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PNX METALS

FOUNTAIN HEAD GOLD PROJECT

WATER MANAGEMENT PLAN

01238D_4_V5

JULY 2022

PNX Metals Ltd

Fountain Head Gold Project

Water Management Plan

01238D_4_v5, July 2022

ERIAS

13–25 Church Street

Hawthorn, Victoria, 3124

Australia

P +61 3 9208 6700

E info@eriasgroup.com

W eriasgroup.com

Client Contact:	James Fox james.fox@pnxmetals.com.au

ERIAS Contact:	David Browne david.browne@eriasgroup.com
ERIAS Alternative Contact:	Kate Sinai kate.sinai@eriasgroup.com

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01238D_4_v1	26/05/2021	S. Breschkin	K. Sinai	D. Browne
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1. Introduction

1.1 Background

PNX Metals Limited (PNX) proposes to develop the Fountain Head Gold Project (the Project). The Project will involve mining at Fountain Head and extracting gold from the ore using carbon in in pulp (CIP) processing.

Fountain Head is located on Ban Ban Springs Station, approximately 170 km south of Darwin in the Northern Territory, approximately 6 km east of the Stuart Highway (Figure 1.1). Mining at Fountain Head was most recently undertaken from 2007 to 2009 by GBS Gold; however, the site has a long history of gold mining and exploration dating back to the 1800s.

This water management plan (WMP) was updated as part of the Fountain Head Gold Project Supplement to the Environmental Impact Statement (EIS), submitted to the Northern Territory Environment Protection Authority (NT EPA) for assessment under the *Environmental Assessment Act 1983* (as in force 1 January 2013)(*EA Act*) on 29 November 2021. In accordance with clause 12 of the EAAP, in January 2022 the NT EPA directed PNX to provide additional information to the draft EIS, responding to the submissions received. This WMP has therefore been updated to address the submissions received.

The WMP will form part of the Project's mining management plan (MMP), as required under the *Mining Management Act 2001* (as in force 1 July 2015) (*MM Act*) and it will also be updated as required once activities commence.

1.2 Purpose and Scope

1.2.1 Purpose

This WMP has been prepared to address water management and to satisfy the information required under the Project's Terms of Reference for Preparation of an Environmental Impact Statement (EIS) issued to PNX 11 May 2020 for assessment under the *EA Act* and to address comments received on the Draft WMP submitted with the Draft EIS in June 2021, and the comments on the Supplement to the EIS (January 2022). This WMP describes how potential impacts to water quality, hydrological processes and aquatic ecosystems will be sufficiently monitored and managed.

1.2.2 Scope

This WMP describes:

- Legislative and regulatory requirements applicable to water management.
- Project activities relevant to water management.
- Existing hydrology, surface water quality, groundwater quality and aquatic ecosystems relevant to the Project.

PROJECT LOCATION

Fountain Head Gold Project | Water Management Plan

FIGURE 1.1

SCALE: 1:1,200,000 @ A4

0 5 10 20 KM

GDA2020 MGA Zone 52

- Populated place
- Site
- Major gold deposit
- Major base metal deposit
- Roads
- Railway
- Watercourse

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ERIAS, 13-25 Church Street
Hawthorn VIC 3122, Australia

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Map ID: 01238D_4_GIS002_v0-a

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DATA SOURCE:
Project data from PNX Metals, 2021.
Base data from NT Government, 2021 & GEODATA 250K, 2006.
Imagery © ESRI, DigitalGlobe and Partners, 2021.

- Potential impacts to hydrological processes, surface water quality, groundwater quality and aquatic ecosystems from Project activities and mitigation and management measures to reduce these impacts.
- Performance objectives, targets, assessment criteria and contingency measures.
- The proposed monitoring program including locations, frequency, parameters and guideline values.
- Management and reporting requirements.

1.3 Objectives

The objectives of this WMP are to:

- Meet the requirements of applicable legislation including the *EA Act*, *MM Act, Environment Protection Act 2019 (EP Act)* and *Water Act 1992*.
- Describe how site waters will be managed to meet the Northern Territory Environmental Protection Agency's (NT EPA's) objectives for inland water environmental quality, hydrological processes and aquatic ecosystems, which are to:
    1. Maintain the quality of groundwater and surface water so that environmental values including ecological health, land uses, and the welfare and amenity of people are protected.
    2. Maintain the hydrological regimes of groundwater and surface water so that environmental values are protected.
    3. Protect aquatic ecosystems to maintain environmental water requirements and the biological diversity of flora and fauna and the ecological functions they perform.
- Describe the controls to be implemented to minimise impacts on water quality, hydrological processes and aquatic ecosystems in and around the Project area.
- Describe how beneficial uses relevant to surface water and groundwater will be protected.

