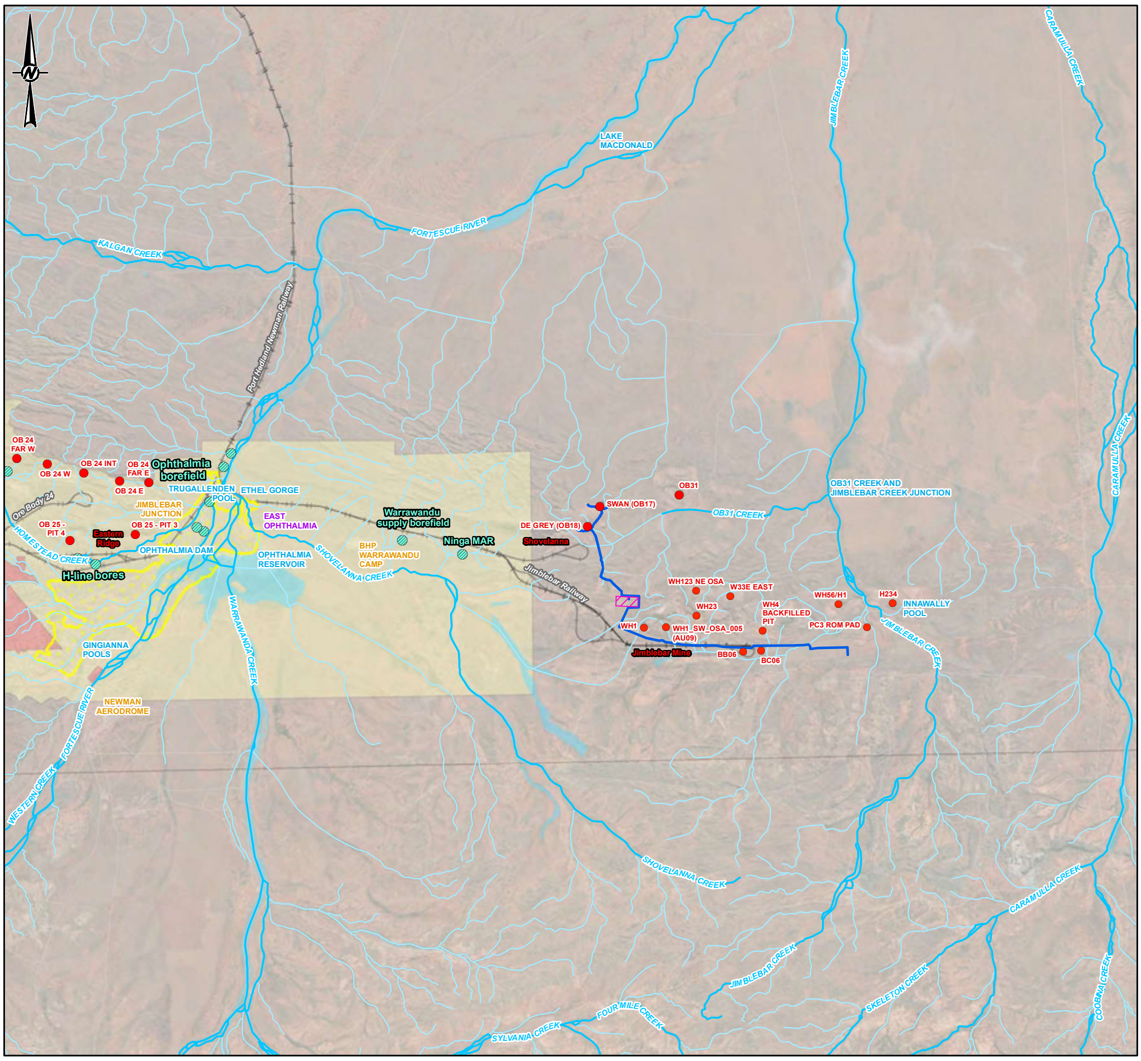
2) Jigalong is an Aboriginal community of approximately 300 people, situated approximately 60 km to the east of Jimblebar.

3) The boundary of the Newman Water Reserve encompasses the groundwater bores that supply the public drinking water for the town of Newman. The IPTSFs are not located within the Newman Water Reserve, but it is adjacent to the eastern boundary of the reserve and has been included in the receptor identification process for completeness.

4) Facilities and infrastructure associated with the town of Newman include a wastewater treatment plant, cemetery, residential, commercial and light industrial areas, and various recreational facilities (e.g., golf course, horse racing track, gun club and shooting range).

5) Parnpajinya is an Aboriginal community of approximately 60 residents and 13 houses that is situated in the northern part of the town of Newman.

6) For the purposes of this report, the Fortescue River has been divided into the upper and lower reaches based on proximity above and below the Ophthalmia Dam. The lower Fortescue River is outside of the scope of this investigation, due to its distance from the IPTSF.



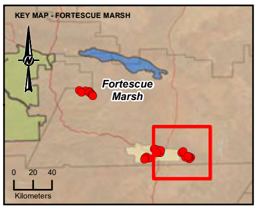
LEGEND

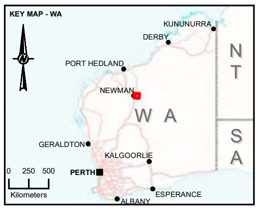
- RAILWAY
- ROAD
- PROPOSED BENFICIATION PLANT
- APPROXIMATE DELIVERY AND DECANT PIPELINE CORRIDOR
- APPROXIMATE ETHEL GORGE TEC

NEWMAN WATER RESERVE

- PRIORITY AREA 1
- PRIORITY AREA 3
- NEWMAN WATER RESERVE DRINKING WATER BOREFIELDS

BHP MINE (CURRENT)
BHP MINE PIT (CURRENT)
BHP MINE (PROPOSED)
OTHER MINE (CURRENT)
ANTHROPOGENIC FEATURE
ECOLOGICAL FEATURE





1:200,000

NOTE:
1. COORDINATE SYSTEM: GDA 1994 MGA ZONE 51

REFERENCES:
1. AERIAL IMAGE SERVICE LAYER CREDITS: SOURCE: ESRI, MAXAR, EARTHSTAR GEOGRAPHICS, AND THE GIS USER COMMUNITY
2. ROADS, RAILWAY, MINES FROM WESTERN AUSTRALIAN LAND INFORMATION AUTHORITY TRADING AS LANDGATE (2016)
3. RIVERS FROM DOW

CLIENT
BHP

PROJECT
JIMBLEBAR PIT TAILINGS

TITLE
SURROUNDING LAND USES AND KEY ANTHROPOGENIC AND ECOLOGICAL FEATURES

CONSULTANT

YYYY-MM-DD	2024-11-27
DESIGNED	MJ
PREPARED	AM/JE
REVIEWED	CA
APPROVED	KB

PROJECT NO.	CONTROL	REV.	FIGURE
PS134791	020 R	2	2.1

25mm
0

3 Scope of the DPS CEM

3.1 Overview

The DPS CEM described in this report builds upon the initial SPS CEM and is augmented by the updated hydrogeological and geochemical studies and information received from BHP. To summarise, the following are the key factors and elements considered in the development of the DPS CEM.

- Assessment of the potential risk of adverse effects to ecological and human receptors (excluding Occupational Health and Safety risk[4]) in accordance with the Western Australian Department of Water and Environmental Regulation (DWER) *Guideline: Risk Assessments* (DWER, 2020). Section 4 provides detail on the risk assessment approach.
- Identification of water being the main pathway by which contamination may be conveyed away from the IPTSFs to receiving environments. The focus of this report is on water resources and the associated modelling studies (surface, groundwater, geochemical) conducted to inform water quality and quantity. Other transport pathways and exposure scenarios were considered including exposure to fugitive dust and direct exposure to waste fines and/or ponded water if receptors enter the TSF containment.
- Consideration of both operations and closure phases, expected to be from 2028 to 2050 (operations) and post-2051 (closure). Summaries of the operations and closure phases are provided in Section 3.1.
- Revision of the SPS CEM based on the updated understanding of the IPTSFs developed through the wider DPS, the closure design and other related studies, which are summarised in Section 3.3.

The scope of the DPS CEM does not consider, with any specificity, the quality of the current surface and groundwater quality and attributes. The state of the current water quality has been used in the identification of chemicals that may be at elevated concentrations due to natural processes or existing mining activities. Prior work by BHP to develop groundwater Site Specific Trigger Values (SSTV) (for a range of physical-chemical properties) and surface water SSTV (for Total Dissolved Solids (TDS) and pH) for the region implicitly consider natural elevation in baseline surface water and groundwater quality.

The DPS CEM does not consider current monitoring or modelling of future air quality (dust). WSP understands that BHP monitors and manages current dust issues as a part of the wider Jimblebar Precinct. The DPS CEM assessment of dust is based on a qualitative assessment and provides a discussion on likely dust management measures.

The approach taken to assigning risk ratings to each of the SPR linkages is described in Section 4.

4 The DWER (2020) risk assessment guidelines excludes employees, visitors, and contractors of the licence holder, and therefore assessment of occupational health and safety related risk has not been included. Occupational health and safety risks to workers during operations or physical safety risk to the community during closure will be assessed and managed elsewhere via other mechanisms.

3.2 Operations and Closure Phases CEM

The operations phase of the IPTSF is considered to occur from FY28 to FY51 (BHP, 2023b). Operations comprises active tailings deposition from FY28 to FY31 as part of the first fill, and subsequent fill phases ("topping up" cycles) through to FY47 prior to closure implementation (FY51). The operations CEM considered SPR linkages while tailings are being deposited into the IPTSF during the first fill and subsequent fills, and the periods of consolidation between the subsequent fills (up to FY51). The land use during operations is considered to be an operational mine site.

The closure phase of the IPTSF is considered to occur from FY51, once tailings deposition has ceased. The closure CEM considers SPR linkages post-FY51, including a period of tailings consolidation before the final landform has been achieved. The preferred closure option is partial backfill (discussed further in Section 6), with the final land use expected to be native ecosystems and potentially some limited grazing. Note that the stability of any pit voids and post-closure rehabilitation measures such as revegetation over tailings would need to be considered and assessed to ascertain suitability for grazing.

3.3 DPS CEM Inputs

Key information used in the DPS CEM assessment has been sourced from the following documents and studies that were prepared to support the DPS and Closure Design:

- Tailings Deposition Model - (WSP Ref: PS134791-WSP-ADL-MNG-MEM-017 Rev3 DPS Tailings Deposition Update at De Grey and Swan pits) BHP Document Number 7731-A85248-VD-00004 Dated 30 September 2024.
- Tailings Consolidation Model - (WSP Ref: PS134791-WSP-ADL-MNG-REP-033 Rev2 DPS Consolidation Modelling Update) BHP Document Number 7731-A85248-VD-00004. Dated 8 October 2024.
- Water Balance Model - (WSP Ref: PS134791-WSP-ADL-MNG-REP-026 Rev1) BHP Document Number 7731-A85248-VD-00018. Dated 29 October 2024.
- Groundwater Assessment - (WSP Ref: PS134791-WSP-PER-MNG-REP-065-Rev2 Groundwater Assessment) BHP Document Number 7731-A85248-VD-00042. Dated 25 September 2024.
- Water Quality Model - (WSP Ref: PS134791-WSP-PER-MNG-REP-058 Rev3) BHP Document Number 7731-A85248-VD-00019. Dated 8 January 2025.

3.3.1 Links between water related components of DPS

WSP has completed a number of water-related assessments as part of the DPS design of the Swan and De Grey IPTSFs. These water components each have separate objectives as well as interdependencies to other water related components on the project. Figure 3.1 summarises the objectives of each component and its links to other water related components. Ultimately all these components inform and are summarised in the detailed design reporting. Key studies informing the CEM are discussed in the following sections.

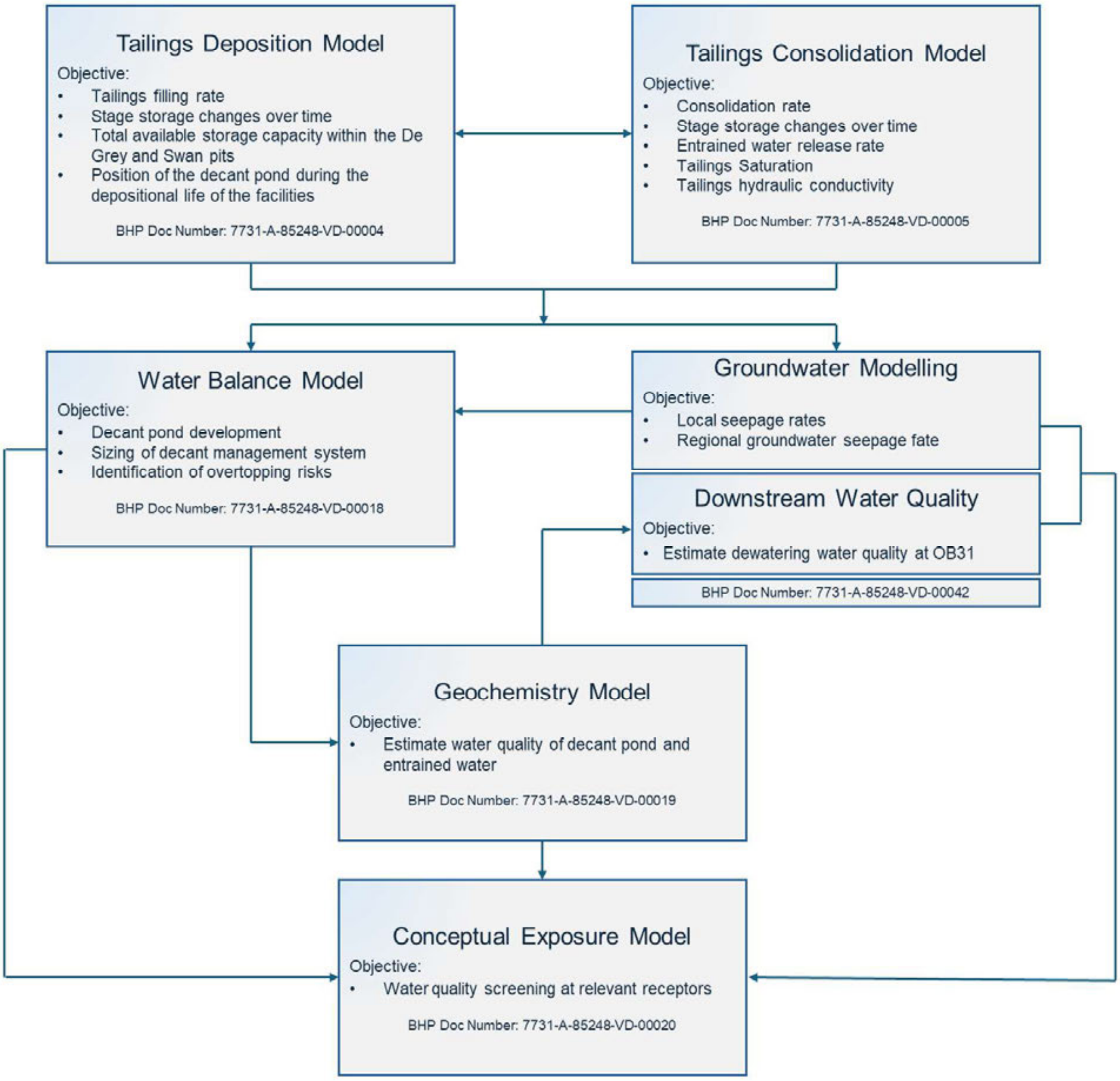


Figure 3.1 Links between water related components of the DPS

3.3.2 *Project design elements*

Information on known project design elements for the DPS was provided to BHP by Calibre[5] consultants. The information included delivery and decant water pipeline routes and proposed measures to manage a failure of a pipeline (BHP, 2024c).

3.3.3 *Geochemical testwork of tailings samples*

WSP Golder assessed the geotechnical and geochemical characteristics of five composite tailings samples, understood to be representative of the tailings likely to be generated at the Jimblebar Beneficiation Plant (WSP Golder, 2022). The tailings composite samples supplied by BHP have a ‘P2 Blend’ base with varying proportions of Joffre and Marra Mamba tailings. The compositions of the tailings samples are presented in Table 3.1.

---

[5] CalibreQuadR, now part of WSP.

Table 3.1 Jimblebar tailings composites samples

Sample ID	P2 Blend (%)	Joffre (%)	Marra Mamba (%)
P2 Blend	100	0	0
High Joffre	40	60	0
High Marra Mamba	50	25	25
SPS Average Tailings Blend	52.5	40	7.5
High P2	82.5	10	7.5
Low P2^	-	-	-

BHP has indicated that SPS Average Tailings Blend and High P2 tailings are likely to be generated during the first five years of Beneficiation plant operation. High P2 has also been assumed to be the representative sample for tailings produced following the first five years of production as mining operations continue. Note that SPS Average Tailings Blend and High P2 were previously named Average Blend and High Dales respectively in the tailings testwork report and corresponding laboratory test reports. Further detail on the analysis is provided in "Jimblebar VD12 Variation: Results of geotechnical and geochemical testwork on tailings composite samples" (WSP Golder, 2022).

WSP understand that two of the tailings blends, "SPS Average Tailings Blend" (formerly Average Blend) and "High P2" (formerly High Dales), will be the predominant blends present in the IPTSFs (BHP, 2023c). Therefore, geochemical analysis of these two blends has been considered in the CEM. The analysis results data for tailing solids and tailings supernatant (slurry) water has been used in the development of the DPS CEM including the associated risk assessment (Section 4).

3.3.4 Water balance

WSP developed an operations water balance model for the DPS using the Goldsim software (WSP, 2024b). The water balance model estimated water surpluses and deficits of the IPTSFs during the operational phases. The mean water quantity estimates provide a basis for the geochemical assessment (discussed in Section 3.3.5). In addition, the water balances assisted with understanding pond behaviour during and in-between tailings filling phases to assess decanting requirements to prevent overtopping during these periods. The water balance model presented the following sensitivity scenarios:

- Climate scenario base case and two climate change scenarios using the Willis Towers Watson (WTW) dataset for rainfall and evaporation mean monthly and annual projections provided by BHP. For the water quality model and assessment in the CEM, only the shared socio-economic pathway (SSP) SSP5-8.5 scenario is simulated, as it represents the worst-case wet scenario.
- Two seepage outflow scenarios have been assessed which reflect the outcomes of the groundwater study component (WSP, 2024c). This includes base case and highest case seepage outflow scenarios.

A simplified water balance was also developed to represent the original Closure Option 1 conditions – Optimised Without, OWO (WSP, 2023) - using the 90 percent tailings consolidated surface to represent the IPTSF closure landform elevations. Note that the preferred closure option is now Partial Backfill (original Option 2), but additional modelling was not seen as essential to provide sufficient indicative information to allow screening risk assessment.

The key inflow is rainfall-runoff, as decommissioning of the beneficiation plant removes the peak inflow of supernatant water from tailings deposition. Two reporting catchment scenarios were assessed looking at the fate of the adjacent Overburden Storage Area (OSA) final landform. One scenario assumes runoff from the final OSA landform crest reports to the IPTSF closure pond (if the crest grading and/or diversions are not maintained during closure), and the other assumes runoff is permanently diverted away from the IPTSF closure pond. The mean water quantity estimates for the conceptual closure condition were also provided as a basis for the geochemical assessment (discussed in Section 3.3.5).

3.3.5 Water Quality

WSP developed an updated operational water quality model (WSP, 2024e). The model is developed from the mean water inflow/outflow results of the water balance assessment (discussed in Section 3.3.4), tailings deposition modelling and pit wall exposure mapping (WSP, 2024c), and laboratory testing ((Golder, 2021a) and (WSP Golder, 2022)). The water quality model output represents the potential water quality within the IPTSF decant pond and the 'at-source' seepage composition from the decant pond. The model considered two sensitivity scenarios in addition to the base case:

- Base Case – comprising a mixture of scenarios with and without geochemical controls (such as equilibrium with atmospheric CO2, precipitation of mineral phases and sorption onto precipitated ferrihydrite surfaces). The base case scenario considers a mix between sensitive scenarios combining 80% geochemically controlled conditions and 20% non-geochemically controlled conditions.
- Highest Case (also referred to as High Seepage) – considering tailings hydraulic conductance is assumed to be 2 times higher than those used in the Base Case.
- Climate Change – comprising scaling of the stochastic climate by the mean projected rainfall and evaporation data for SSP5-8.5 scenarios from the WTW dataset provided by BHP.

Further information on the sensitivity tests is provided in the water quality modelling report (WSP, 2024e). The base case scenario (in both the water balance and water quality modelling) forms the models most expected outcomes based on the information considered in the respective studies.

The water quality model outputs represent the potential water quality of the combined surface runoff going into the pit catchment, including direct rainfall/precipitation and subsequent evaporation. Water quality was modelled for two scenarios for the Swan pit and four scenarios for De Grey pit. The differences between scenarios are the inclusion of OSA runoff and re-exposure of pit wall rock following erosion of consolidated tailings.

3.3.6 Groundwater Assessment

WSP undertook hydrogeological modelling to develop an understanding on how contaminants, present in the proposed IPTSFs, would potentially impact upon groundwater conditions and environmental receptors (WSP, 2024f). The analysis included predicting the potential seepage rates that may occur during the operational period of tailings deposition (including top up events) and the subsequent consolidation phase until the end of the dewatering operation at OB31 in 2055. The analysis evaluated the potential dilution of concentrations of likely contaminants present in the tailings at the OB31 dewatering system. Dilution factors were calculated with time, and dilution factors were calculated considering three periods; initial condition, first filling seepage and sustained seepage. The average dilution factors have been qualitatively discussed in relation to the pond water quality screening assessment, refer to Section 5.6.

3.3.7 Site investigation of PFAS in groundwater

Two targeted site investigations were undertaken, by ERM in 2022 and 2023, as part of a broader regional assessment to understand the nature and extent of per- and poly-fluoroalkly substances (PFAS) in soil and groundwater at the Jimblebar Mine Site ((ERM, 2023). Six groundwater monitoring wells (JBCSGW0001 – JBCSGW0006) were installed and sampled in the vicinity of OB18 Pit and OB31 Pit. Analytical results for PFAS compounds were generally reported as less than the limit of reporting (LOR) or below the adopted assessment criteria for ecological protection and human health, with the exception of monitoring well location JBCSGW006. In the first monitoring round (May 2022) Perfluorooctane sulfonic acid (PFOS) at monitoring well location JBCSGW006 (concentration 0.0012 µg/L) was reported to exceed the PFAS NEPM Ecological water quality guideline value for freshwater 99% species protection (high conservation value system) (criteria of 0.00023 µg/L). However, in the second monitoring round (November 2022) PFAS analytical results were below the LOR, including PFOS which was reported as <0.0002 µg/L.

Therefore, PFAS compounds have not been included as a potential stressor of interest (PSOI) in the DPS CEM because PFAS compounds were observed to be non-detect or at relatively low concentrations in groundwater in the vicinity of OB18 Pit and OB31 Pit. WSP understands that BHP will continue to assess and manage PFAS in the wider Jimblebar Precinct as a separate scope of works.

4 Risk Assessment Approach

The risk assessment component has been carried out according to the DWER *Guideline: Risk Assessments* (DWER, 2020), as the regulatory risk framework. Risk ratings are calculated as a function of likelihood and consequence. The general method outlined in DWER (2020) is as follows:

- Identify the risk events through SPR analysis.
- Establish the consequence of each risk event and apply consequence rating (Table 4.1).
- Establish the likelihood of each risk event and apply a likelihood rating (Table 4.4).
- Apply a risk rating using consequence criteria and likelihood criteria.
- Determine the risk rating via the risk rating matrix (Table 4.5).

4.1 Identifying risk events

Risk events have been identified, as per DWER (DWER, 2020) by the process of identifying potential contamination (emission); a receptor which may be exposed to that hazard through an identified actual or likely pathway; and the potential adverse effect to the receptor from exposure to that hazard. In summary, establishing potential SPR linkages.

4.2 Establishing the consequence - screening assessment

The DWER (DWER, 2020) guidelines recommend the use of specific criteria for consequences to the environment or public health to determine the consequence rating for each identified potential risk event. The specific criteria are applied at the receptor identified as most affected by the emission and considering the nature, value and sensitivity of the receptor. This has been undertaken via a screening assessment process described below. Each risk event is assessed and given a consequence criteria as per Table 4.1.

Table 4.1 Consequence criteria (DWER, 2020)

Consequence	Consequence Description	
	Environment	**Public Health and Amenity**[1]
Severe	On-site impacts: catastrophic. Off-site impacts local scale: high level or above. Off-site impacts wider scale: mid-level or above. Mid to long term or permanent impact to an area of high conservation value. Specific Consequence Criteria are significantly exceeded.	Loss of life. Severe adverse health effects or ongoing medical treatment. Specific Consequence Criteria[2] are significantly exceeded. Local scale impacts: permanent loss of amenity.
Major	On-site impacts: high level. Off-site impacts local scale: mid-level. Off-site impacts wider scale: low level. Short term impact to an area of high conservation value. Specific Consequence Criteria are exceeded.	Adverse health effects or frequent medical treatment. Specific Consequence Criteria exceeded. High level impact to amenity.
Moderate	On-site impacts: mid-level Off-site impacts local scale: low level Off-site impacts wider scale: minimal. Specific Consequence Criteria are not likely met.	Adverse health effects or occasional medical treatment. Specific Consequence Criteria are not likely met. Mid-level impact to amenity.

Consequence	Consequence Description	
	Environment	**Public Health and Amenity**[1]
Minor	On-site impacts: low level. Off-site impacts local scale: minimal. Off-site impacts wider scale: not detectable. Specific Consequence Criteria are likely met.	Specific Consequence Criteria are likely met. Low level impact to amenity
Slight	On-site impacts: minimal. Specific Consequence Criteria met	Specific Consequence Criteria met Minimal impacts to amenity

Notes:

1) Such as air and water quality, noise, and odour.
2) In this assessment, Specific Consequence Criteria are the screening criteria presented in Section 4.2.1).

It is common practice in human health and ecological risk assessment to undertake a screening assessment to establish if any of the identified chemical hazards warrant further investigation. This involves a comparison of the available known concentration of chemical hazard within the media under scrutiny (exposure concentrations) with published and established risk-based guidance levels or SSTV (screening criteria). Risk-based guidance levels are generally derived using the following factors:

- Toxicity of the agent – dose-response information to understand how much will cause an adverse effect.
- Generic exposure scenarios and assumptions – so the criteria can be applied broadly across a range of situations.
- Application of uncertainty and safety factors – to account for variation and uncertainty.

Screening assessments are inherently conservative, and it should be noted that an exceedance of a screening criteria does not mean an adverse effect is imminent or even likely but is simply a trigger for further investigation.

- Firstly, screening criteria have several layers of conservatism or safety applied in their derivation and are set at levels well below concentrations that may cause adverse effects, often by orders of magnitude That is, they err well on the side of caution and are deliberately overly-protective of different environments (e.g., groundwater/groundwater dependent ecosystems, surface water and/or terrestrial environments) and receptors (e.g., ecological fauna, livestock or human health).
- Secondly, the environmental data used will often involve use of upper 90th percentile (P90[6]) or maximum concentrations that are unlikely to present most of the time in likely exposure situations. Note that in this assessment, both the P90 and average chemical concentrations identified within the associated media have been used as the exposure concentrations for screening purposes.
- Screening criteria are also usually derived using general exposure assumptions that are based on worst-case scenarios to cover a wide range of situations and sensitive sub-populations. For example, the NHMRC Recreational Water guideline values are based on the assumption that a person will consume 200 mL of water (approximately half a soft drink can, or nearly a standard cupful) whilst swimming every day for a lifetime. In reality, these types of generic scenarios do not generally occur and the screening criteria likely overestimate the exposure as a precautionary tactic.

The screening process against hazard-based guideline values tryically results in a ratio known as the hazard quotient (HQ). The HQ is calculated using the equation below.

$$\textit{Hazard Quotient:} \quad HQ = \frac{Exposure\ concentration}{Screening\ criteria}$$

The HQ is a measure of the margin of safety rather than a line identifying definite adverse effects. The margin of safety is reflected in the size of the HQ. The smaller the HQ the larger the margin of safety.

[6] P90 is the 90th percentile in the data set. That is 90% of the analysed sample concentrations will be lower than the P90 value.

- If the HQ is less than or equal to one, the exposure concentration is less than or equal to the screening criteria, indicating that the chemical is highly unlikely to cause adverse effects and generally no further assessment is required.
- If the HQ value is greater than one, the exposure concentration is greater than the screening level. Given the screening criteria are overly conservative in relation to risk of adverse effects, this assessment has adopted a HQ of five (5) to be used as the trigger for further evaluation of the potential for risk to a specific receptor or receptors in the site-specific setting.

This assessment has used the lowest screening criterion (i.e. most protective) in instances where multiple guideline values where available for the one exposure scenario (e.g., where two groundwater SSTVs were available for one chemical). Where the use of the alternative SSTVs results in a different outcome, this is included in the discussion.

4.2.1 *Adopted screening criteria*

The following provides the screening criteria that have been adopted for identified risk event and each media type. Note that due to an absence of more site-specific criteria, many of the ecosystem screening criteria are derived from international studies of plants, animals and ecosystems that don't generally apply to Australian flora and fauna, due to differences in soil types, climate, species types and other factors. Regardless, these criteria are not completely unrelated and provide some basis to assess the consequence.

4.2.1.1 Tailings solids screening criteria

In the absence of tailings-specific screening criteria, the tailings solids data has been screened against the following soil quality guidelines grouped by potential receptors and listed in order of preference.

Table 4.2 Summary of tailings solids screening criteria.

Screening Criteria	Guideline
Ecological	National Environment Protection Measures (NEPM, National Environment Protection Council, 2013) Ecological Investigation Levels (EILs) for Areas of Ecological Significance[1].
	Canadian Council of Ministers of the Environment (CCME, 2023) Soil Quality Guidelines (SQG) for land use of Residential/Parkland.
	United States Environmental Protection Agency (US EPA, 2005) ecological soil screening levels (EcoSSLs).
Livestock Health	CCME (2023) SQG for land use of Agriculture.
Human Health	NEPM (NEPC, 2013) Health Investigation Levels (HILs) for Land Use Category C (Recreational).
	US EPA (2023) Regional Screening Levels (RSLs) – Residential Soil adjusted for recreational exposure[2].

Notes:

1) As site-specific soil data for cation exchange capacity, pH, organic carbon and % clay is not currently available, estimated EILs have been developed using generic soil parameters intended to be representative of the Jimblebar Hub.
2) US EPA RSLs for Residential settings have been increased by a factor of 4 (to account for differences in soil ingestion rates) to be more representative of likely recreational exposure.

4.2.1.2 Water Screening criteria

The available water data, including tailings supernatant (dissolved and total), pond water quality modelling data, and OB31 dewatering water quality outcomes, has been screened against the following receptor-specific water quality guidelines.

Table 4.3 Summary of receptor-specific water screening criteria.

Screening Criteria		Guideline
Ecological	Groundwater	Jimblebar Groundwater SSTV SSTVs (Golder, 2015)[3].
		BHP Shovelanna SSTVs (HGG,2023)[4].
	Surface water	Jimblebar Creek Surface water SSTV (BHP, 2018a)
		Ophthalmia Dam Surface water SSTV (BHP, 2018a)
	For parameters without surface water SSTVs, the following were used:	ANZG (2018) 95% species protection Default Guideline Values (DGVs) for Freshwater[5] toxicants (i.e., for slightly to moderately disturbed systems)[5]
		ANZECC and ARMCANZ (2000) physical chemical stressor DGV for tropical wetlands[7]
Livestock		Livestock Drinking Water Trigger Value (low risk) (ANZECC,2000)
Human Health		NHMRC and NRMMC (2011, updated in 2022) Australian Drinking Water Quality Guidelines (ADWG)[1]
		NHMRC (2008) recreational water guidelines (which refer to the ADWGs[2]).

Notes:

1) Applies to total, not filtered (dissolved) concentrations.
2) NHMRC (2008) suggest a 10× increase in the guideline value can be applied when considering incidental ingestion of recreational water during activities such as swimming, wading, fishing, and entry into water bodies. Due to the ephemeral nature of the creeks in the vicinity of Swan and De Grey, the ingestion of waters is likely to be conservative apart from recreation in Ophthalmia Dam, but recreational activities in and on Ophthalmia Dam are prohibited
3) These SSTVs were part of GWL Operating Strategy for Jimblebar (Document number 0019543, Version 4.0, dated 15 February 2018) which forms part of the licence conditions for Licence to Take Water GWL158795(8). The Jimblebar SSTV are used in the first instance given their regional relevance and approval by WA Department of Water and Environmental Regulation (DWER).
4) Groundwater SSTVs for Shovelanna Operations (“Shovelanna Groundwater SSTVs (2023)”) in Hydro Geochem Group (2023) Revision of Site Specific Trigger Values for Groundwater Quality Monitoring (document number J-H-AU0062-001-R-Rev0, dated 23 June 2023). While these SSTVs are more recent and specific for the Shovelanna area, they are yet to be approved by DWER. Therefore, in the interim, both the Jimblebar SSTVs (Golder , 2015) and the Shovelanna SSTVs will be used in the screening processes.
5) In the absence of available water quality data (i.e., total dissolved solids, electrical conductivity) for OB31 Creek, it is assumed that the Creek is a freshwater system.
6) In the absence of site specific information on the ecosystem description of OB31 Creek (e.g., water quality data) and considering the historical and ongoing mining practices in the area, OB31 Creek is considered likely to be representative of a highly disturbed ecosystem (and to which the 90% species protection levels may be applied). However, given the uncertainties in the CEM including the designation of water quality of OB31 Creek and the limitations of the model outputs available to inform the assessment of risk, screening of water quality against the 95% species protection levels (for a slightly to moderately disturbed ecosystem) has been used as a conservative assessment.
7) In the absence of site-specific criteria for phosphorous and total nitrogen based on West Australian River pools provided in ANZECC & ARMCANZ 2000, Vol 2 (Section 8.2.2, Table 8.2.3).

4.3 Establishing the likelihood – exposure evaluation

The likelihood of a risk event has been rated using the likelihood criteria in Table 4.4 as per the DWER (2020) risk assessment process. Rating likelihood has been informed by the outcomes of the associated studies listed in Section 3.3 combined with specialist evaluation of the risk event exposure scenarios and the factors associated with screening criteria exposure assumptions.

Table 4.4 Likelihood criteria (DWER, 2020)

Likelihood	Likelihood Description
Almost Certain	The risk event is expected to occur in most circumstances.
Likely	The risk event will probably occur in most circumstances.
Possible	The risk event could occur at some time.
Unlikely	The risk event will probably not occur in most circumstances.
Rare	The risk event may only occur in exceptional circumstances.

As discussed in Section 4.2, the screening criteria values are established using generic exposure scenario assumptions that over-estimate exposure as a protective measure. These generic exposure factors include certain population characteristics, behaviours, and exposure frequencies and durations in order to be valid for a broad range of applications. For example, the Australian drinking water guidelines assume people drink 2 L of water per day; and the recreational water guidelines are based on the ADWG values include the assumption that 200 mL of water is ingested during recreational activities in the water 365 days per year. Swimming every day of the year and incidentally ingesting 200 mL of water is highly unlikely for most of the Australian population. These types of assumptions are applied to both human health and ecological guideline values.

With this in mind, the likelihood of an actual site-specific exposure occurring (at the scale assumed for the derivation of the screening criteria) for each risk event is considered when applying a likelihood criterion (as per Table 4.4) for each risk event. Where the risk event exposure is decidedly different than that assumed in deriving the applicable screening criterion, it is reflected in the likelihood criterion applied.

The rationale for decisions regarding likelihood are provided in the risk assessment tables in Section 5.7 and Section 6.7.

4.4 Risk ratings

Risk ratings for each risk event have been assessed in accordance with DWER (DWER, 2020) guidance. This involves the assessment of each identified emission or hazard source and consideration of potential SPR linkages. Where linkages are incomplete they have not been considered further in the risk assessment.

Consequence and likelihood criteria are rated for each applicable risk event based on specialist assessment of the fundamental factors and assumptions, considering site-specific information and the various levels of conservatism applied throughout the process. It should be noted that conservatism also exists within the modelling processes used to estimate contamination concentrations within the water and tailings solids.

Table 4.5 Risk rating matrix (DWER, 2020)

Likelihood	Consequence				
	Slight	Minor	Moderate	Major	Severe
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Medium	Medium	High

Operations and Closure risk ratings are present in Section 5.7 and Section 6.7 respectively. The rationale used to reach the risk ratings are presented in Appendix D for Operations and Appendix E for Closure.

5 Operations Conceptual Exposure Model

5.1 Overview

A conceptual site model (CSM) diagram has been generated to visually represent the possible complete SPR linkages associated with operations of the Swan and De Grey IPTSFs (Figure 1.2). The sources (Section 5.2), pathways (Section 5.3), and receptors (Section 5.4) are described in greater detail in the following subsections. This is followed by Table 5.1 (Section 5.6), which presents the SPR linkages associated with operational phase of the Swan and De Grey Jimblebar IPTSF. Table 5.1 also includes the risk ratings assigned to each SPR linkage, including the rationale for these ratings considering mitigation and controls that may be put in place.

A key consideration for the Operations CEM is the hydrogeological understanding, which is discussed in Section 5.1.1.

5.1.1 Hydrogeology

The pre-mining conceptualisation (BHP, 2022) of the hydrogeological setting between Ethel Gorge TEC and OB31 has the groundwater flow direction from Swan and De Grey Pits, from east to west (Figure 5.1) driven by low groundwater gradients of the order of a few metres over approximately 20 km. At least two partial flow barriers (dykes) are thought to exist between OB31 and the Ethel Gorge TEC aquifer (Figure 5.1). One is located south of the De Grey and Swan pit, whilst the other is located between the Ninga MAR borefield and OB18. These produce three quite distinct aquifer compartments. It is important to note that a number of planned mines, borefields and MAR schemes are located downgradient (west) of the Swan and De Grey Pits. The pre-mining conceptualisation does not account for these existing and future facilities that will modify the future groundwater flow paths towards Ethel Gorge.

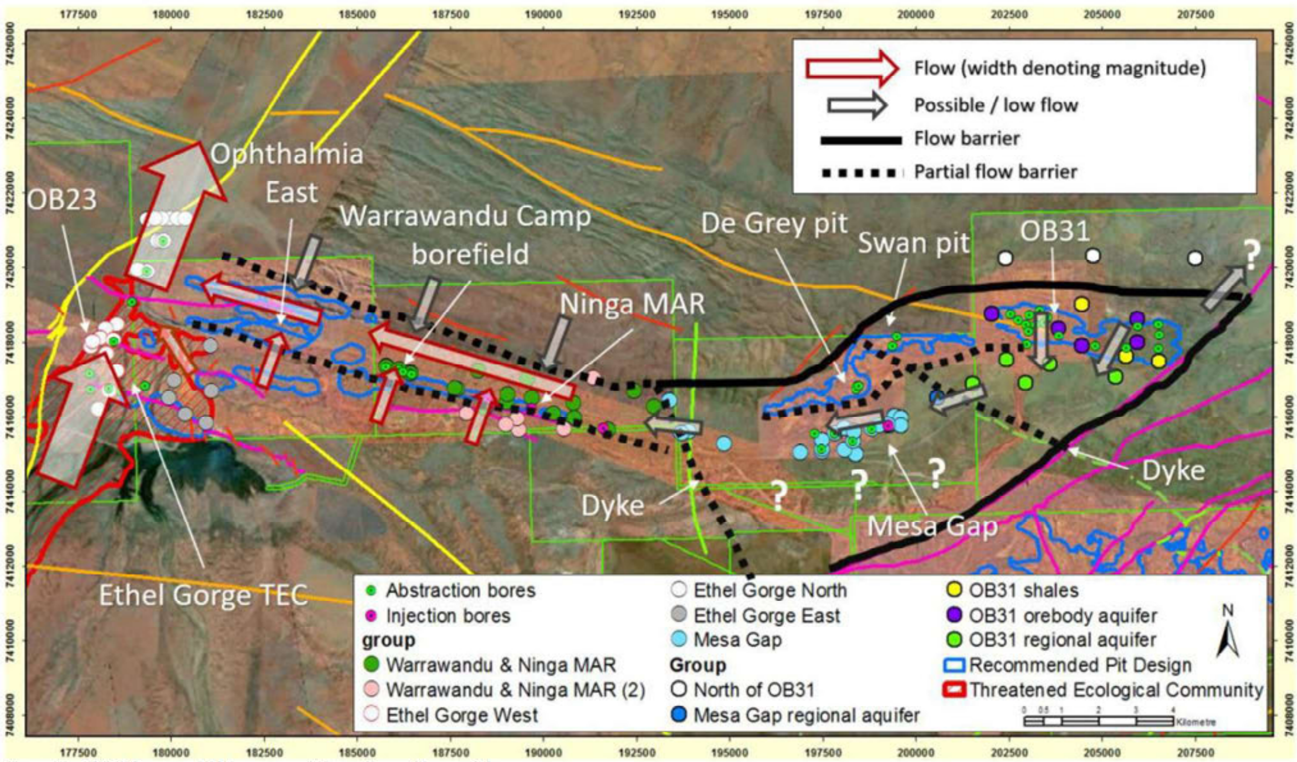


Figure 5.1 Regional conceptual model (pre-mining) (BHP, 2022)

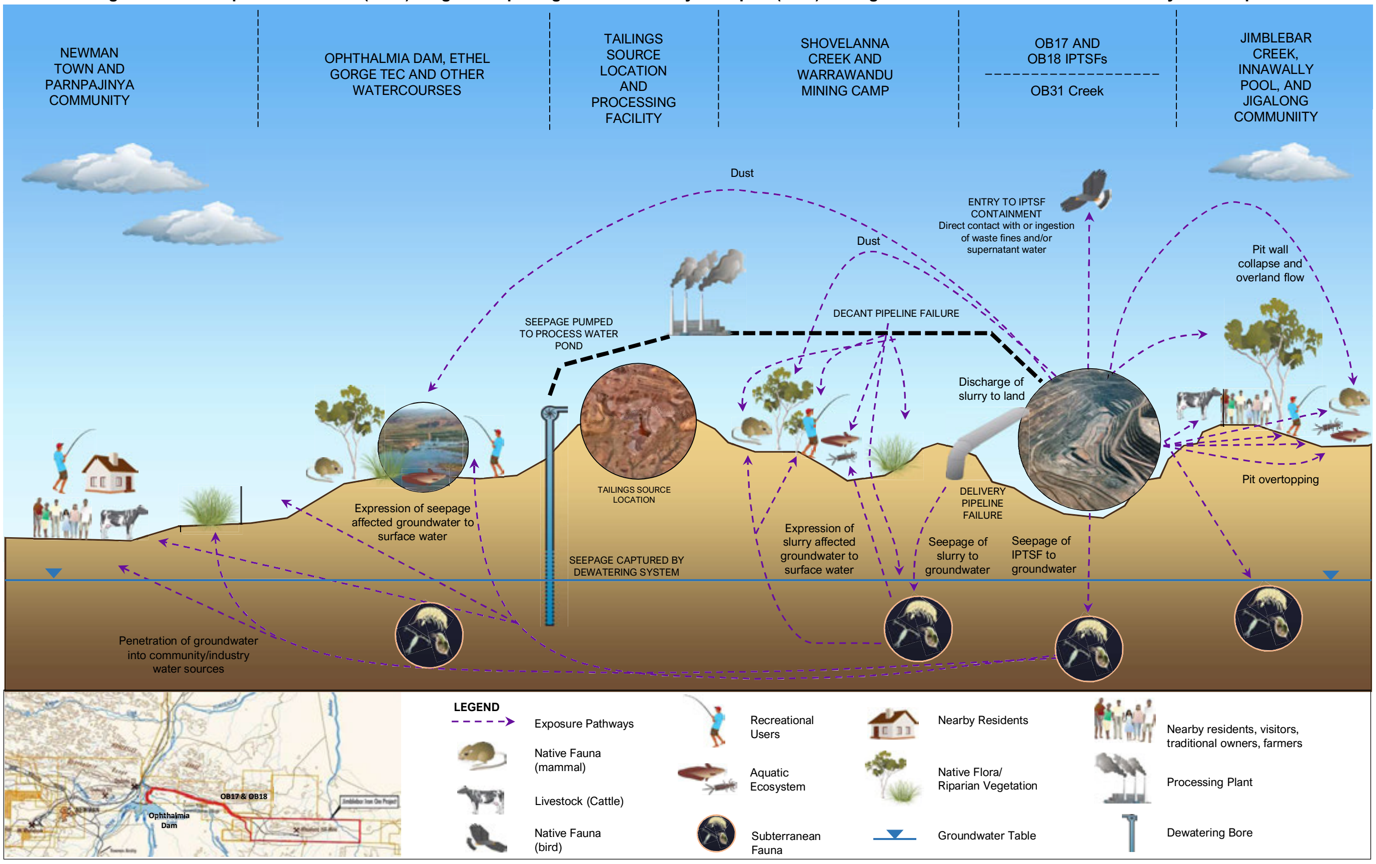
Dewatering operations at OB31 will maintain groundwater levels at Swan Pit below the pit floor and draw groundwater at the Swan Pit to the east. This situation is likely to continue until sometime after dewatering at OB31 ceases, currently scheduled for 2055. The De Grey Pit, however, is not hydraulically connected to OB31 and is not responding to dewatering at OB31.

Hydrogeological modelling has confirmed that there will be some seepage losses from Swan and De Grey IPTSF during the operational phase (WSP, 2024i). The highest seepage rates from the pit occur during the tailings deposition when the tailings are in a slurry form or have not yet undergone significant consolidation. As the saturated tailings are deposited, the hydraulic pressure increases, which results in a gradual increase in infiltration rates until the deposition process is complete. The areas with the highest seepage rates are expected to be where the decant pond directly contacts the pit floor/wall or where the settling tailings come into direct contact with zones of high hydraulic conductivity. During fallow periods, there are minimal water inputs compared to the deposition phase and the tailings will progressively become unsaturated over time and the pressure head diminishes. The tailings also consolidate under their own weight which results in a reduction in hydraulic conductivity. Consequently, it is likely that the rate of tailings seepage will decrease over time.

Surface expressions of seepage are unlikely due to the considerable depth of the water table. Flow is expected to predominantly move downward through the unsaturated zone under gravity, recharging the deeper aquifer rather than moving laterally or toward the surface.

Groundwater modelling (WSP, 2024f) provided insights into the risk of groundwater level rise during IPTSF operations. While Swan Pit shows higher seepage rates than De Grey Pit, groundwater levels are predicted to remain below the Swan Pit floor due to ongoing dewatering at OB31. The majority of seepage from Swan during operations is expected to be captured by the OB31 dewatering system (WSP, 2024i) and the combined water from Swan seepage mixed with OB31 dewatering will be directed to Ophthalmia Dam reinjection facilities. In contrast, the De Grey Pit, which is not hydraulically connected to OB31, revealed localised effects of groundwater mounding. This is due to the pit being bounded by the lower permeability Mount McRae Shale and Mt Sylvia Formations, and due the inferred hydraulic barrier (dyke) between Swan and De Grey. The model predicts that groundwater mounding will not be high enough to result in seepage to ground surface.

Figure 5.2: Conceptual Site Model (CSM) Diagram Depicting Source-Pathway-Receptor (SPR) Linkages Associated with Swan and De Grey IPTSF Operation



5.2 Potential Contamination Sources and Stressors

5.2.1 Potential contamination sources

The main sources of potential contamination, associated with operation of the Swan and De Grey IPTSF are:

- Waste fines/tailings slurry, including tailings solids and tailings supernatant/process water.
- Decant water.
- Ponded water, comprising supernatant water from the tailings, and runoff from pit wall materials.

The contaminants associated with the above identified sources are dependent on the chemistry of the:

- Feed water quality[7].
- Composition of the ore.
- Process chemicals (e.g., flocculants).
- Contribution from blast residues (i.e., nitrogen compounds).

5.2.2 Environmental data

The following data is available for assessment of PSOI for the operation of the Swan and De Grey IPTSF:

- Analytical data for the tailings solids and supernatant water.
- Water quality model outputs from the geochemical assessment for the ponded water in-pit for Swan and De Grey IPTSF.
- Water quality predictions at the OB31 dewatering site (based on dilution factors established in the hydrogeological and water quality assessments for the seepage of water from the Swan and De Grey IPTSF to the OB31 dewatering system (WSP, 2024e)).

5.3 Potential Contaminant Pathways

The following transport pathways have the potential to expose receptors to risk, from PSOI associated with the operations of the Swan and De Grey IPTSF:

- Airborne dust.
- Seepage of IPTSF waters through base and/or pit walls to groundwater.
- Expression of groundwater contaminated with IPTSF waters to surface water.
- Surface water migration downstream along natural waterways/watercourses.
- Spillage from failure of delivery/discharge or decant water pipelines.
- Pit overtopping[8] and/or Collapse of pit wall. (Both events are generally related to localised instability or asymmetry in tailings discharge and could lead to similar outcomes, i.e. tailings release).

---

7 Feed water is the input/source water used to process the iron ore.

8 Tailings can “squeeze” causing overtopping on the opposite side to the point of discharge when freeboard is low (towards termination of filling the pit). This occurs due to weight of the tailings around the discharge point causing localised slumping that can create a surge of tailings to flow and produce overtopping of the ponded water (or tailings) at one side of the pit.

Potential receptors may become exposed to PSOI associated with the operations of the IPTSFs via the following exposure pathways:

- Inhalation of dust by humans.
- Dermal contact by humans or direct contact by native terrestrial fauna[9] with waste fines and/or supernatant water.
- Dermal contact by humans of the seepage water (e.g., during wading, fishing, or other recreational water activities).
- Direct contact/uptake of PSOI from water or other affected media (i.e., soil, sediment, groundwater) by aquatic or terrestrial flora and fauna.
- Ingestion of seepage water (e.g., by livestock or native fauna), including incidental ingestion by human recreational users of natural watercourses or waterbodies.

5.4 Potential Receptors

Based on site knowledge and a review of surrounding land uses (Section 2.2) and readily available information, the following were identified as potential receptors of interest (ROI) that may be exposed (either directly or indirectly as indicated in Table 5.1) by PSOI identified as associated with the IPTSF Operations (Swan and De Grey):

- Ecological Receptors:
  - Surface water aquatic ecosystems (Innawally Pool, OB31 Creek, Jimblebar Creek[10], Shovelanna Creek and Ophthalmia Dam), including aquatic fauna and riparian vegetation.
  - Groundwater Dependent Ecosystems (GDE) as listed in the Australian Government Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas (Appendix B of the SPS CEM):
    - Ethel Gorge aquifer stygobiont Threatened Ecological Community (TEC).
    - Subterranean fauna.
  - Native and terrestrial flora and fauna, including Commonwealth and State listed species of conservation significance (described in Appendix B of the SPS CEM for the full detailed Environment Protection and Biodiversity Conservation [EPBC] Act Protected Matters Reports and NatureMap Species Reports).
  - Livestock (cattle)[11].
- Human Receptors:
  - Recreational users of nearby watercourses and waterbodies for wading, swimming, and fishing.
  - Newman Water Reserve[12] public drinking water source protection zones (Priority Areas 1 and 3) and associated borefields.
  - Nearby residents and visitors to the town of Newman.

---

9 Native terrestrial fauna includes migratory birds.

10 The Jimblebar Creek regional surface water catchment is depicted in Figure 1 of the BHP (2018) Surface Water Management Plan Jimblebar report.

11 The nearest pastoral leases to the Swan and De Grey ISTSF are the Prairie Downs Station to the west and the Sylvania Station to the southeast, both of which operate as cattle stations. The Sylvania Station pastoral lease is jointly owned by BHP and Pilbara Pastoral Co Pty Ltd and is operated by a private pastoral lessee. Ownership of the Prairie Downs Station is unknown.

12 Swan and De Grey are located ~1 km outside of the boundaries of the Newman Water Reserve, the area encompassing the borefields responsible for Newman's public drinking water supply (DOW 2014). Source water from the Newman Water Reserve is extracted and/or treated by BHP and the Water Corporation, prior to potable use.

— Warrawandu potable water borefield.

— Aboriginal residents and visitors of the Parnpajinya and Jigalong Communities.

— Traditional owners (Nyiyaparli people) and custodians (Martu people) of the land.

— Farmers associated with the Prairie Downs and Sylvania Stations.

Further information on the receptor identification process is provided in Appendix A.

It is acknowledged that the Newman town water supply source water is treated by BHP and the Water Corporation to meet the Australian Drinking Water Guidelines ((NHMRC and NRMMC , (2011, updated 2021).), as required by WA Health (BHP, 2021). Based on this, exposure of humans to hazards via drinking water that has indirectly been affected by the OB31 dewatering system is not likely a complete pathway (i.e., the hazard (emission) has been removed from the SPR linkage). However, to ensure completeness, and to protect the Warrawandu source, all town drinking water is being treated as an exposure pathway and assessed in the CEM.

In addition, some of the other exposure pathways are unlikely to be realised to major extents but have been included for completeness.

Assessment of impact to receptors exposed to water piped to Ophthalmia Dam assumes the pathway of exposure is complete and appropriate water quality and quantity data are available. Cumulative impacts from other operations to receptors using water from Ophthalmia Dam are excluded from this assessment.

5.5 Operations - Risk events (SPR linkages)

Table 5.1 presents the identified operations-related risk events as a summary of the exposure pathways that relate to each of the SPR linkages.

Table 5.1 Summary of Operations SPR linkages for IPTSF (Risk events)

Primary and Secondary Sources (Environmental Media)	Transport Pathway	Receptors	Exposure Pathways				
			Ingestion	Inhalation	Dermal Contact	Direct Contact / Uptake	Food Chain[3]
Deposition of tailings slurry in Swan / De Grey IPTSF Dry waste fines (Air quality)	Airborne fugitive dust generated from TSF landform	Native terrestrial flora	-	-	-	✓	-
		Recreational users, nearby residents[1], traditional owners, and/or farmers	-	✓	-	-	-
Failure of delivery pipeline carrying tailings slurry to Swan / De Grey IPTSF (Soil, groundwater, and surface water)	Direct discharge of tailings slurry to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	-	-	-	✓	-
		Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Jimblebar Creek or Shovelanna Creek	Aquatic ecosystems[2]	-	-	-	✓	✓
		Native terrestrial fauna[3]	✓	-	-	-	✓
		Recreational users	✓	-	✓	-	-
		Livestock (cattle)	✓	-	-	-	✓
Decanting supernatant water from tailings in Jimblebar IPTSF Failure of decant water pipeline carrying supernatant water to process water pond (Soil, groundwater, and surface water)	Direct discharge of supernatant water to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	-	-	-	✓	-
		Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek) and downstream receiving waters including Jimblebar Creek or Shovelanna Creek	Aquatic ecosystems[2]	-	-	-	✓	✓
		Native terrestrial fauna[3]	✓	-	-	-	✓
		Recreational users	✓	-	✓	-	-
		Livestock (cattle)	✓	-	-	-	✓

Primary and Secondary Sources (Environmental Media)	Transport Pathway	Receptors	Exposure Pathways				
			Ingestion	Inhalation	Dermal Contact	Direct Contact / Uptake	Food Chain[3]
Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater and surface water)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
	Expression of groundwater contaminated with IPTSF waters to surface water and subsequent surface water migration downstream along natural waterways/ watercourses	Native terrestrial flora	-	-	-	✓	-
		Aquatic ecosystems[2]	-	-	-	✓	✓
		Native terrestrial fauna[3]	✓	-	-	-	✓
		Livestock (cattle)	✓	-	-	-	✓
		Recreational users	✓	-	✓	-	-
Piping of tailings affected (via seepage of IPTSF waters) surplus dewatering volumes to Ophthalmia Dam[5]	Direct discharge of dewatering volumes to Ophthalmia Dam	Groundwater dependent ecosystems including subterranean fauna	✓	-	✓	✓	-
		Aquatic ecosystems[2]	✓	-	✓	✓	✓
		Drinking water	✓	-	-	-	-
Deposition of tailings slurry in Swan / De Grey IPTSF Collapse of pit wall / Pit overtopping (Soil / rock, groundwater, and surface water)	Flow of supernatant water, and/or tailings over the pit rim Contact with falling debris (soil/rock) following collapse of pit wall	Native terrestrial flora	-	-	-	✓	-
		Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
		Aquatic ecosystems[2]	-	-	-	✓	✓
		Native terrestrial fauna[3]	✓	-	-	-	✓
		Livestock (cattle)	✓	-	-	-	✓
		Recreational users	✓	-	✓	-	-

Primary and Secondary Sources (Environmental Media)	Transport Pathway	Receptors	Exposure Pathways				
			Ingestion	Inhalation	Dermal Contact	Direct Contact / Uptake	Food Chain[3]
Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan / De Grey IPTSF containment)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water	Native terrestrial fauna[3]	✓	-	-	✓	-

Notes:

1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Parnpajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.
4) The 'food chain' exposure pathway refers to indirect dietary exposure to PSOI taken up in food items/prey consumed by fauna.
5) Seepage water collected by the dewatering system will be managed as part of BHP's overall water management system and re-used or disposed of (options for management to be considered in the next stage of the study). Seepage-affected groundwater must meet all applicable water quality guidelines and licence discharge criteria prior to being discharged to the receiving environment

5.6 Operations – Consequence analysis (Screening)

The following presents a summary of the screening assessment in relation to operations-related SPR linkages as per Section 4.

5.6.1 Tailings Samples

The results of the geochemical testwork of tailings samples, including supernatant water (slurry) samples as described in Section 3.3.3, were assessed. Where detectable concentrations of PSOI were reported, they have been compared to the adopted criteria in the following tables included in Appendix B:

Tailings solids:

- Table B.1 – Ecological.
- Table B.2 – Livestock.
- Table B.3 – Human health (recreational).

The tailings supernatant water (dissolved concentrations):

- Table B.4 – Ecological.

The tailings supernatant water (total concentrations):

- Table B.5 – Livestock.
- Table B.6 – Human health (recreational).

5.6.2 Exceedances

Exceedances of adopted criteria are detailed below. The concentrations reported for the tailings supernatant water were below the adopted livestock and human health screening criteria.

5.6.2.1 Ecological receptors – screening criteria exceedances

Exceedances of the ecological adopted screening criteria for the tailings solids and supernatant water data and the respective HQs are presented in the following in-text tables.

Table 5.2 Concentrations exceeding adopted screening criteria and calculated Hazard Quotients – Tailings Solids (mg/kg) & Supernatant Water Data (mg/L) – Ecological Receptors

Analyte	**Guideline**	**Guideline Reference**	**Tailings Blend – Average Blend**		**Tailings Blend – High Dales**	
			Conc.	HQ	Conc.	HQ
Tailings Solids (mg/kg)						
Arsenic	20	NEPM (2013) Area of Ecological Significance	17	<1	21.4	1.1
Copper	25	NEPM (2013) Area of Ecological Significance	32	1.3	39	1.6
Manganese	220	US EPA EcoSSL	918	4.2	1185	**5.4**
Antimony	0.27	US EPA EcoSSL	1	3.7	1	3.7
Zinc	50	NEPM (2013) Area of Ecological Significance	61.9	1.2	69.3	1.4

Analyte	Guideline	Guideline Reference	Tailings Blend – Average Blend		Tailings Blend – High Dales	
			Conc.	HQ	Conc.	HQ
Tailings Supernatant Water (Dissolved) – Groundwater screening criteria (mg/L)						
Barium	0.01	Jimblebar Groundwater SSTV (Golder , 2015)	0.0897	**9.0**	0.0937	**9.4**
Copper	0.0014	Jimblebar Groundwater SSTV (Golder , 2015)	<0.0005	N/A	0.0045	3.2
Tailings Supernatant Water (Dissolved) - Surface water screening criteria (mg/L)						
Copper	0.0014	(ANZG, 2018) Freshwater 95% toxicant DGV	<0.0005	N/A	0.0045	3.2
Zinc	0.008	(ANZG, 2018) Freshwater 95% toxicant DGV	0.002	<1	0.015	1.9

Notes:
Shading is applied to the HQ based on the following scale: HQ >5 - 10 = light blue; HQ >10 = dark blue.
N/A – HQ not able to be calculated.

5.6.2.2 Livestock – screening criteria exceedances

Exceedances of the adopted livestock screening criteria for the tailings solids and the respective HQs are presented in the following table:

Table 5.3 Concentrations exceeding adopted screening criteria and calculated Hazard Quotients – Tailings Solids (mg/kg) – Livestock

Analyte	Guideline	Guideline Reference	Average Blend		High Dales	
			Conc.	HQ	Conc.	HQ
Tailings Solids (mg/kg)						
Arsenic	17	CCME SQG	17	<1	21.4	1.3

5.6.2.3 Human Health – screening criteria exceedances

Exceedances of the adopted human health screening criteria for the tailings solids and the respective HQs are presented in the following table:

Table 5.4 Concentrations exceeding adopted screening criteria and calculated Hazard Quotients – Tailings Solids (%) – Human Health

Analyte	Guideline	Guideline Reference	Average Blend		High Dales	
			Conc.	HQ	Conc.	HQ
Tailings Solids (%)						
Iron	22	US EPA Regional Screening Levels for Residential soil	48.4	2.2	48.6	2.2

5.6.2.4 Pond water quality model outputs

The estimated median and 90th percentile (P90) concentrations from the pond water quality modelling for operations (including sensitivity scenarios detailed in Section 3.3.5) are compared to the adopted screening criteria in the following tables included in Appendix B:

- Table B.7 – Ecological.
- Table B.8 – Livestock.
- Table B.9 – Human health (recreational).

For pH the screening criteria are a range, and therefore, minimum results may also be relevant for assessment. An initial acidic pulse is expected in the De Grey (Base Case), resulting from run off from exposed potentially acid forming (PAF) Mt McRae Shale and is predicted to be present for approximately the first few months (until the PAF material is covered by tailings). The pH is predicted to stabilise for mildly alkaline conditions during subsequent fills. No initial acidic pulse is expected from Swan.

Median and 90th percentile results (and predictions post the initial year of tailing deposition) for pH are within the adopted screening criteria.

Calculations for the below HQs are presented in Appendix C:

- Table C.1 – Ecological – Groundwater screening criteria.
- Table C.2 – Ecological – Surface water screening criteria.
- Table C.3 – Livestock.
- Table C.4 – Human Health.

A summary of HQs greater than 5 are presented in the below in-text tables. As noted in **Section 4.2** a HQ value greater than one indicates the exposure concentration for that chemical or stressor is greater than the screening level; however this screening assessment against a screening guideline allows for maximum exposure time in the reported concentration, i.e., it does not account for shorter exposure times than used when deriving the screening levels. In many of the scenarios, the exposure durations will be low and intermittent, in many cases expected to be <20% of the possible exposure duration and hence there would be a 20% lower exposure concentration.

Given the screening criteria are overly conservative in relation to risk of adverse effects, as well as assuming high exposure durations (e.g., exposure every day for a lifetime), this assessment has adopted a HQ of five (5) to be used as the trigger for further evaluation of the potential for risk to a specific receptor or receptors in the site-specific setting.

Table 5.5 De Grey Filling Periods: Ecological Hazard Quotients Greater than 5 with Regards to the Adopted Groundwater GDEs.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Filling periods				High Seepage - Filling periods				Climate Change - Filling periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
Al	Jimblebar Groundwater SSTV (Golder , 2015)	0.055	-	-	0.858	**16**	-	-	0.520	9	-	-	1.167	**21**
Ba	Jimblebar Groundwater SSTV (Golder , 2015)	0.01	0.15	**15**	0.28	**28**	0.15	**15**	0.24	**24**	0.15	**15**	0.25	**25**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.029	-	-	0.28	10	-	-	0.24	8	-	-	0.25	9
Co	Jimblebar Groundwater SSTV (Golder , 2015)	0.001	-	-	-	-	-	-	-	-	-	-	0.006	7
Cu	Jimblebar Groundwater (Golder , 2015)	0.0014	-	-	0.0079	6	-	-	-	-	-	-	0.009	7

Notes: [1]Not Formally adopted

Shading is applied to the HQ based on the following scale: HQ >5 - 10 = light blue; HQ >10 = dark blue

N/A – HQ not able to be calculated.

Table 5.6 De Grey Fallow Periods: Ecological Hazard Quotients Greater than 5 with Regards to the Adopted Groundwater GDEs.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods				High Seepage - Fallow periods				Climate Change - Fallow periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	Jimblebar Groundwater SSTV (Golder , 2015)	430	-	-	19,565	**45**	8,585	**20**	28,009	**65**	5,514	**13**	16,420	**38**
Al	Jimblebar Groundwater SSTV (Golder , 2015)	0.055	-	-	1.074	**19**	0.481	9	1.302	**24**	0.430	8	0.835	**15**
B	Jimblebar Groundwater SSTV (Golder , 2015)	0.37	-	-	2.85	8	-	-	3.6	10	-	-	2.40	6
Ba	Jimblebar Groundwater SSTV (Golder , 2015)	0.01	0.12	**11**	4.84	**484**	1.94	**194**	6.19	**619**	1.23	**123**	4.08	**408**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.029	-	-	4.84	**167**	1.94	**67**	6.19	**213**	1.23	**42**	4.08	**140**
Mo	Jimblebar Groundwater SSTV (Golder , 2015)	0.001	-	-	0.055	**55**	0.020	**20**	0.061	**61**	0.014	**14**	0.045	**45**
Zn	Jimblebar Groundwater SSTV (Golder , 2015)	0.024	-	-	0.518	**21**	0.262	10	0.717	**29**	0.151	7	0.424	**18**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.054	-	-	0.518	9	0.262	18	0.717	13	-	-	0.424	8

Notes: [1]Not Formally adopted

In addition, sulphate (SO4) exceeded the adopted trigger value of 88 mg/L, which was adopted based on the measured P90 value for SO4 in groundwater data from OB31. There is no formal screening level for sulphate. The HQ was greater than 5 for average and P90 values for all scenarios in De Grey Fallow Periods, with HQ >10 for P90, with a maximum of HQ=30 in the High Seepage scenario. These exceedances were not considered a significant risk and were not included in Table 5.6.

Table 5.7 Swan Filling Periods: Ecological Hazard Quotients Greater than 5 with Regards to the Adopted Groundwater GDEs.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Filling periods				High Seepage - Filling periods				Climate Change - Filling periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
Ba	Jimblebar Groundwater SSTV (Golder , 2015)	0.01	0.22	**22**	0.32	**32**	0.21	**21**	0.31	**31**	0.21	**21**	0.31	**31**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.029	0.22	7	0.32	**11**	0.21	7	0.31	**11**	0.21	7	0.31	**11**

Table 5.8 Swan Fallow Periods: Ecological Hazard Quotients Greater than 5 with Regards to the Adopted Groundwater GDEs.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods				High Seepage - Fallow periods				Climate Change - Fallow periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	Jimblebar Groundwater SSTV (Golder , 2015)	430	3704	9	9683	**23**	4551	**11**	10768	**25**	3521	8	9831	**23**
Ba	Jimblebar Groundwater SSTV (Golder , 2015)	0.01	0.80	**80**	2.10	**210**	0.99	**100**	2.38	**238**	0.76	**76**	2.13	**213**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.029	0.80	28	2.10	72	0.99	34	2.38	82	0.76	26	2.13	73
Mo	Jimblebar Groundwater SSTV (Golder , 2015)	0.001	0.007	7	0.016	**16**	0.008	8	0.019	**19**	0.006	6	0.017	**16**
Zn	Jimblebar Groundwater SSTV (Golder , 2015)	0.024	0.141	6	0.322	**13**	0.170	7	0.380	**16**	0.134	6	0.310	**13**
	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)[1]	0.054	-	-	0.322	6	-	-	0.380	7	-	-	0.310	6

Note: Sulphate (SO4) exceeded the adopted trigger value of 88 mg/L (based on the measured P90 value for SO4 in groundwater data from OB31, as there is no formal screening level for sulphate). The HQ was greater than 5 for P90 values only, for all scenarios in Swan Fallow Periods, with HQ = 10-11 (maximum in the High Seepage scenario). These exceedances were not considered a significant risk and were not included in Table 5.8.

Table 5.9 De Grey Filling Periods: Ecological Hazard Quotients Results Greater than 5 with Regards to the Adopted Surface Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Filling periods				High Seepage - Filling periods				Climate Change - Filling periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	60	1011	**17**	1802	**30**	1012	**17**	1798	**30**	1006	**17**	1584	**26**
Al	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	0.055	-	-	0.858	**16**	-	-	0.520	9	-	-	1.168	**21**
Cu	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	0.0014	-	-	0.008	6	-	-	-	-	-	-	0.009	7
Zn	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	0.008	-	-	0.060	7	-	-	0.060	8	-	-	0.063	8

Table 5.10 De Grey Fallow Periods: Ecological Hazard Quotients Results Greater than 5 with Regards to the Adopted Surface Water Guidelines.

Analyte	**Guideline Reference**	**Guideline (mg/L)**	**Base Case - Fallow periods**				**High Seepage - Fallow periods**				**Climate Change - Fallow periods**			
			Average	**HQ**	**90th Percentile**	**HQ**	**Average**	**HQ**	**90th Percentile**	**HQ**	**Average**	**HQ**	**90th Percentile**	**HQ**
TDS	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	60	763	**13**	19565	**326**	8585	**143**	28009	**467**	5514	**92**	16420	**274**
Al	95% species protection - freshwater ecosystems (ANZG, 2018)	0.055	-	-	1.074	**19**	0.481	8	1.302	**24**	0.430	8	0.835	**15**
Total Nitrogen	(ARMCANZ and ANZECC, 2000) Default trigger values for Wetlands	1.15	-	-	-	-	-	-	6.33	5	-	-	-	-
Tl	95% species protection - freshwater ecosystems (ANZG, 2018)	0.00003	-	-	0.00017	6	-	-	0.00020	7	-	-	0.00015	5
U	95% species protection - freshwater ecosystems (ANZG, 2018)	0.0005	-	-	0.0067	**13**	0.0025	5	0.0071	**14**	-	-	0.0054	**11**
Zn	95% species protection - freshwater ecosystems (ANZG, 2018)	0.008	-	-	0.52	**65**	0.26	**33**	0.72	**90**	0.16	**20**	0.42	**53**

Table 5.11 Swan Filling Periods: Ecological Hazard Quotients Results Greater than 5 with Regards to the Adopted Surface Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Filling periods				High Seepage - Filling periods				Climate Change - Filling periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	95% species protection - freshwater ecosystems (ANZG, 2018)	60	1209	**20**	1588	**26**	1228	**20**	1698	**28**	1172	**20**	1568	**26**
Zn	95% species protection - freshwater ecosystems (ANZG, 2018)	0.008	-	-	0.054	7	-	-	0.057	7	-	-	0.05	6

Table 5.12 Swan Fallow Periods: Ecological Hazard Quotients Results Greater than 5 with Regards to the Adopted Surface Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods				High Seepage - Fallow periods				Climate Change - Fallow periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	95% species protection - freshwater ecosystems (ANZG, 2018)	60	4,419	**74**	11,330	**189**	4,461	**74**	10,800	**180**	3704	**62**	9,692	**162**
Zn	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)	0.008	0.141	**17**	0.322	**40**	0.170	**21**	0.380	**47**	0.134	**17**	0.310	**39**

Table 5.13 De Grey: Livestock Hazard Quotients Greater than 5 with Regards to the Adopted Livestock Drinking Water Trigger Values.

Analyte	Guideline Reference	Guideline (mg/L)	Filling periods - Base Case		Filling periods - High Seepage		Filling periods - Climate Change		Fallow periods - Base Case		Fallow periods - High Seepage				Fallow periods - Climate Change			
			90th %ile	HQ	90th %ile	HQ	90th %ile	HQ	90th %ile	HQ	Average	HQ	90th %ile	HQ	Average	HQ	90th %ile	HQ
TDS	ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)	4,000	-	-	-	-	-	-	-	-	-	-	28,009	7	-	-	-	-
F	ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)	2	-	-	11	5	-	-	11	5	-	-	11	5	-	-	15	8

Table 5.14 Swan: Livestock Hazard Quotients Greater than 5 with Regards to the Adopted Livestock Drinking Water Trigger Values.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods		High Seepage – Fallow periods	Climate Change - Fallow periods		
			90th Percentile	HQ	90th Percentile	HQ	90th Percentile	HQ
F	ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)	2	13	7	13	7	13	7

Table 5.15 De Grey- Filling Periods: Human Health Hazard Quotients Greater than 5 with Regards to the Drinking Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Filling periods		High Seepage – Filling periods		Climate Change - Filling periods	
			90th Percentile	HQ	90th Percentile	HQ	90th Percentile	HQ
Al	ADWG Aesthetics (2011, updated 2022)	0.2	-	-	-	-	1.167	6
F	ADWG Health (2011, updated 2022)	1.5	10.6	7	10.6	7	10.5	7

Table 5.16 De Grey- Fallow Periods: Human Health Hazard Quotients Greater than 5 with Regards to the Drinking Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods		High Seepage – Fallow periods				Climate Change - Fallow periods			
			90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	ADWG Health (2011, updated 2022)	600	19,565	**33**	8,392	**14**	28,002	**47**	5,515	9	16,415	**27**
Na	ADWG Health (2011, updated 2022)	180	6,188	**34**	2,532	**14**	8,561	**48**	1,609	9	5,192	**29**
Cl	ADWG Aesthetics (2011, updated 2022)	250	9,600	**38**	3,936	**16**	13,323	**53**	2,499	10	8,049	**32**
SO4	ADWG Aesthetics (2011, updated 2022)	250	1,919	8	-	-	2709	**11**	-	-	1618	6
Al	ADWG Aesthetics (2011, updated 2022)	-	1.07	5	-	-	1.3	6	-	-	-	-
F	ADWG Health (2011, updated 2022)	1.5	15.4	10	13.4	9	17.1	11	12.1	8	14.6	10
Mn	ADWG Aesthetics (2011, updated 2022)	0.1	0.5	6	-	-	0.7	7	-	-	-	-
Se	ADWG Health (2011, updated 2022)	0.01	-	-	-	-	0.05	5	-	-	-	-

Table 5.17 Swan- Filling Periods: Human Health Hazard Quotients Greater than 5 with Regards to the Drinking Water Guidelines.

Analyte		Guideline (mg/L)	Base Case - Filling periods		High Seepage – Filling periods	
	Guideline Reference		90th Percentile	HQ	90th Percentile	HQ
F	ADWG Health (2011, updated 2022)	1.5	8.0	5	9.9	7

Table 5.18 Swan- Fallow Periods: Human Health Hazard Quotients Greater than 5 with Regards to the Drinking Water Guidelines.

Analyte	Guideline Reference	Guideline (mg/L)	Base Case - Fallow periods				High Seepage – Fallow periods				Climate Change - Fallow periods			
			Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ	Average	HQ	90th Percentile	HQ
TDS	ADWG Health (2011, updated 2022)	600	3704	6	9683	**16**	4551	8	10768	**18**	3521	6	9831	**16**
Na	ADWG Health (2011, updated 2022)	180	1063	6	2958	**16**	1333	7	3306	**18**	1005	6	3005	**17**
Cl	ADWG Aesthetics (2011, updated 2022)	250	1653	7	4606	**18**	2074	8	5145	**21**	1562	6	4680	**19**
F	ADWG Health (2011, updated 2022)	1.5	8.05	5	13.14	9	8.36	5	13.46	9	7.95	5	13.11	9

Screening the Swan and De Grey IPTSF water quality is a conservative assessment of PSOI for several of the release scenarios where attenuation along the flow path is expected (except for the exposure pathways of a leak in pipelines used for tailings placement, dewatering, or decanting or direct contact of receptors with pond water).

Note that screening the groundwater concentrations against the BHP SSTVs for groundwater (from Hydro Geochem 2023) indicates a lower HQ and hence lower risk, compared with the Golder 2015 SSTVs. The BHP SSTVs are based on more recent background groundwater monitoring data showing higher background levels of some analytes, assumed to be naturally occurring; these SSTVs have not yet been formally approved for use.

Modelling to estimate concentrations in downgradient groundwater receiving environments is discussed in Section 5.6.3 assumptions made.

5.6.3 Downstream Seepage Water Quality Assessment

A downstream seepage water quality assessment was conducted to predict, at a high level, the composition of seepage-impacted dewatering water abstracted from OB31 (WSP, 2024h). The water quality modelling concept is tailored based on the regional flow and dilution assessment, which estimated the proportion of seepage from the De Grey and Swan IPTSFs that would reach the OB31 dewatering borefield (i.e. the dilution estimate).

For the downstream water quality assessment, the following were considered:

- 'At-source' seepage compositions for De Grey and Swan pits were developed, mixing the 'pond water' and 'entrained tailings water' in the proportion they outflow each pit. This proportion was determined by the combination of water balance and groundwater models outputs:
  - Overall seepage rates at the De Grey and Swan IPTSFs were estimated using three-dimensional (3D) FEFLOW models ((WSP, 2024f) Aconex: 7731-A-85248-VD-00042).
  - Decant pond seepage was estimated using the water balance model (WBM) generated in GoldSim Version 14 (WSP, 2024b) (Aconex: 7731-A-85248-VD-00018).
  - Retained water within the underlying tailing material that gradually seeps out of the De Grey and Swan pits were obtained subtracting the decant pond seepage from the overall seepage rates (on a monthly basis)
- 'At-source' seepage and natural groundwater are then mixed in the proportion indicated by the dilution assessment (i.e., dilution factors). This approach assumes that the entire seepage volume and solutes concentrations reach OB31 without any changes. Processes like dispersion, diffusion, or attenuation within the aquifer are not accounted for.
- The source terms representing inflow water quality at OB31 were defined as follows:
  - Natural groundwater reaching OB31 is represented by average quality monitoring data from bores screened around the pit.
  - Seepage outflow from the De Grey and Swan decant ponds is represented by the results of the water quality model, considering the mixed control scenario for the base case, high seepage, and climate change scenarios (WSP, 2024e) (Aconex: 7731-A-85248-VD-00019).
  - Entrained (saturated) water was derived from tailings composite samples selected by BHP ('High P2,' 'Plant Blend,' and 'High Joffre'), based on geochemical testwork, and aligned with the tailings deposition plan (WSP, 2024c) (Aconex: 7731-A-85248-VD-00004).

It is important to mention, that despite the use of the term 'dilution,' this concept may be misleading, as natural groundwater already contains a base case chemical load. Therefore, the 'dilution factors' should be interpreted as mixing coefficients. Note that no proper transport modelling was conducted in this assessment.

In line with the pond water quality modelling, three sensitivity scenarios were modelled including the base case, highest seepage and climate change scenarios. Downstream water quality modelling data is presented in Table B.10 in Appendix B.

Overall results show that two PSOIs exceeded one or more of the adopted screening levels - Barium and Total Dissolved Solids (TDS). Barium exceeded both the Jimblebar Groundwater SSTVs (Golder , 2015) and BHP Shovelanna SSTVs (Hydro Geochem Group, 2023) (not formally adopted). Natural groundwater has been found to have elevated dissolved Ba concentrations present (WSP, 2024f) and as such these exceedances are likely be more representative of the natural conditions and do not indicate significant additional risk.

Total dissolved solids (TDS) are modelled below both SSTVs for all scenarios and indicate no additional risk to ecological receptors.

In terms of human health, no health effects are directly attributable to TDS and the Australian Drinking Water Guidelines are based on aesthetics and palatability; the TDS exceedances in each modelled scenario are generally in the range of 'fair' drinking water quality in relation to the guidelines.

In addition, alkalinity was slightly above the ADWG level (maximum of 211 mg/L CaCO3, compared with ADWG of 200 mg/L); this is not related to health effects[13] and the exceedance is not considered significant (being <1% of the guideline value).

Hazard quotients (HQ) were calculated for each PSOI and are detailed in Table C.5 in Appendix C. One HQ > 5 was calculated for Barium based on the Non-Climate Change Scenario (NCCS) highest seepage, during later stages (i.e. sustained seepage period). As described above, this is considered to be a product of naturally elevated dissolved Barium within groundwater.

5.6.4 Summary of Operations PSOI

Based on the screening process, the analytes presented in Table 5.19 have been identified as PSOI associated with operation of the Swan and De Grey IPTSF (i.e., the P90 concentration exceeded at least one of the adopted screening levels).

The PSOIs have been identified through screening of available analytical data or modelled/predicted concentrations against generic screening criteria for several receptor scenarios. The next section of the report outlines the transport and exposure pathways by which contamination could potentially reach humans and/or ecological receptors. The risk assessment then describes the likelihood of contamination reaching humans and/or ecological receptors.

---

13 Total hardness above 200 mg/L may lead to excessive scaling of pipes and fittings, and cause blockage of safety relief valves in hot water systems. Soft water may lead to greater corrosion of pipes, depending on other factors such as pH and dissolved oxygen content. Total hardness in major Australian reticulated supplies ranges between ~5 mg/L - 380 mg/L.

Table 5.19 Summary of PSOIs identified for different receptor scenarios during Operations

Data available	Receptor Scenarios	PSOIs Identified
Tailings solids analytical results	Native terrestrial flora and fauna	— Potential for direct toxicity effects to native flora and fauna from antimony, arsenic, copper, manganese, and zinc.
	Recreational users[3]	— Potential for direct toxicity effects to recreational users from iron.
	Livestock (cattle) [3]	— Potential for direct toxicity effects to livestock from arsenic (minor exceedance).
Tailings supernatant analytical results	Groundwater dependent ecosystems, including subterranean fauna	— Potential for direct toxicity effects to groundwater ecosystems from barium and copper.
	Aquatic ecosystems[1]	— Potential for direct toxicity effects to surface water ecosystems from copper and zinc.
	Recreational users[3]	— Concentrations below the adopted screening criteria.
	Livestock (cattle) [3]	— Concentrations below the adopted screening criteria.
Pond water quality predictions	Groundwater dependent ecosystems including subterranean fauna	De Grey — Potential for direct toxicity effects to groundwater ecosystems from TDS, aluminium, antimony, arsenic, boron, barium, molybdenum, lead, selenium, and zinc. It is noted that water quality modelling during fallow periods show the majority of exceedances. — Potential for direct toxicity effects from nutrients (nitrate) and indirect effects from increased nutrient inputs (i.e., nitrogen) such as oxygen depletion. Swan — Potential for direct toxicity effects to groundwater ecosystems from TDS, arsenic, boron, barium, molybdenum and zinc. It is noted that water quality modelling during fallow periods show the majority of exceedances. — Potential for direct toxicity effects from nutrients (nitrate) and indirect effects from increased nutrient inputs (i.e., nitrogen) such as oxygen depletion
	Aquatic ecosystems[1] and native terrestrial flora and fauna[2]	De Grey — Potential for direct toxicity effects to surface water ecosystems from TDS, Aluminium, Arsenic, Boron, Selenium Thallium, Uranium and Zinc. It is noted that water quality modelling during fallow periods show the majority of exceedances. — Potential for direct toxicity effects from nutrients (total nitrogen and nitrate) and indirect effects from increased nutrient inputs (i.e., nitrogen) to watercourses such as harmful algal blooms (HAB) Swan — Potential for direct toxicity effects to surface water ecosystems from TDS, Arsenic and Zinc.
	Livestock (cattle)[3]	De Grey — Potential for direct toxicity effects to livestock from TDS and Fluoride. Swan — Potential for direct toxicity effects to livestock from Fluoride.

Data available	Receptor Scenarios	PSOIs Identified
	Recreational users[3]	De Grey — Potential for direct toxicity from fluoride and nickel. — Potential for aesthetic taste or discolouration (chloride, iron, manganese, sodium, sulphate and TDS). Swan — Potential for direct toxicity from antimony, arsenic, fluoride, lead, nickel and selenium. — Potential for aesthetic taste or discolouration (chloride, iron, manganese, sodium, sulphate and TDS).
	Drinking water[3]	De Grey — Potential for direct toxicity from Sodium, Arsenic, Fluoride, Manganese and Selenium. It is noted that water quality modelling during fallow periods show the majority of exceedances. — Potential for aesthetic taste or discolouration (chloride, sulphate and TDS), scaling problems (alkalinity). Swan — Potential for direct toxicity from, Arsenic, Sodium and TDS. Its noted that only Fluoride shows direct toxicity effects during filling periods. — Potential for aesthetic taste or discolouration (chloride and Sulphate)
Downstream and dilution predictions at OB31 dewatering	Groundwater dependent ecosystems including subterranean fauna Aquatic ecosystems[1] Native terrestrial flora and fauna[2]	— Downstream water quality modelling results suggest that concentrations of PSOIs in groundwater are *likely* to attenuate resulting in reduced concentrations. Barium and TDS exceed the adopted ecological screening criteria at the OB31 dewatering system

Notes:

1) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
2) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.
3) No direct exposure pathway between receptors and the pond water, but this data is considered in the context of a potential failure of the tailings delivery pipeline or decant water pipeline (refer Table 5.1).

5.7 Operations – Likelihood & Risk Assessment

An assessment of risk for the complete SPR linkages associated with the operational phase of the Swan and De Grey IPTSF (Figure 5.1) are presented in Appendix F. The SPR linkages identified along with proposed mitigation strategies and controls, are based on the sources described in Section 5.2, the pathways described in Section 5.3, and the receptors considered in Section 5.4. The risk ratings, assigned to each SPR linkage are based on the DWER guidelines (DWER, 2020) presented in Section 4. Appendix F provides the rationale for these ratings considering mitigation and controls that may be put in place, as well as making recommendations for additional work that may be required.

Table 5.20 Summary Operational Phase Risk Ratings for Jimblebar In-pit Tailings Storage Facilities

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Consequence**	**Likelihood**	**Risk Rating**
Deposition of tailings slurry in Swan / De Grey IPTSF **Dry waste fines** (Air quality)	Fugitive dust generated from TSF landform	Native terrestrial flora	Reduction in photosynthesis, respiration, and transpiration due to dust deposition	Slight	Possible	Low
		Nearby residents, traditional owners, and/or farmers. Recreational users of Ophthalmia Dam (limited exposure)[1]	Acute and chronic adverse health effects and amenity.	Minor	Rare	Low
Failure of delivery pipeline carrying tailings slurry to Swan, De Grey IPTSF (Soil, groundwater, and surface water)	Direct discharge of tailings slurry to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline including riparian vegetation communities	Reduced soil and/or groundwater quality resulting in localised, short-term decline in floristic health	Slight	Unlikely	Low
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems	Minor	Rare	Low
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	Transport Pathway	Receptors	Potential Impacts	Consequence	Likelihood	Risk Rating
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and downgradient receiving waters	Slight	Rare	Low
Decanting supernatant water from tailings in Swan, De Grey IPTSF Failure of decant water pipeline carrying supernatant water to process water pond(Soil, groundwater, and surface water)	Direct discharge of supernatant water to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	Soil and/or groundwater contamination resulting in localised, short-term decline in floristic health	Slight	Possible	Low
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems	Minor	Rare	Low
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Minor	Rare	Low
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and associated creeks	Minor	Rare	Low
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source	Minor	Rare	Low

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Consequence**	**Likelihood**	**Risk Rating**
Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater and surface water)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Degradation of groundwater near Swan / De Grey IPTSF	Minor	Unlikely	Medium
	Expression of groundwater contaminated with IPTSF waters to surface water and subsequent surface water migration downstream along natural waterways/ watercourses Expression of groundwater contaminated with IPTSF waters to OB31 dewatering system	Native terrestrial flora including riparian vegetation communities	Localised, short-term decline in floristic health due to raised water tables, uptake of contaminated shallow groundwater or surface water, and/or increased salts in surface soils due to evapo-concentration	Minor	Rare	Low
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and quantity and associated effects to aquatic ecosystems and the hydro cycle	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek other nearby watercourses and waterbodies	Slight	Rare	Low
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
Deposition of tailings slurry Swan / De Grey IPTSF Pit overtopping (Soil, groundwater, and surface water)	Flow of supernatant water over the pit rim[4]	Native terrestrial flora including riparian vegetation communities	Potential soil erosion and physical damage to vegetation from overland flow and/or floodingSoil and/or groundwater contamination resulting in decline in floristic health	Minor	Rare	Low
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems	Minor	Rare	Low
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	Transport Pathway	Receptors	Potential Impacts	Consequence	Likelihood	Risk Rating
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
		Recreational users	Adverse impacts to human health from recreational use of Ophthalmia Dam, or other nearby watercourses	Minor	Rare	Low
Deposition of tailings slurry in Swan and De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan and De Grey IPTSF containment)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water	Native terrestrial fauna[3]	Acute or chronic effects on health Entrapment in soft fines	Minor	Possible	Medium
Deposition of tailings slurry in Swan and De Grey IPTSF Collapse of pit wall (Soil/rock)	Overland flow of debris and subsequent displacement of tailings and subsequent overland flow to downgradient receiving environments following pit wall collapse	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems Destruction of habitat	Minor	Rare	Low
		Native terrestrial flora and fauna[3]	Smothering and/or entrapment of receptors Destruction of habitat	Minor	Rare	Low

Notes:

1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Pampajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.
4) Pit overtopping may occur as a result of an extreme storm event, collapse of pit wall (if a supernatant pond is present in the TSF), or human failure.

AEP = annual exceedance probability; DMIRS = Department of Mines, Industry Regulation and Safety; ANCOLD = Australian National Committee on Large Dams.

6 Closure Conceptual Exposure Model

6.1 Overview

The DPS is intended to refine the assessments completed in the SPS to support various environmental and economic aspects. In addition, the DPS scope involves the selection and design of the closure Preferred Investment Alternative (PIA) with a set of design elements. Within the DPS scope, WSP prepared and issued the DPS — IPTSF Closure Strategy (WSP, 2024j) report that consolidates the assessment, selection, and design of the PIA. The process encompassed the development of closure concepts with sufficient engineering detail supporting the risk-based Multicriteria Assessment (MCA). The closure strategies assessed for validation of the PIA during the DPS phase were as follows:

- Option 1 Optimised Without (OWO) – No closure activities implemented other than monitoring of the IPTSF as left follow the completion of operations.
- Option 2 Partial Backfill – Tailings surface covered follow the completion of operations resulting in only Partial Backfill of the IPTSF (not water shedding).
- Option 3 Full Backfill - Refinement and updates required for the strategy defined as part of the SPS phase.