This WMP has been prepared in accordance with the Mining Management Plan Structure Guide for Mining Operations, Section 6 – Water Management Plan (DPIR, 2017), and also covers the following specific information requested for inclusion in the WMP as outlined in the Project's Terms of Reference:

- Strategies for managing stormwater including stormwater drainage infrastructure.
- The methodology for treating any poor-quality water from the pit, and a predicted schedule for any controlled discharge.
- Sufficient detail (including reference to the conceptual Mine Closure Plan) to demonstrate that mine closure strategies will be implemented to avoid impacts to values dependent on good water quality, both during operation and into the long-term following closure.

- Containment of runoff or leachate from mine material and tailings[1], along with consideration of the potential for environmental and structural impacts on railway operations and downstream impacts on railway land in a worst-case scenario.
- Details of internal review process for the WMP.

1 The Terms of Reference refers to containment of runoff or leachate from the heap leach facility; however, the Project process now involves CIL processing and tailings storage.

2. Regulatory Framework

2.1 Legislative and Regulatory Requirements

This section describes the key legislation relevant to the management of water.

2.1.1 Environmental Assessment Act and the Environmental Assessment Administrative Procedures

The environmental assessment process is administered under the *EA Act* taking into account the *Environmental Assessment Administrative Procedures* (EAAP). The *EA Act* ensures that each matter affecting the environment is examined and taken into account in relation to:

- Formulation of proposals.
- Carrying out of works and other projects.
- Negotiation, operation and enforcement of agreements and arrangements (including with authorities of the Commonwealth, the state and other territories).
- Making decisions and recommendations and incurring of expenditure.

2.1.2 Environment Protection Act

The *EP Act* replaced the *EA Act* on the 28 June 2020. The Project will be assessed under the *EA Act*; however, approval will be granted under the new *EP Act*.

2.1.3 Mining Management Act

The Department of Industry, Tourism and Trade (DITT) oversees the approval and regulation of mining activities. The Fountain Head mining leases have been in a care and maintenance phase since 2009. As such, no operational mining or processing activities have occurred since that time. Authorisation of the proposed mining operation outlined in the EIS is required under the *MM Act*. To apply for authorisation, PNX will prepare a MMP. Once approved, the WMP will form part of the MMP.

Authorisations for mining operations are granted by the Minister for Mines on the advice of DITT. For projects assessed under the *EA Act*, the Minister may impose conditions relating to recommendations received from the NT EPA. Authorisations are granted following completion of the EIS assessment process. An authorisation is required before any activities can commence on the mining leases.

2.1.4 Water Act and Regulations

The *Water Act* (as in force 20 November 2020) and the *Water Regulations 1992* (as in force 20 November 2020) are administered by the Department of Environment, Parks, and Water Security with assistance from the Environment Protection Agency (EPA). The *Water Act* provides for the administration of water resources in the Northern Territory, including the investigation, allocation, use, control, protection and management of surface water and groundwater resources.

The *Water Act* provides for administration of water resources, including licenses to extract surface water and to discharge wastewater.

A license under the *Water Act* will be required to extract water from the pit, but will not be required to discharge wastewater as it is not proposed to dispose to non-potable water courses, such as rivers and streams.

2.2 Guidelines

The WMP has been developed with reference to the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) guidelines including the following National Water Quality Management Strategy documents:

- Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZG, 2018).
- Australian and New Zealand Guidelines for Freshwater and Marine Water Quality (ANZECC/ARMCANZ, 2000a)[2].
- Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC/ARMCANZ, 2000b).
- Australian Drinking Water Guidelines (NHMRC/NRMMC, 2011).
- Guidelines for Groundwater Quality Protection in Australia (Australian Government, 2013).

[2] While the Australian and New Zealand Government (ANZG) (2018) replace the previous ANZECC/ARMCANZ (2000a) guidelines, default guideline values for the Timor Sea drainage division where the Project is located have not yet been published; therefore, the regional default guidelines values from ANZECC/ARMCANZ (2000a) have been used.

3. Project Description

3.1. Project Overview

PNX proposes to recommence mining of the Fountain Head pit and extract gold from the ore using carbon in leach (CIL) processing to produce gold ore over a period of approximately 3.5 years.

The project will involve the following key water relevant activities:

- Dewatering of existing open pit and remediation and extension of existing evaporation pond walls.
- Expansion of existing integrated waste landform (IWL) and disposal of potentially acid forming (PAF) in the Fountain Head pit.
- Construction of crushing facilities and gold processing plant (CIP).
- Construction of supporting infrastructure (including workshops, power station, roads, offices).
- Construction of surface water management features including sediment and runoff dams.
- Operation of CIL plant and supporting infrastructure.
- Continued dewatering of the pit and evaporation pond.
- Closure and rehabilitation activities including progressive and final rehabilitation of the IWL, capping of the tailings storage area and infrastructure and reshaping disturbed areas. Further detail on closure activities is provided in the Fountain Head Gold Project Mine Closure Plan (ERIAS, 2021).
- Closure monitoring program and maintenance (as required).

The Project area is approximately 634 ha. Existing disturbance from previous mining activities affects 26% of the overall area and the new Project disturbance is estimated to be an additional 13%.