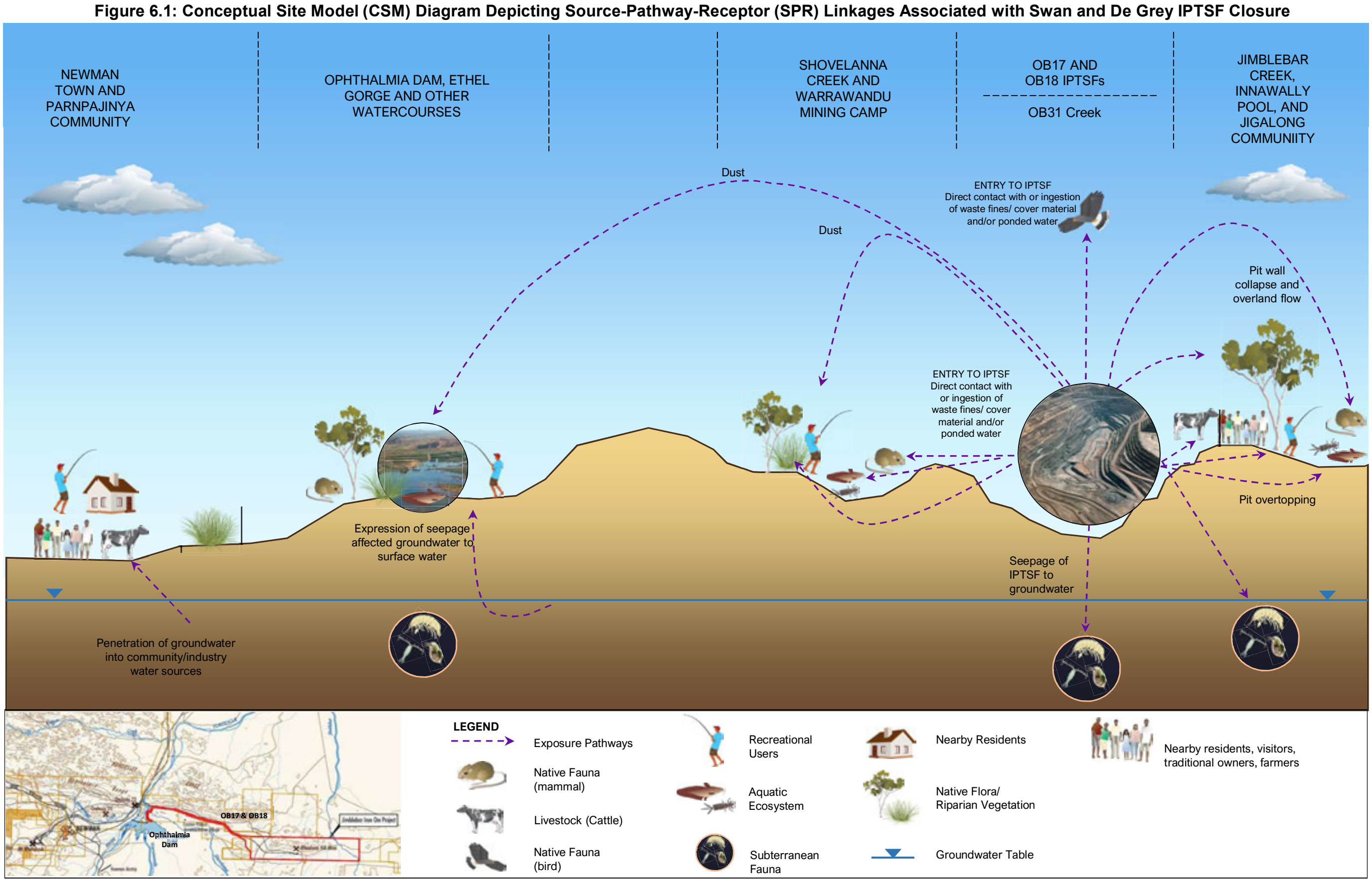
Option 2 Partial Backfill was identified as the PIA for the IPTSF Closure Strategy via the MCA process. As such, the Partial Backfill closure option and associated information has been used to undertake this Closure CEM. The Partial Backfill closure characteristics is summarised in Section 6.1.1.

A CSM diagram has been generated to visually represent the potential SPR linkages associated with closure of the Swan and De Grey IPTSFs (Figure 6.1). The Closure CEM has drawn on the Operations CEM, while considering key differences in the environmental setting and characteristics of the IPTSFs at closure compared to operations.

While the final land use at closure has not been confirmed, based on current information and for the purpose of the CEM, it is considered to be native ecosystems and potentially some limited grazing. Note that the stability of any pit voids and post-closure rehabilitation measures such as revegetation over tailings would need to be considered and assessed to ascertain suitability for grazing.

The sources (Section 6.1.2), pathways (Section 6.3), and receptors (Section 6.4) are described in the following subsections. This is followed by Table 6.2 which presents the SPR linkages associated with closure phase of the IPTSF. Table 6.2 also includes the risk ratings assigned to each SPR linkage, including the rationale for these ratings considering mitigation and controls that may be put in place, as well as making recommendations for additional work that may be required.

Figure 6.1: Conceptual Site Model (CSM) Diagram Depicting Source-Pathway-Receptor (SPR) Linkages Associated with Swan and De Grey IPTSF Closure



6.1.1 Closure Option - Partial Backfill

Partial Backfill closure considers that the tailings surface would be covered after the end of operations resulting in only partial backfill of the IPTSF (not complete backfill and not water shedding). In addition, a cover would be placed over exposed PAF material in the pit walls. Final cover will result in a backfilled surface at a minimum level of 5 m above the post-mining recovered water table, as currently committed in the Mine Closure Plan. This includes:

- Consolidation rate <1m/yr for the tallest tailing column will be reached in 2086 for De Grey and 2072 for Swan.
- A minimum of 5m thick at the perimeter, falling to the centre of the pit at a 12% uniform gradient. This will result in a maximum cover thickness of 26m in De Grey and 20m in Swan.
- A cover constructed of material sourced from within a 5 – 10 km haul, potentially within 2 km from the East OSA, will be placed across the tailings surface (assumes benign backfill).
- Adjacent catchments as per landforms at the end of operations.
- In-pit ponding conditions could be very oscillating post-consolidation, with intermittent shallow ponding potentially occurring after rainfall events.

6.1.2 Hydrogeology

The pre-mining conceptualisation (BHP, 2022) of the hydrogeological setting between Ethel Gorge and OB31 is described in Section 5.

The current groundwater scenario has dewatering operations at OB31 maintaining groundwater levels at Swan Pit below the pit floor and drawing groundwater at the Swan Pit to the east. This situation is likely to continue until some time after dewatering at OB31 ceases, currently scheduled for 2055. The De Grey Pit, however, is not hydraulically connected to OB31 and is not currently responding to dewatering at OB31; if any future seepage does leave De Grey and flow into the regional aquifer system, it too is expected to flow towards OB31 during this time.

At the Swan Pit, the rate of groundwater recovery following dewatering cessation is uncertain and will rely on post-IPTSF-closure water management in the groundwater catchment as well as short and long term rainfall events and recharge conditions. The time taken to reach equilibrium will be measured in hundreds of years. At this stage, the closure strategy for OB31 is unknown and whether the pit is left to form a pit lake (i.e., a regional groundwater sink) or partially or fully backfilled, will affect the rate and magnitude of groundwater level recovery at OB31.

At this stage it is assumed that groundwater level at the Swan Pit following cessation of dewatering at OB31 will return to the pre-mining level of approximately 500 m AHD, and predominantly westerly groundwater flow directions will re-establish (Figure 6.1). No known Groundwater Dependant Ecosystems (GDE's) are located along the westerly pre-mining flow path from Swan and De Grey Pits. The groundwater flow path will swing to the north at Ethel Gorge and likely bypass the Ethel Gorge TEC due to higher groundwater levels in the TEC. Available information indicates that there is little potential for seepage water from Swan or OB31 to enter Ethel Gorge TEC (BHP, 2022).

6.2 Potential Contamination Sources and Stressors

There will be different stages during closure – including consolidation, landform management/reinstatement such as capping and vegetation, post-consolidation and on-going management – which will all have some differences in the environmental fate and transport activities and hence contamination sources. There will be different hazards during the different closure timeframes, for example, supernatant water may be a source hazard during consolidation, but not during long-term closure, i.e., after final landform has been developed.

However the exact nature and duration of these stages and associated environmental fate & transport is unknown, based on available data, so they have not been differentiated in the risk assessment at this stage.

Based on the available environmental data, the main sources of potential contamination associated with closure of the Swan and De Grey IPTSF are:

- Waste fines/tailings (more likely to be generated during dry periods and if no vegetation established).
- In-pit ponded water, comprising runoff from pit wall materials, and basal seepage from waste rock dump into IPTSF (extent will depend on consolidation process and backfilling processes and timing).

The contaminants associated with the above identified sources are dependent on the chemistry of the:

- Residual feed water quality (the input/source water used to process the iron ore).
- Composition of the ore.
- Residual process chemicals (e.g., flocculants).
- Contribution from blast residues (i.e., nitrogen compounds).

The following data is available for assessment of potential PSOI for the closure of the Swan and De Grey IPTSF:

- Analytical data for the tailings solids.
- Interpretation of the operations quality model outputs for the ponded water. (High-level water quality model outputs for the ponded water in-pit for Swan and De Grey IPTSF was considered in the SPS CEM however data is not considered relevant for the current closure strategy)

6.3 Potential Contaminant Pathways

The following transport pathways have the potential to expose receptors to risk from PSOI associated with the closure phase of the Swan and De Grey IPTSF:

- Airborne dust, primarily during consolidation period when dry, without vegetation or other capping.
- Seepage of IPTSF waters through base and/or pit walls to groundwater.
- Spillage from failure of decant water pipelines – Contaminant transport due to failure of a decant water pipeline has been retained in the Closure CEM. The decant system will likely be decommissioned post-operations, because the risk of overtopping is reduced at closure and therefore it is unlikely that the pond will need to be maintained (i.e., regularly decanted/pumped down) to keep it within a defined operating range. Mitigation for reducing runoff volumes from reporting to the pond (thereby keeping the pond volumes as low as reasonably practicable) includes constructing upstream diversions to direct runoff elsewhere downstream. However, noting the above, there is still the potential that at some stage during closure there will be a need to decant water from ponds within the pits and therefore, this exposure pathway has been retained in the Closure CEM. Decanting at closure will be at a significantly reduced rate to that of operations.
- Pit overtopping and/or Collapse of pit wall. (Both events could lead to similar outcomes, i.e. tailings release.)

As tailings deposition will have ceased at closure, spillage from the failure of delivery pipeline is no longer relevant, therefore this contaminant transport pathway has been removed from the Closure CEM.

In addition, migration of in-pit water from groundwater to surface water has been removed, based on advice from the IPTSF Closure Strategy (WSP, 2024j) that any water that accumulates in the pit will remain in the pit and/or be managed so that there is minimal likelihood of expression to surface water or other media outside the pit (e.g., soil or sediment). Therefore there is minimal likelihood of direct contact or ingestion of PSOI from seepage or surface water by aquatic or terrestrial flora and fauna or livestock or native fauna, including incidental ingestion by recreational users of natural watercourses or waterbodies.

Potential receptors may become exposed to PSOI associated with the closure phase of the IPTSFs via the following exposure pathways:

- Inhalation of dust by humans.
- Direct contact /uptake of PSOI by terrestrial or aquatic flora and fauna[14] from waste fines and/or supernatant water within Swan or De Grey pits: – While exclusion bunding is expected to discourage access of humans, livestock and wildlife to the pits, the effectiveness of exclusion bunding is unknown. In addition, at closure there will no longer be active machinery onsite to deter wildlife access. There may be intermittent water collection within the pits, with some potential for ephemeral aquatic habitats to establish; however, permanent ponding is unlikely. Any ecosystems that may establish are considered to be highly modified and likely not representative of local native surface waters, and any contact with pond water by humans or other terrestrial fauna is unlikely to be significant.
- Direct contact with surface water impacted by tailings release through overtopping or pit wall collapse, in the event of emergency. The potential of this scenario occurring is likely to decrease significantly as consolidation progresses.

6.4 Potential Receptors

Based on site knowledge, a review of surrounding land uses (Section 2.2), readily available information and the identified closure option, the potential receptors at Closure are essentially the same as during Operations, except that most will be at a lower likelihood of exposure provided the proposed management measure are in place, as included in the IPTSF Closure Strategy (WSP 2024c).

The following were identified as potential receptors of interest (ROI) that may be exposed (either directly or indirectly as indicated in Table 6.1) by PSOI identified as associated with the IPTSF (Swan and De Grey) at Closure:

- Ecological Receptors:
  - Surface water aquatic ecosystems (Innawally Pool, OB31 Creek, Jimblebar Creek[15], Shovelanna Creek and Ophthalmia Dam), including aquatic fauna and riparian vegetation.
  - Groundwater Dependent Ecosystems (GDE) as listed in the Australian Government Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas (Appendix B of the SPS CEM):
    - Ethel Gorge aquifer stygobiont Threatened Ecological Community (TEC).
    - Subterranean fauna.
  - Native and terrestrial flora and fauna, including Commonwealth and State listed species of conservation significance (described in Appendix B of the SPS CEM for the full detailed Environment Protection and Biodiversity Conservation [EPBC] Act Protected Matters Reports and NatureMap Species Reports).
  - Livestock (cattle)[16].
- Human Receptors:
  - Recreational users (e.g., campers) and Traditional owners[17] visiting the IPTSFs landforms at Closure.
  - Recreational users of nearby watercourses and waterbodies for wading, swimming, and fishing.

---

14 Native terrestrial fauna includes migratory birds.

15 The Jimblebar Creek regional surface water catchment is depicted in Figure 1 of the (BHP, 2018) Surface Water Management Plan Jimblebar report.

16 A potential future use of the IPTSFs at closure is pastoral land, including cattle grazing.

17 The IPTSF project area itself has no registered aboriginal heritage sites. Therefore, exposure of Traditional Owners to the IPTSFs at Closure is considered to represented by recreational exposure.

- Newman Water Reserve[18] public drinking water source protection zones (Priority Areas 1 and 3) and associated borefields.
- Nearby residents and visitors to the town of Newman.
- Aboriginal residents and visitors of the Parnpajinya and Jigalong Communities.
- Traditional owners (Nyiyaparli people) and custodians (Martu people) of the land.
- Farmers associated with the Prairie Downs and Sylvania Stations.

Further information on the receptor identification process is provided in Appendix A.

It is acknowledged that drinking water (Newman town water supply) source water is treated by BHP and the Water Corporation to meet the Australian Drinking Water Guidelines (NHMRC and NRMMC , (2011, updated 2021).), as required by WA Health (BHP 2012). Therefore, there is likely an incomplete pathway for exposure of humans via drinking water that has indirectly been affected by water sourced from the OB31 dewatering system. However, for completeness, drinking water has still been considered as an exposure pathway in the CEM.

In addition, some of the other exposure pathways are unlikely to be realised to major extents but have been included for completeness.

6.5 Closure – Risk events (SPR linkages)

Table 6.1 presents the identified closure-related risk events as a summary of the exposure pathways that relate to each of the SPR linkages for closure.

[18] Swan and De Grey are located ~1 km outside of the boundaries of the Newman Water Reserve, the area encompassing the borefields responsible for Newman's public drinking water supply (DOW 2014). Source water from the Newman Water Reserve is extracted and/or treated by BHP and the Water Corporation, prior to potable use.

Table 6.1 Summary of Closure SPR linkages for IPTSF (Risk events)

Primary and Secondary Sources (Environmental Media)	Transport Pathway	Receptors	Exposure Pathways: Ingestion	Inhalation	Dermal Contact	Direct Contact / Uptake	Food Chain[4]
Post-Deposition activities in Swan / De Grey IPTSF Dry waste fines (Air quality)	Airborne fugitive dust generated from TSF landform, prior to complete vegetation and during any in-pit mechanical activities. (Expected to be mainly in consolidation phase.)	Native terrestrial flora	-	-	-	✓	-
		Recreational users, nearby residents[1], traditional owners, and/or farmers	-	✓	-	-	-
Post-Deposition in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
Post-Deposition in Swan / De Grey IPTSF	Flow of ponded and/or tailings over the pit rim, Contact with falling debris (soil/rock) following collapse of pit wall	Native terrestrial flora	-	-	-	✓	-
		Groundwater dependent ecosystems including subterranean fauna	✓	-	-	✓	-
		Aquatic ecosystems[2]	-	-	-	✓	✓

Primary and Secondary Sources (Environmental Media)	Transport Pathway	Receptors	Exposure Pathways				
			Ingestion	Inhalation	Dermal Contact	Direct Contact / Uptake	Food Chain[4]
Collapse of pit wall / Pit overtopping (Soil / rock, groundwater, and surface water)		Native terrestrial fauna[3]	✓	-	-	-	✓
Post-Deposition in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan / De Grey IPTSF containment)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water	Native terrestrial fauna[3]	✓	-	-	✓	-
		Aquatic ecosystem within in-pit ponds	-	-	-	✓	✓

Notes:

1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Parnpajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.

The 'food chain' exposure pathway refers to indirect dietary exposure to PSOI taken up in food items/prey consumed by fauna

6.6 Closure – Consequence analysis (Screening)

The following presents a summary of the screening assessment for closure related SPR linkages as per Section 4.

6.6.1 Tailings data

The tailings solids data is compared to the adopted screening criteria in Section 4.1.

6.6.2 Pond water quality predictions

The Partial Backfill closure option (Option 2) was the preferred selected option for closure, which resulted in an improved outcome with respect to Option 1 (OWO option). The compounded/weighted residual risk score during the MCA was almost in the zone of "well within the risk appetite". Only one risk scenario was assessed to be outside of appetite, i.e., direct exposure of fauna to ponded surface water (seepage management was not considered to be required for the closure landform). However, the following engineering controls were recommended to be applied to reduce the likelihood and/or duration of ponded surface water within the IPTSF:

- Development of a partial backfill geometry that increases surface evaporation (flat surface, large evaporation area, and shallow water ponding); and
- Surface water diversions to reduce runoff into the IPTSFs.

Assuming the recommended engineering controls are implemented, the access of fauna to permanent or temporary ponded surface water at closure will be minimized. Therefore, water quality for the Partial Backfill closure option is not considered in the CEM at this level of study. Future closure study phases should incorporate more detailed water quality assessments to the target study level and be supplementary to other studies (e.g., hydrology, hydrogeology, CEM, etc.).

6.6.3 Summary of Closure PSOI

In the absence of water quality modelling specific to the proposed closure strategy, the screening processes analytes presented in Section 5.2 have been identified as potential PSOI's associated with closure of the Swan and De Grey IPTSF.

It is acknowledged that the closure concentrations are expected to be as a result of secondary seepage of tailings water post-deposition and consolidation and therefore the PSOIs are predicted to be at reduced concentrations. As such, reduction of concentrations will remove analytes from being identified as a stressor. Water quality modelling considering the proposed closure design and conditions should be undertaken to confirm these assumptions.

6.6.4 Downstream Water Quality at Closure

Downstream water quality has been assessed in the context of the Operation Conceptual Exposure Model (Section 5.6.3). No downstream modelling has been undertaken within the context of the Closure strategy and further assessment is recommended. However, screening results for the operational downstream water quality indicated elevated concentrations of TDS and Barium are present. It can be assumed that conditions at closure are likely to be similar, however as noted further assessment is recommended.

6.7 Closure – Likelihood & Risk Assessment

An assessment of risk for the complete SPR linkages associated with the closure phase of the Swan and De Grey IPTSF (Figure 6.1) are presented in Table 6.2. The SPR linkages identified in Table 6.2 along with proposed mitigation strategies and controls, are based on the sources described in Section 6.1.2, the pathways described in Section 6.3, and the receptors considered in Section 6.4.

The risk ratings, assigned to each SPR linkage are based on the DWER (DWER, 2020) guidelines presented in Section 4. Appendix G also provides the rationale for these ratings considering mitigation and controls that may be put in place.

Table 6.2 Summary Closure Phase Risk Ratings for Jimblebar In-pit Tailings Storage Facilities

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	Transport Pathway	Receptors	Potential Impacts	Closure Strategy - Partial Backfill		
				Consequence	Likelihood	Risk Rating
Post-Deposition of tailings slurry in Swan / De Grey IPTSF Dry waste fines (Air quality)	Fugitive dust generated from TSF landform	Native terrestrial flora	Reduction in photosynthesis, respiration, and transpiration due to dust deposition	Slight	Rare	Low
		Recreational users, nearby residents[1], traditional owners, and/or farmers	Acute and chronic effects on human respiratory system and general health and amenity	Minor	Rare	Low
	Direct discharge of supernatant water to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	Soil and/or groundwater contamination resulting in localised, short-term decline in floristic health	Minor	Rare	Low
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems	Minor	Rare	Low
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and associated creeks	Slight	Rare	Low
Post Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater and surface water)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Degradation of groundwater near Swan / De Grey IPTSF	Minor	Unlikely	Medium
	Expression of groundwater contaminated with IPTSF waters to surface water and subsequent surface water migration downstream along natural waterways/ watercourses	Native terrestrial flora including riparian vegetation communities	Localised, short-term decline in floristic health due to raised water tables, uptake of contaminated shallow groundwater or surface water, and/or increased salts in surface soils due to evapo-concentration	Minor	Rare	Low
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and quantity and associated effects to aquatic ecosystems and the hydro cycle	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low

Risk Event				Risk Assessment		
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	Transport Pathway	Receptors	Potential Impacts	Closure Strategy - Partial Backfill		
				Consequence	Likelihood	Risk Rating
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek other nearby watercourses and waterbodies	Slight	Rare	Low
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
Post Deposition of tailings slurry Swan / De Grey IPTSF Pit overtopping (Soil, groundwater, and surface water)	Flow of supernatant water over the pit rim[4]	Native terrestrial flora including riparian vegetation communities	Potential soil erosion and physical damage to vegetation from overland flow and/or floodingSoil and/or groundwater contamination resulting in decline in floristic health	Minor	Rare	Low
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems	Minor	Rare	Low
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source	Minor	Rare	Low
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source	Slight	Rare	Low
		Recreational users	Adverse impacts to human health from recreational use of Ophthalmia Dam, or other nearby watercourses	Slight	Rare	Low
Post Deposition of tailings slurry in Swan and De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan and De Grey IPTSF)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or intermittent pond water	Native terrestrial fauna[3]	Acute or chronic effects on health Entrapment in soft fines	Minor	Possible	Medium
		Aquatic ecosystem within in-pit ponds	Acute or chronic effects on health	Slight	Rare	Low

Risk Event				Risk Assessment		
Primary and Secondary Sources **(and Affected or Impacted Environmental Media)**	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Closure Strategy - Partial Backfill**		
				Consequence	**Likelihood**	**Risk Rating**
		Livestock (cattle)	Acute or chronic effects on health	Slight	Rare	Low
		Recreational users	Acute or chronic effects on health	Minor	Rare	Low
Post Deposition of tailings slurry in Swan and De Grey IPTSF Collapse of pit wall (Soil/rock)	Overland flow of debris and subsequent displacement of tailings and subsequent overland flow to downgradient receiving environments following pit wall collapse	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	Minor	Rare	Low
		Native terrestrial flora and fauna[3]	Smothering and/or entrapment of receptors Destruction of habitat	Minor	Rare	Low
		Livestock (cattle)	Destruction of grazing land	Minor	Rare	Low
		Recreational users	Destruction of recreational areas/ significant sites	Minor	Rare	Low

Notes:

1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Pampajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.

Pit overtopping may occur as a result of an extreme storm event, collapse of pit wall (if a supernatant pond is present in the TSF), or human failure.

AEP = annual exceedance probability; DMIRS = Department of Mines, Industry Regulation and Safety; ANCOLD = Australian National Committee on Large Dams

7 Uncertainties

Table 7.1 provides the uncertainties identified as potentially impacting the CEM.

Table 7.1 Uncertainty analysis

Area of uncertainty	Detail	Impact on CEM
Design and associated factors	The CEM relies on the accuracy of the design parameters and criteria outlined in the Basis of Design (WSP, 2024) and other supporting studies.	Modification to the design and/or inaccuracy may result in changes to CEM and the risk assessment. May result in over- or under-estimate of risk ratings.
Supporting studies	The risk ratings presented in the CEM are informed by the outputs of the water balance, hydrogeological, and geochemical modelling which includes the assumption that the Swan, De Grey, and adjacent pits (OB31) dewatering system are operational	Conservatism of modelling in the supporting studies will result in over-estimation of risk ratings Inaccuracies in support study modelling may result in over- or -under estimation of risk ratings
Supporting studies	The water balance and geochemical studies undertaken to support the closure assessment are considered high-level. Therefore, these results should be considered preliminary and may be subject to change, as more refined modelling is completed at later stages of the closure assessment.	High-level, less refined modelling results may over- or -under estimate risk ratings
Supporting studies	There are uncertainties associated with the groundwater conditions at closure creating uncertainties regarding the potential receptors that might be exposed to PSOIs in seepage that migrate in groundwater from the IPTSF. Based on the current understanding and available information, for this CEM it has been assumed that dewatering at OB31 will cease and westerly groundwater flow directions will re-establish.	Uncertainty in groundwater conditions may result in over- or -under estimation of risk ratings
Consequence assessment criteria, guideline values, screening criteria	The adopted screening criteria are derived with uncertainty and safety factors and are set at levels well below concentrations that may cause adverse effects, often by orders of magnitude.	Can result in over-estimation of consequence and risk rating.
Consequence assessment criteria, guideline values, screening criteria.	Screening criteria are also usually derived using general exposure assumptions that are based on worst-case scenarios to cover a wide range of situations and sensitive sub-populations.	Can result in over-estimation of consequence, likelihood and risk rating
Environmental data	Use of 90th percentile (P90) concentrations that are not likely present at all times in all exposure situations.	Can result in over-estimation of likelihood and risk rating

Area of uncertainty	Detail	Impact on CEM
Environmental data	Air quality data was not available to inform the chemical composition and particle size distribution of the fugitive dust generated by the TSF landform. CEM assessment authors assumed that any windblown dust generated would be dominated by the coarse sized particulate matter fraction.	If finer respirable dust is generated, risk ratings possible under-estimated.
Environmental data and screening	Additional conservatism may be included for some aquatic ecosystems by use of 95% species protection levels, when some of the receiving surface waters appear likely to be highly disturbed ecosystems and may allow the use of 90% protection levels	Can result in over-estimation of consequence and risk rating.
Operations and controls	The rating of risk due to pipeline failure has been conducted on the basis that the delivery pipeline system will be equipped with pressure sensors and an automatic line shut off designed to trigger in event of a pressure drop	If pipeline controls are not utilised, risk ratings may likely be under-estimated.
Closure	The preferred Partial Backfill Closure Option involves the tailings material being capped after the period of consolidation with a benign material (indicated to be waste rock covered by locally sourced surface soils). Assessment of the cover material is outside of the scope of this CEM. However, it is recommended that the suitability of the cover material in relation to chemical exposure risks of humans and wildlife is assessed prior to use.	Type of closure material can impact exposure and may result in over- or -under estimation of risk ratings.

8 Conclusions

The CEM describes complete source-pathway-receptor (SPR) linkages (i.e., potential interactions between the IPTSF, air [dust], surface water and groundwater, and receptors [humans and ecology]) associated with the Swan and De Grey IPTSF. The DPS CEM considers both operations and closure phases. The preferred closure option has been assessed as Option 2 – Partial backfill.

The Operations and Closure CEMs assess potential risks to ecological and human receptors posed by chemical stressors associated with the Swan and De Grey IPTSFs. The CEMs exclude occupational and safety risk. Health and safety risks to workers during operations or physical safety risk to the community during closure will be assessed and managed separately.

The risk ratings of the complete source-pathway-receptor (SPR) linkages associated with operation and closure of the De Grey and Swan IPTSF are summarised as follows:

8.1 Operations

No high-risk ratings were identified for Operations. The medium risks are summarised below. The remaining risk ratings were low, and therefore, have not been discussed in this summary.

Medium Risk:

- Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems (subterranean fauna), and the migration of seepage-impacted groundwater from the IPTSFs to the OB31 dewatering system and subsequent disposal of surplus water to the receiving environment (including Ophthalmia Dam) resulting in impacts to surface water aquatic ecosystems and native terrestrial flora (including riparian vegetation communities) and fauna.
    - Groundwater modelling (WSP 2023e) predicts that groundwater mounding will not be high enough to result in seepage to ground surface. Groundwater impacted by seepage from the IPTSFs through OB31 dewatering and disposal of surplus water to the receiving environment may provide a potential exposure pathway for surface water aquatic ecosystems, native terrestrial fauna and flora (including riparian vegetation), livestock and humans (recreational users and drinking water).
    - Modelling of the chemistry of the seepage impacted OB31 dewatering water (i.e., downstream) indicates that TDS and Barium exceed the screening criteria, with one high seepage scenario during sustained seepage (late stages of the operational period) resulting in a HQ> 5.
    - Further monitoring of the groundwater is recommended to determine if the water quality is suitable to be discharged to a sensitive receiving environment[20] or if further management measures are needed.
    - The pathway for exposure to humans via drinking water is likely to be incomplete. Any impact is likely to be due to water sourced from the OB31 dewatering system and to be diluted and treated before any drinking water exposure. The concentrations of PSOIs in seepage- impacted groundwater present a low risk to livestock and drinking water, with low Hazard Quotients[21].

---

[20] It is assumed that seepage water collected by the OB31 dewatering system will be managed as part of BHP's overall water management system and re-used or dispose. Seepage affected groundwater must meet applicable water quality guidelines and licence discharge criteria (e.g., SSTVs) prior to being discharged to the receiving environment (including Ophthalmia Dam).

[21] For livestock and drinking water, is it assumed that water in Ophthalmia Dam would be required to seep into the underlying groundwater and then migrate to an abstraction bore before it is used for livestock feeding or drinking water. It is likely that some further dilution of the PSOIs would occur during migration in groundwater and this would reduce the risks posed to human health from drinking water or livestock. In addition, it is acknowledged that drinking water (Newman town water supply) source water is treated by

Entry to IPTSF containment and subsequent direct contact with, or ingestion of, waste fines and/or supernatant water by native terrestrial fauna.

- There were minor exceedances of some screening criteria, which would require assessment of the likelihood of terrestrial fauna coming in direct contact with the surface water or waste fines. The screening criteria for both apply more to a chronic (i.e., long-term) exposure scenario, rather than sporadic exposures for short durations. If there are only short-term intermittent exposures, the risk is likely to be low.
- However, due to the unknown potential for exposure, a likelihood rank of possible is applied which derives a medium risk to native terrestrial fauna from entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water22.

8.2 Closure – Option 2, Partial Backfill

No high-risk ratings were identified for Closure Option 2. The medium risks are virtually the same as those identified for the Operations phase and are summarised below, with the remaining risk ratings being low.

Medium Risk:

- Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems (subterranean fauna and riparian vegetation communities).
- Entry to IPTSF containment and subsequent direct contact with or ingestion of waste fines and/or intermittent pond water by native terrestrial fauna within in-pit ponds.

BHP and the Water Corporation to meet the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011), as required by WA Health (BHP 2012).

[22] WSP anticipates that BHP will manage the potential risks to the environment from the rare event of a pit wall collapse through implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure). As a result, the risk to aquatic ecosystems and native terrestrial flora and fauna is assessed to be low on the assumption that minor consequences are only expected under exceptional circumstances.

9 Recommendations

9.1 Reducing uncertainties

Where uncertainties are impacting on the outcome, additional assessment and modelling works may reduce uncertainties in the CEM risk ratings and fill information gaps to help decide on the final outcome.

9.1.1 Operations and Closure CEM

Assessing background environmental data further (in addition to the groundwater data already collected e.g. OB31 Groundwater Quality) would increase understanding of the potential for naturally elevated metal concentrations in the area surrounding the IPTSFs. Understanding background conditions may be used to refine the risk ratings by assessing whether PSOI concentrations in environmental media are elevated above the natural background conditions and whether the derived Site-Specific Trigger Values are relevant.

It may also be used to establish baseline conditions to assist with understanding the magnitude of potential discharges to the environment (such as pipeline spills) and the requirement for cleanup; for this purpose, background environmental data should be collected before deposition of tailings commences.

This additional data could include the collection of soil data, surface water quality data (e.g., OB31 Creek, Shovelanna Creek, Jimblebar Creek) and sediment/soil quality data along drainage and creek lines (OB31 Creek, Shovelanna Creek, Jimblebar Creek).

9.1.2 Closure CEM

The seepage risk from the IPTSFs to groundwater may be refined through hydrogeological modelling for closure to understand changes in groundwater levels and flow direction once OB31 dewatering has ceased and once the closure strategy for OB31 Pit is known. The rate of recovery of groundwater levels following the cessation of dewatering operations at OB31 is unknown; it has not been numerically modelled and may take hundreds of years.

In addition, as the water balance and geochemical studies that have been undertaken to support the closure assessment are considered high-level and focused on Closure Option 1, the results can be considered preliminary; additional hydrogeological modelling focused on Closure Option 2 may assist in reducing uncertainties associated with seepage migration at closure and the identification of potential receptors.

- Note: Water balance models or water quality models were not developed for the Closure Option 2, and updating those for Option 2, potentially incorporating updated design elements as relevant and the final landform and land use/s to confirm the ecological and human receptors that may be exposed, would assist with refining the risk rankings.

The preferred Closure Option (Option 2, with partial backfill) incorporates the tailings material being capped after the consolidation period with a benign material (indicated to be waste rock). Assessment of the cover material is outside of the scope of this CEM, however, it is recommended that the suitability of the cover material is assessed prior to use to minimise chemical exposure risks of humans and wildlife.

9.2 Risk control and mitigation measures

A number of engineering and management measures are recommended to protect the local environment and ecosystems, including human health. These include protection of air quality and soil, groundwater and surface water (from tailings delivery systems, decant water and tailings slurry deposition) and are outlined in the Risk Assessment tables for Operation (Appendix D) and Closure (Appendix E).

This section discusses the recommendations for the two medium risk scenarios identified for both Operation and Closure:

- Seepage of IPTSF waters through base and/or pit walls to groundwater resulting in impacts to groundwater dependent ecosystems (subterranean fauna and riparian vegetation); and to aquatic ecosystems and native terrestrial flora (including riparian vegetation) and fauna from expression of seepage impacted groundwater to surface water.

  Risk controls could include:

  - Monitoring of groundwater and surface water quality and quantity (water level, flow).
  - Continued operation of dewatering system to manage seepage.

- Entry to IPTSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water by native terrestrial fauna and aquatic ecosystems within in-pit ponds.

  Risk controls could include:

  - Exclusion bunding around pit to discourage access.
  - Routine surveillance program, including regular fauna checks.

These recommendations are in addition to the management measures outlined in IPTSF Closure Strategy (WSP 2024C).

Other resources that may assist in mitigating hazards and risks include:
WA Department of Energy, Mines, Industry Regulation and Safety (2022) - Guidance about tailings storage.

This includes guidance and a Code of Practice on siting, designing, constructing, operating and decommissioning a Tailings Storage facility (TSF).

Global Tailings Review, 2020 (partnering with International Council on Mining & Metals, ICMM; UN Environment Program, UNEP; and Principles for Responsible Investment, PRI) - Global Industry Standard on Tailings management global-industry-standard_EN.pdf.

To be compliant with the Standard, Operators must … "implement best practices in planning, design, construction, operation, maintenance, monitoring, closure and post closure activities".

10 Limitations

10.1 Permitted purpose

This Report is provided by WSP for the purpose described in the Agreement and no responsibility is accepted by WSP for the use of the Report in whole or in part, for any other purpose (*Permitted Purpose*).

10.2 Qualifications and assumptions

The services undertaken by WSP in preparing this Report were limited to those specifically detailed in the Report and are subject to the scope, qualifications, assumptions and limitations set out in the Report or otherwise communicated to the Client.

Except as otherwise stated in the Report and to the extent that statements, opinions, facts, conclusion and / or recommendations in the Report (*Conclusions*) are based in whole or in part on information provided by the Client and other parties identified in the report (*Information)*, those Conclusions are based on assumptions by WSP of the reliability, adequacy, accuracy and completeness of the Information and have not been verified. WSP accepts no responsibility for the Information.

WSP has prepared the Report without regard to any special interest of any person other than the Client when undertaking the services described in the Agreement or in preparing the Report.

10.3 Use and reliance

This Report should be read in its entirety and must not be copied, distributed or referred to in part only. The Report must not be reproduced without the written approval of WSP. WSP will not be responsible for interpretations or conclusions drawn by the reader. This Report (or sections of the Report) should not be used as part of a specification for a project or for incorporation into any other document without the prior agreement of WSP.

WSP is not (and will not be) obliged to provide an update of this Report to include any event, circumstance, revised Information or any matter coming to WSP's attention after the date of this Report. Data reported and Conclusions drawn are based solely on information made available to WSP at the time of preparing the Report. The passage of time; unexpected variations in ground conditions; manifestations of latent conditions; or the impact of future events (including (without limitation) changes in policy, legislation, guidelines, scientific knowledge; and changes in interpretation of policy by statutory authorities); may require further investigation or subsequent re-evaluation of the Conclusions.

This Report can only be relied upon for the Permitted Purpose and may not be relied upon for any other purpose. The Report does not purport to recommend or induce a decision to make (or not make) any purchase, disposal, investment, divestment, financial commitment or otherwise. It is the responsibility of the Client to accept (if the Client so chooses) any Conclusions contained within the Report and implement them in an appropriate, suitable and timely manner.

In the absence of express written consent of WSP, no responsibility is accepted by WSP for the use of the Report in whole or in part by any party other than the Client for any purpose whatsoever. Without the express written consent of WSP, any use which a third party makes of this Report or any reliance on (or decisions to be made) based on this Report is at the sole risk of those third parties without recourse to WSP. Third parties should make their own enquiries and obtain independent advice in relation to any matter dealt with or Conclusions expressed in the Report.

10.4 Disclaimer

No warranty, undertaking or guarantee whether expressed or implied, is made with respect to the data reported or the Conclusions drawn. To the fullest extent permitted at law, WSP, its related bodies corporate and its officers, employees and agents assumes no responsibility and will not be liable to any third party for, or in relation to any losses, damages or expenses (including any indirect, consequential or punitive losses or damages or any amounts for loss of profit, loss of revenue, loss of opportunity to earn profit, loss of production, loss of contract, increased operational costs, loss of business opportunity, site depredation costs, business interruption or economic loss) of any kind whatsoever, suffered on incurred by a third party.

11 References

ANZG. (2018). Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Governments and Australian state and territory governments, Canberra ACT, Australia. Available at www.waterquality.gov.au/anz guidelines. *Accessed July 2023*.

ARMCANZ and ANZECC. (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, National Water Quality Management Strategy Paper No. 4. Volume 1 – The Guidelines.* Canberra ACT, Australia.

BHP. (2018). *GWL Operating Strategy for Jimblebar. Version 4.0, dated 15 February 2018.*

BHP. (2018a). *Eastern Pilbara Water Resource Management Plan. Version 6.0, dated 13 April 2018.*

BHP. (2021). *Risk Management, Our Requirements. Version 7.4 dated 1 July 2021.*

BHP. (2022). *Hydraulic connection between OB17/18 and the Ethel Gorge TEC. Jimblebar Beneficiation – Selection Phase Study. BHP Memorandum dated 3 May 2022.*

BHP. (2023a). *JBB DPS – Tailings Mass Flow Rate. BHPIO-MEMO-000066.*

BHP. (2023b). *Response to RFI: BHPIO-RTRFI-000252: JBB DPS - WSP RFI 26. Reference no.: BHPIO-MEMO-001365, dated 20 July 2023.*

BHP. (2023c). *Response to BHPIO-RTRFI-000077: RFI014 Jimblebar Pilot Bene Process Water. Reference no.: WSP ANZ-RFI-000010, dated 4 April 2023.*

BHP. (2024a). De Grey and Swan Water Balance Model Summary – Jimblebar In-Pit Tailings Storage Facilities Definition Phase Study. WSP document no.: PS134791-WSP-ADL-MNG-REP-026 Rev3. Dated December 2024. *7731-A-85248-VD-00018*.

Butler R. (2009). *Vulnerability of Plant Functional Types to Dust Deposition in the Pilbara, NW Australia. Honours Thesis, School of Plant Biology, The University of Western Australia. Supervised by Pauline Grierson, Garth Humphries & Gerald Page.*

CCME. (2023). *Canadian Environmental Quality Guidelines - Soil Quality Guidelines (SQG) Canadian Council of Ministers of the Environment. Available at: https://ccme.ca/en/current-activities/canadian-environmental-quality-guidelines. Accessed July 2023.*

DPIRD. (2021). *Climate in the Pilbara Region of Western Australia. Department of Primary Industries and Regional Development, Agriculture and Food. Available at https://www.agric.wa.gov.au/climate-change/climate-pilbara-region-western-australia. Accessed February 2022.*

DWER. (2020). Guideline: Risk Assessments. Government of Western Australia, Department of Water and Environmental Regulation. Final, v3. December 2020. Available at https://www.der.wa.gov.au/images/documents/our work/licences and works approvals/GS_Risk_Assessments.pdf. *Accessed May 2021.*

ERM. (2023). Second Targeted Site Investigation – Factual Report, Jimblebar Mine Site. ERM Refence Project No. 0638834, Version 1, Revision 0. Dated 29 May 2023.

Golder . (2015). Update of Site Specific Trigger Values for Jimblebar. Golder reference: 1415963-01-M-Rev0. Dated 13 October 2015.

Golder . (2021). Studies to Support In pit TSF for the Selection Phase Study of the Jimblebar Beneficiation Study, Groundwater Impact Assessment. Golder reference: 20377058 006 M Rev0. Dated December 2021.

Golder. (2021a). Jimblebar Beneficiation Project Selection Phase Study: De Grey and Swan In-Pit Tailings Water Quality Modelling. Golder reference: 20377058-005-R-Rev0). Dated 10 December 2021.

Grieson P. (2015). Dust suppression and likelihood of adverse impact on Acacia sp. East Fortescue at Orebody 31. Confidential report to BHP Billiton Iron Ore. University of Western Australia.

Hydro Geochem Group. (2023). Revision of Site Specific Trigger Values for Groundwater Quality Monitoring. document number J-H-AU0062-001-R-Rev0. Dated 23 June 2023.

McNaughton et al. (2024). A South Australian tailings storage facility: dust emissions study. 2024 Australian Centre for Geomechanics, Perth, ISBN 978-1-7636842-0-1.

NEPC. (2013). National Environment Protection (Assessment of Site Contamination) Measure 1999. National Environment Protection Council / Standing Council on Environment and Water.

NHMRC. (2008). Guidelines for Managing Risks in Recreational Water. National Health and Medical Research Council. Australian Government, Canberra.

NHMRC and NRMMC . ((2011, updated 2021).). Australian Drinking Water Quality Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

Onshore Environmental. (2017). Mining Area C Southern Flank. Flora and Vegetation Impact Assessment. Prepared for BHP Billiton Iron Ore Pty Ltd. March 2017.

RPS. (2013). OB31 Surface Water and Groundwater Management – Selection Phase Study. Prepared by RPS for BHP Billiton Iron Ore.

SKR. (2020). Whaleback In pit Tailings Disposal Assessment. Report prepared for BHP Iron Ore by SRK Consulting. Reference number BHP257 Rev 1. June 2020.

Turner GF. (2013). Vulnerability of Plant Functional Types to Mining Dust Deposition at the Jack Hills, Western Australia. Masters Thesis, School of Plant Biology, The University of Western Australia. Supervised by Pauline Grierson & Gerald Page.

US EPA . (2005). Interim Ecological Soil Screening Level Documents. United States Environmental Protection Agency. Available at: https://www.epa.gov/chemical-research/interim-ecological-soil-screening-level-documents. Accessed July 2023.

US EPA. (2023). Regional Screening Levels for Chemical Contaminants at Superfund Sites. United States Environmental Protection Agency. Available at https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables. Accessed July 2023.

Woodman Environmental. (2017). Pardoo Direct Shipping Ore Project Priority Flora Monitoring 2017. Atlas17-02-01 (Rev 0) prepared for Atlas Iron Pty Ltd, May 2017.

WSP. (2023). Multicriteria Assessment and Cost Benefit Outcomes. WSP document no.: PS134761-WSP-ADL-MEM-0067 Rev0. Dated September 2023. *7731-A-85248-VD-00037*.

WSP. (2023a). Conceptual Exposure Model (Selection Phase Study) De Grey (OB18) In-pit Tailings Storage Facility, Jimblebar Mine. WSP document no.: 20377058-WSP-MEL-REP-007 Rev3. Dated May 2023. *7731-A-85248-VD-00020*.

WSP. (2024a). BHP Jimblebar Pit Wall Stability, Definition Phase Study – In-pit Tailings Storage Facilities for the De Grey and Swan Pits. WSP document no.: PS134791-WSP-MEL-MNG-REP-108 Rev3. Dated December 2024.

WSP. (2024b). De Grey and Swan Water Balance Model Summary – Jimblebar In-Pit Tailings Storage Facilities Definition Phase Study. WSP document no.: PS134791-WSP-ADL-MNG-REP-026 Rev3. Dated December 2024.

WSP. (2024c). Jimblebar In-Pit Tailings Storage Facilities – Tailings Deposition Modelling Update for Definition Phase Study at De Grey and Swan pits. WSP document no.: PS134791-WSP-ADL-MNG-017 Rev3. Dated September 2024. *7731-A-85248-VD-00004*.

WSP. (2024d). Consolidation Modelling Update at De Grey and Swan Pits – Jimblebar Definition Phase Study. WSP document no.: PS134791-WSP-ADL-MNG-033 Rev3. Dated October 2024. *7731-A-85248-VD-00005*.

WSP. (2024e). Jimblebar In-Pit Tailings Storage Facility DPS Water Quality Modelling. WSP document no.: PS134791-WSP-PER-MNG-REP-058 Rev3. Dated 8 January 2025. *7731-A-85248-VD-00019*.

WSP. (2024f). Studies to support in-pit TSF for the Definition Phase Study of Jimblebar Beneficiation Study – Groundwater Assessment. WSP document no.: PS134791-WSP-ADL-MNG-065 Rev3. Dated December 2024. *7731-A-85248-VD-00042*.

WSP. (2024g). Basis of Design for Definition Phase Study – Jimblebar In-Pit Tailings Storage Facilities. WSP document no.: PS134791-WSP-ADL-MNG-010 Rev0. Dated December 2024. *DESB-1200-G-00089*.

WSP. (2024h). Basis of Modelling for Definition Phase Study – Jimblebar In-Pit Tailings Storage Facilities. WSP document no.: PREP-1200-G-12674 _Rev3 DPS. Dated October 2024. *PREP-1200-G-12674*.

WSP. (2024i). Jimblebar In-Pit Tailings Storage Facility Definition Phase Study (DPS), IPTSF Closure Basis of Design Class 4. WSP document no:. PS134791-WSP-PER-MNG-REP-089 Rev1. Dated October 2024. *DESB-1200-G-00090*.

WSP. (2024j). Jimblebar In-Pit Tailings Storage Facility Definition Phase Study (DPS), IPTSF Closure Strategy WSP document no. PS134791-WSP-ADL-MNG-REP-091 Rev0. Dated December 2024. *7731-A-85248-VD-00029*.

WSP Golder. (2022). Jimblebar VD12 Variation: Results of geotechnical and geochemical testwork on tailings composite samples. WSP Golder Reference: PS129317-037-R-Rev0. Dated 21 December 2022. .

Appendix A

Receptors of Interest

1 Ecological Receptors

The Pilbara is characterised by a much higher evaporation rate than precipitation rate, and approximately 70% of the precipitation occurs between the months of November and April. This causes several extremely dry months so that the creeks and river systems in the Pilbara are ephemeral and often groundwater-dependent. The catchments and the associated groundwater within the Jimblebar and Wheelarra Hill areas, are habitat for approximately 20 stygofauna species (Bennelongia 2013a, 2014a, 2014b).

Mining activities in the region have resulted in drawdown of water table and consequently these surface water systems, which are naturally groundwater fed, are currently receiving reduced groundwater inputs. It is understood that BHP manage aquifer recharge of the local aquifer, to counteract effects of dewatering in the system.

1.1 Aquatic Ecosystems

The aquatic communities of ephemeral waters, such as Jimblebar Creek, are characterised by receptors that typically have short reproductive life cycles that are triggered by, and completed within, periods of inundation. Inundation is followed by drought during which time these receptors enter a period of dormancy (e.g., production of eggs that are desiccation-resistant) where life processes are halted until inundation occurs, or find refuges (such as springs, or permanent standing water).

Innawally Pool is a permanent waterbody formed by the erosion by high water flows from the incised gorge of Jimblebar Creek. The pool is approximately 700 m long and 30 m wide and retains water throughout the year (BHP 2021). Limited information is available on the aquatic communities of the local waterways (BHP 2019). The exception being Innawally Pool, which has been found to support a freshwater turtle (Steindachner's turtle), native frogs, and invertebrates (BHP 2021).

Other receptors such as fish and macroinvertebrates may find refuges during periods of drought in groundwater-fed springs or permanent pools. Fish may colonise the local ephemeral waters after transport from upstream locations during periods of inundation. Examples of invertebrates that are adapted for extended periods of desiccation and may be found within local creeks and receiving waters include aquatic molluscs (e.g., snails [Gastropoda]), water mites, and crustaceans (copepods [Copepoda], water fleas [Cladocera], seed shrimp [Ostracoda], and side swimmers [Amphipoda]).

The ephemeral creeks and pools within the Jimblebar area also support riparian vegetation communities along their main drainage channels and adjacent floodplains. These communities include the facultative tree species *Eucalyptus camaldulensis subsp. refulgens* and *Eucalyptus victrix* found on the flood plains (BHP 2019). A survey of riparian and aquatic flora and vegetation in Jimblebar Creek and Innawally Pool by Onshore Environmental (2016[1] cited in Onshore Environmental 2018) identified the following significant flora species: *Rhagodia sp* and *Goodenia nuda*.

1.2 Groundwater Dependent Ecosystems

Groundwater plays an important role in sustaining aquatic and terrestrial ecosystems, such as springs, wetlands, rivers, and vegetation in arid settings. Understanding these groundwater-dependent ecosystems (GDE) is essential for groundwater management and planning.

---

1 Not sighted.

[redacted]

A search of the GDE Atlas was undertaken to assess the presence of aquatic, terrestrial, and subterranean GDEs proximate to the Swan and De Grey pits. Further information on the search of the GDE Atlas database is found in Appendix B. The lower and upper reaches of the Fortescue River, the Warrawanda Creek and Shovelanna Creek were identified to be moderate and high potential aquatic GDEs (national assessment), respectively. The areas surrounding the upper Fortescue River and Warrawanda Creek were identified as having moderate and low potential for terrestrial GDE. The areas surrounding Shovelanna Creek and Jimblebar Creek also displayed low potential for terrestrial GDE. No data was available for subterranean GDEs, as no analysed ecosystems were present within a 2 km radius of the Jimblebar Mine. As stated in SRK (2020), Ethel Gorge is designated as a Threatened Ecological Community (TEC) whereas Fortescue Marsh (Marsh located approximately 100 km to the northwest of OB17 and OB18) is designated as a Priority Ecological Community (PEC). The depth to groundwater in the vicinity of Jimblebar Creek and Innawally Pool is approximately 40-50 m bgl indicating these waterbodies are not GDE (SRK 2020).

1.2.1 Subterranean Fauna

Subterranean fauna includes stygofauna and troglofauna. Troglofauna are air-breathing animals that live in caves and voids in the sub-surface. Stygofauna are aquatic subterranean species (including micro and macroinvertebrates) that live below the earth's surface in aquifers, cave lakes, and groundwater systems. Stygofauna generally inhabit groundwater habitats with substantial fissures or voids, which in the vicinity of the area of study includes saturated Tertiary alluvium, along with orebody, dolomite, and fractured rock aquifers (SRK 2013). Subterranean fauna are predominantly invertebrates with a small number of vertebrates also having been identified to date (such as fish and a reptile).

The preservation and protection of subterranean ecosystem is a priority due to the unique biology, and function this fauna perform in groundwater systems. Stygofauna maintain the pore spaces in aquifers and remove organic material and nutrients in groundwater thereby providing an important ecosystem service of bio-remediating groundwater contaminants and maintaining groundwater quality. The Pilbara region is reported to have high diversity subterranean fauna (EPA 2016). It is conservatively estimated that the region supports between 500 and 550 species of stygofauna (Bennelongia 2015). As of 2015, more than 650 morphospecies of troglofauna had been recorded in the Pilbara to date, with the total number of species present likely to be much higher (Bennelongia 2015).

Stygofauna and other subterranean species are a focus of environmental assessment because a high proportion of them have localised distributions (Gibert and Deharveng 2002). According to Eberhard et al (2009), around 70% of Pilbara stygofauna species are likely to be short range endemics due to the limited physical connections between groundwater systems (Bennelongia 2013).

Limited research has been conducted on the effects of toxicant stressors on stygofauna. The physiology of stygofauna can differ from surface species and as such they may be expected to respond differently to toxicants compared to populations of surface taxa (Hose 2005, 2007 cited in Hose et al. 2015). It is considered likely that stygofauna communities may be more sensitive to some toxicants compared to surface water communities (Hose 2005 cited in Hose et al. 2015) and because of this, groundwater ecosystems are recommended to be protected (ANZG 2018).

Although no subterranean GDE were identified by the Atlas search, the Ethel Gorge/Ophthalmia Basin alluvium calcrete aquifer on the Fortescue River supports the Ethel Gorge Aquifer Stygobiont Community. This community is classified as a Threatened Ecological Community (TEC) B (ii) community based on it being of "limited distribution, with few occurrences, each of which is small and/or isolated and all or most occurrences are very vulnerable to known threatening processes" (DBCA 2020).

Several stygofauna assessments have been conducted in the study area in 2013 and 2014 to assess risks posed to stygofauna from proposed dewatering at OB17 (Swan), OB18 (De Grey), and OB31. Sampling yielded a total of 78 stygofauna species in Newman and surrounds, 59 of which occur in the Ethel Gorge TEC. Specific investigations at Jimblebar found only one species near the OB17 (Swan) and OB18 (De Grey) pits, 11 species in the OB31 footprint, 15 species in the vicinity of the Wheelarra Hill/Jimblebar mine area, and nine species surrounding the Sylvania Station (Bennelongia 2013a, 2014a, 2014b).

Several trogolofauna studies have also been undertaken within the Jimblebar footprint, revealing approximately 38 species present at Jimblebar/Wheelarra Hill. Investigations indicate that these species are likely to be constrained to the clay rich habitat of the tertiary detritals and all species found in the area are likely to have widespread dispersals expanding outside of the area.

1.3 Terrestrial Ecosystems

1.3.1 General Description

The Pilbara region supports high species richness and many endemic species of plants and animals, including one of the richest reptile assemblages in the world, more than 125 species of acacia, and more than 1,000 species of aquatic invertebrates (DPAW 2017).

Jimblebar is located on the plains and low hills between three bioregions, with ephemeral creeks occurring in the eastern portion of the project area. Jimblebar is located between the eastern portion of the Hamersley and Fortescue subregions of the Pilbara, and the Augustus subregion of the Gascoyne. The surrounding vegetation is classified by BHP (2019) as follows:

- *Triodia* hummock/open hummock grass on hill slopes and low undulating hills
- *Acacia* high open shrubland (Mulga) and *Triodia* hummock grassland on floodplains
- *Triodia* hummock grasslands.

The gorges and summits of the highest peaks of the Hamersley Range protect isolated populations of land snails, skinks, and plants (DPAW 2017). Many endemic plant species, including the Threatened flora species *Aluta quadrata* and rare ecosystems are also found in the Hamersley subregion. Additional information pertaining to the conservation significant flora and fauna found in the study area is presented in subsequent sections.

Environment Protection and Biodiversity Conservation (EPBC) and NatureMap database searches were conducted to identify Commonwealth and State listed species of conservation significance that may be present within a 25 km radius of the study areas. Database search results are presented in Appendix B, with a summary of the flora and fauna species of conservation significance identified by the database searches provided in Tables B1 and B2, respectively. Additional details are provided in subsequent sections.

1.3.2 Flora and Vegetation of Conservation Significance

The NatureMap database search identified 15 priority flora species that may occur within a 25 km radius of the Swan an De Grey pits. The EPBC database searches also identified one threatened flora species that may occur within the 25 km radius. Mt Augustus Foxglove (*Pityrodia augustensis*) is listed as Vulnerable under the EPBC Act 1999 (Commonwealth) and as a Declared Rare Flora under the Wildlife Conservation Action 1950 (Western Australia). Mt Augustus Foxglove is a small flowering shrub endemic to a small area of Western Australia, spanning the rocky hillsides in the Mt Augustus area, north-east of Carnarvon, and Mt Fraser in the Robinson Range, north of Meekatharra in the Geraldton district of Western Australia (Brown et al. 1998)

1.3.3 Vertebrate Fauna of Conservation Significance

Together, the EPBC and NatureMap database searches identified species of birds, mammals and reptiles of conservation significance that may be present within a 25 km radius of Swan and De Grey, including:

- 11 Commonwealth listed threatened[2] species
- 15 listed migratory[3] and/or protected under an international agreement bird species
- 12 listed marine bird species

---

2 Threatened fauna and flora may be listed in any one of the following categories pursuant to Section 179 of the *EPBC Act 1999*: Extinct, Extinct in the Wild, Critically Endangered, Endangered, Vulnerable, or Conservation Dependent.

3 Many migratory species are listed under international conventions and agreements to which Australia is party. The list of migratory species is established under Section 209 of the *EPBC Act 1999* and relates to the following conventions and agreements: Bonn Convention, JAMBA, CAMBA, and ROKAMBA.

- Three Priority 4 mammals[4]
- One Priority 1 and two Vulnerable reptiles
- One other specially protected fauna (Schedule 7).

1.3.4 Short Range Endemic Species

Fauna surveys conducted in 2013 and 2014 revealed six potential short range endemic (SRE) species. Two mygalomorph spiders (*Karaops* 'ARA003-DNA', and 'ARA004-DNA'), a pseudoscorpion (*Xenolpium* 'PSE079'), and three isopods (*Buddelundia* '10NM', '49', and *Buddelundiinae* 'WN') (Biologic 2013, 2014). These SREs are minorly impacted by habitat fragmentation, but are not expected to be further impacted by the proposed IPTSFs at Jimblebar Mine.

2 Livestock

The dominant land uses in the region are grazing, native pastures, ecological conservation, mining and urban. Unallocated Crown Land (UCL) and the Sylvania Pastoral Lease are the underlying land tenures occupying the Swan and De Grey areas. Sylvania Station is located approximately 28 km to the southwest of OB17 and OB18.

3 Humans

The human receptors considered in the conceptual exposure model (CEM) that were identified at the site and surrounds include:

- Nearby residents and visitors to the town of Newman and Aboriginal residents of Parnpajinya Community and traditional owners (Nyiyaparli people) and custodians (Martu people) of the land that:
- Consume drinking water sourced from the Newman Water Reserve[5] public drinking water source protection zones (Priority Areas 1 and 3) and associated borefields; and
- Undertake recreational activities in Ophthalmia Dam, OB31 Creek, Fortescue River, Jimblebar Creek, Ethel Gorge, or other nearby watercourses and waterbodies for wading, swimming, and fishing.

Drinking water (Newman town water supply) will not be considered further, as source water is treated by BHP and the Water Corporation to meet the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011), as required by WA Health (BHP 2012). Incidental ingestion of creek water is considered in the CEM according to the recreational guidelines for managing risks in recreational water (NHMRC 2008).

Cultural heritage sites are listed in Appendix B for completeness, given their cultural and spiritual value and potential to be impacted by current and ongoing mining activities (refer to Section 3.1). With respect to Swan and De Grey IPTSFs, these sites may be affected where they are situated in the path of unmanaged releases. However, cultural heritage sites have not been explicitly considered in the CEM.

---

[4] Priority species are still considered to be of conservation significance (i.e., they may be rare or threatened) but cannot be considered for listing under the Western Australian Wildlife Conservation Act 1950 (WC Act) until there is adequate understanding of threat levels imposed on them.

[5] Jimblebar mining activities are not located within the boundaries of the Newman Water Reserve, the area encompassing the borefields responsible for Newman's public drinking water supply (DOW 2014); therefore, they have not been explicitly considered further in this CEM.

3.1 Cultural Heritage Sites

According to the Aboriginal Heritage Inquiry System database, which is maintained by the Department of Planning, Lands and Heritage (DPLH 2021), there are 18 registered Aboriginal sites and 19 other indigenous heritage sites within an approximate 5 km radius surrounding the proposed Swan and De Grey IPTSF pits. It is noted that there are no registered Aboriginal site within the IPTSF project area. Items or areas of significance that may be present within a 5 km radius of the proposed Swan and De Grey IPTSF include:

- Quarry
- Modified trees
- Artefacts/scatter
- Rock shelters
- Arch deposits
- Ceremonial man-made structures.

The crown lease for the OB17 and OB18 area falls within the boundary of Nyiyaparli Native Title Claim. BHP has a comprehensive agreement with the Nyiyaparli people, the objective of which is to minimise impacts, engage with the Nyiyaparli people, and provide an opportunity to influence the management of environmental issues (NNTT 2021). For example, recognition of the Innawally Pool (located on Jimblebar Creek) as having historical significance to the Nyiyaparli people.

4 References

Bennelongia (2013). Stygofauna Assessment at OB29/30/35, Mount Whaleback. Bennelongia Environmental Consultants. Prepared for BHP Billiton Iron Ore. Report No. 2013/190.

Bennelongia (2015). Strategic Environmental Assessment: Description of Regional Subterranean Fauna. Prepared for BHP Billiton Iron Ore by Bennelongia Environmental Consultants. September 2015 Final Report, No. 2015/202.

BHP (2012). Western Australia Iron Ore (WAIO) Newman Potable Source Protection Plan. Prepared by BHP Billiton Iron Ore.

BHP (2019). Jimblebar Optimisation Project: Jimblebar Iron Ore Mine Revised Proposal. Environmental Review Document – referral supplementary report, August 2019. Available at https://www.epa.wa.gov.au/sites/default/files/Referral_Documentation/Environmental%20Review%20Document_0.pdf

BHP (2021). Protecting water resources and biodiversity at Innawally Pool. Available at https://www.bhp.com/news/case-studies/2021/09/innawally-pool-clean (Accessed in September 2021)

Brown A, Thomson-Dans C, Marchant N (eds) (1998). Western Australia's Threatened Flora, Department of Conservation and Land Management, Western Australia.

DOW (2014). Newman Water Reserve – Drinking water source protection review, Report WRP 147. Government of Western Australia, Department of Water.

DPAW (2017). Pilbara Conservation Strategy. Government of Western Australia, Department of Biodiversity, Conservation and Attractions, Parks and Wildlife Service. Available at https://www.dpaw.wa.gov.au/images/documents/conservation-management/pilbara/pilbara_conservation_strategy.pdf. Accessed March 2021.

DBCA (2020). Ethel Gorge Aquifer Stygobiont Community. Threatened Ecological Community – Fact Sheet. Recovery plans and interim recovery plans. Available at https://www.dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatenedecological- communities. Accessed April 2021.

DPLH (2021). Aboriginal Heritage Inquiry System. Available at https://www.dplh.wa.gov.au/ahis. Accessed February 2021.

Eberhard SM, Halse SA, Williams MR, Scanlon MD, Cocking J, Barron HJ (2009). Exploring the relationship between sampling efficiency and short-range endemism for groundwater fauna in the Pilbara region, Western Australia. Freshwater Biology. Vol 54(4): 885-901.

EPA (2016). Environmental Factor Guidelines: Subterranean Fauna. Environmental Protection Authority, Western Australia.

Gibert J, Deharveng L (2002). Subterranean Ecosystems: A Truncated Functional Biodiversity: This article emphasizes the truncated nature of subterranean biodiversity at both the bottom (no primary producers) and the top (very few strict predators) of food webs and discusses the implications of this truncation both from functional and evolutionary perspectives. BioScience. Vol 52(6): 473-481.

Hose G, Sreekanth J, Barron O, Pollino C (2015). Stygofauna in Australian Groundwater Systems: Extent of Knowledge. Report to the Australian Coal Association Research Program (ACARP). Commonwealth Scientific and Industrial Research Organisation (CSIRO) Australia. Draft dated 15 July 2015.

NHMRC (2008). Guidelines for Managing Risks in Recreational Water. National Health and Medical Research Council. Australian Government, Canberra.

NHMRC and NRMMC (2011). Australian Drinking Water Quality Guidelines Paper 6 National Water Quality Management Strategy. National Health and Medical Research Council, National Resource Management Ministerial Council, Commonwealth of Australia, Canberra.

Onshore Environmental (2016). Level 2 Riparian and Aquatic Flora and Vegetation survey Jimblebar Creek and Innawally Pool. Prepared for BHP Billiton Iron Ore.

Onshore Environmental (2018). Reconnaissance Flora and Vegetation Survey, Caramulla. Prepared for BHP Western Australia Iron Ore, July 2018

RPS Aquaterra (2013). Hydrogeological Assessment of Orebodies 29, 30 & 35 for Mining Below Water Table Approvals. Unpublished Report Prepared for BHP Billiton Iron Ore. March 2013.

SRK (2013). Orebodies 29, 30 and 35: Preliminary Acid and Metalliferous Drainage Risk Assessment. Prepared for BHP Billiton Iron Ore. July 2013.

SRK (2020). Jimblebar In-Pit Tailings Storage Identification Phase Study. Prepared for BHP Iron Ore. September 2020.

NNTT 2021. Native Title Determination Details, WCD2018/008 – Nyiyaparli and Myiyaparli #3. Accessed at http://www.nntt.gov.au/SearchRegApps/NativeTitleClaims/Pages/Determination_details.aspx?NNTT_Fileno=WCD2018/008 on 29 September 2021.

Appendix B

Comparison of Environmental Data and Modelling Predictions to Adopted Screening Criteria

TBL B2 Tailings Solids - Livestock

Sample	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe
	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%
Livestock (CCME SQG)			17					3.8			64#		63	
Total Elemental Composition Results														
Tailings Blend - SPS Average Tailings Blend	0.007	3.8	16.95	89	2.28	0.226	0.04	0.025	106	5.61	41.3	0.1	32	48.4
Tailings Blend - High P2	0.011	3.8	21.4	81	2.11	0.265	0.04	0.029	106	6.29	47.3	0.09	39	48.6

Sample	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo	Na	Nb	Ni	P	Pb	Rb
	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	%	mg/kg	mg/kg	%	mg/kg	mg/kg	%	mg/kg	mg/kg
Livestock (CCME SQG)													45		70	
Total Elemental Composition Results																
Tailings Blend - SPS Average Tailings Blend	7.1	0.8	1.81	0.038	0.01	56.4	5.4	0.05	918	1.47	0.013	4.35	21	0.146	9.49	1.09
Tailings Blend - High P2	7.8	0.6	2	0.051	0.02	58.7	5.4	0.06	1185	1.64	0.013	4.33	23.3	0.15	9.25	1.21

Sample	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Livestock (CCME SQG)					1							1	33	130			250	
Total Elemental Composition Results																		
Tailings Blend - SPS Average Tailings Blend	<0.0004	0.02	1	6.52	0.701	0.92	40.8	0.35	0.09	5.85	0.103	0.046	2.22	31.3	1.74	17.65	61.9	74.9
Tailings Blend - High P2	<0.0004	0.02	1	7.39	0.529	0.98	42.9	0.36	0.113	6.22	0.109	0.058	2.54	34.2	1.82	18.85	69.3	78.2

Notes:
Cr value based on total chromium

Sample		Ag mg/kg	Al %	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	Ca mg/kg	Cd mg/kg	Ce mg/kg	Co mg/kg	Cr mg/kg	Cs mg/kg	Cu mg/kg
Ecology - area of ecological significance	NEPM EIL or ESL Area of ecological significance (mg/kg)			20								120*		25
	CCME (mg/kg)	NA			200*	4*			1*		20*			
	USEPA EcoSSLs	4.2	<5.5 pH		300	21			0.36		13			
	Total Elemental Composition Results													
	Tailings Blend - SPS Average Tailings Blend	0.007	3.8	17.0	89	2.28	0.226	0.04	0.025	106	5.61	41.3	0.1	32
	Tailings Blend - High P2	0.011	3.8	21.4	81	2.11	0.265	0.04	0.029	106	6.29	47.3	0.09	39

Sample		Fe %	Ga mg/kg	Ge mg/kg	Hf mg/kg	In mg/kg	K %	La mg/kg	Li mg/kg	Mg %	Mn mg/kg	Mo mg/kg	Na %	Nb mg/kg	Ni mg/kg	P %	Pb mg/kg	Rb mg/kg	Re mg/kg
Ecology - area of ecological significance	NEPM EIL or ESL Area of ecological significance (mg/kg)														40		470		
	CCME (mg/kg)											4*							
	USEPA EcoSSLs										220								
	Total Elemental Composition Results																		
	Tailings Blend - SPS Average Tailings Blend	48.4	7.1	0.8	1.81	0.038	0.01	56.4	5.4	0.05	918	1.47	0.013	4.35	21	0.146	9.49	1.09	<0.0004
	Tailings Blend - High P2	48.6	7.8	0.6	2	0.051	0.02	58.7	5.4	0.06	1185	1.64	0.013	4.33	23.3	0.15	9.25	1.21	<0.0004

Sample		S %	Sb mg/kg	Sc mg/kg	Se mg/kg	Sn mg/kg	Sr mg/kg	Ta mg/kg	Te mg/kg	Th mg/kg	Ti %	Tl mg/kg	U mg/kg	V mg/kg	W mg/kg	Y mg/kg	Zn mg/kg	Zr mg/kg
Ecology - area of ecological significance	NEPM EIL or ESL Area of ecological significance (mg/kg)																50	
	CCME (mg/kg)		N/A		1	NA							500	130				
	USEPA EcoSSLs		0.27															
	Total Elemental Composition Results																	
	Tailings Blend - SPS Average Tailings Blend	0.02	1	6.52	0.701	0.92	40.8	0.35	0.09	5.85	0.103	0.046	2.22	31.3	1.74	17.65	61.9	74.9
	Tailings Blend - High P2	0.02	1	7.39	0.529	0.98	42.9	0.36	0.113	6.22	0.109	0.058	2.54	34.2	1.82	18.85	69.3	78.2

Notes:

*low reliablity value

NA - not applicable, CCME value based upon ambient or background concentrations in Canada, therefore not applicable to Australian conditions.

Table B.3 – Comparison of Tailings Solids Data to Human Health (Recreational) Screening Criteria

Sample	Ag	Al	As	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf	In	K	La	Li	Mg	Mn	Mo
	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	%	mg/kg	mg/kg
NEPM HILs Recreational C			300		90			90		300	300		17000										19000	
US EPA Regional Screening Levels - Resident Soil Adjusted*	1560	31		60000										22							640			1560
Total Elemental Composition Results																								
Tailings Blend - SPS Average Tailings Blend	0.007	3.8	17.0	89	2.28	0.226	0.04	0.025	106	5.61	41.3	0.1	32	48.4	7.1	0.8	1.81	0.038	0.01	56.4	5.4	0.05	918	1.47
Tailings Blend - High P2	0.011	3.8	21.4	81	2.11	0.265	0.04	0.029	106	6.29	47.3	0.09	39	48.6	7.8	0.6	2	0.051	0.02	58.7	5.4	0.06	1185	1.64

Sample	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
	%	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	%	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
NEPM HILs Recreational C			1200		600						700												30000	
US EPA Regional Screening Levels - Resident Soil Adjusted*									124			188000	188000					3	64	1560				
Total Elemental Composition Results																								
Tailings Blend - SPS Average Tailings Blend	0.013	4.35	21	0.146	9.49	1.09	<0.0004	0.02	1	6.52	0.701	0.92	40.8	0.35	0.09	5.85	0.103	0.046	2.22	31.3	1.74	17.65	61.9	74.9
Tailings Blend - High P2	0.013	4.33	23.3	0.15	9.25	1.21	<0.0004	0.02	1	7.39	0.529	0.98	42.9	0.36	0.113	6.22	0.109	0.058	2.54	34.2	1.82	18.85	69.3	78.2

Notes:
^ US EPA RSLs for Residential settings have been adjusted by a factor of 4 (to account for differences in soil ingestion rates) to be representative of recreational exposure.
Criteria for Al and Fe have been converted to %

Tailings Supernatant (Dissolved)

	Sample ID	pH (1:5)	EC (1:5)	Redox Potential	Cl	SO_4	F	OH Alkalinity	CO_3 Alkalinity	HCO_3 Alkalinity	Total Alkalinity	Ca	K	P	Mg	Na	Si	NH_4	NO_2	NO_3	NO_2+NO_3	TKN As N	Total N as N	Total P as P	Reactive p as P
		pH Units	uS/m	mV	mg/L			mg/L $CaCO_3$				mg/L						mgNH_3/L	mg NO_2/L	mg NO_3/L	mg NO_2+NO_3/L				
Groundwater	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)	6.0-8.5	1200																	10.6					
	Jimblebar Groundwater SSTV (Golder, 2015)	6.0-8.5	670-1800											0.05						3.1*				0.05	
Surface water	Jimblebar Creek Surface water SSTV (BHP, 2018a)	6.0-9.0																							
	Ophthalmia Dam Surface water SSTV (BHP, 2018a)																								
	ANZG (2018) Freshwater 95% toxicant DGVs	6.0-8.0																		10.6					
	ANZECC (2000) Default trigger values for Wetlands	7.5-8.5												0.08									1.15	0.08	
	SPS Average Tailings Blend	8.04	780	208	194	39	1	<1	<1	72	72	25	10	<1	8	107	5.85	<0.01	<0.01	0.14	0.14	<0.1	0.1	<0.01	<0.01
	High P2	8.03	772	210	215	40	1	<1	<1	66	66	25	10	<1	8	105	5.31	<0.01	<0.01	0.09	0.09	0.1	0.2	<0.01	<0.01

	Sample ID	Ag	Al	As	B	Ba	Be	Bi	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sr	Tl	Th	Sn	U	V	W	Zn	Zr
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Groundwater	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)		0.055	0.013[B]	0.37	0.029			0.001		0.006	0.0014	0.03	0.0006	1.9	0.001	0.074	0.059		0.011								0.054	
	Jimblebar Groundwater SSTV (Golder, 2015)	0.00005	0.055	0.013	0.61	0.01	0.01		0.0002	0.001	0.01	0.01	0.1	0.0006	1.9	0.01	0.011	0.0034	0.001	0.011				0.001				0.024	
Surface water	Jimblebar Creek Surface water SSTV (BHP, 2018a)																												
	Ophthalmia Dam Surface water SSTV (BHP, 2018a)																												
	ANZG (2018) Freshwater 95% toxicant DGVs	0.0005	0.055[A]	0.013	0.94				0.0002		0.001[C]	0.0014		0.0006	1.9		0.011	0.0034	0.009	0.011		0.0003			0.0005	0.006		0.008	
	ANZECC (2000) Default trigger values for Wetlands																												
	SPS Average Tailings Blend	<0.0001	<0.005	<0.0002	0.05	0.0897	<0.0001	<0.00005	<0.00005	<0.0001	<0.0002	<0.0005	<0.002	<0.00004	<0.0005	0.0007	<0.0005	<0.0001	<0.0002	0.0009	0.15	0.00003	<0.0001	<0.0002	0.00007	<0.0002	<0.001	0.002	<0.005
	High P2	<0.0001	<0.005	0.0003	0.054	0.0937	<0.0001	<0.00005	<0.00005	<0.0001	<0.0002	0.0045	<0.002	<0.00004	<0.0005	0.0007	0.0006	0.0002	<0.0002	0.001	0.152	0.00004	<0.0001	<0.0002	0.00008	<0.0002	<0.001	0.015	<0.005

Notes:

* NO_3 value from ANZECC and ARMCANZ (2000) was erroneous (ANZG, 2018). Therefore has not been adopted in this screening assessment.

Table B.5 - Comparison of Tailings Supernatant Water to Livestock Screening Criteria

Tailings Supernatant (Total)

Sample	pH (1:5)	EC (1:5)	Redox Potential	Cl	SO_4	F	OH Alkalinity	CO_3 Alkalinity	HCO_3 Alkalinity	Total Alkalinity
	pH Units	uS/m	mV	mg/L			mg/L $CaCO_3$			
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)					1000	2				
SPS Average Tailings Blend	Filtered-only									
High P2										

Sample	Ca	K	P	Mg	Na	NH_4 as N	NO_2 as N	NO_3 as N	NO_2+NO_3 as N	TKN As N	Total N as N	Total P as P	Reactive p as P
	mg/L												
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)	1000						9.1	92					
SPS Average Tailings Blend	27	10	<1	8	97	Filtered-only							
High P2	28	10	<1	8	97								

Sample	Ag	Al	As	B	Ba	Be	Bi	Cd	Co	Cr	Cu	Fe	Hg	Mn
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)		5	0.5	5				0.01	1	1	0.4		0.002	
SPS Average Tailings Blend	<0.0001	0.007	0.0008	0.05	0.0803	0.001	0.00014	0.00056	0.0002	<0.0002	0.001	<0.002	<0.00004	0.0006
High P2	<0.0001	0.008	0.0004	0.054	0.0872	<0.0001	<0.00005	<0.00005	<0.0001	<0.0002	0.0058	0.003	<0.00004	<0.0005

Sample	Mo	Ni	Pb	Sb	Se	Sr	Tl	Th	Sn	U	V	W	Zn	Zr
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)	0.15	1	0.1		0.02					0.2			20	
SPS Average Tailings Blend	0.0005	<0.0005	0.0006	0.0006	0.0005	0.154	0.00033	0.0002	<0.0002	0.00033	<0.0002	<0.001	0.003	<0.005
High P2	0.0005	0.0005	0.0004	<0.0002	0.0006	0.153	0.00006	<0.0001	<0.0002	0.00013	<0.0002	<0.001	0.016	<0.005

A = Al value based on pH>6.5
B = As value based on As5+ criteria
C = Cr value based on Cr6+ criteria

Table B.6 Comparison of Tailings Supernatant Water Data to Human Health Screening Criteria

Tailings Supernatant (Total)

	Sample ID	pH (1:5)	EC (1:5)	Redox Potential	Cl	SO_4	F	OH Alkalinity	CO_3 Alkalinity	HCO_3 Alkalinity	Total Alkalinity	Ca	K	P	Mg	Na	NH_3	NO_2	NO_3	NO_2+NO_3 as N	TKN As N	Total N as N	Total P as P	Reactive p as P
		pH Units	uS/m	mV	mg/L			mg/L $CaCO_3$				mg/L					$mgNH_3/L$	mg NO_2/L	mg NO_3/L					
Drinking Water	ADWG Health (2011, updated 2022)						1.5											3	50					
	ADWG Aesthetics (2011, updated 2022)	6.5-8.5			250	250										180	0.5							
Recreation	ADWG Health (2011, updated 2022) x10 for inorganics	6.5-8.5			250	250	15									180	0.5	30	500					
	SPS Average Tailings Blend	Filtered-only										27	10	<1	8	97	Filtered-only							
	High P2											28	10	<1	8	97								

	Sample ID	Ag	Al	As	B	Ba	Be	Bi	Cd	Co	Cr	Cu	Fe	Hg	Mn	Mo	Ni	Pb	Sb	Se	Sr	Tl	Th	Sn	U	V	W	Zn	Zr
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Drinking Water	ADWG Health (2011, updated 2022)	0.1		0.01	4	2	0.06		0.002		0.05[C]	2		0.001	0.5	0.05	0.02	0.01	0.003	0.01					0.02				
	ADWG Aesthetics (2011, updated 2022)											1	0.3		0.1													3	
Recreation	ADWG Health (2011, updated 2022) x10 for inorganics	1		0.1	40	20	0.6		0.02		0.5	20	0.3	0.01	5	0.5	0.2	0.1	0.03	0.1					0.2			3	
	SPS Average Tailings Blend	<0.0001	0.007	0.0008	0.05	0.0803	0.001	0.00014	0.00056	0.0002	<0.0002	0.001	<0.002	<0.00004	0.0006	0.0005	<0.0005	0.0006	0.0006	0.0005	0.154	0.00033	0.0002	<0.0002	0.00033	<0.0002	<0.001	0.003	<0.005
	High P2	<0.0001	0.008	0.0004	0.054	0.0872	<0.0001	<0.00005	<0.00005	<0.0001	<0.0002	0.0058	0.003	<0.00004	<0.0005	0.0005	0.0005	0.0004	<0.0002	0.0006	0.153	0.00006	<0.0001	<0.0002	0.00013	<0.0002	<0.001	0.016	<0.005

A = Al value based on pH>6.5
B = As value based on As5+ criteria
C = Cr value based on Cr6+ criteria

Table B.7 - Comparison of In-Pit Water Quality Modelled Data to Ecological Screening Criteria

Parameter				pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO_4	Al	Sb	As	B	Ba	Be
Unit				pH Units	pe units	mg/L	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Groundwater (and GDEs)	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)			6.0-8.5	-	804 [A]	-	-	-	-	-	-	88 [B]	0.055	-	0.013 [D]	0.37	0.029	-
Groundwater (and GDEs)	Jimblebar Groundwater SSTV (BHP, 2018)			6.0-8.5	-	430-1150 [A]	-	-	-	-	-	-	-	0.055	0.001	0.013	0.61	0.01	0.01
Surface water	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)			6.0-8	-	60-603 [A]	-	-	-	-	-	-		0.055 [C]	0.009	0.013 [D]	0.94	-	-
Surface water	Jimblebar Creek Surface water SSTV (BHP, 2018a)			6.0-9.0	-	3000	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface water	Ophthalmia Dam Surface water SSTV (BHP, 2018a)			-	-	2000	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface water	ANZECC (2000) Default trigger values for Wetlands			7.5-8.5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
De Grey - Base Line	Filling periods	Median		7.8	6.3	763	96.4	27.8	20.7	11.4	173.6	283.8	65.8	0.02	0.00001	0.0005	0.11	0.12	0
		Average		7.8	6.3	1011	136.5	28.3	41.2	14.6	225.0	355.6	94.5	0.17	0.00003	0.0007	0.13	0.15	0
		P90		7.6	6.2	1802	72.9	36.8	80.1	25.7	422.7	656.2	175.8	0.86	0.00006	0.0021	0.24	0.28	0
	Fallow periods	Median		8.0	6.3	2241	245.0	27.5	86.5	36.1	562.0	865.3	184.8	0.26	0.00018	0.0025	0.28	0.47	0
		Average		8.0	6.3	5958	298.9	60.5	168.9	106.8	1742.5	2707.7	**600.4**	0.46	0.00025	0.0073	0.79	1.33	0
		P90		7.7	6.2	19565	215.2	157.9	418.0	381.6	6188.2	9600.7	**1918.9**	1.07	0.00054	0.0203	2.85	4.84	0
De Grey - High Seepage	Filling periods	Median		7.8	6.3	762	96.0	27.8	20.5	11.4	172.6	286.3	65.8	0.02	0.00001	0.0005	0.11	0.12	0
		Average		7.8	6.3	1012	136.6	28.3	41.2	14.6	225.4	356.2	94.2	0.15	0.00003	0.0007	0.13	0.15	0
		P90		7.6	6.2	1798	72.9	36.2	80.3	25.6	421.4	654.3	176.1	0.52	0.00006	0.0022	0.24	0.28	0
	Fallow periods	Median		8.0	6.3	2238	244.9	27.3	86.8	36.2	556.7	859.3	184.2	0.26	0.00018	0.0026	0.28	0.47	0
		Average		8.0	6.3	8585	356.5	86.8	214.8	157.6	2594.5	4033.6	**831.4**	0.48	0.00032	0.0179	1.15	1.94	0
		P90		7.7	6.2	28009	215.4	250.6	564.5	510.2	8561.1	13322.8	**2709.7**	1.30	0.00064	0.0323	3.60	6.19	0
De Grey -Climate Change	Filling periods	Median		7.8	6.3	773	97.0	27.8	20.3	11.5	173.1	286.4	67.4	0.03	0.00002	0.0005	0.11	0.12	0
		Average		7.8	6.3	1006	135.8	28.2	41.1	14.6	223.4	353.0	95.0	0.23	0.00003	0.0007	0.13	0.15	0
		P90		7.5	6.2	1584	72.6	36.1	80.4	23.3	350.6	550.7	177.0	1.17	0.00006	0.0019	0.23	0.24	0
	Fallow periods	Median		8.0	6.3	2227	246.0	27.8	87.4	36.1	556.3	860.3	182.0	0.25	0.00017	0.0025	0.28	0.47	0
		Average		8.0	6.3	5514	293.9	56.0	154.9	98.9	1608.9	2499.5	**532.9**	0.43	0.00024	0.0072	0.73	1.24	0
		P90		7.8	6.2	16420	214.1	154.7	352.6	322.0	5192.0	8049.6	**1619.4**	0.84	0.00048	0.0168	2.41	4.08	0
Swan - Base Line	Filling periods	Median		7.8	6.3	810	105.3	35.1	18.3	11.5	179.1	283.4	64.0	0.01	0.00001	0.0019	0.10	0.13	0
		Average		7.8	6.3	1209	120.6	37.3	31.6	19.0	305.1	477.1	104.4	0.02	0.00001	0.0041	0.17	0.22	0
		P90		7.7	6.2	1588	73.9	50.3	56.5	25.1	371.0	615.5	138.8	0.05	0.00002	0.0091	0.21	0.32	0
	Fallow periods	Median		7.8	6.4	1538	148.6	47.6	38.4	24.3	384.1	594.6	124.2	0.09	0.00005	0.0101	0.19	0.33	0
		Average		7.8	6.4	3704	214.6	62.8	86.3	64.3	1063.2	1653.1	325.3	0.10	0.00006	0.0149	0.46	0.80	0
		P90		7.7	6.2	9683	108.2	118.7	216.0	174.4	2957.6	4605.8	**875.6**	0.15	0.00010	0.0249	1.20	2.10	0
Swan - High Seepage	Filling periods	Median		7.8	6.3	803	104.8	33.5	18.2	11.3	177.7	279.9	63.1	0.01	0.00001	0.0017	0.10	0.13	0
		Average		7.8	6.3	1228	123.8	37.1	33.8	19.2	308.1	481.7	109.5	0.02	0.00001	0.0035	0.18	0.21	0
		P90		7.7	6.2	1698	73.9	50.2	64.7	26.0	402.2	627.2	142.6	0.05	0.00002	0.0081	0.22	0.31	0
	Fallow periods	Median		7.8	6.4	1614	147.6	48.5	40.6	25.6	412.1	636.6	129.4	0.09	0.00005	0.0101	0.19	0.33	0
		Average		7.8	6.4	4551	234.9	73.9	101.3	80.2	1333.5	2074.0	404.9	0.10	0.00006	0.0178	0.57	0.99	0
		P90		7.7	6.2	10768	108.0	123.2	241.1	195.9	3305.7	5144.5	**984.0**	0.17	0.00011	0.0280	1.36	2.38	0
Swan -Climate Change	Filling periods	Median		7.8	6.3	815	106.6	35.3	18.3	11.7	175.9	282.9	64.7	0.01	0.00001	0.0018	0.11	0.13	0
		Average		7.8	6.4	1172	117.1	37.5	29.9	18.3	294.8	461.1	101.2	0.02	0.00001	0.0043	0.16	0.21	0
		P90		7.7	6.2	1568	73.2	50.0	48.9	24.8	368.8	611.9	128.8	0.05	0.00003	0.0102	0.21	0.31	0
	Fallow periods	Median		7.8	6.4	1588	149.3	48.2	40.0	25.2	398.2	618.1	127.4	0.09	0.00005	0.0093	0.18	0.33	0
		Average		7.8	6.4	3521	209.8	60.9	82.6	60.8	1004.8	1562.2	307.9	0.09	0.00005	0.0139	0.44	0.76	0
		P90		7.7	6.2	9831	107.6	110.7	220.6	177.1	3005.0	4679.7	**889.2**	0.14	0.00009	0.0246	1.22	2.13	0

Parameter			Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Unit			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Groundwater (and GDEs)	BHP Shovelanna SSTVs (Hydro Geochem Group, 2023)		0.001	-	0.0014	0.006	-	0.03	0.0006	1.9	0.001	-	0.074	-	0.059	0.011	-	-	-	-	-	-	-	0.054
Groundwater (and GDEs)	Jimblebar Groundwater SSTV (BHP, 2018)		0.0002	0.001	0.01	0.01	-	0.1	0.0006	1.9	0.01	-	0.011	0.05	0.0034	0.011	-	0.00005	0.001	-	-	-	-	0.024
Surface water	95% species protection guideline values for freshwater ecosystems (ANZG, 2018)		0.0002	-	0.0014	0.001 [E]	-	-	0.0006	1.9	-	-	0.011	-	0.0034	0.011	-	0.00005	-	-	0.00003	0.0005	0.006	0.008
Surface water	Jimblebar Creek Surface water SSTV (BHP, 2018a)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface water	Ophthalmia Dam Surface water SSTV (BHP, 2018a)		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surface water	ANZECC (2000) Default trigger values for Wetlands		-	-	-	-	-	-	-	-	-	1.15	-	0.08	-	-	-	-	-	-	-	-	-	-
De Grey - Base Line	Filling periods	Median	0.00000	0.0002	0.0030	0.0000	1.2	0.005	0	0.0348	0.0014	0.14	0.0022	0	0.00005	0.00397	8.6	0	0	0.2	0.000004	0.0002	0.00002	0.021
		Average	0.00001	0.0018	0.0035	0.0001	4.7	0.026	0	0.1306	0.0016	0.30	0.0043	0	0.00008	0.00397	22.8	0	0	0.2	0.000010	0.0003	0.00006	0.029
		P90	0.00002	0.0048	0.0079	0.0001	10.6	0.056	0	0.1820	0.0029	0.38	0.0093	0	0.00021	0.00650	46.6	0	0	0.4	0.000022	0.0005	0.00015	0.060
	Fallow periods	Median	0.00001	0.0011	0.0007	0.0000	11.1	0.051	0	0.1743	0.0065	0.56	0.0061	0	0.00030	0.00773	48.6	0	0	0.7	0.000052	0.0009	0.00000	0.078
		Average	0.00001	0.0016	0.0009	0.0001	12.2	0.059	0	0.2531	0.0151	1.39	0.0121	0	0.00057	0.01485	53.8	0	0	3.0	0.000074	0.0018	0.00001	0.171
		P90	0.00003	0.0038	0.0012	0.0001	15.4	0.107	0	0.5624	0.0549	4.86	0.0427	0	0.00146	0.04532	69.9	0	0	10.8	0.000172	0.0068	0.00002	0.519
De Grey - High Seepage	Filling periods	Median	0.00000	0.0002	0.0027	0.0000	1.2	0.005	0	0.0348	0.0013	0.14	0.0019	0	0.00005	0.00379	8.6	0	0	0.2	0.000003	0.0002	0.00002	0.019
		Average	0.00001	0.0016	0.0032	0.0001	4.7	0.023	0	0.1223	0.0016	0.30	0.0039	0	0.00008	0.00377	22.8	0	0	0.2	0.000008	0.0002	0.00005	0.029
		P90	0.00001	0.0035	0.0069	0.0001	10.6	0.040	0	0.1407	0.0029	0.38	0.0073	0	0.00022	0.00634	46.6	0	0	0.4	0.000016	0.0004	0.00010	0.061
	Fallow periods	Median	0.00001	0.0012	0.0007	0.0000	11.1	0.051	0	0.1739	0.0065	0.56	0.0062	0	0.00031	0.00767	48.7	0	0	0.7	0.000052	0.0009	0.00000	0.079
		Average	0.00002	0.0021	0.0021	0.0001	13.4	0.067	0	0.3151	0.0203	2.00	0.0168	0	0.00147	0.02146	59.3	0	0	3.3	0.000093	0.0025	0.00007	0.262
		P90	0.00004	0.0045	0.0014	0.0001	17.1	0.113	0	0.6832	0.0612	6.32	0.0449	0	0.00218	0.05215	76.6	0	0	11.6	0.000199	0.0072	0.00002	0.718
De Grey -Climate Change	Filling periods	Median	0.00000	0.0002	0.0040	0.0000	1.2	0.005	0	0.0335	0.0014	0.14	0.0024	0	0.00005	0.00442	8.7	0	0	0.2	0.000004	0.0002	0.00002	0.024
		Average	0.00001	0.0025	0.0044	0.0001	4.7	0.035	0	0.1526	0.0016	0.30	0.0055	0	0.00008	0.00450	22.8	0	0	0.2	0.000013	0.0003	0.00008	0.032
		P90	0.00003	0.0066	0.0095	0.0002	10.5	0.099	0	0.2997	0.0027	0.34	0.0153	0	0.00019	0.00681	46.6	0	0	0.4	0.000038	0.0005	0.00021	0.063
	Fallow periods	Median	0.00001	0.0011	0.0006	0.0000	11.1	0.049	0	0.1728	0.0066	0.56	0.0060	0	0.00028	0.00762	48.5	0	0	0.7	0.000051	0.0009	0.00000	0.078
		Average	0.00001	0.0016	0.0009	0.0001	12.1	0.059	0	0.2495	0.0140	1.30	0.0114	0	0.00053	0.01393	53.5	0	0	3.1	0.000073	0.0017	0.00001	0.158
		P90	0.00002	0.0032	0.0013	0.0001	14.6	0.087	0	0.4913	0.0458	4.01	0.0335	0	0.00122	0.03437	64.9	0	0	10.5	0.000154	0.0054	0.00002	0.424
Swan - Base Line	Filling periods	Median	0.00000	0.0001	0.0002	0.0000	1.4	0.004	0	0.0171	0.0012	0.15	0.0010	0	0.00009	0.00145	10.5	0	0	0.2	0.000001	0.0001	0.00001	0.017
		Average	0.00000	0.0001	0.0003	0.0000	3.3	0.009	0	0.0213	0.0018	0.24	0.0017	0	0.00016	0.00239	23.2	0	0	0.3	0.000007	0.0002	0.00002	0.034
		P90	0.00000	0.0002	0.0006	0.0001	8.1	0.018	0	0.0427	0.0026	0.38	0.0031	0	0.00026	0.00334	45.9	0	0	0.4	0.000014	0.0003	0.00004	0.054
	Fallow periods	Median	0.00000	0.0003	0.0001	0.0000	6.1	0.040	0	0.0599	0.0031	0.45	0.0042	0	0.00027	0.00415	46.4	0	0	0.4	0.000033	0.0003	0.00001	0.067
		Average	0.00000	0.0003	0.0002	0.0000	8.1	0.040	0	0.0645	0.0066	0.89	0.0074	0	0.00072	0.00912	49.9	0	0	1.3	0.000039	0.0007	0.00001	0.141
		P90	0.00000	0.0006	0.0004	0.0000	13.1	0.064	0	0.0980	0.0163	2.16	0.0158	0	0.00138	0.02120	59.7	0	0	3.3	0.000070	0.0018	0.00002	0.322
Swan - High Seepage	Filling periods	Median	0.00000	0.0001	0.0002	0.0000	1.4	0.004	0	0.0171	0.0012	0.14	0.0010	0	0.00009	0.00146	10.3	0	0	0.2	0.000002	0.0001	0.00001	0.017
		Average	0.00000	0.0001	0.0004	0.0000	3.5	0.008	0	0.0201	0.0018	0.23	0.0017	0	0.00016	0.00228	23.3	0	0	0.3	0.000006	0.0002	0.00003	0.034
		P90	0.00000	0.0002	0.0007	0.0001	9.9	0.017	0	0.0424	0.0026	0.36	0.0030	0	0.00030	0.00326	46.0	0	0	0.5	0.000014	0.0003	0.00004	0.057
	Fallow periods	Median	0.00000	0.0003	0.0001	0.0000	5.8	0.040	0	0.0601	0.0031	0.45	0.0041	0	0.00028	0.00404	46.4	0	0	0.5	0.000033	0.0003	0.00001	0.067
		Average	0.00000	0.0004	0.0002	0.0000	8.4	0.041	0	0.0694	0.0081	1.08	0.0087	0	0.00092	0.01071	51.8	0	0	1.5	0.000043	0.0009	0.00001	0.170
		P90	0.00000	0.0007	0.0005	0.0000	13.5	0.064	0	0.1076	0.0191	2.50	0.0185	0	0.00174	0.02485	64.4	0	0	4.7	0.000082	0.0021	0.00002	0.380
Swan -Climate Change	Filling periods	Median	0.00000	0.0001	0.0002	0.0000	1.5	0.004	0	0.0179	0.0012	0.15	0.0010	0	0.00009	0.00148	10.1	0	0	0.2	0.000001	0.0001	0.00002	0.017
		Average	0.00000	0.0001	0.0003	0.0000	3.2	0.009	0	0.0213	0.0018	0.23	0.0017	0	0.00015	0.00238	23.1	0	0	0.3	0.000007	0.0002	0.00003	0.032
		P90	0.00000	0.0002	0.0007	0.0001	6.2	0.019	0	0.0409	0.0026	0.38	0.0030	0	0.00022	0.00335	45.9	0	0	0.4	0.000015	0.0003	0.00004	0.051
	Fallow periods	Median	0.00000	0.0003	0.0001	0.0000	5.8	0.040	0	0.0618	0.0030	0.44	0.0041	0	0.00027	0.00406	46.3	0	0	0.5	0.000033	0.0003	0.00001	0.067
		Average	0.00000	0.0003	0.0002	0.0000	7.9	0.039	0	0.0630	0.0063	0.85	0.0071	0	0.00066	0.00868	49.4	0	0	1.2	0.000038	0.0007	0.00001	0.134
		P90	0.00000	0.0006	0.0005	0.0000	13.1	0.059	0	0.0945	0.0166	2.18	0.0161	0	0.00145	0.02240	58.5	0	0	3.4	0.000067	0.0019	0.00002	0.310

A= TDS SSTV is calculated, EC, is converted to TDS using an approximate conversion factor of 0.67
B = As requested by BHP, in the absence of a trigger value for sulfate, the P90 for groundwater data (OB31) was used as the trigger value. The bold values are >5 time the trigger value.
C = Al value based on pH>6.5
D = As value based on As5+ criteria
E = Cr value based on Cr6+ criteria
F = NO_3 value from ANZECC and ARMCANZ (2000) was erroneous (ANZG, 2018). Therefore, this value has not been adopted in this screening assessment.

Table B.8 Comparison of In-Pit Water Quality Modelled Data to Livestock Screening Criteria

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO_4	Al	Sb	As	B	Ba
Unit			pH Units	pe units	mg/L	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)			-	-	4000	-	1000	-	-	-	-	1000	5	-	0.5	5	-
De Grey - Base Line	Filling periods	Median	7.8	6.3	763	96.4	28	20.7	11.4	173.6	283.8	66	0.02	0.00001	0.0005	0.11	0.12
		Average	7.8	6.3	1011	136.5	28	41.2	14.6	225.0	355.6	94	0.17	0.00003	0.0007	0.13	0.15
		P90	7.6	6.2	1802	72.9	37	80.1	25.7	422.7	656.2	176	0.86	0.00006	0.0021	0.24	0.28
	Fallow periods	Median	8.0	6.3	2241	245.0	27	86.5	36.1	562.0	865.3	185	0.26	0.00018	0.0025	0.28	0.47
		Average	8.0	6.3	5958	298.9	61	168.9	106.8	1742.5	2707.7	600	0.46	0.00025	0.0073	0.79	1.33
		P90	7.7	6.2	19565	215.2	158	418.0	381.6	6188.2	9600.7	1919	1.07	0.00054	0.0203	2.85	4.84
De Grey - High Seepage	Filling periods	Median	7.8	6.3	762	96.0	28	20.5	11.4	172.6	286.3	66	0.02	0.00001	0.0005	0.11	0.12
		Average	7.8	6.3	1012	136.6	28	41.2	14.6	225.4	356.2	94	0.15	0.00003	0.0007	0.13	0.15
		P90	7.6	6.2	1798	72.9	36	80.3	25.6	421.4	654.3	176	0.52	0.00006	0.0022	0.24	0.28
	Fallow periods	Median	8.0	6.3	2238	244.9	27	86.8	36.2	556.7	859.3	184	0.26	0.00018	0.0026	0.28	0.47
		Average	8.0	6.3	8585	356.5	87	214.8	157.6	2594.5	4033.6	831	0.48	0.00032	0.0179	1.15	1.94
		P90	7.7	6.2	28009	215.4	251	564.5	510.2	8561.1	13322.8	2710	1.30	0.00064	0.0323	3.60	6.19
De Grey -Climate Change	Filling periods	Median	7.8	6.3	773	97.0	28	20.3	11.5	173.1	286.4	67	0.03	0.00002	0.0005	0.11	0.12
		Average	7.8	6.3	1006	135.8	28	41.1	14.6	223.4	353.0	95	0.23	0.00003	0.0007	0.13	0.15
		P90	7.5	6.2	1584	72.6	36	80.4	23.3	350.6	550.7	177	1.17	0.00006	0.0019	0.23	0.24
	Fallow periods	Median	8.0	6.3	2227	246.0	28	87.4	36.1	556.3	860.3	182	0.25	0.00017	0.0025	0.28	0.47
		Average	8.0	6.3	5514	293.9	56	154.9	98.9	1608.9	2499.5	533	0.43	0.00024	0.0072	0.73	1.24
		P90	7.8	6.2	16420	214.1	155	352.6	322.0	5192.0	8049.6	1619	0.84	0.00048	0.0168	2.41	4.08
Swan - Base Line	Filling periods	Median	7.8	6.3	810	105.3	35	18.3	11.5	179.1	283.4	64	0.01	0.00001	0.0019	0.10	0.13
		Average	7.8	6.3	1209	120.6	37	31.6	19.0	305.1	477.1	104	0.02	0.00001	0.0041	0.17	0.22
		P90	7.7	6.2	1588	73.9	50	56.5	25.1	371.0	615.5	139	0.05	0.00002	0.0091	0.21	0.32
	Fallow periods	Median	7.8	6.4	1538	148.6	48	38.4	24.3	384.1	594.6	124	0.09	0.00005	0.0101	0.19	0.33
		Average	7.8	6.4	3704	214.6	63	86.3	64.3	1063.2	1653.1	325	0.10	0.00006	0.0149	0.46	0.80
		P90	7.7	6.2	9683	108.2	119	216.0	174.4	2957.6	4605.8	876	0.15	0.00010	0.0249	1.20	2.10
Swan - High Seepage	Filling periods	Median	7.8	6.3	803	104.8	33	18.2	11.3	177.7	279.9	63	0.01	0.00001	0.0017	0.10	0.13
		Average	7.8	6.3	1228	123.8	37	33.8	19.2	308.1	481.7	109	0.02	0.00001	0.0035	0.18	0.21
		P90	7.7	6.2	1698	73.9	50	64.7	26.0	402.2	627.2	143	0.05	0.00002	0.0081	0.22	0.31
	Fallow periods	Median	7.8	6.4	1614	147.6	48	40.6	25.6	412.1	636.6	129	0.09	0.00005	0.0101	0.19	0.33
		Average	7.8	6.4	4551	234.9	74	101.3	80.2	1333.5	2074.0	405	0.10	0.00006	0.0178	0.57	0.99
		P90	7.7	6.2	10768	108.0	123	241.1	195.9	3305.7	5144.5	984	0.17	0.00011	0.0280	1.36	2.38
Swan -Climate Change	Filling periods	Median	7.8	6.3	815	106.6	35	18.3	11.7	175.9	282.9	65	0.01	0.00001	0.0018	0.11	0.13
		Average	7.8	6.4	1172	117.1	37	29.9	18.3	294.8	461.1	101	0.02	0.00001	0.0043	0.16	0.21
		P90	7.7	6.2	1568	73.2	50	48.9	24.8	368.8	611.9	129	0.05	0.00003	0.0102	0.21	0.31
	Fallow periods	Median	7.8	6.4	1588	149.3	48	40.0	25.2	398.2	618.1	127	0.09	0.00005	0.0093	0.18	0.33
		Average	7.8	6.4	3521	209.8	61	82.6	60.8	1004.8	1562.2	308	0.09	0.00005	0.0139	0.44	0.76
		P90	7.7	6.2	9831	107.6	111	220.6	177.1	3005.0	4679.7	889	0.14	0.00009	0.0246	1.22	2.13

Parameter			Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Unit			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
ANZECC 2000 Livestock Drinking Water Trigger Value (low risk)			-	0.01	1	0.4	1	2.0	-	0.002	-	0.15	-	1	-	0.1	0.02	-	-	-	-	-	0.2	-	20
De Grey - Base Line	Filling periods	Median	0	0.00000	0.0002	0.0030	0.0000	1.2	0.005	0	0.0348	0.0014	0.14	0.0022	0	0.00005	0.00397	8.6	0	0	0.2	0.000004	0.00018	0.00002	0.021
		Average	0	0.00001	0.0018	0.0035	0.0001	4.7	0.026	0	0.1306	0.0016	0.30	0.0043	0	0.00008	0.00397	22.8	0	0	0.2	0.000010	0.00026	0.00006	0.029
		P90	0	0.00002	0.0048	0.0079	0.0001	10.6	0.056	0	0.1820	0.0029	0.38	0.0093	0	0.00021	0.00650	46.6	0	0	0.4	0.000022	0.00046	0.00015	0.060
	Fallow periods	Median	0	0.00001	0.0011	0.0007	0.0000	11.1	0.051	0	0.1743	0.0065	0.56	0.0061	0	0.00030	0.00773	48.6	0	0	0.7	0.000052	0.00088	0.00000	0.078
		Average	0	0.00001	0.0016	0.0009	0.0001	12.2	0.059	0	0.2531	0.0151	1.39	0.0121	0	0.00057	0.01485	53.8	0	0	3.0	0.000074	0.00181	0.00001	0.171
		P90	0	0.00003	0.0038	0.0012	0.0001	15.4	0.107	0	0.5624	0.0549	4.86	0.0427	0	0.00146	0.04532	69.9	0	0	10.8	0.000172	0.00677	0.00002	0.519
De Grey - High Seepage	Filling periods	Median	0	0.00000	0.0002	0.0027	0.0000	1.2	0.005	0	0.0348	0.0013	0.14	0.0019	0	0.00005	0.00379	8.6	0	0	0.2	0.000003	0.00018	0.00002	0.019
		Average	0	0.00001	0.0016	0.0032	0.0001	4.7	0.023	0	0.1223	0.0016	0.30	0.0039	0	0.00008	0.00377	22.8	0	0	0.2	0.000008	0.00025	0.00005	0.029
		P90	0	0.00001	0.0035	0.0069	0.0001	10.6	0.040	0	0.1407	0.0029	0.38	0.0073	0	0.00022	0.00634	46.6	0	0	0.4	0.000016	0.00039	0.00010	0.061
	Fallow periods	Median	0	0.00001	0.0012	0.0007	0.0000	11.1	0.051	0	0.1739	0.0065	0.56	0.0062	0	0.00031	0.00767	48.7	0	0	0.7	0.000052	0.00087	0.00000	0.079
		Average	0	0.00002	0.0021	0.0021	0.0001	13.4	0.067	0	0.3151	0.0203	2.00	0.0168	0	0.00147	0.02146	59.3	0	0	3.3	0.000093	0.00250	0.00007	0.262
		P90	0	0.00004	0.0045	0.0014	0.0001	17.1	0.113	0	0.6832	0.0612	6.32	0.0449	0	0.00218	0.05215	76.6	0	0	11.6	0.000199	0.00719	0.00002	0.718
De Grey -Climate Change	Filling periods	Median	0	0.00000	0.0002	0.0040	0.0000	1.2	0.005	0	0.0335	0.0014	0.14	0.0024	0	0.00005	0.00442	8.7	0	0	0.2	0.000004	0.00018	0.00002	0.024
		Average	0	0.00001	0.0025	0.0044	0.0001	4.7	0.035	0	0.1526	0.0016	0.30	0.0055	0	0.00008	0.00450	22.8	0	0	0.2	0.000013	0.00028	0.00008	0.032
		P90	0	0.00003	0.0066	0.0095	0.0002	10.5	0.099	0	0.2997	0.0027	0.34	0.0153	0	0.00019	0.00681	46.6	0	0	0.4	0.000038	0.00048	0.00021	0.063
	Fallow periods	Median	0	0.00001	0.0011	0.0006	0.0000	11.1	0.049	0	0.1728	0.0066	0.56	0.0060	0	0.00028	0.00762	48.5	0	0	0.7	0.000051	0.00088	0.00000	0.078
		Average	0	0.00001	0.0016	0.0009	0.0001	12.1	0.059	0	0.2495	0.0140	1.30	0.0114	0	0.00053	0.01393	53.5	0	0	3.1	0.000073	0.00172	0.00001	0.158
		P90	0	0.00002	0.0032	0.0013	0.0001	14.6	0.087	0	0.4913	0.0458	4.01	0.0335	0	0.00122	0.03437	64.9	0	0	10.5	0.000154	0.00543	0.00002	0.424
Swan - Base Line	Filling periods	Median	0	0.00000	0.0001	0.0002	0.0000	1.4	0.004	0	0.0171	0.0012	0.15	0.0010	0	0.00009	0.00145	10.5	0	0	0.2	0.000001	0.00014	0.00001	0.017
		Average	0	0.00000	0.0001	0.0003	0.0000	3.3	0.009	0	0.0213	0.0018	0.24	0.0017	0	0.00016	0.00239	23.2	0	0	0.3	0.000007	0.00021	0.00002	0.034
		P90	0	0.00000	0.0002	0.0006	0.0001	8.1	0.018	0	0.0427	0.0026	0.38	0.0031	0	0.00026	0.00334	45.9	0	0	0.4	0.000014	0.00028	0.00004	0.054
	Fallow periods	Median	0	0.00000	0.0003	0.0001	0.0000	6.1	0.040	0	0.0599	0.0031	0.45	0.0042	0	0.00027	0.00415	46.4	0	0	0.4	0.000033	0.00033	0.00001	0.067
		Average	0	0.00000	0.0003	0.0002	0.0000	8.1	0.040	0	0.0645	0.0066	0.89	0.0074	0	0.00072	0.00912	49.9	0	0	1.3	0.000039	0.00074	0.00001	0.141
		P90	0	0.00000	0.0006	0.0004	0.0000	13.1	0.064	0	0.0980	0.0163	2.16	0.0158	0	0.00138	0.02120	59.7	0	0	3.3	0.000070	0.00184	0.00002	0.322
Swan - High Seepage	Filling periods	Median	0	0.00000	0.0001	0.0002	0.0000	1.4	0.004	0	0.0171	0.0012	0.14	0.0010	0	0.00009	0.00146	10.3	0	0	0.2	0.000002	0.00014	0.00001	0.017
		Average	0	0.00000	0.0001	0.0004	0.0000	3.5	0.008	0	0.0201	0.0018	0.23	0.0017	0	0.00016	0.00228	23.3	0	0	0.3	0.000006	0.00021	0.00003	0.034
		P90	0	0.00000	0.0002	0.0007	0.0001	9.9	0.017	0	0.0424	0.0026	0.36	0.0030	0	0.00030	0.00326	46.0	0	0	0.5	0.000014	0.00027	0.00004	0.057
	Fallow periods	Median	0	0.00000	0.0003	0.0001	0.0000	5.8	0.040	0	0.0601	0.0031	0.45	0.0041	0	0.00028	0.00404	46.4	0	0	0.5	0.000033	0.00034	0.00001	0.067
		Average	0	0.00000	0.0004	0.0002	0.0000	8.4	0.041	0	0.0694	0.0081	1.08	0.0087	0	0.00092	0.01071	51.8	0	0	1.5	0.000043	0.00091	0.00001	0.170
		P90	0	0.00000	0.0007	0.0005	0.0000	13.5	0.064	0	0.1076	0.0191	2.50	0.0185	0	0.00174	0.02485	64.4	0	0	4.7	0.000082	0.00214	0.00002	0.380
Swan -Climate Change	Filling periods	Median	0	0.00000	0.0001	0.0002	0.0000	1.5	0.004	0	0.0179	0.0012	0.15	0.0010	0	0.00009	0.00148	10.1	0	0	0.2	0.000001	0.00014	0.00002	0.017
		Average	0	0.00000	0.0001	0.0003	0.0000	3.2	0.009	0	0.0213	0.0018	0.23	0.0017	0	0.00015	0.00238	23.1	0	0	0.3	0.000007	0.00020	0.00003	0.032
		P90	0	0.00000	0.0002	0.0007	0.0001	6.2	0.019	0	0.0409	0.0026	0.38	0.0030	0	0.00022	0.00335	45.9	0	0	0.4	0.000015	0.00027	0.00004	0.051
	Fallow periods	Median	0	0.00000	0.0003	0.0001	0.0000	5.8	0.040	0	0.0618	0.0030	0.44	0.0041	0	0.00027	0.00406	46.3	0	0	0.5	0.000033	0.00032	0.00001	0.067
		Average	0	0.00000	0.0003	0.0002	0.0000	7.9	0.039	0	0.0630	0.0063	0.85	0.0071	0	0.00066	0.00868	49.4	0	0	1.2	0.000038	0.00070	0.00001	0.134
		P90	0	0.00000	0.0006	0.0005	0.0000	13.1	0.059	0	0.0945	0.0166	2.18	0.0161	0	0.00145	0.02240	58.5	0	0	3.4	0.000067	0.00187	0.00002	0.310

Table B.9 Comparison of In-Pit Water Quality Modelled Data to Human Health Screening Criteria

	Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO_4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
	Unit			pH Units	pe units	mg/L	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mgP/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Drinking water	ADWG Health (2011, updated 2022)			-	-	-	-	-	-	-	-	-	-	-	0.003	0.01	4	2	0.06	0.002	-	2	0.05	1.5	-	0.001	0.5	0.05	-	0.02	-	0.01	0.01	-	0.1	-	-	-	0.02	-	-
	ADWG Aesthetics (2011, updated 2022)			6.5-8.5	-	600	200	-	-	-	180	250	250	-	-	-	-	-	-	-	-	1	-	-	0.3	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	3
Recreation	ADWG Health (2011, updated 2022) (x10 for inorganics)			6.5-8.5	-	600	200	-	-	-	180	250	250	-	0.03	0.1	40	20	0.60	0.02	-	20	0.5	15	0.3	0.01	0.1	0.5	-	0.2	-	0.1	0.1	-	1	-	-	-	0.2	-	3
	De Grey - Base Line	Filling periods	Median	7.8	6.3	763	96	28	21	11	174	284	66	0.02	0.00001	0.00	0.11	0.12	0	0.000002	0.0002	0.0030	0.00003	1.2	0.005	0	0.03	0.0014	0.14	0.0022	0	0.00005	0.0040	8.6	0	0	0.2	0.000004	0.00018	0.000022	0.021
			Average	7.8	6.3	1011	136	28	41	15	225	356	94	0.17	0.00003	0.00	0.13	0.15	0	0.000008	0.0018	0.0035	0.00007	4.7	0.026	0	0.13	0.0016	0.30	0.0043	0	0.00008	0.0040	22.8	0	0	0.2	0.000010	0.00026	0.000059	0.029
			P90	7.6	6.2	1802	73	37	80	26	423	656	176	0.86	0.00006	0.00	0.24	0.28	0	0.000018	0.0048	0.0079	0.00013	10.6	0.056	0	0.18	0.0029	0.38	0.0093	0	0.00021	0.0065	46.6	0	0	0.4	0.000022	0.00046	0.000148	0.060
		Fallow periods	Median	8.0	6.3	2241	245	27	87	36	562	865	185	0.26	0.00018	0.00	0.28	0.47	0	0.000008	0.0011	0.0007	0.00004	11.1	0.051	0	0.17	0.0065	0.56	0.0061	0	0.00030	0.0077	48.6	0	0	0.7	0.000052	0.00088	0.000003	0.078
			Average	8.0	6.3	5958	299	61	169	107	1742	2708	600	0.46	0.00025	0.01	0.79	1.33	0	0.000012	0.0016	0.0009	0.00005	12.2	0.059	0	0.25	0.0151	1.39	0.0121	0	0.00057	0.0149	53.8	0	0	3.0	0.000074	0.00181	0.000011	0.171
			P90	7.7	6.2	19565	215	158	418	382	6188	9601	1919	1.07	0.00054	0.02	2.85	4.84	0	0.000029	0.0038	0.0012	0.00012	15.4	0.107	0	0.56	0.0549	4.86	0.0427	0	0.00146	0.0453	69.9	0	0	10.8	0.000172	0.00677	0.000016	0.519
	De Grey - High Seepage	Filling periods	Median	7.8	6.3	762	96	28	21	11	173	286	66	0.02	0.00001	0.00	0.11	0.12	0	0.000002	0.0002	0.0027	0.00003	1.2	0.005	0	0.03	0.0013	0.14	0.0019	0	0.00005	0.0038	8.6	0	0	0.2	0.000003	0.00018	0.000023	0.019
			Average	7.8	6.3	1012	137	28	41	15	225	356	94	0.15	0.00003	0.00	0.13	0.15	0	0.000007	0.0016	0.0032	0.00006	4.7	0.023	0	0.12	0.0016	0.30	0.0039	0	0.00008	0.0038	22.8	0	0	0.2	0.000008	0.00025	0.000053	0.029
			P90	7.6	6.2	1798	73	36	80	26	421	654	176	0.52	0.00006	0.00	0.24	0.28	0	0.000014	0.0035	0.0069	0.00011	10.6	0.040	0	0.14	0.0029	0.38	0.0073	0	0.00022	0.0063	46.6	0	0	0.4	0.000016	0.00039	0.000103	0.061
		Fallow periods	Median	8.0	6.3	2238	245	27	87	36	557	859	184	0.26	0.00018	0.00	0.28	0.47	0	0.000010	0.0012	0.0007	0.00004	11.1	0.051	0	0.17	0.0065	0.56	0.0062	0	0.00031	0.0077	48.7	0	0	0.7	0.000052	0.00087	0.000003	0.079
			Average	8.0	6.3	8585	357	87	215	158	2594	4034	831	0.48	0.00032	0.02	1.15	1.94	0	0.000018	0.0021	0.0021	0.00007	13.4	0.067	0	0.32	0.0203	2.00	0.0168	0	0.00147	0.0215	59.3	0	0	3.3	0.000093	0.00250	0.000072	0.262
			P90	7.7	6.2	28009	215	251	565	510	8561	13323	2710	1.30	0.00064	0.03	3.60	6.19	0	0.000043	0.0045	0.0014	0.00014	17.1	0.113	0	0.68	0.0612	6.32	0.0449	0	0.00218	0.0521	76.6	0	0	11.6	0.000199	0.00719	0.000024	0.718
	De Grey -Climate Change	Filling periods	Median	7.8	6.3	775	97	28	20	12	173	286	67	0.03	0.00002	0.00	0.11	0.12	0	0.000002	0.0002	0.0040	0.00004	1.2	0.005	0	0.03	0.0014	0.14	0.0024	0	0.00005	0.0040	8.7	0	0	0.2	0.000004	0.00018	0.000023	0.024
			Average	7.8	6.3	1006	136	28	41	15	223	353	95	0.23	0.00003	0.00	0.13	0.15	0	0.000011	0.0025	0.0044	0.00009	4.7	0.035	0	0.15	0.0016	0.30	0.0055	0	0.00008	0.0045	22.8	0	0	0.2	0.000013	0.00028	0.000079	0.032
			P90	7.5	6.2	1384	73	36	80	23	351	551	177	1.17	0.00006	0.00	0.23	0.28	0	0.000032	0.0066	0.0095	0.00020	10.5	0.099	0	0.30	0.0027	0.54	0.0175	0	0.00019	0.0068	46.6	0	0	0.4	0.000038	0.00048	0.000211	0.063
		Fallow periods	Median	8.0	6.3	2227	246	28	87	36	556	860	182	0.25	0.00017	0.00	0.28	0.47	0	0.000007	0.0011	0.0006	0.00004	11.1	0.049	0	0.17	0.0066	0.56	0.0060	0	0.00028	0.0076	48.5	0	0	0.7	0.000051	0.00088	0.000003	0.078
			Average	8.0	6.5	5318	204	56	135	99	1600	2499	525	0.43	0.00024	0.01	0.75	1.20	0	0.000010	0.0016	0.0009	0.00005	12.1	0.059	0	0.25	0.0140	1.30	0.0114	0	0.00053	0.0170	55.5	0	0	3.1	0.000073	0.00172	0.000010	0.158
			P90	7.8	6.2	16420	214	155	355	322	5192	8050	1619	0.84	0.00048	0.02	2.41	4.00	0	0.000023	0.0032	0.0013	0.00010	14.4	0.087	0	0.49	0.0458	4.01	0.0375	0	0.00122	0.0340	64.9	0	0	10.5	0.000154	0.00543	0.000016	0.424
	Swan - Base Line	Filling periods	Median	7.8	6.3	810	103	35	18	12	179	283	64	0.03	0.00001	0.00	0.10	0.13	0	0.000000	0.0003	0.0002	0.00003	1.4	0.004	0	0.02	0.0012	0.15	0.0010	0	0.00009	0.0015	10.5	0	0	0.2	0.000003	0.00014	0.000014	0.017
			Average	7.8	6.3	1209	121	37	32	19	305	477	100	0.02	0.00001	0.00	0.17	0.22	0	0.000000	0.0001	0.0003	0.00003	3.5	0.009	0	0.02	0.0018	0.24	0.0017	0	0.00016	0.0026	25.2	0	0	0.3	0.000007	0.00021	0.000019	0.034
			P90	7.7	6.2	1588	74	50	57	25	371	614	159	0.05	0.00002	0.00	0.21	0.32	0	0.000000	0.0001	0.0006	0.00005	8.1	0.018	0	0.04	0.0026	0.38	0.0033	0	0.00026	0.0033	45.9	0	0	0.6	0.000014	0.00028	0.000035	0.054
		Fallow periods	Median	7.8	6.4	1708	149	48	58	28	384	595	124	0.09	0.00005	0.01	0.19	0.33	0	0.000001	0.0003	0.0003	0.00003	4.1	0.040	0	0.06	0.0051	0.45	0.0042	0	0.00027	0.0042	46.4	0	0	0.6	0.000033	0.00053	0.000006	0.067
			Average	7.8	6.4	3708	215	63	86	64	1063	1633	325	0.10	0.00006	0.01	0.46	0.80	0	0.000003	0.0003	0.0002	0.00002	4.3	0.040	0	0.06	0.0066	0.99	0.0074	0	0.00072	0.0091	49.9	0	0	1.3	0.000039	0.00074	0.000013	0.141
			P90	7.7	6.2	9683	198	119	216	174	2939	4660	876	0.13	0.00010	0.02	1.20	2.20	0	0.000005	0.0006	0.0004	0.00004	11.1	0.064	0	0.10	0.0163	2.16	0.0158	0	0.00158	0.0271	59.7	0	0	3.3	0.000079	0.00184	0.000021	0.322
	Swan - High Seepage	Filling periods	Median	7.9	6.3	801	105	35	18	11	178	280	61	0.03	0.00001	0.00	0.10	0.13	0	0.000000	0.0001	0.0002	0.00003	1.4	0.004	0	0.02	0.0012	0.14	0.0010	0	0.00009	0.0015	10.5	0	0	0.2	0.000003	0.00014	0.000014	0.017
			Average	7.8	6.3	1228	124	37	34	19	308	482	100	0.02	0.00001	0.00	0.18	0.23	0	0.000000	0.0001	0.0004	0.00005	3.2	0.008	0	0.02	0.0018	0.23	0.0017	0	0.00016	0.0025	25.3	0	0	0.3	0.000006	0.00021	0.000028	0.034
			P90	7.7	6.2	1698	74	50	65	26	402	627	143	0.05	0.00002	0.00	0.22	0.31	0	0.000000	0.0002	0.0007	0.00009	9.9	0.017	0	0.04	0.0026	0.36	0.0030	0	0.00030	0.0033	46.0	0	0	0.5	0.000014	0.00027	0.000033	0.057
		Fallow periods	Median	7.8	6.4	1614	158	48	41	26	412	637	129	0.09	0.00005	0.01	0.19	0.33	0	0.000001	0.0003	0.0001	0.00001	3.6	0.040	0	0.06	0.0051	0.45	0.0041	0	0.00028	0.0040	46.4	0	0	0.5	0.000033	0.00054	0.000007	0.067
			Average	7.8	6.4	4551	255	74	101	80	1333	2074	405	0.10	0.00006	0.01	0.57	0.99	0	0.000003	0.0004	0.0002	0.00002	4.6	0.041	0	0.07	0.0081	1.08	0.0087	0	0.00092	0.0107	51.6	0	0	1.5	0.000043	0.00091	0.000013	0.170
			P90	7.7	6.2	10788	198	133	241	196	3306	5165	984	0.17	0.00011	0.02	1.36	2.48	0	0.000002	0.0007	0.0005	0.00004	11.9	0.064	0	0.11	0.0191	2.50	0.0185	0	0.00178	0.0308	64.0	0	0	4.7	0.000082	0.00218	0.000023	0.380
	Swan -Climate Change	Filling periods	Median	7.8	6.3	815	107	35	18	12	178	283	65	0.03	0.00001	0.00	0.11	0.13	0	0.000000	0.0001	0.0002	0.00005	1.5	0.004	0	0.02	0.0012	0.15	0.0010	0	0.00009	0.0015	10.1	0	0	0.2	0.000003	0.00014	0.000015	0.017
			Average	7.8	6.3	1175	117	37	30	18	295	461	101	0.02	0.00001	0.00	0.16	0.21	0	0.000000	0.0001	0.0002	0.00004	3.2	0.009	0	0.02	0.0018	0.23	0.0017	0	0.00015	0.0024	23.1	0	0	0.3	0.000007	0.00020	0.000020	0.032
			P90	7.7	6.2	1568	75	50	49	25	369	613	129	0.05	0.00003	0.01	0.21	0.32	0	0.000000	0.0002	0.0007	0.00005	8.2	0.019	0	0.04	0.0026	0.38	0.0030	0	0.00022	0.0033	45.9	0	0	0.6	0.000015	0.00027	0.000035	0.053
		Fallow periods	Median	7.8	6.4	1586	149	48	40	25	398	614	127	0.09	0.00005	0.01	0.18	0.33	0	0.000001	0.0003	0.0001	0.00001	3.8	0.040	0	0.06	0.0050	0.44	0.0041	0	0.00027	0.0041	46.3	0	0	0.5	0.000033	0.00052	0.000006	0.067
			Average	7.8	6.4	3522	210	61	83	61	1005	1562	308	0.09	0.00005	0.01	0.44	0.76	0	0.000003	0.0003	0.0002	0.00002	7.9	0.039	0	0.06	0.0063	0.95	0.0071	0	0.00066	0.0087	49.4	0	0	1.2	0.000038	0.00070	0.000011	0.134
			P90	7.7	6.2	9821	188	111	221	177	2995	4600	889	0.14	0.00009	0.01	1.22	2.13	0	0.000001	0.0006	0.0005	0.00004	12.1	0.059	0	0.09	0.0166	2.18	0.0161	0	0.00145	0.0259	58.5	0	0	3.6	0.000067	0.00187	0.000020	0.319

Table B.10 - Comparison of Downstream Water Quality Modelled Data to Screening Criteria

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO_4	Al	Sb	As	B
Unit			pH Units	pe units	mg/L	mg/L as $CaCO_3$	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Groundwater (and GDEs)	Shovelana SSTVs (HGG, 2023)		6.0-8.5	-	804.00	-	-	-	-	-	-	88.00	0.06	0.001	0.01	0.37
	Golder (2015)		6.0-8.5	-	1150.00	-	-	-	-	-	-	-	0.06	0.001	0.01	0.61
	Drinking water guidelines health (ADWG, 2011)		-	-	600.00	200.00	-	-	-	180.00	250.00	250.00	-	0.003	0.01	4.00
NCCS - Base Seepage	Initial Condition	Median	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		Average	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		P90	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
	First Filling Seepage	Median	7.6	4.8	738	206	45	53	13	86	177	75	0.0003	1.32E-07	0.0001	0.20
		Average	7.6	4.8	740	205	45	53	13	86	177	75	0.0005	2.15E-07	0.0001	0.20
		P90	7.6	4.9	748	202	46	54	13	88	179	77	0.0012	4.61E-07	0.0001	0.20
	Sustained Seepage	Median	7.6	4.8	747	209	45	55	13	84	175	77	0.0014	7.28E-07	0.0001	0.21
		Average	7.6	4.8	754	210	45	55	13	86	179	78	0.0013	7.15E-07	0.0001	0.21
		P90	7.6	4.8	774	208	45	56	13	93	189	80	0.0024	1.33E-06	0.0002	0.21
NCCS - High Seepage	Initial Condition	Median	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		Average	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		P90	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
	First Filling Seepage	Median	7.6	4.9	739	202	46	50	13	90	181	74	0.0004	2.38E-07	0.0001	0.19
		Average	7.6	4.8	744	203	46	51	13	90	181	75	0.0009	4.30E-07	0.0001	0.19
		P90	7.6	4.9	761	198	46	54	13	94	186	78	0.0019	1.10E-06	0.0001	0.20
	Sustained Seepage	Median	7.6	4.8	752	209	45	55	13	86	178	77	0.0025	1.28E-06	0.0002	0.21
		Average	7.6	4.8	782	209	45	55	13	95	193	80	0.0023	1.36E-06	0.0003	0.21
		P90	7.6	4.8	836	208	46	57	15	113	220	85	0.0042	2.47E-06	0.0004	0.22
CCS - Base Seepage	Initial Condition	Median	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		Average	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
		P90	7.6	4.8	739	211	45	56	13	79	170	77	0	0	0	0.21
	First Filling Seepage	Median	7.6	4.8	738	206	45	53	13	86	177	75	0.0004	1.35E-07	0.0001	0.20
		Average	7.6	4.8	740	205	45	53	13	86	177	75	0.0006	2.16E-07	0.0001	0.20
		P90	7.6	4.9	747	202	46	54	13	88	179	77	0.0012	4.76E-07	0.0001	0.20
	Sustained Seepage	Median	7.6	4.8	747	209	45	55	13	84	175	77	0.0013	7.33E-07	0.0001	0.21
		Average	7.6	4.8	754	210	45	55	13	86	179	78	0.0012	6.97E-07	0.0001	0.21
		P90	7.6	4.8	772	208	45	56	13	92	188	79	0.0023	1.31E-06	0.0002	0.21

Parameter			Ba	Cd	Co	Cu	Cr	F	Fe	Mn	Mo	Total Nitrogen	Ni	Pb	Se	Si	Sr	Tl	U	V	Zn
Unit			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Groundwater (and GDEs)	Shovelana SSTVs (HGG, 2023)		0.03	0.001	0.001	0.001	0.01	-	0.03	1.90	0.001	-	0.07	0.06	0.01	-	-	-	-	-	0.05
	Golder (2015)		0.01	0.0002	0.001	0.01	0.01	-	0.10	1.90	0.01	-	0.01	0.003	0.01	-	-	-	-	-	0.02
	Drinking water guidelines health (ADWG, 2011)		2.00	0.002	-	2.00	0.05	1.50	0.30	0.50	0.05	-	0.02	0.01	0.01	-	-	-	0.02	-	3*
NCCS - Base Seepage	Initial Condition	Median	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		Average	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		P90	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
	First Filling Seepage	Median	0.035	0	1.02E-06	4.97E-06	9.73E-08	0.4	0.001	0.0014	0.0001	0.2318	4.19E-05	0.00000	0.00010	8.3	0.014	3.63E-08	0.00001	0	0.001
		Average	0.035	0	1.57E-06	1.58E-05	1.18E-07	0.4	0.001	0.0011	0.0001	0.2314	4.42E-05	0.00000	0.00010	8.5	0.015	1.12E-07	0.00001	0	0.001
		P90	0.038	0	2.99E-06	4.32E-05	2.65E-07	0.5	0.001	0.0020	0.0001	0.2369	8.24E-05	0.00001	0.00014	8.9	0.020	3.29E-07	0.00001	0	0.002
	Sustained Seepage	Median	0.033	0	4.38E-06	2.04E-06	8.00E-08	0.4	0.001	0.0009	0.0001	0.2409	6.98E-05	0.00000	0.00008	9.0	0.008	4.59E-07	0.00001	0	0.001
		Average	0.034	0	4.48E-06	2.44E-06	8.53E-08	0.4	0.001	0.0008	0.0001	0.2418	7.72E-05	0.00000	0.00009	8.9	0.011	4.54E-07	0.00001	0	0.001
		P90	0.039	0	8.20E-06	4.35E-06	1.36E-07	0.5	0.001	0.0016	0.0001	0.2465	1.22E-04	0.00001	0.00014	9.2	0.019	9.17E-07	0.00001	0	0.002
NCCS - High Seepage	Initial Condition	Median	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		Average	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		P90	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
	First Filling Seepage	Median	0.039	0	1.57E-06	7.79E-06	1.76E-07	0.4	0.001	0.0019	0.0001	0.2287	5.96E-05	0.00001	0.00015	8.3	0.022	7.49E-08	0.00001	0	0.001
		Average	0.039	0	2.96E-06	2.62E-05	1.89E-07	0.5	0.001	0.0019	0.0001	0.2281	7.18E-05	0.00001	0.00016	8.7	0.023	2.38E-07	0.00001	0	0.002
		P90	0.043	0	6.55E-06	7.44E-05	3.48E-07	0.6	0.001	0.0034	0.0001	0.2380	1.36E-04	0.00001	0.00021	9.9	0.031	5.67E-07	0.00002	0	0.003
	Sustained Seepage	Median	0.035	0	8.16E-06	3.99E-06	1.44E-07	0.5	0.001	0.0017	0.0001	0.2415	1.10E-04	0.00001	0.00013	9.4	0.011	8.57E-07	0.00001	0	0.002
		Average	0.042	0	8.49E-06	4.66E-06	1.59E-07	0.5	0.001	0.0015	0.0001	0.2470	1.51E-04	0.00001	0.00018	9.3	0.024	8.60E-07	0.00001	0	0.003
		P90	0.054	0	1.50E-05	8.60E-06	2.54E-07	0.7	0.001	0.0028	0.0002	0.2593	2.69E-04	0.00001	0.00034	9.8	0.051	1.65E-06	0.00003	0	0.005
CCS - Base Seepage	Initial Condition	Median	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		Average	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
		P90	0.028	0	0	0	0	0.3	0.001	0	0	0.2410	0	0	0	8.3	0	0	0	0	0
	First Filling Seepage	Median	0.035	0	1.18E-06	5.76E-06	1.02E-07	0.4	0.001	0.0014	0.0001	0.2318	4.25E-05	0.00000	0.00009	8.3	0.013	3.76E-08	0.00001	0	0.001
		Average	0.035	0	1.70E-06	1.63E-05	1.25E-07	0.4	0.001	0.0011	0.0001	0.2315	4.47E-05	0.00000	0.00010	8.5	0.015	1.15E-07	0.00001	0	0.001
		P90	0.038	0	3.50E-06	4.36E-05	2.69E-07	0.5	0.001	0.0020	0.0001	0.2366	8.26E-05	0.00001	0.00014	9.0	0.020	3.60E-07	0.00001	0	0.002
	Sustained Seepage	Median	0.033	0	4.45E-06	2.04E-06	8.32E-08	0.4	0.001	0.0009	0.0001	0.2408	6.72E-05	0.00000	0.00008	9.0	0.008	4.87E-07	0.00001	0	0.001
		Average	0.034	0	4.42E-06	2.43E-06	8.68E-08	0.4	0.001	0.0008	0.0001	0.2416	7.59E-05	0.00000	0.00009	8.9	0.011	4.50E-07	0.00001	0	0.001
		P90	0.038	0	7.91E-06	4.21E-06	1.34E-07	0.5	0.001	0.0015	0.0001	0.2458	1.27E-04	0.00001	0.00014	9.2	0.018	9.05E-07	0.00001	0	0.002

A= TDS SSTV is calculated, EC, is converted to TDS using an approximate conversion factor of 0.67

B = Alkalinity exceedances are noted but are not significant, being less than 1% of the guideline value (based on potential scaling of pipes).

C = Al value based on pH>6.5

D = As value based on As5+ criteria

E = Cr value based on Cr6+ criteria

F = NO_3 value from ANZECC and ARMCANZ (2000) was erroneous (ANZG, 2018). Therefore, this value has not been adopted in this screening assessment.

G = SO4 TV based on 90th Percentile from monitoring data from OB31

Appendix C

Hazard Quotient Calculations

Table C.1
Groundwater HQ Calculations - De Grey

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4
Lowest Criteria			6		430							
De Grey - Base Line	Filling periods	Average	7.812372	6.305121	1010.967	136.4734	28.25646	41.16155	14.62731	225.0346	355.5985	94.45524
		HQ	1.302062		2.351087							
		90th Percentile	7.582001	6.236972	1802.36	72.8621	36.7913	80.1467	25.7278	422.654	656.247	175.806
		HQ	1.263667		4.191535							
De Grey - High Seepage	Filling periods	Average	7.817555	6.30486	1011.878	136.5686	28.25173	41.18643	14.64005	225.3814	356.2313	94.20965
		HQ	1.302926		2.353206							
		90th Percentile	7.616247	6.236972	1798.05	72.8531	36.1936	80.3286	25.6463	421.403	654.301	176.091
		HQ	1.269375		4.181512							
De Grey -Climate Change	Filling periods	Average	7.797279	6.312318	1005.978	135.8095	28.17056	41.05649	14.55749	223.4333	352.9598	94.98588
		HQ	1.299547		2.339484							
		90th Percentile	7.498732	6.236972	1583.73	72.5977	36.0643	80.3773	23.3016	350.618	550.685	177.009
		HQ	1.249789		3.683093							
De Grey - Base Line	Fallow periods	Average	7.967671	6.26677	762.61	96.443	27.8135	20.6635	11.437	173.61	283.79	65.812
		HQ	1.327945		1.773512							
		90th Percentile	7.72535	6.236972	19565.1	215.248	157.909	418.042	381.58	6188.15	9600.69	1918.9
		HQ	1.287558		45.50023							
De Grey - High Seepage	Fallow periods	Average	7.953056	6.336871	8585.263	356.5453	86.83241	214.824	157.5746	2594.476	4033.551	831.3832
		HQ	1.325509		19.96573							
		90th Percentile	7.699612	6.236972	28009	215.351	250.61	564.525	510.183	8561.08	13322.8	2709.73
		HQ	1.283269		65.13721							
De Grey -Climate Change	Fallow periods	Average	7.974495	6.330529	5514.203	293.8519	56.03691	154.9424	98.93797	1608.867	2499.469	532.9272
		HQ	1.329082		12.82373							
		90th Percentile	7.771239	6.236972	16420	214.117	154.666	352.59	322.02	5192	8049.6	1619.4
		HQ	1.295207		38.18605							

Parameter			Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn
Lowest Criteria			0.055	0.001	0.013	0.37	0.01	0.01	0.0002	0.001	0.0014	0.006		0.03	0.0006	1.9
De Grey - Base Line	Filling periods	Average	0.17287	2.71E-05	0.000711	0.134211	0.151858		8.35E-06	0.001807	0.003534	6.63E-05	4.665475	0.026343		0.130588
		HQ	3.143082	0.027063	0.054668	0.362733	15.18585		0.041728	1.807399	2.524423	0.011057		0.878105		0.06873
		90th Percentile	0.858364	5.63E-05	0.002089	0.242846	0.284029		1.85E-05	0.004802	0.007915	0.000127	10.6157	0.05617		0.181958
		HQ	15.60662	0.056323	0.160693	0.656341	28.4029		0.092302	4.80177	5.653629	0.021163		1.872317		0.095767
De Grey - High Seepage	Filling periods	Average	0.152818	2.68E-05	0.000737	0.134456	0.152067		7.49E-06	0.001555	0.003212	6.01E-05	4.664838	0.023468		0.122303
		HQ	2.778514	0.02683	0.056716	0.363395	15.20667		0.037425	1.554553	2.294612	0.010015		0.782264		0.06437
		90th Percentile	0.520156	5.58E-05	0.002212	0.242946	0.283088		1.45E-05	0.003511	0.006943	0.000109	10.6254	0.039782		0.140698
		HQ	9.457382	0.055774	0.170122	0.656611	28.3088		0.072458	3.511	4.958979	0.018244		1.326057		0.074052
De Grey -Climate Change	Filling periods	Average	0.229913	2.9E-05	0.000688	0.133479	0.150771		1.12E-05	0.002524	0.004388	8.68E-05	4.661561	0.034801		0.152604
		HQ	4.180245	0.028951	0.052927	0.360753	15.07708		0.055873	2.524045	3.134621	0.014469		1.160044		0.080318
		90th Percentile	1.16753	6.42E-05	0.001891	0.229012	0.241667		3.17E-05	0.006634	0.009527	0.000197	10.5365	0.098518		0.299678
		HQ	21.22782	0.064212	0.145468	0.618951	24.1667		0.158486	6.63402	6.804793	0.03287		3.28392		0.157725
De Grey - Base Line	Fallow periods	Average	0.023995	1.45E-05	0.00049	0.10665	0.12197		2.05E-06	0.000204	0.003038	3.46E-05	1.22445	0.004591		0.034843
		HQ	0.436264	0.014533	0.037685	0.288243	12.197		0.010275	0.20371	2.170286	0.005768		0.153017		0.018338
		90th Percentile	1.07408	0.000536	0.020296	2.8493	4.8387		2.9E-05	0.00383	0.001195	0.000121	15.4211	0.107304		0.562416
		HQ	19.52873	0.536209	1.561231	7.700811	483.87		0.144761	3.82976	0.85335	0.02023		3.5768		0.296008
De Grey - High Seepage	Fallow periods	Average	0.481541	0.000315	0.017887	1.146796	1.939908		1.83E-05	0.002107	0.002112	7.06E-05	13.42138	0.067438		0.315122
		HQ	8.75529	0.315075	1.375904	3.099449	193.9908		0.09175	2.107276	1.508387	0.01176		2.247943		0.165854
		90th Percentile	1.30244	0.000643	0.032252	3.60399	6.19348		4.3E-05	0.004503	0.001357	0.000135	17.0688	0.11263		0.683168
		HQ	23.68073	0.643387	2.480946	9.740514	619.348		0.21499	4.50326	0.969114	0.022524		3.754333		0.359562
De Grey -Climate Change	Fallow periods	Average	0.430486	0.000243	0.007184	0.731923	1.23534		1.04E-05	0.001603	0.000902	5.46E-05	12.09867	0.058537		0.249547
		HQ	7.827012	0.243216	0.552579	1.978171	123.534		0.051908	1.602926	0.644188	0.0091		1.95125		0.13134
		90th Percentile	0.835396	0.000484	0.016815	2.4055	4.0844		2.08E-05	0.003224	0.001344	9.96E-05	14.577	0.087002		0.491325
		HQ	15.18902	0.484128	1.293438	6.501351	408.44		0.103829	3.22441	0.959714	0.016605		2.900067		0.258592

Parameter			Mo	otal Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			0.001		0.011	0.05	0.0034	0.011		0.00005	0.001					0.024
De Grey - Base Line	Filling periods	Average	0.00160627	0.30086	0.004341		7.74E-05	0.003965	22.78928			0.242685	9.54E-06	0.000257	5.89E-05	0.029491
		HQ	1.606274		0.394656		0.022777	0.360474								1.228777
		90th Percentile	0.00290369	0.377999	0.00929		0.000207	0.0065	46.6114			0.444668	2.2E-05	0.000465	0.000148	0.060271
		HQ	2.90369		0.844542		0.061028	0.590879								2.5113
De Grey - High Seepage	Filling periods	Average	0.00160771	0.30087	0.003945		7.97E-05	0.003772	22.78364			0.242801	8.37E-06	0.000247	5.28E-05	0.028769
		HQ	1.60771113		0.358666		0.023442	0.342944								1.198695
		90th Percentile	0.00289086	0.377511	0.007322		0.000217	0.006337	46.6046			0.443324	1.59E-05	0.000395	0.000103	0.060894
		HQ	2.89086		0.665672		0.063808	0.576124								2.537246
De Grey -Climate Change	Filling periods	Average	0.00161123	0.299585	0.005481		7.57E-05	0.004497	22.76925			0.241146	1.33E-05	0.000282	7.95E-05	0.031506
		HQ	1.61123425		0.498294		0.022264	0.40882								1.312765
		90th Percentile	0.00267975	0.338046	0.015299		0.000193	0.006807	46.5873			0.396693	3.77E-05	0.000479	0.000211	0.063212
		HQ	2.67975		1.390809		0.056854	0.618824								2.633829
De Grey - Base Line	Fallow periods	Average	0.00135135	0.135849	0.002167		4.83E-05	0.003971	8.6457			0.191975	3.51E-06	0.000183	2.22E-05	0.020533
		HQ	1.35135		0.196964		0.014191	0.361								0.855521
		90th Percentile	0.054862	4.855857	0.042659		0.001458	0.045323	69.864			10.8398	0.000172	0.006774	1.58E-05	0.51872
		HQ	54.862		3.878091		0.428676	4.120273								21.61333
De Grey - High Seepage	Fallow periods	Average	0.02030674	2.002758	0.016846		0.00147	0.021456	59.3043			3.282438	9.27E-05	0.002501	7.19E-05	0.261907
		HQ	20.3067411		1.531422		0.432404	1.950588								10.91279
		90th Percentile	0.0612031	6.323877	0.044879		0.002178	0.052147	76.6212			11.607	0.000199	0.007191	2.42E-05	0.71765
		HQ	61.2031		4.079909		0.64045	4.740645								29.90208
De Grey -Climate Change	Fallow periods	Average	0.01402146	1.299003	0.011386		0.000533	0.013927	53.46009			3.058046	7.33E-05	0.001719	9.81E-06	0.158446
		HQ	14.0214608		1.035071		0.156628	1.266077								6.601931
		90th Percentile	0.0458263	4.007415	0.03354		0.001217	0.034373	64.9221			10.5004	0.000154	0.005428	1.6E-05	0.42413
		HQ	45.8263		3.049091		0.357906	3.124818								17.67208

Groundwater HQ Calculations - Swan

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4
Lowest Criteria			6		430							
Swan - Base Line	Filling periods	Average	7.793157	6.345817	1208.638	120.5747	37.33328	31.63374	18.95317	305.0659	477.0869	104.401
		HQ	1.298859		2.810786							
		90th Percentile	7.682797	6.236972	1587.65	73.916	50.3199	56.5492	25.1236	370.965	615.527	138.787
		HQ	1.280466		3.692209							
Swan - High Seepage	Filling periods	Average	7.798996	6.336314	1227.862	123.7945	37.09409	33.80398	19.1879	308.1113	481.6586	109.4676
		HQ	1.299833		2.855493							
		90th Percentile	7.681231	6.236972	1697.81	73.8573	50.1615	64.6988	25.9669	402.21	627.168	142.607
		HQ	1.280205		3.948395							
Swan -Climate Change	Filling periods	Average	7.786382	6.350507	1172.336	117.0674	37.46864	29.92809	18.33696	294.8073	461.0858	101.2331
		HQ	1.29773		2.726364							
		90th Percentile	7.674338	6.236972	1568.46	73.1593	49.9634	48.9152	24.7955	368.772	611.896	128.836
		HQ	1.279056		3.647581							
Swan - Base Line	Fallow periods	Average	7.832163	6.425893	3704.352	214.572	62.79733	86.27361	64.31119	1063.208	1653.102	325.3194
		HQ	1.305361		8.614772							
		90th Percentile	7.730923	6.236972	9682.96	108.184	118.71	216.024	174.356	2957.6	4605.79	875.61
		HQ	1.288487		22.51851							
Swan - High Seepage	Fallow periods	Average	7.819581	6.428821	4550.822	234.9312	73.91965	101.3335	80.21045	1333.454	2073.972	404.9175
		HQ	1.303264		10.58331							
		90th Percentile	7.724812	6.236972	10768	108.035	123.168	241.12	195.882	3305.74	5144.51	984.029
		HQ	1.287469		25.04186							
Swan -Climate Change	Fallow periods	Average	7.833114	6.42959	3520.82	209.8336	60.92065	82.5528	60.8474	1004.834	1562.238	307.855
		HQ	1.305519		8.187955							
		90th Percentile	7.729618	6.236972	9831.22	107.555	110.72	220.631	177.116	3005.02	4679.66	889.206
		HQ	1.28827		22.8633							

Parameter			Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn
Lowest Criteria			0.055	0.001	0.013	0.37	0.01	0.01	0.0002	0.001	0.0014	0.006		0.03	0.0006	1.9
Swan - Base Line	Filling periods	Average	0.021584	1.17E-05	0.004119	0.165629	0.215882		1.46E-07	7.98E-05	0.000283	3.28E-05	3.349151	0.00919		0.021272
		HQ	0.392434	0.011682	0.316868	0.447647	21.58816	0	0.000731	0.079788	0.201816	0.005463		0.306334	0	0.011196
		90th Percentile	0.048189	2.5E-05	0.009125	0.208418	0.31555		2.61E-07	0.000159	0.000589	5.16E-05	8.06359	0.01842		0.042652
		HQ	0.876164	0.024961	0.701889	0.563292	31.555	0	0.001303	0.159071	0.420408	0.008597		0.614007	0	0.022448
Swan - High Seepage	Filling periods	Average	0.020469	1.06E-05	0.003508	0.180475	0.211407		2.68E-07	9.82E-05	0.000366	4.65E-05	3.475738	0.008274		0.020121
		HQ	0.372155	0.010596	0.269832	0.487771	21.14069	0	0.001342	0.098159	0.261301	0.007748		0.275795	0	0.01059
		90th Percentile	0.048766	2.41E-05	0.008123	0.215402	0.31025		2.59E-07	0.000174	0.000696	5.49E-05	9.88168	0.017359		0.042432
		HQ	0.886656	0.024064	0.624848	0.582168	31.025	0	0.001294	0.173802	0.497379	0.009144		0.578643	0	0.022333
Swan -Climate Change	Filling periods	Average	0.021912	1.15E-05	0.0043	0.160951	0.208465		2.76E-07	0.000101	0.000341	3.8E-05	3.198062	0.009071		0.021307
		HQ	0.398404	0.011546	0.330733	0.435004	20.84648	0	0.001378	0.10137	0.243625	0.006336		0.302352	0	0.011214
		90th Percentile	0.053852	2.66E-05	0.010179	0.208446	0.31024		3.51E-07	0.000191	0.000664	5.01E-05	6.21109	0.018866		0.040888
		HQ	0.979127	0.026561	0.783035	0.563368	31.024	0	0.001755	0.191436	0.473934	0.008354		0.62885	0	0.02152
Swan - Base Line	Fallow periods	Average	0.09612	5.55E-05	0.014893	0.459594	0.801038		7.01E-07	0.000341	0.000213	2.09E-05	8.052613	0.039642		0.064522
		HQ	1.74763	0.055511	1.145652	1.242147	80.10382	0	0.003507	0.340723	0.152433	0.003477		1.321395	0	0.033959
		90th Percentile	0.151763	9.8E-05	0.024948	1.19952	2.09894		1.25E-06	0.00058	0.000449	3.55E-05	13.1351	0.063565		0.098042
		HQ	2.759327	0.097974	1.919077	3.241946	209.894	0	0.006227	0.58029	0.320764	0.005922		2.118823	0	0.051601
Swan - High Seepage	Fallow periods	Average	0.104008	6.08E-05	0.017793	0.568757	0.992062		7.96E-07	0.000381	0.000235	2.29E-05	8.364499	0.041346		0.06939
		HQ	1.891057	0.060833	1.368685	1.537182	99.2062	0	0.003979	0.381303	0.167924	0.003825		1.378199	0	0.036521
		90th Percentile	0.1675	0.000108	0.028009	1.35626	2.38215		1.51E-06	0.000663	0.000454	4.47E-05	13.459	0.064347		0.10756
		HQ	3.045455	0.108273	2.154554	3.665568	238.215	0	0.007535	0.662709	0.324444	0.00745		2.144893	0	0.056611
Swan -Climate Change	Fallow periods	Average	0.09357	5.37E-05	0.01395	0.43527	0.759029		6.78E-07	0.00033	0.000212	2.1E-05	7.947175	0.038823		0.06298
		HQ	1.701275	0.053731	1.073053	1.176405	75.90287	0	0.003388	0.330318	0.151288	0.003494		1.294088	0	0.033147
		90th Percentile	0.142085	9.24E-05	0.024569	1.218	2.13179		1.2E-06	0.000558	0.000458	3.62E-05	13.107	0.058596		0.094482
		HQ	2.583364	0.092411	1.889938	3.291892	213.179	0	0.005975	0.55839	0.3272	0.006032		1.9532	0	0.049727

Parameter			Mo	otal Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			0.001		0.011	0.05	0.0034	0.011		0.00005	0.001					0.024
Swan - Base Line	Filling periods	Average	0.00183797	0.237929	0.001686		0.000158	0.002387	23.17536			0.33505	7.04E-06	0.000208	1.9E-05	0.033833
		HQ	1.83797388		0.153287	0	0.046466	0.216974		0	0					1.409711
		90th Percentile	0.00257437	0.380028	0.003073		0.000264	0.003342	45.9472			0.429897	1.4E-05	0.000278	3.53E-05	0.054116
		HQ	2.57437		0.279379	0	0.077699	0.303806		0	0					2.254829
Swan - High Seepage	Filling periods	Average	0.00184999	0.23082	0.001741		0.000162	0.002281	23.29888			0.332161	6.25E-06	0.000209	2.77E-05	0.034484
		HQ	1.8499915		0.158308	0	0.047662	0.207377		0	0					1.436819
		90th Percentile	0.00256629	0.356393	0.002995		0.000299	0.003262	45.9877			0.450796	1.42E-05	0.000274	3.53E-05	0.057337
		HQ	2.56629		0.272295	0	0.088024	0.296565		0	0					2.389021
Swan -Climate Change	Filling periods	Average	0.00178312	0.230909	0.001674		0.000152	0.002381	23.09146			0.323677	7.04E-06	0.000202	2.63E-05	0.032469
		HQ	1.78311513		0.15222	0	0.044707	0.216471		0	0					1.352886
		90th Percentile	0.0025722	0.376377	0.002959		0.000224	0.003347	45.8907			0.439313	1.53E-05	0.000274	3.54E-05	0.051402
		HQ	2.5722		0.268967	0	0.065793	0.304232		0	0					2.141754
Swan - Base Line	Fallow periods	Average	0.0066355	0.886598	0.007374		0.000719	0.009117	49.87008			1.26774	3.9E-05	0.000737	1.09E-05	0.140701
		HQ	6.63550082		0.670364	0	0.211428	0.828862		0	0					5.862552
		90th Percentile	0.0163364	2.155357	0.015846		0.001378	0.021199	59.674			3.33618	7E-05	0.001844	2.1E-05	0.322288
		HQ	16.3364		1.440582	0	0.405382	1.927155		0	0					13.42867
Swan - High Seepage	Fallow periods	Average	0.00811197	1.076306	0.008712		0.000925	0.010705	51.79523			1.516677	4.3E-05	0.000905	1.29E-05	0.169995
		HQ	8.11196943		0.791999	0	0.271988	0.973204		0	0					7.083112
		90th Percentile	0.0190509	2.496479	0.018543		0.001739	0.024847	64.3839			4.67028	8.16E-05	0.002139	2.16E-05	0.38042
		HQ	19.0509		1.685718	0	0.511326	2.258855		0	0					15.85083
Swan -Climate Change	Fallow periods	Average	0.00630103	0.845074	0.00707		0.00066	0.008683	49.43825			1.199407	3.77E-05	0.000699	1.07E-05	0.134461
		HQ	6.30103424		0.642713	0	0.194078	0.789372		0	0					5.602539
		90th Percentile	0.0165828	2.176019	0.016061		0.001447	0.022401	58.486			3.44776	6.68E-05	0.001872	2.04E-05	0.31
		HQ	16.5828		1.460045	0	0.425638	2.036491		0	0					12.91667

HQ >1
HQ >5
HQ > 10

Table C.2

Surface Water HQ Calculations - De Grey

Scenario	Period	Parameter	pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba
		Lowest Criteria	6		60								0.055	0.009	0.013	0.94	
De Grey - Base Line	Filling periods	Average	7.812372	6.305121	1010.967	136.4734	28.25646	41.16155	14.62731	225.0346	355.5985	94.45524	0.17287	2.71E-05	0.000711	0.134211	0.151858
		HQ	1.302062		16.84945								3.143082	0.003007	0.054668	0.142778	
		90th Percentile	7.582001	6.236972	1802.36	72.8621	36.7913	80.1467	25.7278	422.654	656.247	175.806	0.858364	5.63E-05	0.002089	0.242846	0.284029
		HQ	1.263667		30.03933								15.60662	0.006258	0.160693	0.258347	
De Grey - High Seepage	Filling periods	Average	7.817555	6.30486	1011.878	136.5686	28.25173	41.18643	14.64005	225.3814	356.2313	94.20965	0.152818	2.68E-05	0.000737	0.134456	0.152067
		HQ	1.302926		16.86464								2.778514	0.002981	0.056716	0.143038	
		90th Percentile	7.616247	6.236972	1798.05	72.8531	36.1936	80.3286	25.6463	421.403	654.301	176.091	0.520156	5.58E-05	0.002212	0.242946	0.283088
		HQ	1.269375		29.9675								9.457382	0.006197	0.170122	0.258453	
De Grey -Climate Change	Filling periods	Average	7.797279	6.312318	1005.978	135.8095	28.17056	41.05649	14.55749	223.4333	352.9598	94.98588	0.229913	2.9E-05	0.000688	0.133479	0.150771
		HQ	1.299547		16.7663								4.180245	0.003217	0.052927	0.141999	
		90th Percentile	7.498732	6.236972	1583.73	72.5977	36.0643	80.3773	23.3016	350.618	550.685	177.009	1.16753	6.42E-05	0.001891	0.229012	0.241667
		HQ	1.249789		26.3955								21.22782	0.007135	0.145468	0.24363	
De Grey - Base Line	Fallow periods	Average	7.967671	6.26677	762.61	96.443	27.8135	20.6635	11.437	173.61	283.79	65.812	0.023995	1.45E-05	0.00049	0.10665	0.12197
		HQ	1.327945		12.71017								0.436264	0.001615	0.037685	0.113457	
		90th Percentile	7.72535	6.236972	19565.1	215.248	157.909	418.042	381.58	6188.15	9600.69	1918.9	1.07408	0.000536	0.020296	2.8493	4.8387
		HQ	1.287558		326.085								19.52873	0.059579	1.561231	3.03117	
De Grey - High Seepage	Fallow periods	Average	7.953056	6.336871	8585.263	356.5453	86.83241	214.824	157.5746	2594.476	4033.551	831.3832	0.481541	0.000315	0.017887	1.146796	1.939908
		HQ	1.325509		143.0877								8.75529	0.035008	1.375904	1.219996	
		90th Percentile	7.699612	6.236972	28009	215.351	250.61	564.525	510.183	8561.08	13322.8	2709.73	1.30244	0.000643	0.032252	3.60399	6.19348
		HQ	1.283269		466.8167								23.68073	0.071487	2.480946	3.834032	
De Grey -Climate Change	Fallow periods	Average	7.974495	6.330529	5514.203	293.8519	56.03691	154.9424	98.93797	1608.867	2499.469	532.9272	0.430486	0.000243	0.007184	0.731923	1.23534
		HQ	1.329082		91.90339								7.827012	0.027024	0.552579	0.778642	
		90th Percentile	7.771239	6.236972	16420	214.117	154.666	352.59	322.02	5192	8049.6	1619.4	0.835396	0.000484	0.016815	2.4055	4.0844
		HQ	1.295207		273.6667								15.18902	0.053792	1.293438	2.559043	

Scenario	Period	Parameter	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	otal Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
		Lowest Criteria		0.0002		0.0014	0.001			0.0006	1.9		1.15	0.011	0.08	0.0034	0.011		0.00005			0.00003	0.0005	0.006	0.008
De Grey - Base Line	Filling periods	Average		8.35E-06	0.001807	0.003534	6.63E-05	4.665475	0.026343		0.130588	0.00160627	0.30086	0.004341		7.74E-05	0.003965	22.78928			0.242685	9.54E-06	0.000257	5.89E-05	0.029491
		HQ		0.041728		2.524423	0.066343			0	0.06873		0.261618	0.394656	0	0.022777	0.360474		0			0.31816	0.51302	0.009825	3.686331
		90th Percentile		1.85E-05	0.004802	0.007915	0.000127	10.6157	0.05617		0.181958	0.00290369	0.377999	0.00929		0.000207	0.0065	46.6114			0.444668	2.2E-05	0.000465	0.000148	0.060271
		HQ		0.092302		5.653629	0.126978			0	0.095767		0.328695	0.844542	0	0.061028	0.590879		0			0.732807	0.929418	0.02474	7.5339
De Grey - High Seepage	Filling periods	Average		7.49E-06	0.001555	0.003212	6.01E-05	4.664838	0.023468		0.122303	0.00160771	0.30087	0.003945		7.97E-05	0.003772	22.78364			0.242801	8.37E-06	0.000247	5.28E-05	0.028769
		HQ		0.037425		2.294612	0.06009			0	0.06437		0.261626	0.358666	0	0.023442	0.342944		0			0.279012	0.494666	0.008795	3.596084
		90th Percentile		1.45E-05	0.003511	0.006943	0.000109	10.6254	0.039782		0.140698	0.00289086	0.377511	0.007322		0.000217	0.006337	46.6046			0.443324	1.59E-05	0.000395	0.000103	0.060894
		HQ		0.072458		4.958979	0.109462			0	0.074052		0.328271	0.665672	0	0.063808	0.576124		0			0.529697	0.789474	0.017178	7.611738
De Grey -Climate Change	Filling periods	Average		1.12E-05	0.002524	0.004388	8.68E-05	4.661561	0.034801		0.152604	0.00161123	0.299585	0.005481		7.57E-05	0.004497	22.76925			0.241146	1.33E-05	0.000282	7.95E-05	0.031506
		HQ		0.055873		3.134621	0.086812			0	0.080318		0.260509	0.498294	0	0.022264	0.40882		0			0.44467	0.564098	0.013248	3.938296
		90th Percentile		3.17E-05	0.006634	0.009527	0.000197	10.5365	0.098518		0.299678	0.00267975	0.338046	0.015299		0.000193	0.006807	46.5873			0.396693	3.77E-05	0.000479	0.000211	0.063212
		HQ		0.158486		6.804793	0.197218			0	0.157725		0.293953	1.390809	0	0.056854	0.618824		0			1.255683	0.957402	0.035153	7.901488
De Grey - Base Line	Fallow periods	Average		2.05E-06	0.000204	0.003038	3.46E-05	1.22445	0.004591		0.034843	0.00135135	0.135849	0.002167		4.83E-05	0.003971	8.6457			0.191975	3.51E-06	0.000183	2.22E-05	0.020533
		HQ		0.010275		2.170286	0.034606			0	0.018338		0.11813	0.196964	0	0.014191	0.361		0			0.11694	0.36561	0.003698	2.566563
		90th Percentile		2.9E-05	0.00383	0.001195	0.000121	15.4211	0.107304		0.562416	0.054862	4.855857	0.042659		0.001458	0.045323	69.864			10.8398	0.000172	0.006774	1.58E-05	0.51872
		HQ		0.144761		0.85335	0.12138			0	0.296008		4.222484	3.878091	0	0.428676	4.120273		0			5.7286	13.54716	0.002641	64.84
De Grey - High Seepage	Fallow periods	Average		1.83E-05	0.002107	0.002112	7.06E-05	13.42138	0.067438		0.315122	0.02030674	2.002758	0.016846		0.00147	0.021456	59.3043			3.282438	9.27E-05	0.002501	7.19E-05	0.261907
		HQ		0.09175		1.508387	0.070558			0	0.165854		1.741529	1.531422	0	0.432404	1.950588		0			3.090447	5.001263	0.011983	32.73838
		90th Percentile		4.3E-05	0.004503	0.001357	0.000135	17.0688	0.11263		0.683168	0.0612031	6.323877	0.044879		0.002178	0.052147	76.6212			11.607	0.000199	0.007191	2.42E-05	0.71765
		HQ		0.21499		0.969114	0.135145			0	0.359562		5.499023	4.079909	0	0.64045	4.740645		0			6.629	14.3812	0.004032	89.70625
De Grey -Climate Change	Fallow periods	Average		1.04E-05	0.001603	0.000902	5.46E-05	12.09867	0.058537		0.249547	0.01402146	1.299003	0.011386		0.000533	0.013927	53.46009			3.058046	7.33E-05	0.001719	9.81E-06	0.158446
		HQ		0.051908		0.644188	0.054601			0	0.13134		1.129568	1.035071	0	0.156628	1.266077		0			2.442242	3.438389	0.001636	19.80579
		90th Percentile		2.08E-05	0.003224	0.001344	9.96E-05	14.577	0.087002		0.491325	0.0458263	4.007415	0.03354		0.001217	0.034373	64.9221			10.5004	0.000154	0.005428	1.6E-05	0.42413
		HQ		0.103829		0.959714	0.099629			0	0.258592		3.484708	3.049091	0	0.357906	3.124818		0			5.146033	10.8568	0.002669	53.01625

Surface water HQ Calculations - Swan

Scenario	Period	Parameter	pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba
		Lowest Criteria	6		60								0.055	0.009	0.013	0.94	
Swan - Base Line	Filling periods	Average	7.793157	6.345817	1208.638	120.5747	37.33328	31.63374	18.95317	305.0659	477.0869	104.401	0.021584	1.17E-05	0.004119	0.165629	0.215882
		HQ	1.298859		20.14397								0.392434	0.001298	0.316868	0.176201	
		90th Percentile	7.682797	6.236972	1587.65	73.916	50.3199	56.5492	25.1236	370.965	615.527	138.787	0.048189	2.5E-05	0.009125	0.208418	0.31555
		HQ	1.280466		26.46083								0.876164	0.002773	0.701889	0.221721	
Swan - High Seepage	Filling periods	Average	7.798996	6.336314	1227.862	123.7945	37.09409	33.80398	19.1879	308.1113	481.6586	109.4676	0.020469	1.06E-05	0.003508	0.180475	0.211407
		HQ	1.299833		20.46437								0.372155	0.001177	0.269832	0.191995	
		90th Percentile	7.681231	6.236972	1697.81	73.8573	50.1615	64.6988	25.9669	402.21	627.168	142.607	0.048766	2.41E-05	0.008123	0.215402	0.31025
		HQ	1.280205		28.29683								0.886656	0.002674	0.624848	0.229151	
Swan -Climate Change	Filling periods	Average	7.786382	6.350507	1172.336	117.0674	37.46864	29.92809	18.33696	294.8073	461.0858	101.2331	0.021912	1.15E-05	0.0043	0.160951	0.208465
		HQ	1.29773		19.53894								0.398404	0.001283	0.330733	0.171225	
		90th Percentile	7.674338	6.236972	1568.46	73.1593	49.9634	48.9152	24.7955	368.772	611.896	128.836	0.053852	2.66E-05	0.010179	0.208446	0.31024
		HQ	1.279056		26.141								0.979127	0.002951	0.783035	0.221751	
Swan - Base Line	Fallow periods	Average	7.832163	6.425893	3704.352	214.572	62.79733	86.27361	64.31119	1063.208	1653.102	325.3194	0.09612	5.55E-05	0.014893	0.459594	0.801038
		HQ	1.305361		61.7392								1.74763	0.006168	1.145652	0.48893	
		90th Percentile	7.730923	6.236972	9682.96	108.184	118.71	216.024	174.356	2957.6	4605.79	875.61	0.151763	9.8E-05	0.024948	1.19952	2.09894
		HQ	1.288487		161.3827								2.759327	0.010886	1.919077	1.276085	
Swan - High Seepage	Fallow periods	Average	7.819581	6.428821	4550.822	234.9312	73.91965	101.3335	80.21045	1333.454	2073.972	404.9175	0.104008	6.08E-05	0.017793	0.568757	0.992062
		HQ	1.303264		75.84703								1.891057	0.006759	1.368685	0.605061	
		90th Percentile	7.724812	6.236972	10768	108.035	123.168	241.12	195.882	3305.74	5144.51	984.029	0.1675	0.000108	0.028009	1.35626	2.38215
		HQ	1.287469		179.4667								3.045455	0.01203	2.154554	1.44283	
Swan -Climate Change	Fallow periods	Average	7.833114	6.42959	3520.82	209.8336	60.92065	82.5528	60.8474	1004.834	1562.238	307.855	0.09357	5.37E-05	0.01395	0.43527	0.759029
		HQ	1.305519		58.68034								1.701275	0.00597	1.073053	0.463053	
		90th Percentile	7.729618	6.236972	9831.22	107.555	110.72	220.631	177.116	3005.02	4679.66	889.206	0.142085	9.24E-05	0.024569	1.218	2.13179
		HQ	1.28827		163.8537								2.583364	0.010268	1.889938	1.295745	

Scenario	Period	Parameter	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	otal Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
		Lowest Criteria		0.0002		0.0014	0.001			0.0006	1.9		1.15	0.011	0.08	0.0034	0.011		0.00005			0.00003	0.0005	0.006	0.008
Swan - Base Line	Filling periods	Average		1.46E-07	7.98E-05	0.000283	3.28E-05	3.349151	0.00919		0.021272	0.00183797	0.237929	0.001686		0.000158	0.002387	23.17536			0.33505	7.04E-06	0.000208	1.9E-05	0.033833
		HQ		0.000731		0.201816	0.03278			0	0.011196		0.206894	0.153287	0	0.046466	0.216974		0			0.234558	0.415184	0.003168	4.229132
		90th Percentile		2.61E-07	0.000159	0.000589	5.16E-05	8.06359	0.01842		0.042652	0.00257437	0.380028	0.003073		0.000264	0.003342	45.9472			0.429897	1.4E-05	0.000278	3.53E-05	0.054116
		HQ		0.001303		0.420408	0.051579			0	0.022448		0.330459	0.279379	0	0.077699	0.303806		0			0.467993	0.55604	0.005882	6.764488
Swan - High Seepage	Filling periods	Average		2.68E-07	9.82E-05	0.000366	4.65E-05	3.475738	0.008274		0.020121	0.00184999	0.23082	0.001741		0.000162	0.002281	23.29888			0.332161	6.25E-06	0.000209	2.77E-05	0.034484
		HQ		0.001342		0.261301	0.046488			0	0.01059		0.200713	0.158308	0	0.047662	0.207377		0			0.208414	0.417329	0.004611	4.310456
		90th Percentile		2.59E-07	0.000174	0.000696	5.49E-05	9.88168	0.017359		0.042432	0.00256629	0.356393	0.002995		0.000299	0.003262	45.9877			0.450796	1.42E-05	0.000274	3.53E-05	0.057337
		HQ		0.001294		0.497379	0.054867			0	0.022333		0.309907	0.272295	0	0.088024	0.296565		0			0.47361	0.548594	0.005888	7.167063
Swan -Climate Change	Filling periods	Average		2.76E-07	0.000101	0.000341	3.8E-05	3.198062	0.009071		0.021307	0.00178312	0.230909	0.001674		0.000152	0.002381	23.09146			0.323677	7.04E-06	0.000202	2.63E-05	0.032469
		HQ		0.001378		0.243625	0.038017			0	0.011214		0.20079	0.15222	0	0.044707	0.216471		0			0.234817	0.403419	0.004389	4.058658
		90th Percentile		3.51E-07	0.000191	0.000664	5.01E-05	6.21109	0.018866		0.040888	0.0025722	0.376377	0.002959		0.000224	0.003347	45.8907			0.439313	1.53E-05	0.000274	3.54E-05	0.051402
		HQ		0.001755		0.473934	0.050121			0	0.02152		0.327284	0.268967	0	0.065793	0.304232		0			0.510957	0.54824	0.005896	6.425263
Swan - Base Line	Fallow periods	Average		7.01E-07	0.000341	0.000213	2.09E-05	8.052613	0.039642		0.064522	0.0066355	0.886598	0.007374		0.000719	0.009117	49.87008			1.26774	3.9E-05	0.000737	1.09E-05	0.140701
		HQ		0.003507		0.152433	0.020865			0	0.033959		0.770955	0.670364	0	0.211428	0.828862		0			1.301014	1.473592	0.00181	17.58766
		90th Percentile		1.25E-06	0.00058	0.000449	3.55E-05	13.1351	0.063565		0.098042	0.0163364	2.155357	0.015846		0.001378	0.021199	59.674			3.33618	7E-05	0.001844	2.1E-05	0.322288
		HQ		0.006227		0.320764	0.035533			0	0.051601		1.874224	1.440582	0	0.405382	1.927155		0			2.334143	3.68806	0.003505	40.286
Swan - High Seepage	Fallow periods	Average		7.96E-07	0.000381	0.000235	2.29E-05	8.364499	0.041346		0.06939	0.00811197	1.076306	0.008712		0.000925	0.010705	51.79523			1.516677	4.3E-05	0.000905	1.29E-05	0.169995
		HQ		0.003979		0.167924	0.02295			0	0.036521		0.935918	0.791999	0	0.271988	0.973204		0			1.434946	1.810107	0.002143	21.24933
		90th Percentile		1.51E-06	0.000663	0.000454	4.47E-05	13.459	0.064347		0.10756	0.0190509	2.496479	0.018543		0.001739	0.024847	64.3839			4.67028	8.16E-05	0.002139	2.16E-05	0.38042
		HQ		0.007535		0.324444	0.044699			0	0.056611		2.170851	1.685718	0	0.511326	2.258855		0			2.719433	4.27786	0.003605	47.5525
Swan -Climate Change	Fallow periods	Average		6.78E-07	0.00033	0.000212	2.1E-05	7.947175	0.038823		0.06298	0.00630103	0.845074	0.00707		0.00066	0.008683	49.43825			1.199407	3.77E-05	0.000699	1.07E-05	0.134461
		HQ		0.003388		0.151288	0.020964			0	0.033147		0.734847	0.642713	0	0.194078	0.789372		0			1.256793	1.398485	0.00179	16.80762
		90th Percentile		1.2E-06	0.000558	0.000458	3.62E-05	13.107	0.058596		0.094482	0.0165828	2.176019	0.016061		0.001447	0.022401	58.486			3.44776	6.68E-05	0.001872	2.04E-05	0.31
		HQ		0.005975		0.3272	0.036193			0	0.049727		1.89219	1.460045	0	0.425638	2.036491		0			2.2252	3.74404	0.003396	38.75

HQ >1
HQ >5
HQ > 10

Table C.3
Livestock HQ Calculations - De Grey

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
	Lowest Criteria		-	-	4000	-	1000	-	-	-	-	1000	5.00	-	0.50	5.00	-	-	0.01	1.00	0.40	1.00	2.00	-	0.002	-	0.15	-	1.00	-	0.10	0.02	-	-	-	-	-	0.20	-	20.00
De Grey - Base Line	Filling periods	Average	7.812372	6.305121	1010.967	136.4734	28.25646	41.16155	14.62731	225.0346	355.5985	94.45524	0.17287	2.71E-05	0.000711	0.134211	0.151858		8.35E-06	0.001807	0.003534	6.63E-05	4.665475	0.026343		0.130588	0.001606	0.30086	0.004341		7.74E-05	0.003965	22.78928			0.242685	9.54E-06	0.000257	5.89E-05	0.029491
		HQ			0.252742		0.028256					0.094455	0.034574		0.001421	0.026842			0.000835	0.001807	0.008835	6.63E-05	2.332738		0		0.010708		0.004341		0.000774	0.198261						0.001283		0.001475
		90th Percentile	7.582001	6.236972	1802.36	72.8621	36.7913	80.1467	25.7278	422.654	656.247	175.806	0.858364	5.63E-05	0.002089	0.242846	0.284029		1.85E-05	0.004802	0.007915	0.000127	10.6157	0.05617		0.181958	0.002904	0.377999	0.00929		0.000207	0.0065	46.6114			0.444668	2.2E-05	0.000465	0.000148	0.060271
		HQ			0.45059		0.036791					0.175806	0.171673		0.004178	0.048569			0.001846	0.004802	0.019788	0.000127	5.30785		0		0.019358		0.00929		0.002075	0.324984						0.002324		0.003014
De Grey - High Seepage	Filling periods	Average	7.817555	6.30486	1011.878	136.5686	28.25173	41.18643	14.64005	225.3814	356.2313	94.20965	0.152818	2.68E-05	0.000737	0.134456	0.152067		7.49E-06	0.001555	0.003212	6.01E-05	4.664838	0.023468		0.122303	0.001608	0.30087	0.003945		7.97E-05	0.003772	22.78364			0.242801	8.37E-06	0.000247	5.28E-05	0.028769
		HQ			0.25297		0.028252					0.09421	0.030564		0.001475	0.026891			0.000749	0.001555	0.008031	6.01E-05	2.332419		0		0.010718		0.003945		0.000797	0.188619						0.001237		0.001438
		90th Percentile	7.616247	6.236972	1798.05	72.8531	36.1936	80.3286	25.6463	421.403	654.301	176.091	0.520156	5.58E-05	0.002212	0.242946	0.283088		1.45E-05	0.003511	0.006943	0.000109	10.6254	0.039782		0.140698	0.002891	0.377511	0.007322		0.000217	0.006337	46.6046			0.443324	1.59E-05	0.000395	0.000103	0.060894
		HQ			0.449513		0.036194					0.176091	0.104031		0.004423	0.048589			0.001449	0.003511	0.017356	0.000109	5.3127		0		0.019272		0.007322		0.002169	0.316868						0.001974		0.003045
De Grey -Climate Change	Filling periods	Average	7.797279	6.312318	1005.978	135.8095	28.17056	41.05649	14.55749	223.4333	352.9598	94.98588	0.229913	2.9E-05	0.000688	0.133479	0.150771		1.12E-05	0.002524	0.004388	8.68E-05	4.661561	0.034801		0.152604	0.001611	0.299585	0.005481		7.57E-05	0.004497	22.76925			0.241146	1.33E-05	0.000282	7.95E-05	0.031506
		HQ			0.251495		0.028171					0.094986	0.045983		0.001376	0.026696			0.001117	0.002524	0.010971	8.68E-05	2.330781		0		0.010742		0.005481		0.000757	0.224851						0.00141		0.001575
		90th Percentile	7.498732	6.236972	1583.73	72.5977	36.0643	80.3773	23.3016	350.618	550.685	177.009	1.16753	6.42E-05	0.001891	0.229012	0.241667		3.17E-05	0.006634	0.009527	0.000197	10.5365	0.098518		0.299678	0.00268	0.338046	0.015299		0.000193	0.006807	46.5873			0.396693	3.77E-05	0.000479	0.000211	0.063212
		HQ			0.395933		0.036064					0.177009	0.233506		0.003782	0.045802			0.00317	0.006634	0.023817	0.000197	5.26825		0		0.017865		0.015299		0.001933	0.340353						0.002394		0.003161
De Grey - Base Line	Fallow periods	Average	7.967671	6.26677	762.61	96.443	27.8135	20.6635	11.437	173.61	283.79	65.812	0.023995	1.45E-05	0.00049	0.10665	0.12197		2.05E-06	0.000204	0.003038	3.46E-05	1.22445	0.004591		0.034843	0.001351	0.135849	0.002167		4.83E-05	0.003971	8.6457			0.191975	3.51E-06	0.000183	2.22E-05	0.020533
		HQ			0.190653		0.027814					0.065812	0.004799		0.00098	0.02133			0.000205	0.000204	0.007596	3.46E-05	0.612225		0		0.009009		0.002167		0.000483	0.19855						0.000914		0.001027
		90th Percentile	7.72535	6.236972	19565.1	215.248	157.909	418.042	381.58	6188.15	9600.69	1918.9	1.07408	0.000536	0.020296	2.8493	4.8387		2.9E-05	0.00383	0.001195	0.000121	15.4211	0.107304		0.562416	0.054862	4.855857	0.042659		0.001458	0.045323	69.864			10.8398	0.000172	0.006774	1.58E-05	0.51872
		HQ			4.891275		0.157909					1.9189	0.214816		0.040592	0.56986			0.002895	0.00383	0.002987	0.000121	7.71055		0		0.365747		0.042659		0.014575	2.26615						0.033868		0.025936
De Grey - High Seepage	Fallow periods	Average	7.953056	6.336871	8585.263	356.5453	86.83241	214.824	157.5746	2594.476	4033.551	831.3832	0.481541	0.000315	0.017887	1.146796	1.939908		1.83E-05	0.002107	0.002112	7.06E-05	13.42138	0.067438		0.315122	0.020307	2.002758	0.016846		0.00147	0.021456	59.3043			3.282438	9.27E-05	0.002501	7.19E-05	0.261907
		HQ			2.146316		0.086832					0.831383	0.096308		0.035773	0.229359			0.001835	0.002107	0.005279	7.06E-05	6.710691		0		0.135378		0.016846		0.014702	1.072823						0.012503		0.013095
		90th Percentile	7.699612	6.236972	28009	215.351	250.61	564.525	510.183	8561.08	13322.8	2709.73	1.30244	0.000643	0.032252	3.60399	6.19348		4.3E-05	0.004503	0.001357	0.000135	17.0688	0.11263		0.683168	0.061203	6.323877	0.044879		0.002178	0.052147	76.6212			11.607	0.000199	0.007191	2.42E-05	0.71765
		HQ			7.00225		0.25061					2.70973	0.260488		0.064505	0.720798			0.0043	0.004503	0.003392	0.000135	8.5344		0		0.408021		0.044879		0.021775	2.607355						0.035953		0.035883
De Grey -Climate Change	Fallow periods	Average	7.974495	6.330529	5514.203	293.8519	56.03691	154.9424	98.93797	1608.867	2499.469	532.9272	0.430486	0.000243	0.007184	0.731923	1.23534		1.04E-05	0.001603	0.000902	5.46E-05	12.09867	0.058537		0.249547	0.014021	1.299003	0.011386		0.000533	0.013927	53.46009			3.058046	7.33E-05	0.001719	9.81E-06	0.158446
		HQ			1.378551		0.056037					0.532927	0.086097		0.014367	0.146385			0.001038	0.001603	0.002255	5.46E-05	6.049337		0		0.093476		0.011386		0.005325	0.696343						0.008596		0.007922
		90th Percentile	7.771239	6.236972	16420	214.117	154.666	352.59	322.02	5192	8049.6	1619.4	0.835396	0.000484	0.016815	2.4055	4.0844		2.08E-05	0.003224	0.001344	9.96E-05	14.577	0.087002		0.491325	0.045826	4.007415	0.03354		0.001217	0.034373	64.9221			10.5004	0.000154	0.005428	1.6E-05	0.42413
		HQ			4.105		0.154666					1.6194	0.167079		0.033629	0.4811			0.002077	0.003224	0.003359	9.96E-05	7.2885		0		0.305509		0.03354		0.012169	1.71865						0.027142		0.021207

Livestock HQ Calculations - Swan

			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitroge	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
	Lowest Criteria		-	-	4000	-	1000	-	-	-	-	1000	5	-	0.5	5	-	-	0.01	1	0.4	1	2	-	0.002	-	0.15	-	1	-	0.1	0.02	-	-	-	-	-	0.2	-	20
Swan - Base Line	Filling periods	Average	7.793157	6.345817	1208.638	120.5747	37.33328	31.63374	18.95317	305.0659	477.0869	104.401	0.021584	1.17E-05	0.004119	0.165629	0.215882		1.46E-07	7.98E-05	0.000283	3.28E-05	3.349151	0.00919		0.021272	0.001838	0.237929	0.001686		0.000158	0.002387	23.17536			0.33505	7.04E-06	0.000208	1.9E-05	0.033833
		HQ			0.30216		0.037333					0.104401	0.004317		0.008239	0.033126			1.46E-05	7.98E-05	0.000706	3.28E-05	1.674575		0		0.012253		0.001686		0.00158	0.119336						0.001038		0.001692
		90th Percentile	7.682797	6.236972	1587.65	73.916	50.3199	56.5492	25.1236	370.965	615.527	138.787	0.048189	2.5E-05	0.009125	0.208418	0.31555		2.61E-07	0.000159	0.000589	5.16E-05	8.06359	0.01842		0.042652	0.002574	0.380028	0.003073		0.000264	0.003342	45.9472			0.429897	1.4E-05	0.000278	3.53E-05	0.054116
		HQ			0.396913		0.05032					0.138787	0.009638		0.018249	0.041684			2.61E-05	0.000159	0.001471	5.16E-05	4.031795		0		0.017162		0.003073		0.002642	0.167094						0.00139		0.002706
Swan - High Seepage	Filling periods	Average	7.798996	6.336314	1227.862	123.7945	37.09409	33.80398	19.1879	308.1113	481.6586	109.4676	0.020469	1.06E-05	0.003508	0.180475	0.211407		2.68E-07	9.82E-05	0.000366	4.65E-05	3.475738	0.008274		0.020121	0.00185	0.23082	0.001741		0.000162	0.002281	23.29888			0.332161	6.25E-06	0.000209	2.77E-05	0.034484
		HQ			0.306966		0.037094					0.109468	0.004094		0.007016	0.036095			2.68E-05	9.82E-05	0.000915	4.65E-05	1.737869		0		0.012333		0.001741		0.001621	0.114057						0.001043		0.001724
		90th Percentile	7.681231	6.236972	1697.81	73.8573	50.1615	64.6998	25.9669	402.21	627.168	142.607	0.048766	2.41E-05	0.008123	0.215402	0.31025		2.59E-07	0.000174	0.000696	5.49E-05	9.88168	0.017359		0.042432	0.002566	0.356393	0.002995		0.000299	0.003262	45.9877			0.450796	1.42E-05	0.000274	3.53E-05	0.057337
		HQ			0.424453		0.050162					0.142607	0.009753		0.016246	0.04308			2.59E-05	0.000174	0.001741	5.49E-05	4.94084		0		0.017109		0.002995		0.002993	0.163111						0.001371		0.002867
Swan -Climate Change	Filling periods	Average	7.786382	6.350507	1172.336	117.0674	37.46864	29.92809	18.33696	294.8073	461.0858	101.2331	0.021912	1.15E-05	0.0043	0.160951	0.208465		2.76E-07	0.000101	0.000341	3.8E-05	3.198062	0.009071		0.021307	0.001783	0.230909	0.001674		0.000152	0.002381	23.09146			0.323677	7.04E-06	0.000202	2.63E-05	0.032469
		HQ			0.293084		0.037469					0.101233	0.004382		0.008599	0.03219			2.76E-05	0.000101	0.000853	3.8E-05	1.599031		0		0.011887		0.001674		0.00152	0.119059						0.001009		0.001623
		90th Percentile	7.674338	6.236972	1568.46	73.1593	49.9634	48.9152	24.7955	368.772	611.896	128.836	0.053852	2.66E-05	0.010179	0.208446	0.31024		3.51E-07	0.000191	0.000664	5.01E-05	6.21109	0.018866		0.040888	0.002572	0.376377	0.002959		0.000224	0.003347	45.8907			0.439313	1.53E-05	0.000274	3.54E-05	0.051402
		HQ			0.392115		0.049963					0.128836	0.01077		0.020359	0.041689			3.51E-05	0.000191	0.001659	5.01E-05	3.105545		0		0.017148		0.002959		0.002237	0.167328						0.001371		0.00257
Swan - Base Line	Fallow periods	Average	7.832163	6.425893	3704.352	214.572	62.79733	86.27361	64.31119	1063.208	1653.102	325.3194	0.09612	5.55E-05	0.014893	0.459594	0.801038		7.01E-07	0.000341	0.000213	2.09E-05	8.052613	0.039642		0.064522	0.006636	0.886598	0.007374		0.000719	0.009117	49.87008			1.26774	3.9E-05	0.000737	1.09E-05	0.140701
		HQ			0.926088		0.062797					0.325319	0.019224		0.029787	0.091919			7.01E-05	0.000341	0.000534	2.09E-05	4.026307		0		0.044237		0.007374		0.007189	0.455874						0.003684		0.007035
		90th Percentile	7.730923	6.236972	9682.96	108.184	118.71	216.024	174.356	2957.6	4605.79	875.61	0.151763	9.8E-05	0.024948	1.19952	2.09894		1.25E-06	0.00058	0.000449	3.55E-05	13.1351	0.063565		0.098042	0.016336	2.155357	0.015846		0.001378	0.021199	59.674			3.33618	7E-05	0.001844	2.1E-05	0.322288
		HQ			2.42074		0.11871					0.87561	0.030353		0.049896	0.239904			0.000125	0.00058	0.001123	3.55E-05	6.56755		0		0.108909		0.015846		0.013783	1.059935						0.00922		0.016114
Swan - High Seepage	Fallow periods	Average	7.819581	6.428821	4550.822	234.9312	73.91965	101.3335	80.21045	1333.454	2073.972	404.9175	0.104008	6.08E-05	0.017793	0.568757	0.992062		7.96E-07	0.000381	0.000235	2.29E-05	8.364499	0.041346		0.06939	0.008112	1.076306	0.008712		0.000925	0.010705	51.79523			1.516677	4.3E-05	0.000905	1.29E-05	0.169995
		HQ			1.137706		0.07392					0.404918	0.020802		0.035586	0.113751			7.96E-05	0.000381	0.000588	2.29E-05	4.18225		0		0.05408		0.008712		0.009248	0.535262						0.004525		0.0085
		90th Percentile	7.724812	6.236972	10768	108.035	123.168	241.12	195.882	3305.74	5144.51	984.029	0.1675	0.000108	0.028009	1.35626	2.38215		1.51E-06	0.000663	0.000454	4.47E-05	13.459	0.064347		0.10756	0.019051	2.496479	0.018543		0.001739	0.024847	64.3839			4.67028	8.16E-05	0.002139	2.16E-05	0.38042
		HQ			2.692		0.123168					0.984029	0.0335		0.056018	0.271252			0.000151	0.000663	0.001136	4.47E-05	6.7295		0		0.127006		0.018543		0.017385	1.24237						0.010695		0.019021
Swan -Climate Change	Fallow periods	Average	7.833114	6.42959	3520.82	209.8336	60.92065	82.5528	60.6474	1004.834	1562.238	307.855	0.09557	5.37E-05	0.01395	0.43527	0.759029		6.78E-07	0.00033	0.000212	2.1E-05	7.947175	0.038823		0.06298	0.006301	0.845074	0.00707		0.00066	0.008683	49.43825			1.199407	3.77E-05	0.000699	1.07E-05	0.134461
		HQ			0.880205		0.060921					0.307855	0.019114		0.027899	0.087054			6.78E-05	0.00033	0.00053	2.1E-05	3.973587		0		0.042007		0.00707		0.006599	0.434135						0.003496		0.006723
		90th Percentile	7.729618	6.236972	9831.22	107.555	110.72	220.631	177.116	3005.02	4679.66	889.206	0.142085	9.24E-05	0.024569	1.218	2.13179		1.2E-06	0.000558	0.001145	3.62E-05	13.107	0.058596		0.094482	0.016583	2.176019	0.016061		0.001447	0.022401	58.486			3.44776	6.68E-05	0.001872	2.04E-05	0.31
		HQ			2.457805		0.11072					0.889206	0.028417		0.049138	0.2436			0.00012	0.000558	0.001145	3.62E-05	6.5535		0		0.110552		0.016061		0.014472	1.12007						0.00936		0.0155

HQ >1
HQ >5
HQ > 10

Table C4 and C5 Operations Hazard Quotient Calculations

Table C.4
Drinking Water HQ Calculations - De Grey

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			6.5		600	200				180	250	250	0.2	0.003	0.01	4	2	0.06	0.002		1	0.05	1.5	0.3	0.001	0.1	0.05		0.02		0.01	0.01		0.1				0.02		3
De Grey - Base Line	Filling periods	Average	7.812372	6.305121	1010.96725	136.4734	28.25646	41.16155	14.62731	225.0346	355.5985	94.45524	0.17287	2.71E-05	0.000711	0.134211	0.151858		8.35E-06	0.001807	0.003534	6.63E-05	4.665475	0.026343		0.130588	0.001606	0.300860194	0.004341		7.74E-05	0.003965	22.78928			0.242685	9.54E-06	0.000257	5.89E-05	0.029491
		HQ	1.201903		1.684945417	0.682367				1.250192	1.422394	0.377821	0.864348	0.009021	0.071069	0.033553	0.075929		0.004173		0.003534	0.001327	3.110317	0.08781		1.305878	0.032125		0.217061		0.007744	0.396521						0.012826		0.00983
		90th Percentile	7.582001	6.236972	1802.36	72.8621	36.7913	80.1467	25.7278	422.654	656.247	175.806	0.858364	5.63E-05	0.002089	0.242846	0.284029		1.85E-05	0.004802	0.007915	0.000127	10.6157	0.05617		0.181958	0.002904	0.377999401	0.00929		0.000207	0.0065	46.6114			0.444668	2.2E-05	0.000465	0.000148	0.060271
		HQ	1.166462		3.003933333	0.364311				2.348078	2.624988	0.703224	4.29182	0.018774	0.208901	0.060712	0.142015		0.00923		0.007915	0.00254	7.077133	0.187232		1.81958	0.058074		0.464498		0.02075	0.649967						0.023235		0.02009
De Grey - High Seepage	Filling periods	Average	7.817555	6.30486	1011.878375	136.5686	28.25173	41.18643	14.64005	225.3814	356.2313	94.20965	0.152818	2.68E-05	0.000737	0.134456	0.152067		7.49E-06	0.001555	0.003212	6.01E-05	4.664838	0.023468		0.122303	0.001608	0.30086966	0.003945		7.97E-05	0.003772	22.78364			0.242801	8.37E-06	0.000247	5.28E-05	0.028769
		HQ	1.202701		1.686463958	0.682843				1.252119	1.424925	0.376839	0.764091	0.008943	0.073731	0.033614	0.076033		0.003743		0.003212	0.001202	3.109892	0.078226		1.223029	0.032154		0.197266		0.00797	0.377238						0.012367		0.00959
		90th Percentile	7.616247	6.236972	1798.05	72.8531	36.1936	80.3286	25.6463	421.403	654.301	176.091	0.520156	5.58E-05	0.002212	0.242946	0.283088		1.45E-05	0.003511	0.006943	0.000109	10.6254	0.039782		0.140698	0.002891	0.377511257	0.007322		0.000217	0.006337	46.6046			0.443324	1.59E-05	0.000395	0.000103	0.060894
		HQ	1.17173		2.99675	0.364266				2.341128	2.617204	0.704364	2.60078	0.018591	0.221159	0.060737	0.141544		0.007246		0.006943	0.002189	7.0836	0.132606		1.40698	0.057817		0.36612		0.021695	0.633736						0.019737		0.020298
De Grey -Climate Change	Filling periods	Average	7.797279	6.312318	1005.978125	135.8095	28.17056	41.05649	14.55749	223.4333	352.9598	94.98588	0.229913	2.9E-05	0.000688	0.133479	0.150771		1.12E-05	0.002524	0.004388	8.68E-05	4.661561	0.034801		0.152604	0.001611	0.299585443	0.005481		7.57E-05	0.004497	22.76925			0.241146	1.33E-05	0.000282	7.95E-05	0.031506
		HQ	1.199581		1.676630208	0.679047				1.241296	1.411839	0.379944	1.149567	0.00965	0.068806	0.03337	0.075385		0.005587		0.004388	0.001736	3.107708	0.116004		1.526036	0.032225		0.274062		0.00757	0.449702						0.014102		0.010502
		90th Percentile	7.498732	6.236972	1583.73	72.5977	36.0643	80.3773	23.3016	350.618	550.685	177.009	1.16753	6.42E-05	0.001891	0.229012	0.241667		3.17E-05	0.006634	0.009527	0.000197	10.5365	0.098518		0.299678	0.00268	0.338046494	0.015299		0.000193	0.006807	46.5873			0.396693	3.77E-05	0.000479	0.000211	0.063212
		HQ	1.153651		2.63955	0.362989				1.947878	2.20274	0.708036	5.83765	0.021404	0.189108	0.057253	0.120834		0.015849		0.009527	0.003944	7.024333	0.328392		2.99678	0.053595		0.764945		0.019331	0.680706						0.023935		0.021071
De Grey - Base Line	Fallow periods	Average	7.967671	6.26677	762.61	96.443	27.8135	20.6635	11.437	173.61	283.79	65.812	0.023995	1.45E-05	0.00049	0.10665	0.12197		2.05E-06	0.000204	0.003038	3.46E-05	1.22445	0.004591		0.034843	0.001351	0.135849383	0.002167		4.83E-05	0.003971	8.6457			0.191975	3.51E-06	0.000183	2.22E-05	0.020533
		HQ	1.225796		1.271016667	0.482215				0.9645	1.13516	0.263248	0.119973	0.004844	0.048991	0.026663	0.060985		0.001027		0.003038	0.000692	0.8163	0.015302		0.348425	0.027027		0.10833		0.004825	0.3971						0.00914		0.006844
		90th Percentile	7.72535	6.236972	19565.1	215.248	157.909	418.042	381.58	6188.15	9600.69	1918.9	1.07408	0.000536	0.020296	2.8493	4.8387		2.9E-05	0.00383	0.001195	0.000121	15.4211	0.107304		0.562416	0.054862	4.855856508	0.042659		0.001458	0.045323	69.864			10.8398	0.000172	0.006774	1.58E-05	0.51872
		HQ	1.188515		32.6085	1.07624				34.37861	38.40276	7.6756	5.3704	0.178736	2.0296	0.712325	2.41935		0.014476		0.001195	0.002428	10.28073	0.35768		5.62416	1.09724		2.13295		0.14575	4.5323						0.338679		0.172907
De Grey - High Seepage	Fallow periods	Average	7.953056	6.336871	8585.263291	356.5453	86.83241	214.824	157.5746	2594.476	4033.551	831.3832	0.481541	0.000315	0.017887	1.146796	1.939908		1.83E-05	0.002107	0.002112	7.06E-05	13.42138	0.067438		0.315122	0.020307	2.002757835	0.016846		0.00147	0.021456	59.3043			3.282438	9.27E-05	0.002501	7.19E-05	0.261907
		HQ	1.223547		14.30877215	1.782727				14.41376	16.13421	3.325533	2.407705	0.105025	1.788675	0.286699	0.969954		0.009175		0.002112	0.001411	8.947587	0.224794		3.151223	0.406135		0.842282		0.147017	2.145647						0.125032		0.087302
		90th Percentile	7.699612	6.236972	28009	215.351	250.61	564.525	510.183	8561.08	13322.8	2709.73	1.30244	0.000643	0.032252	3.60399	6.19348		4.3E-05	0.004503	0.001357	0.000135	17.0688	0.11263		0.683168	0.061203	6.323876578	0.044879		0.002178	0.052147	76.6212			11.607	0.000199	0.007191	2.42E-05	0.71765
		HQ	1.184556		46.68166667	1.076755				47.56156	53.2912	10.83892	6.5122	0.214462	3.22523	0.900998	3.09674		0.021499		0.001357	0.002703	11.3792	0.375433		6.83168	1.224062		2.24395		0.217753	5.21471						0.35953		0.239217
De Grey -Climate Change	Fallow periods	Average	7.974495	6.330529	5514.203165	293.8519	56.03691	154.9424	98.93797	1608.867	2499.469	532.9272	0.430486	0.000243	0.007184	0.731923	1.23534		1.04E-05	0.001603	0.000902	5.46E-05	12.09867	0.058537		0.249547	0.014021	1.299003469	0.011386		0.000533	0.013927	53.46009			3.058046	7.33E-05	0.001719	9.81E-06	0.158446
		HQ	1.226845		9.190338608	1.469259				8.938151	9.997877	2.131709	2.152428	0.081072	0.718353	0.182981	0.61767		0.005191		0.000902	0.001092	8.065783	0.195125		2.495466	0.280429		0.569289		0.053254	1.392685						0.08596		0.052815
		90th Percentile	7.771239	6.236972	16420	214.117	154.666	352.59	322.02	5192	8049.6	1619.4	0.835396	0.000484	0.016815	2.4055	4.0844		2.08E-05	0.003224	0.001344	9.96E-05	14.577	0.087002		0.491325	0.045826	4.007414684	0.03354		0.001217	0.034373	64.9221			10.5004	0.000154	0.005428	1.6E-05	0.42413
		HQ	1.195575		27.36666667	1.070585				28.84444	32.1984	6.4776	4.17698	0.161376	1.68147	0.601375	2.0422		0.010383		0.001344	0.001993	9.718	0.290007		4.91325	0.916526		1.677		0.121688	3.4373						0.27142		0.141377

Drinking Water HQ Calculations - Swan

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			6.5		600	200				180	250	250		0.003	0.01	4	2	0.06	0.002		1	0.05	1.5	0.3	0.001	0.1	0.05		0.02		0.01	0.01		0.1				0.02		3
Swan - Base Line	Filling periods	Average	7.793157	6.345817	1208.638125	120.5747	37.33328	31.63374	18.95317	305.0659	477.0869	104.401	0.021584	1.17E-05	0.004119	0.165629	0.215882		1.46E-07	7.98E-05	0.000283	3.28E-05	3.349151	0.00919		0.021272	0.001838	0.237928643	0.001686		0.000158	0.002387	23.17536			0.33505	7.04E-06	0.000208	1.9E-05	0.033833
		HQ	1.198947		2.014396875	0.602873				1.69481	1.908348	0.417604		0.003894	0.411929	0.041407	0.107941		7.31E-05		0.000283	0.000656	2.232767	0.030633		0.212719	0.036759		0.084308		0.015799	0.238672						0.01038		0.011278
		90th Percentile	7.682797	6.236972	1587.65	73.916	50.3199	56.5492	25.1236	370.965	615.527	138.787	0.048189	2.5E-05	0.009125	0.208418	0.31555		2.61E-07	0.000159	0.000589	5.16E-05	8.06359	0.01842		0.042652	0.002574	0.380028115	0.003073		0.000264	0.003342	45.9472			0.429897	1.4E-05	0.000278	3.53E-05	0.054116
		HQ	1.181969		2.646083333	0.36958				2.060917	2.462108	0.555148		0.00832	0.912456	0.052105	0.157775		0.00013		0.000589	0.001032	5.375727	0.061401		0.426519	0.051487		0.153659		0.026418	0.334187						0.013901		0.018039
Swan - High Seepage	Filling periods	Average	7.798996	6.336314	1227.862	123.7945	37.09409	33.80398	19.1879	308.1113	481.6586	109.4676	0.020469	1.06E-05	0.003508	0.180475	0.211407		2.68E-07	9.82E-05	0.000366	4.65E-05	3.475738	0.008274		0.020121	0.00185	0.230819963	0.001741		0.000162	0.002281	23.29888			0.332161	6.25E-06	0.000209	2.77E-05	0.034484
		HQ	1.199846		2.046436667	0.618972				1.711729	1.926635	0.437871		0.003532	0.350781	0.045119	0.105703		0.000134		0.000366	0.00093	2.317159	0.02758		0.201212	0.037		0.087069		0.016205	0.228114						0.010433		0.011495
		90th Percentile	7.681231	6.236972	1697.81	73.8573	50.1615	64.6988	25.9669	402.21	627.168	142.607	0.048766	2.41E-05	0.008123	0.215402	0.31025		2.59E-07	0.000174	0.000696	5.49E-05	9.88168	0.017359		0.042432	0.002566	0.356392846	0.002995		0.000299	0.003262	45.9877			0.450796	1.42E-05	0.000274	3.53E-05	0.057337
		HQ	1.181728		2.829683333	0.369287				2.2345	2.508672	0.570428		0.008021	0.812302	0.053851	0.155125		0.000129		0.000696	0.001097	6.587787	0.057864		0.424322	0.051326		0.149763		0.029928	0.326222						0.013715		0.019112
Swan -Climate Change	Filling periods	Average	7.786382	6.350507	1172.336375	117.0674	37.46864	29.92809	18.33696	294.8073	461.0858	101.2331	0.021912	1.15E-05	0.0043	0.160951	0.208465		2.76E-07	0.000101	0.000341	3.8E-05	3.198062	0.009071		0.021307	0.001783	0.2309086	0.001674		0.000152	0.002381	23.09146			0.323677	7.04E-06	0.000202	2.63E-05	0.032469
		HQ	1.197905		1.953893958	0.585337				1.637818	1.844343	0.404932		0.003849	0.429953	0.040238	0.104232		0.000138		0.000341	0.00076	2.132041	0.030235		0.213072	0.035662		0.083721		0.0152	0.238118						0.010085		0.010823
		90th Percentile	7.674338	6.236972	1568.46	73.1593	49.9634	48.9152	24.7955	368.772	611.896	128.836	0.053852	2.66E-05	0.010179	0.208446	0.31024		3.51E-07	0.000191	0.000664	5.01E-05	6.21109	0.018866		0.040888	0.002572	0.376376952	0.002959		0.000224	0.003347	45.8907			0.439313	1.53E-05	0.000274	3.54E-05	0.051402
		HQ	1.180667		2.6141	0.365797				2.048733	2.447584	0.515344		0.008854	1.017946	0.052112	0.15512		0.000175		0.000664	0.001002	4.140727	0.062885		0.408875	0.051444		0.147932		0.02237	0.334655						0.013706		0.017134
Swan - Base Line	Fallow periods	Average	7.832163	6.425893	3704.352089	214.572	62.79733	86.27361	64.31119	1063.208	1653.102	325.3194	0.09612	5.55E-05	0.014893	0.459594	0.801038		7.01E-07	0.000341	0.000213	2.09E-05	8.052613	0.039642		0.064522	0.006636	0.886598277	0.007374		0.000719	0.009117	49.87008			1.26774	3.9E-05	0.000737	1.09E-05	0.140701
		HQ	1.204948		6.173920148	1.07286				5.906713	6.612407	1.301278		0.018504	1.489347	0.114899	0.400519		0.000351		0.000213	0.000417	5.368409	0.13214		0.645215	0.13271		0.3687		0.071885	0.911748						0.03684		0.0469
		90th Percentile	7.730923	6.236972	9682.96	108.184	118.71	216.024	174.356	2957.6	4605.79	875.61	0.151763	9.8E-05	0.024948	1.19952	2.09894		1.25E-06	0.00058	0.000449	3.55E-05	13.1351	0.063565		0.098042	0.016336	2.155357335	0.015846		0.001378	0.021199	59.674			3.33618	7E-05	0.001844	2.1E-05	0.322288
		HQ	1.189373		16.13826667	0.54092				16.43111	18.42316	3.50244		0.032658	2.4948	0.29988	1.04947		0.000623		0.000449	0.000711	8.756733	0.211882		0.980419	0.326728		0.79232		0.13783	2.11987						0.092202		0.107429
Swan - High Seepage	Fallow periods	Average	7.819581	6.428821	4550.822089	234.9312	73.91965	101.3335	80.21045	1333.454	2073.972	404.9175	0.104008	6.08E-05	0.017793	0.568757	0.992062		7.96E-07	0.000381	0.000235	2.29E-05	8.364499	0.041346		0.06939	0.008112	1.076305972	0.008712		0.000925	0.010705	51.79523			1.516677	4.3E-05	0.000905	1.29E-05	0.169995
		HQ	1.203012		7.584703481	1.174656				7.408079	8.29589	1.61967		0.020278	1.77929	0.142189	0.496031		0.000398		0.000235	0.000459	5.576333	0.13782		0.6939	0.162239		0.435599		0.092476	1.070525						0.045253		0.056665
		90th Percentile	7.724812	6.236972	10768	108.035	123.168	241.12	195.882	3305.74	5144.51	984.029	0.1675	0.000108	0.028009	1.35626	2.38215		1.51E-06	0.000663	0.000454	4.47E-05	13.459	0.064347		0.10756	0.019051	2.49647892	0.018543		0.001739	0.024847	64.3839			4.67028	8.16E-05	0.002139	2.16E-05	0.38042
		HQ	1.188433		17.94666667	0.540175				18.36522	20.57804	3.936116		0.036091	2.80092	0.339065	1.191075		0.000753		0.000454	0.000894	8.972667	0.214489		1.0756	0.381018		0.927145		0.173851	2.48474						0.106947		0.126807
Swan -Climate Change	Fallow periods	Average	7.833114	6.42959	3520.820443	209.8336	60.92065	82.5528	60.8474	1004.834	1562.238	307.855	0.09357	5.37E-05	0.01395	0.43527	0.759029		6.78E-07	0.00033	0.000212	2.1E-05	7.947175	0.038823		0.06298	0.006301	0.845073941	0.00707		0.00066	0.008683	49.43825			1.199407	3.77E-05	0.000699	1.07E-05	0.134461
		HQ	1.205095		5.868034072	1.049168				5.582414	6.248952	1.23142		0.01791	1.394969	0.108817	0.379514		0.000339		0.000212	0.000419	5.298116	0.129409		0.629801	0.126021		0.353492		0.065986	0.868309						0.034962		0.04482
		90th Percentile	7.729618	6.236972	9831.22	107.555	110.72	220.631	177.116	3005.02	4679.66	889.206	0.142085	9.24E-05	0.024569	1.218	2.13179		1.2E-06	0.000558	0.000458	3.62E-05	13.107	0.058596		0.094482	0.016583	2.176018724	0.016061		0.001447	0.022401	58.486			3.44776	6.68E-05	0.001872	2.04E-05	0.31
		HQ	1.189172		16.38536667	0.537775				16.69456	18.71864	3.556824		0.030804	2.45692	0.3045	1.065895		0.000598		0.000458	0.000724	8.738	0.19532		0.944815	0.331656		0.803025		0.144717	2.24014						0.093601		0.103333

HQ >1
HQ >5
HQ > 10

Table C.5
Recreation HQ Calculations - De Grey

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			6.5	-	60000	20000	-	-	-	18000	25000	25000	-	3	10	4000	2000	60	2	-	2000	50	1500	30	1	10	50	-	20	-	10	10	-	-	-	-	-	20	-	300
De Grey - Base Line	Filling periods	Average	7.812372	6.305121	1010.96725	136.4734	28.25646	41.16155	14.62731	225.0346	355.5985	94.45524	0.17287	2.71E-05	0.000711	0.134211	0.151858		8.35E-06	0.001807	0.003534	6.63E-05	4.665475	0.026343		0.130588	0.001606	0.300860194	0.004341		7.74E-05	0.003965	22.78928			0.242685	9.54E-06	0.000257	5.89E-05	0.029491
		HQ	1.201903		0.016849454	0.006824				0.012502	0.014224	0.003778		9.02E-06	7.11E-05	3.36E-05	7.59E-05		4.17E-06		1.77E-06	1.33E-06	0.00311	0.000878		0.013059	3.21E-05		0.000217		7.74E-06	0.000397						1.28E-05		9.83E-05
		90th Percentile	7.582001	6.236972	1802.36	72.8621	36.7913	80.1467	25.7278	422.654	656.247	175.806	0.858364	5.63E-05	0.002089	0.242846	0.284029		1.85E-05	0.004802	0.007915	0.000127	10.6157	0.05617		0.181958	0.002904	0.377999401	0.00929		0.000207	0.0065	46.6114			0.444668	2.2E-05	0.000465	0.000148	0.060271
		HQ	1.166462		0.030039333	0.003643				0.023481	0.02625	0.007032		1.88E-05	0.000209	6.07E-05	0.000142		9.23E-06		3.96E-06	2.54E-06	0.007077	0.001872		0.018196	5.81E-05		0.000464		2.07E-05	0.00065						2.32E-05		0.000201
De Grey - High Seepage	Filling periods	Average	7.817555	6.30486	1011.878375	136.5686	28.25173	41.18643	14.64005	225.3814	356.2313	94.20965	0.152818	2.68E-05	0.000737	0.134456	0.152067		7.49E-06	0.001555	0.003212	6.01E-05	4.664838	0.023468		0.122303	0.001608	0.30086966	0.003945		7.97E-05	0.003772	22.78364			0.242801	8.37E-06	0.000247	5.28E-05	0.028769
		HQ	1.202701		0.01686464	0.006828				0.012521	0.014249	0.003768		8.94E-06	7.37E-05	3.36E-05	7.6E-05		3.74E-06		1.61E-06	1.2E-06	0.00311	0.000782		0.01223	3.22E-05		0.000197		7.97E-06	0.000377						1.24E-05		9.59E-05
		90th Percentile	7.616247	6.236972	1798.05	72.8531	36.1936	80.3286	25.6463	421.403	654.301	176.091	0.520156	5.58E-05	0.002212	0.242946	0.283088		1.45E-05	0.003511	0.006943	0.000109	10.6254	0.039782		0.140698	0.002891	0.377511257	0.007322		0.000217	0.006337	46.6046			0.443324	1.59E-05	0.000395	0.000103	0.060894
		HQ	1.17173		0.0299675	0.003643				0.023411	0.026172	0.007044		1.86E-05	0.000221	6.07E-05	0.000142		7.25E-06		3.47E-06	2.19E-06	0.007084	0.001326		0.01407	5.78E-05		0.000366		2.17E-05	0.000634						1.97E-05		0.000203
De Grey -Climate Change	Filling periods	Average	7.797279	6.312318	1005.978125	135.8095	28.17056	41.05649	14.55749	223.4333	352.9598	94.98588	0.229913	2.9E-05	0.000688	0.133479	0.150771		1.12E-05	0.002524	0.004388	8.68E-05	4.661561	0.034801		0.152604	0.001611	0.299585443	0.005481		7.57E-05	0.004497	22.76925			0.241146	1.33E-05	0.000282	7.95E-05	0.031506
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
		90th Percentile	7.498732	6.236972	1583.73	72.5977	36.0643	80.3773	23.3016	350.618	550.685	177.009	1.16753	6.42E-05	0.001891	0.229012	0.241667		3.17E-05	0.006634	0.009527	0.000197	10.5365	0.098518		0.299678	0.00268	0.338046494	0.015299		0.000193	0.006807	46.5873			0.396693	3.77E-05	0.000479	0.000211	0.063212
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
De Grey - Base Line	Fallow periods	Average	7.967671	6.26677	762.61	96.443	27.8135	20.6635	11.437	173.61	283.79	65.812	0.023995	1.45E-05	0.00049	0.10665	0.12197		2.05E-06	0.000204	0.003038	3.46E-05	1.22445	0.004591		0.034843	0.001351	0.135849383	0.002167		4.83E-05	0.003971	8.6457			0.191975	3.51E-06	0.000183	2.22E-05	0.020533
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
		90th Percentile	7.72535	6.236972	19565.1	215.248	157.909	418.042	381.58	6188.15	9600.69	1918.9	1.07408	0.000536	0.020296	2.8493	4.8387		2.9E-05	0.00383	0.001195	0.000121	15.4211	0.107304		0.562416	0.054862	4.855856508	0.042659		0.001458	0.045323	69.864			10.8398	0.000172	0.006774	1.58E-05	0.51872
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
De Grey - High Seepage	Fallow periods	Average	7.953056	6.336871	8585.263291	356.5453	86.83241	214.824	157.5746	2594.476	4033.551	831.3832	0.481541	0.000315	0.017887	1.146796	1.939908		1.83E-05	0.002107	0.002112	7.06E-05	13.42138	0.067438		0.315122	0.020307	2.002757835	0.016846		0.00147	0.021456	59.3043			3.282438	9.27E-05	0.002501	7.19E-05	0.261907
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
		90th Percentile	7.699612	6.236972	28009	215.351	250.61	564.525	510.183	8561.08	13322.8	2709.73	1.30244	0.000643	0.032252	3.60399	6.19348		4.3E-05	0.004503	0.001357	0.000135	17.0688	0.11263		0.683168	0.061203	6.323876578	0.044879		0.002178	0.052147	76.6212			11.607	0.000199	0.007191	2.42E-05	0.71765
		HQ	[illegible]		[illegible]	[illegible]				[illegible]	[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]		[illegible]	[illegible]	[illegible]	[illegible]		[illegible]	[illegible]		[illegible]		[illegible]	[illegible]						[illegible]		[illegible]
De Grey -Climate Change	Fallow periods	Average	7.974495	6.330529	5514.203165	293.8519	56.03691	154.9424	98.93797	1608.867	2499.469	532.9272	0.430486	0.000243	0.007184	0.731923	1.23534		1.04E-05	0.001603	0.000902	5.46E-05	12.09867	0.058537		0.249547	0.014021	1.299003469	0.011386		0.000533	0.013927	53.46009			3.058046	7.33E-05	0.001719	9.81E-06	0.158446
		HQ	1.226845		0.091903386	0.014693				0.089382	0.099979	0.021317		8.11E-05	0.000718	0.000183	0.000618		5.19E-06		4.51E-07	1.09E-06	0.008066	0.001951		0.024955	0.00028		0.000569		5.33E-05	0.001393						8.6E-05		0.000528
		90th Percentile	7.771239	6.236972	16420	214.117	154.666	352.59	322.02	5192	8049.6	1619.4	0.835396	0.000484	0.016815	2.4055	4.0844		2.08E-05	0.003224	0.001344	9.96E-05	14.577	0.087002		0.491325	0.045826	4.007414684	0.03354		0.001217	0.034373	64.9221			10.5004	0.000154	0.005428	1.6E-05	0.42413
		HQ	1.195575		0.273666667	0.010706				0.288444	0.321984	0.064776		0.000161	0.001681	0.000601	0.002042		1.04E-05		6.72E-07	1.99E-06	0.009718	0.0029		0.049133	0.000917		0.001677		0.000122	0.003437						0.000271		0.001414

Recreation HQ Calculations - Swan

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba	Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			6.5	-	60000	20000	-	-	-	18000	25000	25000	-	3	10	4000	2000	60	2	-	2000	50	1500	30	1	10	50	-	20	-	10	10	-	-	-	-	-	20	-	300
Swan - Base Line	Filling periods	Average	7.793157	6.345817	1208.638125	120.5747	37.33328	31.63374	18.95317	305.0659	477.0869	104.401	0.021584	1.17E-05	0.004119	0.165629	0.215882		1.46E-07	7.98E-05	0.000283	3.28E-05	3.349151	0.00919		0.021272	0.001838	0.237928643	0.001686		0.000158	0.002387	23.17536			0.33505	7.04E-06	0.000208	1.9E-05	0.033833
		HQ	1.198947		0.020143969	0.006029				0.016948	0.019083	0.004176		3.89E-06	0.000412	4.14E-05	0.000108		7.31E-08		1.41E-07	6.56E-07	0.002233	0.000306		0.002127	3.68E-05		8.43E-05		1.58E-05	0.000239						1.04E-05		0.000113
		90th Percentile	7.682797	6.236972	1587.65	73.916	50.3199	56.5492	25.1236	370.965	615.527	138.787	0.048189	2.5E-05	0.009125	0.208418	0.31555		2.61E-07	0.000159	0.000589	5.16E-05	8.06359	0.01842		0.042652	0.002574	0.380028115	0.003073		0.000264	0.003342	45.9472			0.429897	1.4E-05	0.000278	3.53E-05	0.054116
		HQ	1.181969		0.026460833	0.003696				0.020609	0.024621	0.005551		8.32E-06	0.000912	5.21E-05	0.000158		1.3E-07		2.94E-07	1.03E-06	0.005376	0.000614		0.004265	5.15E-05		0.000154		2.64E-05	0.000334						1.39E-05		0.00018
Swan - High Seepage	Filling periods	Average	7.798996	6.336314	1227.862	123.7945	37.09409	33.80398	19.1879	308.1113	481.6586	109.4676	0.020469	1.06E-05	0.003508	0.180475	0.211407		2.68E-07	9.82E-05	0.000366	4.65E-05	3.475738	0.008274		0.020121	0.00185	0.230819963	0.001741		0.000162	0.002281	23.29888			0.332161	6.25E-06	0.000209	2.77E-05	0.034484
		HQ	1.199846		0.020464367	0.00619				0.017117	0.019266	0.004379		3.53E-06	0.000351	4.51E-05	0.000106		1.34E-07		1.83E-07	9.3E-07	0.002317	0.000276		0.002012	3.7E-05		8.71E-05		1.62E-05	0.000228						1.04E-05		0.000115
		90th Percentile	7.681231	6.236972	1697.81	73.8573	50.1615	64.6988	25.9669	402.21	627.168	142.607	0.048766	2.41E-05	0.008123	0.215402	0.31025		2.59E-07	0.000174	0.000696	5.49E-05	9.88168	0.017359		0.042432	0.002566	0.356392846	0.002995		0.000299	0.003262	45.9877			0.450796	1.42E-05	0.000274	3.53E-05	0.057337
		HQ	1.181728		0.028296833	0.003693				0.022345	0.025087	0.005704		8.02E-06	0.000812	5.39E-05	0.000155		1.29E-07		3.48E-07	1.1E-06	0.006588	0.000579		0.004243	5.13E-05		0.00015		2.99E-05	0.000326						1.37E-05		0.000191
Swan -Climate Change	Filling periods	Average	7.786382	6.350507	1172.336375	117.0674	37.46864	29.92809	18.33696	294.8073	461.0858	101.2331	0.021912	1.15E-05	0.0043	0.160951	0.208465		2.76E-07	0.000101	0.000341	3.8E-05	3.198062	0.009071		0.021307	0.001783	0.2309086	0.001674		0.000152	0.002381	23.09146			0.323677	7.04E-06	0.000202	2.63E-05	0.032469
		HQ	1.197905		0.01953894	0.005853				0.016378	0.018443	0.004049		3.85E-06	0.00043	4.02E-05	0.000104		1.38E-07		1.71E-07	7.6E-07	0.002132	0.000302		0.002131	3.57E-05		8.37E-05		1.52E-05	0.000238						1.01E-05		0.000108
		90th Percentile	7.674338	6.236972	1568.46	73.1593	49.9634	48.9152	24.7955	368.772	611.896	128.836	0.053852	2.66E-05	0.010179	0.208446	0.31024		3.51E-07	0.000191	0.000664	5.01E-05	6.21109	0.018866		0.040888	0.002572	0.376376952	0.002959		0.000224	0.003347	45.8907			0.439313	1.53E-05	0.000274	3.54E-05	0.051402
		HQ	1.180667		0.026141	0.003658				0.020487	0.024476	0.005153		8.85E-06	0.001018	5.21E-05	0.000155		1.75E-07		3.32E-07	1E-06	0.004141	0.000629		0.004089	5.14E-05		0.000148		2.24E-05	0.000335						1.37E-05		0.000171
Swan - Base Line	Fallow periods	Average	7.832163	6.425893	3704.352089	214.572	62.79733	86.27361	64.31119	1063.208	1653.102	325.3194	0.09612	5.55E-05	0.014893	0.459594	0.801038		7.01E-07	0.000341	0.000213	2.09E-05	8.052613	0.039642		0.064522	0.006636	0.886598277	0.007374		0.000719	0.009117	49.87008			1.26774	3.9E-05	0.000737	1.09E-05	0.140701
		HQ	1.204948		0.061739201	0.010729				0.059067	0.066124	0.013013		1.85E-05	0.001489	0.000115	0.000401		3.51E-07		1.07E-07	4.17E-07	0.005368	0.001321		0.006452	0.000133		0.000369		7.19E-05	0.000912						3.68E-05		0.000469
		90th Percentile	7.730923	6.236972	9682.96	108.184	118.71	216.024	174.356	2957.6	4605.79	875.61	0.151763	9.8E-05	0.024948	1.19952	2.09894		1.25E-06	0.00058	0.000449	3.55E-05	13.1351	0.063565		0.098042	0.016336	2.155357335	0.015846		0.001378	0.021199	59.674			3.33618	7E-05	0.001844	2.1E-05	0.322288
		HQ	1.189373		0.161382667	0.005409				0.164311	0.184232	0.035024		3.27E-05	0.002495	0.0003	0.001049		6.23E-07		2.25E-07	7.11E-07	0.008757	0.002119		0.009804	0.000327		0.000792		0.000138	0.00212						9.22E-05		0.001074
Swan - High Seepage	Fallow periods	Average	7.819581	6.428821	4550.822089	234.9312	73.91965	101.3335	80.21045	1333.454	2073.972	404.9175	0.104008	6.08E-05	0.017793	0.568757	0.992062		7.96E-07	0.000381	0.000235	2.29E-05	8.364499	0.041346		0.06939	0.008112	1.076305972	0.008712		0.000925	0.010705	51.79523			1.516677	4.3E-05	0.000905	1.29E-05	0.169995
		HQ	1.203012		0.075847035	0.011747				0.074081	0.082959	0.016197		2.03E-05	0.001779	0.000142	0.000496		3.98E-07		1.18E-07	4.59E-07	0.005576	0.001378		0.006939	0.000162		0.000436		9.25E-05	0.001071						4.53E-05		0.000567
		90th Percentile	7.724812	6.236972	10768	108.035	123.168	241.12	195.882	3305.74	5144.51	984.029	0.1675	0.000108	0.028009	1.35626	2.38215		1.51E-06	0.000663	0.000454	4.47E-05	13.459	0.064347		0.10756	0.019051	2.49647892	0.018543		0.001739	0.024847	64.3839			4.67028	8.16E-05	0.002139	2.16E-05	0.38042
		HQ	1.188433		0.179466667	0.005402				0.183652	0.20578	0.039361		3.61E-05	0.002801	0.000339	0.001191		7.53E-07		2.27E-07	8.94E-07	0.008973	0.002145		0.010756	0.000381		0.000927		0.000174	0.002485						0.000107		0.001268
Swan -Climate Change	Fallow periods	Average	7.833114	6.42959	3520.820443	209.8336	60.92065	82.5528	60.8474	1004.834	1562.238	307.855	0.09357	5.37E-05	0.01395	0.43527	0.759029		6.78E-07	0.00033	0.000212	2.1E-05	7.947175	0.038823		0.06298	0.006301	0.845073941	0.00707		0.00066	0.008683	49.43825			1.199407	3.77E-05	0.000699	1.07E-05	0.134461
		HQ	1.205095		0.058680341	0.010492				0.055824	0.06249	0.012314		1.79E-05	0.001395	0.000109	0.00038		3.39E-07		1.06E-07	4.19E-07	0.005298	0.001294		0.006298	0.000126		0.000353		6.6E-05	0.000868						3.5E-05		0.000448
		90th Percentile	7.729618	6.236972	9831.22	107.555	110.72	220.631	177.116	3005.02	4679.66	889.206	0.142085	9.24E-05	0.024569	1.218	2.13179		1.2E-06	0.000558	0.000458	3.62E-05	13.107	0.058596		0.094482	0.016583	2.176018724	0.016061		0.001447	0.022401	58.486			3.44776	6.68E-05	0.001872	2.04E-05	0.31
		HQ	1.189172		0.163853667	0.005378				0.166946	0.187186	0.035568		3.08E-05	0.002457	0.000305	0.001066		5.98E-07		2.29E-07	7.24E-07	0.008738	0.001953		0.009448	0.000332		0.000803		0.000145	0.00224						9.36E-05		0.001033

HQ >1
HQ >5
HQ > 10

Table C.5
Downstream HQ Calculations

Parameter			pH	pe	TDS	Alkalinity	Ca	Mg	K	Na	Cl	SO4	Al	Sb	As	B	Ba
Lowest Criteria			6		600	200				180	250	88	0.055	0.001	0.01	0.37	0.01
NCCS - Base Seepage	Initial Condition	Average	7.6365	4.8313	738.6400	211.2200	44.8880	56.1522	12.8700	79.3550	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311	1.0561				0.4409	0.6804	0.8807	0.0000	0.0000	0.0000	0.5670	2.8052
		90th Percentile	7.6365	4.8313	738.6400	211.2200	44.8880	56.1530	12.8700	79.3550	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311								0.0000	0.0000	0.0000	0.5670	2.8052
NCCS - High Seepage	Initial Condition	Average	7.6365	4.8313	738.6400	211.2200	44.8880	56.1522	12.8700	79.3554	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311	1.0561				0.4409	0.6804	0.8807	0.0000	0.0000	0.0000	0.5670	2.8052
		90th Percentile	7.6365	4.8313	738.6400	211.2200	44.8880	56.1530	12.8700	79.3560	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311	1.0561				0.4409	0.6804	0.8807	0.0000	0.0000	0.0000	0.5670	2.8053
CCS - Base Seepage	Initial Condition	Average	7.6365	4.8313	738.6400	211.2200	44.8880	56.1522	12.8700	79.3550	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311	1.0561				0.4409	0.6804	0.8807	0.0000	0.0000	0.0000	0.5670	2.8052
		90th Percentile	7.6365	4.8313	738.6400	211.2200	44.8880	56.1530	12.8700	79.3550	170.0900	77.4990	0.0000	0.0000	0.0000	0.2098	0.0281
		HQ	1.2728		1.2311	1.0561				0.4409	0.6804	0.8807	0.0000	0.0000	0.0000	0.5670	2.8052
NCCS - Base Seepage	First Filling Seepage	Average	7.6269	4.8438	739.6155	205.3345	45.4720	52.7647	12.6191	85.7950	176.5907	75.2590	0.0005	0.0000	0.0001	0.1984	0.0351
		HQ	1.2712		1.2327	1.0267				0.4766	0.7064	0.8552	0.0091	0.0002	0.0055	0.5363	3.5135
		90th Percentile	7.6217	4.8505	747.9840	202.2230	45.9493	54.0761	12.8107	88.1641	179.0710	76.7283	0.0012	0.0000	0.0001	0.2034	0.0377
		HQ	1.2703		1.2466	1.0111				0.4898	0.7163	0.8719	0.0213	0.0005	0.0090	0.5498	3.7729
NCCS - High Seepage	First Filling Seepage	Average	7.6224	4.8497	743.7690	202.7590	45.7954	51.2690	12.5665	89.7286	181.0588	74.5413	0.0009	0.0000	0.0001	0.1937	0.0392
		HQ	1.2704		1.2396	1.0138				0.4985	0.7242	0.8471	0.0168	0.0004	0.0092	0.5234	3.9248
		90th Percentile	7.6140	4.8607	761.2970	197.6230	46.4059	53.9479	12.9726	93.5176	185.9350	77.5512	0.0019	0.0000	0.0001	0.2029	0.0429
		HQ	1.2690		1.2688	0.9881				0.5195	0.7437	0.8813	0.0351	0.0011	0.0131	0.5484	4.2922
CCS - Base Seepage	First Filling Seepage	Average	7.6269	4.8439	739.5797	205.3195	45.4767	52.7572	12.6189	85.7891	176.5817	75.2577	0.0006	0.0000	0.0001	0.1984	0.0351
		HQ	1.2711		1.2326	1.0266				0.4766	0.7063	0.8552	0.0101	0.0002	0.0055	0.5363	3.5138
		90th Percentile	7.6217	4.8506	747.3220	202.2350	45.9477	54.0698	12.8132	88.0431	179.0970	76.5961	0.0012	0.0000	0.0001	0.2033	0.0376
		HQ	1.2703		1.2455	1.0112				0.4891	0.7164	0.8704	0.0212	0.0005	0.0094	0.5495	3.7565
NCCS - Base Seepage	Sustained Seepage	Average	7.6334	4.8350	754.4636	209.5683	45.1545	55.2153	13.0320	86.2157	179.2188	77.9476	0.0013	0.0000	0.0001	0.2073	0.0344
		HQ	1.2722		1.2574	1.0478				0.4790	0.7169	0.8858	0.0229	0.0007	0.0139	0.5602	3.4443
		90th Percentile	7.6318	4.8373	774.4220	208.4840	45.3370	56.0652	13.3904	92.7120	189.3400	79.7110	0.0024	0.0000	0.0002	0.2096	0.0391
		HQ	1.2720		1.2907	1.0424				0.5151	0.7574	0.9058	0.0432	0.0013	0.0187	0.5664	3.9107
NCCS - High Seepage	Sustained Seepage	Average	7.6326	4.8357	781.5013	209.4845	45.3797	55.3043	13.4776	95.4022	192.8444	80.0339	0.0023	0.0000	0.0003	0.2089	0.0418
		HQ	1.2721		1.3025	1.0474				0.5300	0.7714	0.9095	0.0422	0.0014	0.0252	0.5645	4.1830
		90th Percentile	7.6302	4.8392	835.8240	207.6600	45.9032	56.7997	14.5042	112.8260	219.9710	85.1391	0.0042	0.0000	0.0004	0.2158	0.0544
		HQ	1.2717		1.3930	1.0383				0.6268	0.8799	0.9675	0.0755	0.0025	0.0353	0.5833	5.4400
CCS - Base Seepage	Sustained Seepage	Average	7.6334	4.8350	753.7888	209.5528	45.1493	55.2013	13.0190	85.9977	178.8802	77.8819	0.0012	0.0000	0.0001	0.2072	0.0343
		HQ	1.2722		1.2563	1.0478				0.4778	0.7155	0.8850	0.0226	0.0007	0.0137	0.5599	3.4280
		90th Percentile	7.6318	4.8373	771.8870	208.4870	45.3517	56.0145	13.3536	91.8856	187.9730	79.4952	0.0023	0.0000	0.0002	0.2093	0.0385
		HQ	1.2720		1.2865	1.0424				0.5105	0.7519	0.9034	0.0421	0.0013	0.0188	0.5658	3.8476

Parameter			Be	Cd	Co	Cu	Cr	F	Fe	Hg	Mn	Mo	Total Nitrogen	Nitrate	Nitrite	Ni	P	Pb	Se	Si	Ag	Sn	Sr	Tl	U	V	Zn
Lowest Criteria			0.01	0.0002	0.001	0.0014	0.006	1.5	0.03	0.0006	0.5	0.001				0.011	0.05	0.0034	0.01		0.00005	0.001			0.02		0.024
NCCS - Base Seepage	Initial Condition	Average			0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3316			0.0000		0.0000	0.0000	0.0000
		HQ			0.0000	0.0000	0.0000	0.2000	0.0376		0.0000	0.0000				0.0000		0.0000	0.0000						0.0000		0.0000
		90th Percentile			0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3317			0.0000		0.0000	0.0000	0.0000
		HQ			0.0000	0.0000	0.0000		0.0376		0.0000	0.0000				0.0000		0.0000	0.0000								0.0000
NCCS - High Seepage	Initial Condition	Average			0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3316			0.0000		0.0000	0.0000	0.0000
		HQ			0.0000	0.0000	0.0000	0.2000	0.0376		0.0000	0.0000				0.0000		0.0000	0.0000						0.0000		0.0000
		90th Percentile			0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3317			0.0000		0.0000	0.0000	0.0000
		HQ			0.0000	0.0000	0.0000	0.2000	0.0376		0.0000	0.0000				0.0000		0.0000	0.0000						0.0000		0.0000
CCS - Base Seepage	Initial Condition	Average		0.0000	0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3316			0.0000	0.0000	0.0000	0.0000	0.0000
		HQ		0.0000	0.0000	0.0000	0.0000	0.2000	0.0376		0.0000	0.0000				0.0000		0.0000	0.0000						0.0000		0.0000
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.3000	0.0011		0.0000	0.0000	0.2410			0.0000		0.0000	0.0000	8.3317			0.0000		0.0000	0.0000	0.0000
		HQ		0.0000	0.0000	0.0000	0.0000	0.2000	0.0376		0.0000	0.0000				0.0000		0.0000	0.0000						0.0000		0.0000
NCCS - Base Seepage	First Filling Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4041	0.0011		0.0011	0.0001	0.2314			0.0000		0.0000	0.0001	8.4554			0.0152	0.0000	0.0000		0.0011
		HQ		0.0000	0.0016	0.0113	0.0000	0.2694	0.0360		0.0022	0.0685				0.0040		0.0011	0.0103						0.0004		0.0442
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.4520	0.0011		0.0020	0.0001	0.2369			0.0001		0.0000	0.0001	8.9461			0.0204	0.0000	0.0000		0.0020
		HQ		0.0000	0.0030	0.0308	0.0000	0.3014	0.0381		0.0039	0.0967				0.0075		0.0018	0.0142						0.0006		0.0818
NCCS - High Seepage	First Filling Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4694	0.0011		0.0019	0.0001	0.2281			0.0001		0.0000	0.0002	8.6804			0.0235	0.0000	0.0000		0.0016
		HQ		0.0000	0.0030	0.0187	0.0000	0.3129	0.0359		0.0038	0.1061				0.0065		0.0017	0.0159						0.0006		0.0685
		90th Percentile		0.0000	0.0000	0.0001	0.0000	0.5866	0.0012		0.0034	0.0001	0.2380			0.0001		0.0000	0.0002	9.9034			0.0308	0.0000	0.0000		0.0030
		HQ		0.0000	0.0065	0.0532	0.0001	0.3911	0.0406		0.0068	0.1491				0.0124		0.0026	0.0215						0.0009		0.1244
CCS - Base Seepage	First Filling Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4033	0.0011		0.0011	0.0001	0.2315			0.0000		0.0000	0.0001	8.4563			0.0151	0.0000	0.0000		0.0011
		HQ		0.0000	0.0017	0.0116	0.0000	0.2688	0.0361		0.0022	0.0686				0.0041		0.0011	0.0103						0.0004		0.0442
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.4592	0.0012		0.0020	0.0001	0.2366			0.0001		0.0000	0.0001	8.9603			0.0203	0.0000	0.0000		0.0020
		HQ		0.0000	0.0035	0.0311	0.0000	0.3061	0.0385		0.0039	0.0964				0.0075		0.0019	0.0142						0.0006		0.0820
NCCS - Base Seepage	Sustained Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4084	0.0012		0.0008	0.0001	0.2418			0.0001		0.0000	0.0001	8.8575			0.0111	0.0000	0.0000		0.0014
		HQ		0.0000	0.0045	0.0017	0.0000	0.2723	0.0399		0.0017	0.0636				0.0070		0.0014	0.0090						0.0004		0.0587
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.4821	0.0013		0.0016	0.0001	0.2465			0.0001		0.0000	0.0001	9.2133			0.0190	0.0000	0.0000		0.0022
		HQ		0.0001	0.0082	0.0031	0.0000	0.3214	0.0435		0.0031	0.0999				0.0111		0.0018	0.0144						0.0006		0.0925
NCCS - High Seepage	Sustained Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4888	0.0013		0.0015	0.0001	0.2470			0.0002		0.0000	0.0002	9.2584			0.0244	0.0000	0.0000		0.0028
		HQ		0.0001	0.0085	0.0033	0.0000	0.3259	0.0421		0.0031	0.1297				0.0138		0.0026	0.0180						0.0007		0.1164
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.6642	0.0014		0.0028	0.0002	0.2593			0.0003		0.0000	0.0003	9.8168			0.0509	0.0000	0.0000		0.0052
		HQ		0.0001	0.0150	0.0061	0.0000	0.4428	0.0483		0.0056	0.2228				0.0245		0.0036	0.0344						0.0013		0.2182
CCS - Base Seepage	Sustained Seepage	Average		0.0000	0.0000	0.0000	0.0000	0.4081	0.0012		0.0008	0.0001	0.2416			0.0001		0.0000	0.0001	8.8578			0.0107	0.0000	0.0000		0.0014
		HQ		0.0000	0.0044	0.0017	0.0000	0.2721	0.0399		0.0017	0.0623				0.0069		0.0014	0.0088						0.0004		0.0576
		90th Percentile		0.0000	0.0000	0.0000	0.0000	0.4801	0.0013		0.0015	0.0001	0.2458			0.0001		0.0000	0.0001	9.2137			0.0180	0.0000	0.0000		0.0022
		HQ		0.0000	0.0079	0.0030	0.0000	0.3201	0.0434		0.0031	0.1000				0.0115		0.0018	0.0138						0.0006		0.0920

HQ > 1
HQ > 5
HQ > 10

Appendix D

Operations – Risk Assessment

Risk Event				Risk Assessment				
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Proposed Controls/ Mitigation Strategies**	**Consequence**	**Likelihood**	**Risk Rating**	**Rationale and Recommendations**
Deposition of tailings slurry in Swan / De Grey IPTSF **Dry waste fines** (Air quality)	Fugitive dust generated from TSF landform	Native terrestrial flora	Reduction in photosynthesis, respiration, and transpiration due to dust deposition	— Engineering and management controls (eg, vegerations windbreaks, dust suppression, as required) — Waste fines surface is below the pit crest, reducing evaporation, wind exposure, and dust generation — Air quality and dust deposition monitoring will be undertaken	Slight	Possible	Low	The risk to native terrestrial flora from airborne fugitive dust is considered **low**. In general, dust associated with iron ore mining (i.e., dust generated from mining activities in totality and not necessarily considering the dust generated from tailings alone) in the Pilbara is generally chemically inert (Butler 2009, Turner 2013). Effects on vegetation tend to be physical (e.g., dust loading blocking stomata of leaves and interfering with photosynthetic processes and transpiration loss) (Grierson 2015). Long-term studies of vegetation in other iron ore mining areas in surrounding areas have demonstrated the resilience of vegetation to dust exposure (Onshore Environmental, 2017). Additonally, monitored dust levels on vegetation at another iron ore related site in the Pilbara was not noted to cause significant stress or death to the vegetation monitored (Woodman Environmental, 2017). This is in part attributed to the fact that plant growth in arid environments is typically limited by rainfall with the growth period confined to the wet season when dust generation and loading are at their least and rainfall has dampened the landscape and washed leaves free of dust. Dust control measures will be implemented at various stages of tailings deposition and upon completion, surface dust levels are expected to be comparable to those from surrounding landforms.
		Nearby residents, traditional owners, and/or farmers. Recreational users of Ophthalmia Dam (limited exposure)[1]	Acute and chronic adverse health effects and amenity.		Minor	Rare	Low	Despite ongoing deposition of new waste fines slurry, tailings beaches have the potential to dry out. If left undisturbed, these types of surfaces tend to form crusts and hence, their susceptibility to wind erosion is low. If the surfaces are frequently disturbed, or the materials do not form a physical crust, then these tailings beaches can be subject to wind erosion and long-term deflation. Fugitive particulate matter or dust generated by wind from crustal sources are generally found in the >10 µm diamter range (>PM10) and require a threshold wind speed velocity in the range of 5-10 m/s to become dislodged and airborne. Long-term wind erosion potential of tailing storage has been identified as very low to negligible, and the magnitude of emissions is lower than emissions from other local and regional surfaces (McNaughton, et al, 2024). Additonally, the surface area available for dust generation of the tailings beaches is a small proportion of the local area. Initially, in-filling of Swan and De Grey with tailings has very low potential to produce wind-blown fugitive dust. There is an approximate 50% reduction of coarse dust (>PM10) emissions from these types of sources due to "in-pit retention". Tailings will be deposited to within the minimum allowable freeboard limits **(WSP, 2024b).** Therefore, near the end of the Swan and De Grey fill, there is the potential for tailings fines to be subject to greater wind erosion. These emissions are episodic and may become more frequent near the end-of-life for Swan and De Grey. These emissions can be reduced by implementing engineering and management controls (e.g. wind speed reduction via vegetation wind breaks, surface stabilisation, dust surpression). The effectiveness of the dust emissions controls will be assessed using ambient air quality and dust deposition monitoring. Placement of tailings slurry in the IPTSF has the potential to generate dust, some of which - depending on its grain size and quantity - may potentially reach the town of Newman (25 km west), and the Aboriginal communities of Parnpajinya or Jigalong, located approximately 25 km west and 60 km east of the IPTSF, respectively. Coarse dust (>PM10) generated from mining activities typically settles within 10's to 100's of metres from the source. Iron ore tailings also generates fine dust (PM10) however, the proportion of generated PM10 will likely be low, ie, much lower than dust >PM10. The potential exists for the dust to contain a proportion of crystalline silica, however, the dust needs to be within the respirable size range (PM10) in significant proportions to exert noticable adverse effects. It is generally understood that airborne particulate matter from crsutal sources is less hazardous than that from combustion sources. Fine dust (PM10) has the potential to travel 100's of metres to a few kilometres. Given then nearest communities are located further than 10 km from the IPTSF and they reside in a mining district, potential exposure to dust is a cumulative effects issue, rather than a risk attributed exclusively to the use of Swan and De Grey as IPTSF. If necessary, potential exposure of residents or sensitive environmental receptors to dust generated from the Swan / De Grey IPTSF, and/or other sources, can be **assessed through air quality monitoring and modelling.** Overall, based on the rare potential for inhalation exposure (required for health effects) and therefore minor outcomes, this pathway is assigned a **low** risk rating.
Failure of delivery pipeline carrying tailings slurry to Swan, De Grey IPTSF (Soil, groundwater, and surface water)	Direct discharge of tailings slurry to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline including riparian vegetation communities	Reduced soil and/or groundwater quality resulting in localised, short-term decline in floristic health	— Pipelines are specifically engineered for the material (i.e., tailings) being transported — Use of pipeline containment bunds — Regular (i.e., daily) visual inspections of pipeline integrity — Periodic pipeline wear assessments — Flow and pressure monitoring of pipelines for leaks	Slight	Unlikely	Low	The risk to receptors from failure of the delivery pipeline ranges is ranked as low. Firstly, the proposed controls and mitigation strategies are expected to minimise the release of tailing slurry in theunlikely event of delivery pipeline failure. The system will be equipped with flow and pressure sensors and a time variable set-point is included in the control system, with the intent to initiate a shut-down as quickly as practical. This will effectively minimise the release of tailings slurry to the ground surface, and together with the contaminant bunds, will limit the distance that tailings slurry is able to travel as overland flow. Any impacts from direct discharge of tailings slurry to the ground surface are expected to be localised, with the option of removing and discarding contaminated soil, if deemed necessary.
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems		Minor	Rare	Low	Groundwater in the vicinity of the Swan and De Grey area has been significantly drawn down to permit mining operations. Swan and OB31 have a hydraulic connection, therefore impacts to groundwater quality in the vicinity of Swan have the potential to impact the broader regional aquifer. The delivery pipeline route is expected to travel northwest from the proposed new beneficiation plant to the Swan / De Grey IPTSF locations along a bunded corridor (Figure 1.2).
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems		Minor	Rare	Low	To understand the consequence resulting from exposure of identifed receptors to the tailings slurry (solids and supernatant water), the tailings slurry was screened against adopted assessment criteria (Section Error! Reference source not found.). Firstly, tailings slurry was below adopted trigger criteria for human health (recreational) and livestock exposure scenarios. Additionally, the likely realistic exposure situations for humans and livestock would be much less frequent and for shorter durations than the scenarios assumed in the screening criteria Therefore, the slurry is considered to present a low to negligible risk to these human and livestock receptors.
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna		Minor	Rare	Low	The tailings solids material and the tailings supernatant water reported concentrations of PSOI predominantly below the adopted ecological screening levels. Low level exceedances of screening critieria were identified in tailing solids, groundwater, and surface (refer to HQ presented in Section 5.5.). As discussed in the report, an exceedence of screening critieria doesn't mean an adverse effect but triggers investigation. In regard to **native terrestrial flora the following have been considered in assigning a low risk ratin**g:
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	- Surface water screening criteria aply to aquatic ecosystms not terrestrial - Adopted tailings solids screening criteria are for long term exposure not acute short term scenarios like a pipe failure - The proposed management and controls spills from a pipe failure will be localised - The likelihood of a failure is unlikley.
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and downgradient receiving waters		Slight	Rare	Low	In regard to aquatic ecosystems, and other receptors drinking or having direct contact with surface waters, the following factors were considered in thevent that OB31 Creek, as the nearest surface water receptor, is impacted due to a delivery pipeline failure: — At its closest point, the pipeline corridor is located within approximately 3.8 km of OB31 Creek — The proposed new beneficiation plant will be located within approximately 4.7 km of OB31 Creek — At its closest point, Swan/De Grey is located within approximately 400 m of OB31 Creek — The close proximity of small tributaries of OB31 Creek to the pipeline corridor (Figure 1.2), which have the potential to direct/channel the flow of tailings slurry to OB31 Creek. However, given the proposed management controls outlined above, the likelihood of tailings slurry material reaching OB31 creek in the event of a pipeline failure is considered rare. OB31 Creek, an east flowing tributary of Jimblebar Creek, is an ephemeral waterway, experiencing only occasional short-lived flows in response to rainfall (RPS, 2013). As such, the presence of aquatic receptors (which are naturally adapted to completing their life cycle when water is present) and use of the watercourse by terrestrial fauna would be confined to a relatively short period of time during the year. This would limit receptor exposure to contamination in the event of a pipeline failure. Should a delivery pipeline failure occur, provided there is limited to minimal to no residual contamination in the creek bed after clean up, adverse effects for aquatic receptors are likely to be limited to one season, with any legacy contaminants likely to be dispersed downstream by the next high rainfall event. Therefore, the risk to receptors associated with OB31 creek are considered **low**.

Risk Event				Risk Assessment				
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Proposed Controls/ Mitigation Strategies**	**Consequence**	**Likelihood**	**Risk Rating**	**Rationale and Recommendations**
Decanting supernatant water from tailings in Swan, De Grey IPTSF Failure of decant water pipeline carrying supernatant water to process water pond (Soil, groundwater, and surface water)	Direct discharge of supernatant water to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	Soil and/or groundwater contamination resulting in localised, short-term decline in floristic health	— Pipelines are specifically engineered for the material (i.e., supernatant water) being transported — Use of pipeline containment bunds — Flow and pressure monitoring of pipelines for leaks	Slight	Possible	Low	Supernatant water, unlike tailings slurry, is a less viscous liquid, which, in the event of a decant pipe failure, may travel greater distances as overland flow if unimpeded and/or unmonitored. However, proposed controls and management of the decant pipeline (including bunding and flow/pressure monitoring) will reduce the risk of excess reelase. Supernatant water will to be piped back to the beneficiation plant for reuse in processing. However, excess decant water will need to be stored in a process water pond, the location of which is yet to be confirmed.
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems		Minor	Rare	Low	Geochemical modelling results indicate that a majority of the PSOI in ponded water from Swan / De Grey IPTSF will be at concentrations below the adopted ecological screening levels for surface waters and groundwater (refer to HQ presented in Section 5.5.3). Some low level exceedences of metals were identified in the surface water (Copper and Zinc) and groundwater (Barium and Copper) were identified during the screening process. Barium was the only PSOI with HQ greater than 5, resulting in a consequence rating of minor. Additionally, there is a lack of evuidence that a pipelines spill will result in direct contact of ecological receptors in surface waters and groundwater. So there are several factors to consider in terms of likelood: - the likelihood of a decant pipe failure - the supernatant water from a spill reaching surrounding creeks or watercourses - the short period that the supernatant water will be released in the event of a decant pipe failure the exposure durations of ecosystems within impacted surface water areas (whcih are expected to be limited and low) As the location of the process water pond is unconfirmed, there is uncertainty in the assessment of likelihood that supernatant water will reach the surrounding creeks (OB31 Creek) or other nearby watercourses in the event of a decant pipeline failure.
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems		Minor	Rare	Low	
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna		Minor	Rare	Low	
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Minor	Rare	Low	The concentrations of PSOIs in the ponded water from the IPTSFs were all below adopted screening levels for livestock, indicating the limited potential for direct impacts to livestock (cattle). Additionally, livestock direct exposure (ingestion) to supernatant water as a result of a pipeline spill is deemed to be rare. Pipeline spill water pooling in surface water systems is likely to be for a short period and dilution of the PSOIs from the ponded water would occur once it reached groundwater which may be used for consumption. Therefore, the risk to livestock from the failure of the decant water pipeline is considered low.
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and associated creeks		Minor	Rare	Low	The concentrations of PSOIs in the ponded water from the IPTSFs were below the screening levels for human health (recreational exposure and drinking water). In terms of likelihood for humans, exposure may occur where a pipeline spill was to result in water pooling in surface water systems or where it migrates into groundwater and is captured by a groundwater bore used for drinking water. Ponded water pooling in surface water systems is likely to be for a short period and therefore, on-going exposure to people undertaking recreational activities (such as swimming, wading and fishing) in the water is considered unlikely. It is likely that some dilution of the PSOIs from the ponded water would occur once it reached groundwater and this would further reduce the risks posed to human health from drinking water. Therefore, the risk to human health (recreational exposure and drinking water) from the failure of the decant water pipeline is considered low.
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source		Minor	Rare	Low	Given the above considerations, the risk to receptors from failure of the decant water pipeline ranges from **low .**
Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater and surface water)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna and riparian vegetation	Degradation of groundwater near Swan / De Grey IPTSF	— Groundwater and surface water quality and quantity (water level, flow) monitoring — Continued operation of dewatering system to manage seepage	Minor	Unlikely	Medium	Downstream water quality modelling has been conducted to assess water quality parameters at OB31 during operational periods which consider a mixture of pond seepage and natural groundwater in the proportions indicated by the groundwater modelling, as a time series (monthly basis). Screening results of the downstream water quality predictions indicate TDS and Barium exceed the screening criteria (See Section 5.5.4). Of the exceedances, one scenario detailing high seepage scenario during sustained seepage (late stages of the operational period) resulted in a HQ> 5. In summary, downstream water quality (upon entry into the groundwater system) may have concentrations of PSOI with some exceedences of the adopted screening levels
	Expression of groundwater contaminated with IPTSF waters to surface water and subsequent surface water migration downstream along natural waterways/ watercourses Expression of groundwater contaminated with IPTSF waters to OB31 dewatering system	Native terrestrial flora including riparian vegetation communities	Localised, short-term decline in floristic health due to raised water tables, uptake of contaminated shallow groundwater or surface water, and/or increased salts in surface soils due to evapo-concentration		Minor	Rare	Low	Surface expressions of seepage is unlikely, as the relative permeability between hydrogeological units is more likely to promote flows towards the deep aquifer rather than towards the surface. Groundwater modelling (WSP 2023e) provided insights into the risk of groundwater level rise during IPTSF operations. While Swan Pit shows higher seepage rates than De Grey Pit, groundwater levels are predicted to remain below the Swan Pit floor due to ongoing dewatering at OB31. Furthermore, the majority of seepage of IPTSF waters from Swan during operations is expected to be captured by the OB31 dewatering system (WSP, 2023e). In contrast, the De Grey Pit, which is not hydraulically connected to OB31, revealed localised effects of groundwater mounding. This is due to the pit being bounded by the lower permeability Mount McRae Shale and Mt Sylvia Formations, and due the inferred hydraulic barrier (dyke) between Swan and De Grey. The model predicts that groundwater mound will not be high enough to result in seepage to ground surface.
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and quantity and associated effects to aquatic ecosystems and the hydro cycle		Minor	Rare	Low	There is a potential pathway of exposure for surface water aquatic ecosystems, native terrestrial flora (including riparian vegetation communities) and fauna, livestock and humas (recreational users and drinking water) to groundwater impacted by seepage from the IPTSFs through the OB31 dewatering system, and the disposal of surplus water from this system to the receiving environment (including Ophthalmia Dam). Downstream water quality modelling has been conducted to assess water quality parameters at OB31 during operational periods which consider a mixture of pond seepage and natural groundwater in the proportions indicated by the groundwater modelling, as a time series (monthly basis). Screening results of the downstream water quality predictions indicate TDS and Barium exceed the screening criteria (See Section 5.5.4). Of the exceedances, one scenario detailing high seepage scenario during sustained seepage (late stages of the operational period) resulted in a HQ> 5. In summary, downstream water quality (upon entry into the groundwater system) after closure may have concentrations of PSOI with some exceedences of the adopted screening levels.
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source		Minor	Rare	Low	It is assumed that seepage water collected by the OB31 dewatering system will be managed as part of BHP's overall water management system and re-used or dispose. Seepage affected groundwater must meet applicable water quality guidelines and licence discharge criteria (e.g., SSTVs) prior to being discharged to the receiving environment (including Ophthalmia Dam). Based on the potential exceedance of adopted screening criteria (including the SSTVs) for aquatic environments, livestock and human drink water at the OB31 dewatering system may require treatment prior to re-use or disposal.
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	Without treatment prior to disposal to receiving environments (including Ophthalmia Dam), the concentrations of PSOIs in groundwater impacted by seepage at the OB31 dewatering system present a medium risk to surface water aquatic ecosystems and native terrestrial flora (including riparian vegetation communities) and fauna.
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek other nearby watercourses and waterbodies		Slight	Rare	Low	For livestock and drinking water, is it assumed that water in Ophthalmia Dam would be required to seep into the underlying groundwater and then migrate to an abstraction bore before it is used for livestock feeding or drinking water. It is likely that some further dilution of the PSOIs would occur during migration in groundwater and this would reduce the risks posed to human health from drinking water or livestock. In addition, it is acknowledged that drinking water (Newman town water supply) source water is treated by BHP and the Water Corporation to meet the Australian Drinking Water Guidelines (NHMRC and NRMMC 2011), as required by WA Health (BHP 2012). Therefore, there is likely an incomplete pathway for exposure of humans via drinking water that has indirectly been affected by water sourced from the OB31 dewatering system. Therefore, the concentrations of PSOIs in groundwater impacted by seepage at the OB31 dewatering system present a low risk to livestock and drinking water.
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	Based on the available information,a **medium** risk ranking is warranted for aquatic ecosystems. A **low** risk rating is assigned to native terrestrial flora and fauna, and a **low** risk to livestock, and recreational users of creeks and the groundwater receiving waters such as Ophthalmia Dam[5] from seepage losses.

Risk Event				Risk Assessment				
Primary and Secondary Sources (and Affected or Impacted Environmental Media)	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Proposed Controls/ Mitigation Strategies**	**Consequence**	**Likelihood**	**Risk Rating**	**Rationale and Recommendations**
Deposition of tailings slurry Swan / De Grey IPTSF Pit overtopping (Soil, groundwater, and surface water)	Flow of supernatant water over the pit rim[4]	Native terrestrial flora including riparian vegetation communities	Potential soil erosion and physical damage to vegetation from overland flow and/or flooding Soil and/or groundwater contamination resulting in decline in floristic health	— Engineering assessment of water balance and capacity to contain significant flood events — Contingency freeboard within relevant regulatory (i.e., DMIRS and ANCOLD) guidelines	Minor	Rare	Low	As detailed in the water balance model (WSP, 2023b), De Grey and Swan in-pit IPTSFs are located on Shovelanna Hill; therefore, flood risks from extreme storm events for these pits are minimal as they are not adjacent to any major watercourses. The reporting catchments are relatively small and would not cause excessive runoff inflow volumes during extreme storm events. Critical surface water management structures (i.e., diversions such as channels, dikes, and/or bunds) are not planned under future flood management strategies for these orebodies. In addition: — the final tailings elevation of the in-pit TSFs is such that the 1 in 1,000 AEP, 72-hour extreme storm event can be stored which complies with Global Industry Standard on Tailings Management (GISTM) requirements for a consequence category of 'Significant' and aligns with BHP's key risk indicators (KRIs) for TSFs; and — the contingency freeboard on top of the extreme storm event is the largest vertical distance of either 0.5 m above the stored event according to DMIRS requirements, or an additional 0.3 m plus freeboard for 1 in 10 AEP wind according to ANCOLD requirements. The most likely cause of a pit overtopping is an extreme storm event (and if there is overtopping of the diversion drains), beyond what the Swan / De Grey IPTSF have been designed for. Overtopping above the stored 1 in 1,000 AEP, 72-hour event may occur if another event occurs right after; however, the likelihood of consecutive independent events is extremely rare. In the rare event that the containment area overtops, the escaping supernatant water is likely to be diluted by heavy rainfall and thus, the risk to potential receptors from water quality and quantity in the receiving environment is considered **low**.
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems		Minor	Rare	Low	
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems		Minor	Rare	Low	
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	
		Recreational users	Adverse impacts to human health from recreational use of Ophthalmia Dam, or other nearby watercourses		Minor	Rare	Low	
Deposition of tailings slurry in Swan and De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan and De Grey IPTSF containment)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water	Native terrestrial fauna[3]	Acute or chronic effects on health Entrapment in soft fines	— Exclusion bunding around pit to discourage access — Routine surveillance program, including daily fauna checks	Minor	Possible	Medium	To guage the consequence to ecological receptors if exposed to tailings solids, the tailings solids data were screened against available assessment criteria (Section 5.5.). Concentrations of manganese and antimony concentrations had minor exceedences of the adopted ecological tailings screening values which triggerd further investigation as to the likelihood of direct contact by terrestrial fauna. In terms of the consequence to ecological receptors from exposure to supernatant water, modelling predictions for the in-pit ponded water were screened against available assessment criteria (Section 5.5). Low level exeedences of copper and zinc were identified. This triggered further investigation as to the likelihood of direct contact to the surface water by terrestrial fauna. Note that the screening criteria for both tailings solid and supernatant water apply to more of a chronic exposure scenario, rather than sporadic or intermittant exposures for short durations. The logic therefore leads to a minor consequence. In addition, there may be potential for direct or indirect effects from nutrients, such as harmful algal blooms (HAB) based on the nitrogen concentrations. In terms of likeloood of direct contact to tailings solid and supernatant water, the presence of a supernatant pond with beaches of tailings solids, may attract terrestrial fauna, particularly birds. However, the presence of moving plant and equipment in and around the TSF may deter some wildlife. Furthermore, the presence of nearby water storage dams which fauna may favour rather than accessing the supernatant pond. Regardless of the minor consequence, due to the unknown potential exposure, a likehood rank of possible is applied which derives a medium risk to native terrestrial fauna from entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water. WSP anticipates that BHP will manage the potential risks to the environment from the rare event of a pit wall collapse through implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure). As a result, the risk to aquatic ecosystems and native terrestrial flora and fauna is assessed to be **low** on the assumption that minor consequences are only expected under exceptional circumstances.
Deposition of tailings slurry in Swan and De Grey IPTSF Collapse of pit wall (Soil/rock)	Overland flow of debris and subsequent displacement of tailings and subsequent overland flow to downgradient receiving environments following pit wall collapse	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems Destruction of habitat	— Implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure)	Minor	Rare	Low	WSP anticipates that BHP will manage the potential risks to the environment from the rare event of a pit wall collapse through implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure). As a result, the risk to aquatic ecosystems and native terrestrial flora and fauna is assessed to be **low** on the assumption that minor consequences are only expected under exceptional circumstances.
		Native terrestrial flora and fauna[3]	Smothering and/or entrapment of receptors Destruction of habitat		Minor	Rare	Low	

Notes:

1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Parnpajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.
4) Pit overtopping may occur as a result of an extreme storm event, collapse of pit wall (if a supernatant pond is present in the TSF), or human failure.
5) Ophthalmia Dam is currently subject to limited recreational use which prohibits entry and activities associated with contact of the dam waters (BHP and East Pilbara Shire 2021).

AEP = annual exceedance probability; DMIRS = Department of Mines, Industry Regulation and Safety; ANCOLD = Australian National Committee on Large Dams.

Prepared: NA
Reviewed: JM

Appendix E

Closure – Risk Assessment

Risk Event				Risk Assessment				
Primary and Secondary Sources **(and Affected or Impacted Environmental Media)**	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Proposed Controls/ Mitigation Strategies**	**Closure Strategy - Partial Backfill**			**Rationale and Recommendations**
					Consequence	**Likelihood**	**Risk Rating**	
Post Deposition of tailings slurry in Swan / De Grey IPTSF Dry waste fines (Air quality)	Fugitive dust generated from TSF landform	Native terrestrial flora	Reduction in photosynthesis, respiration, and transpiration due to dust deposition	— Engineering and management controls Waste fines surface is below the pit crest, reducing evaporation, wind exposure, and dust generation — Air quality (i.e., dust) monitoring will be undertaken — Proposed closure strategy create seperation/barrier to source	Slight	Rare	Low	The risk to native terrestrial flora from airborne fugitive dust is considered **low**. In general, dust associated with iron ore mining (i.e., dust generated from mining activities in totality and not necessarily considering the dust generated from tailings alone) in the Pilbara is generally chemically inert (Butler 2009, Turner 2013). Effects on vegetation tend to be physical (e.g., dust loading blocking stomata of leaves and interfering with photosynthetic processes and transpiration loss) (Grierson 2015). Long-term studies of vegetation in other iron ore mining areas in surrounding areas have demonstrated the resilience of vegetation to dust exposure (Onshore Environmental 2017). This is in part attributed to the fact that plant growth in arid environments is typically limited by rainfall with the growth period confined to the wet season when dust generation and loading are at their least and rainfall has dampened the landscape and washed leaves free of dust.
		Recreational users, nearby residents[1], traditional owners, and/or farmers	Acute and chronic effects on human respiratory system and general health and amenity		Minor	Rare	Low	The partial backfill strategy option incorporates a cover layer with revegetation, which is considered to minimise dust generation. However, revegetation can only commence post the tailings consolidation period. During tailings consolidation (approximately 20 years post-2051), the dust generation potential would be similar to the operational period . These emissions can be reduced by implementing engineering and management controls. **The effectiveness of the dust emissions controls can be assessed using ambient air quality and dust deposition monitoring.** In addition, progressive remediation of the tailings surface, as consolidations allows, will reduce the area of tailings exposed and unvegetated overtime, further reducing the risk of dust. Overall, this pathway is assigned a **low** risk rating based on the final revegetated landform and the management of dust prior to revegetation being completed.
	Direct discharge of supernatant water to land and seepage to groundwater	Native terrestrial flora within the vicinity of the pipeline	Soil and/or groundwater contamination resulting in localised, short-term decline in floristic health	— Pipelines are specifically engineered for the material (i.e., supernatant water) being transported — Use of pipeline containment bunds — Flow and pressure monitoring of pipelines for leaks — Porposed closure strategy decomissions pipeline infastucture therefore removing potential source/pathway	Minor	Rare	Low	The decant system will likely be decommissioned post-operations. The risk of overtopping is reduced at closure and therefore, it is unlikely that the pond will need to be maintained (i.e., regularly decanted/pumped down) to keep it within a defined operating range. Futhermore, the closure design assumes that no perminant pond will exist however intermittent ponding from rain events may occur. Mitigation for reducing runoff volumes from the pit (thereby keeping any ponding volumes as low as reasonably practicable) includes constructing upstream diversions to direct runoff elsewhere downstream. However, noting the above, there is still the potential that at some stage during closure there will be a need to decant water from ponds within the pits and therefore, this exposure pathway has been retained in the Closure CEM. Decanting at closure will be at a significantly reduced rate to that of operations. Therefore, the risk of a pipe carrying decanting water is reduced at closure because water will be decanted at a significantly reduced frequency.
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems		Minor	Rare	Low	The water quality of ponds for Partial backfill closure has not been modelled. In the absence of predicted water quality modelling for Partial Backfill Closure, it has been assumed that the water quality of the ponds will have not concetrations greater that the modelling results from the Operations water quality. Given the discussion above on the reduced frequency of decanting, the likelihood of exposure has been assessed as rare, resulting in a risk rating of **low**. However further studies are recommended to increase the understanding of the geochemical conditions and influence to the regional hydrogeology at closure.
	Expression of contaminated groundwater to surface water and subsequent migration further downgradient; overland flow to surrounding creeks (OB31 Creek and other tributaries) and downstream receiving waters including Shovelanna Creek	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems		Minor	Rare	Low	
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source by fauna		Minor	Rare	Low	
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek and associated creeks		Slight	Rare	Low	
Deposition of tailings slurry in Swan / De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Groundwater and surface water)	Seepage of IPTSF waters through base and/or pit walls to groundwater	Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Degradation of groundwater near Swan / De Grey IPTSF	— Groundwater and surface water quality and quantity (water level, flow) monitoring	Minor	Unlikely	Medium	The draft DSP design included three (3) different closure options - Option 1 – Optimise Without (OWO); Option 2 - Partial Backfill; Option 3 - Full Backfill. Subsequent revision and workshopping of the 3 closure options confirmed that the Partical Backfill Closure was considered most beneficial and subsequently selected as the preferred closure strategy. No modelling was undertaken for partial backfill. No permanent in-pit ponds were expected to be present for the Partial Backfill Closure option however intemittent ponding and the seepage of rainwater through the consolidated tailings may occur. Water quality modelling based on the closure design conditions is recommended to fully understand future geochemical and hydrogeological conditions at closure.
	Expression of groundwater contaminated with IPTSF waters to surface water and subsequent surface water migration downstream along natural waterways/ watercourses	Native terrestrial flora including riparian vegetation communities	Localised, short-term decline in floristic health due to raised water tables, uptake of contaminated shallow groundwater or surface water, and/or increased salts in surface soils due to evapo-concentration		Minor	Rare	Low	Hydrogeological modelling was undertaken for operations but not for closure (post-2051). Informed by the operations hydrogeological modelling outcomes, it is assumed that seepage from the in-pit ponded water to underlying groundwater will continue at closure. Downstream water quality modelling has been conducted to assess water quality parameters at OB31 during operational periods which consider a mixture of pond seepage and natural groundwater in the proportions indicated by the groundwater modelling, as a time series (monthly basis). Screening results of the downstream water quality predictions indicate TDS and Barium exceed the screening criteria (See Section 5.5.4). Of the exceedances, one scenario detailing high seepage scenario during sustained seepage (late stages of the operational period) resulted in a HQ> 5. In summary, downstream water quality (upon entry into the groundwater system) after closure may have concentrations of PSOI with some exceedences of the adopted screening levels which are likly to be reduced. further
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and quantity and associated effects to aquatic ecosystems and the hydro cycle		Minor	Rare	Low	Based on the adopted results from the in-pit ponded water modelling during closure and downstream modelling results during operations, **a risk rating of Low to Medium has been assigned in relation to groundwater dependent ecosystems (primarily subterranean fauna)** to groundwater contaminated with IPTSF waters.
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source		Minor	Rare	Low	High-level water quality modelling undertaken for Closure Option 1 for the in-pit ponded water for the IPTSFs indicates that PSOI concentrations in the ponded water will below the adopted screening criteria for livestock and human health (with the exception of minor exceedances of taste thresholds for iron and manganese). Therefore, a risk rating of **low** has been assigned to exposure of livestock and humans to groundwater contaminated with IPTSF waters.
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	
		Recreational users	Adverse impacts to human health from recreational use of OB31 Creek other nearby watercourses and waterbodies		Slight	Rare	Low	
		Drinking water	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	

Risk Event				Risk Assessment				
Primary and Secondary Sources **(and Affected or Impacted Environmental Media)**	**Transport Pathway**	**Receptors**	**Potential Impacts**	**Proposed Controls/ Mitigation Strategies**	**Closure Strategy - Partial Backfill**			**Rationale and Recommendations**
					Consequence	**Likelihood**	**Risk Rating**	
Deposition of tailings slurry Swan / De Grey IPTSF Pit overtopping (Soil, groundwater, and surface water)	Flow of supernatant water over the pit rim[4]	Native terrestrial flora including riparian vegetation communities	Potential soil erosion and physical damage to vegetation from overland flow and/or flooding Soil and/or groundwater contamination resulting in decline in floristic health	— Engineering assessment of water balance and capacity to contain significant flood events — Contingency freeboard within relevant regulatory (i.e., DMIRS and ANCOLD) guidelines — Proposed closure stragey design for no-perminant pond and management intemittent ponding	Minor	Rare	Low	The risks associated with pit overtopping at closure are the same or less than the risks identified for operations. GISTM requirements for facilities in passive closure require the management of the 1 in 10,000 AEP event to be managed (or stored) as a minimum, which is already a rare event. Whereas other relevant guidance documents require the management of the probable maximum flood (PMF) event. The closure design criteria for managing extreme flood events will consider these requirements which are more conservative compared to operational flood design criteria. In addition, with the consolidated tailings surface and partial backfill, more runoff inflow volumes can be stored compared to the final design tailings surface during operations (i.e., more storage capacity). As supernatant water is the dominant inflow during operations, the dominant inflow during closure would be from the external catchments (assuming beneficiation plant is decommissioned). Proposed mitigation for reducing runoff volumes from reporting to the pond (thereby keeping the pond volumes as low as reasonably practicable) is constructing upstream diversions to direct runoff elsewhere downstream. In the rare event that the containment area overtops, the escaping ponded water is likely to be diluted by heavy rainfall and thus, the risk to potential receptors from water quality and quantity in the receiving environment is considered **low**.
		Groundwater dependent ecosystems including subterranean fauna and riparian vegetation communities	Adverse impacts to groundwater quality and associated ecosystems		Minor	Rare	Low	
		Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems		Minor	Rare	Low	
		Native terrestrial fauna[3]	Adverse health impacts resulting from ingestion of contaminated drinking water source		Minor	Rare	Low	
		Livestock (cattle)	Adverse health impacts resulting from ingestion of contaminated drinking water source		Slight	Rare	Low	
		Recreational users	Adverse impacts to human health from recreational use of Ophthalmia Dam, or other nearby watercourses		Slight	Rare	Low	
Deposition of tailings slurry in Swan and De Grey IPTSF Consolidation of tailings slurry and resulting supernatant water (Waste fines and supernatant water inside Swan and De Grey IPTSF)	Entry to TSF containment and subsequent direct contact with or ingestion of waste fines and/or supernatant water/ponded water	Native terrestrial fauna[3]	Acute or chronic effects on health Entrapment in soft fines	— Exclusion bunding around pit to discourage access	Minor	Possible	Medium	While exclusion bunding to discourage access of humans, livestock and wildlife to the pits is proposed, the effectiveness of exclusion bunds in preventing access to the pits by these receptors is unknown. In addition, at closure there will not be moving and operating equipment deterring wildlife access. The Partial Backfill Closure Strategy incorporates the tailings material being capped after the period of consolidation with a benign material (indicated to be waste rock covered by locally sourced surface soils). Therefore, direct exposure to tailings is considered unlikely. Assessment of the cover material is outside of the scope of this CEM. However, it is recommended that the suitability of the cover material in relation to chemical exposure risks of humans and wildlife is assessed prior to use.
		Aquatic ecosystem within in-pit ponds	Acute or chronic effects on health		Minor	Rare	Low	The tailings solids data was screened against available screening criteria (see Section 6.5.1). The tailings solids were below adopted criteria for the protection of human health (recreational use) and livestock and the material is considered to present a low risk for direct contact to these receptors. The tailings solids had PSOI concentrations above the adopted ecological screening levels (refer to HQ presented in Section 6.5.1), indicating that there is the potential for direct toxicity effects to ecological receptors (wildlife) if direct contact with tailings solids occurs. However, contact is unlikley based on the incorperated capping material and likelihood is ranked as rare. This translate to a **low** risk to human health and livestock. Intemittent ponding may occur in both the IPTSFs for the Partial Backfill Closure Strategy. Therefore, there is the potential for an aquatic habitat to establish in the pond overtime. However, these ecosystems are considered to be highly modified and likely not representative of native surface waters in the area. The water quality of these ponds has not been modelled as such further modelling is recommended. The potential exposure frequency and durations of terrestrial fauna is relatively unknown, and therefore a likelihood of possible has been allocated. This results in a risk rating of **medium** for native terrestrial fauna as a result of entry to TSF containment and subsequent direct contact with or ingestion of ponded water. Based on direct toxicity and likehood, if in-pit aquatic ecosystems establish, the risk ranking for this scenario is **low**. If aquatic ecosystem do not establish, this scenrio does not require assessment and exposure to in-pit water is non-existant.
		Livestock (cattle)	Acute or chronic effects on health		Slight	Rare	Low	
		Recreational users	Acute or chronic effects on health		Minor	Rare	Low	
Deposition of tailings slurry in Swan and De Grey IPTSF Collapse of pit wall (Soil/rock)	Overland flow of debris and subsequent displacement of tailings and subsequent overland flow to downgradient receiving environments following pit wall collapse	Aquatic ecosystems[2]	Adverse impacts to surface water quality and associated ecosystems	— Implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure)	Minor	Rare	Low	Detailed assessment of the physical safety risks associated with slope stability is outside the scope of this CEM and will be considered as a part of the Closure scope (WSP, 2023b). WSP anticipates that BHP will manage the potential risks to the environment from the rare event of a pit wall collapse through implementation of engineering controls (e.g., regular inspections of pit wall stability/slope failure). As a result, the risk to aquatic ecosystems and native terrestrial flora and fauna is assessed to be low on the assumption that minor consequences are only expected under exceptional circumstances. The risk of potential destruction of grazing land and recreational areas is also considered **low**.
		Native terrestrial flora and fauna[3]	Smothering and/or entrapment of receptors Destruction of habitat		Minor	Rare	Low	
		Livestock (cattle)	Destruction of grazing land		Minor	Rare	Low	
		Recreational users	Destruction of recreational areas/ significant sites		Minor	Rare	Low	

Notes:
1) Nearby residents refers to residents and visitors to the town of Newman, as well as Aboriginal residents and visitors to the Parnpajinya and Jigalong Communities.
2) Aquatic ecosystems includes surface waterbodies and watercourses, and their associated aquatic flora and fauna.
3) Native terrestrial fauna includes ground-dwelling mammals, reptiles, and birds.
4) Pit overtopping may occur as a result of an extreme storm event, collapse of pit wall (if a supernatant pond is present in the TSF), or human failure.

Prepared: ARC
Reviewed: JM

AEP = annual exceedance probability; DMIRS = Department of Mines, Industry Regulation and Safety; ANCOLD = Australian National Committee on Large Dams.