There is a surface flow path from the south which flows into the mine lease to Fountain Head Lake. Some minor alterations to the existing drainage lines within the mine lease are proposed to divert water around the mine processing area and along the western toe of the IWL, to reinstate the natural flow path and to divert natural catchment runoff to the Fountain Head Lake. A diversion is also proposed along the northern side of the evaporation pond as the expanded footprint includes the existing flow path.

The following section describes the project components relevant to water management.

3.2 Project Components

3.2.1 Dewatering

The existing Fountain Head pit has filled with ground water inflows, surface water runoff and rainfall since mining ceased in 2008. Currently there is approximately 2,064 ML of water contained in the pit. Dewatering of the Fountain Head pit is required to enable mining to recommence. The dewatering of the pit was addressed in the Fountain Head Tally Ho Mining Management Plan (MMP) approved in March 2021. An overview of the dewatering activities is outlined below for completeness.

Dewatering of the current pit will need to be strictly scheduled and managed so that dewatering occurs sufficiently in advance of mining so that no production delays result. Not all water is required to be removed before mining can recommence and subsequently a staged approach to dewatering is proposed. Three evaporators will be used to dewater the pit by increasing natural evaporation rates (it is expected that evaporators will work at a rate of 135 m^3/hr and remove around 2 to 4.5 ML/d depending on evaporation efficiency and assuming 20.3 operating hours per day, daily). A typical setup of these evaporators is shown in Plate 3.1.

Six to nine months of dewatering the pit using evaporators around the perimeter of the pit will occur before mining commences. Once mining has commenced, the evaporators will operate in the pit for a further three months and will then be moved to a central pad within the remediated evaporation pond to continue pit dewatering during mining. At this time, water will be pumped from the pit to the evaporation pond for natural and forced evaporation and retention.

Plate 3.1 – Typical Evaporator System

Source: Minetek.

The evaporation pond will be developed from an existing water storage dam following minor remediation to one section of the dam where erosion to the wall has occurred and extension of the length and height of the northern dam wall to increase the storage capacity. Remediation of the dam will provide structural integrity and potential for use post-closure for other uses such as water storage for stock water and/or irrigation.

3.2.2 Ore Processing

3.2.2.1 Processing Plant

The processing plant will extract gold from mining ore via a leaching circuit that includes CIL tanks. This leaching process produces the gold doré and is referred to as the CIL method. Gold bearing ore from mining will be stockpiled on a ROM pad at a rate of 750,000 tonnes per annum, and the process plant will then treat the ore via the leaching circuit within the process plant. The major components of the plant will include crushing, grinding and leaching circuits, gold recovery, cyanide detoxification circuit, reagents store, plant infrastructure services, laboratory and offices.

Construction of the gold processing plant will take approximately ten months with major components being manufactured off site in accordance with construction specifications for the facility.

3.2.2.2 Process Description

The CIL process will comprise the following key activities:

- Delivery and stockpiling of ore at the ROM pad.
- Crushing and screening of a three-stage crushing circuit.
- Addition of lime to slurry entering the leach circuit and milling/grinding of ore.
- Gravity gold recovery via a Knelson concentrator and gravity table.
- Leaching within the CIL circuit, including the addition of cyanide solution. The CIL circuit eventually discharges gold-loaded carbon to bulk bags, and slurry to the tails hopper to be pumped to the tailings thickener.
- Stripping of gold-loaded carbon in an elution system, producing a concentrated gold-cyanide elution solution.
- Pumping of the elution solution to an electrowinning cell and smelting of gold into a doré.
- Filtering of tailings from the CIL for disposal within the bunker in the IWL, and cyanide removal.

3.2.2.3 Waste Rock and Tailings Management

Current pit design estimates that a total of approximately 18 Mt of waste rock will be moved to access the ore. Selective handling and management of waste rock will be carried out during mining. Geochemical testing during the mine life will determine whether waste rock is potentially acid forming (PAF) or non-acid forming (NAF). Waste rock will be co-disposed with tailings in the

IWL. The IWL is an engineered landform to provide stability and minimise infiltration, the formation of AMD and surface erosion.

PAF Material

PAF materials, i.e., sulphur content above 0.4%, will be segregated and stockpiled within the Fountain Head pit. PAF waste rock will be placed in one of three pods that are all located within the pit perimeter. Runoff from these pods will be managed within the pit perimeter and as part of the ongoing dewatering of the pit during mining. The runoff will be diluted by rainfall and groundwater inputs; however, if needed, the water will be treated in situ prior to pumping to the evaporation pond, which will occur throughout mining operations to maintain a dry pit.

All 3 pods could be used during mining, with all material in Pods 1, 2 and 3 being relocated to the bottom of the pit at the end of the mine life, so it can be inundated by natural groundwater recharge and rainfall. Once submerged, any potential impacts relating to acid and metalliferous drainage (AMD) will be mitigated.

Integrated Waste Landform (Co-disposal)

The IWL landform will be designed to have a total waste rock capacity of 20.81 Mt and will be constructed to allow for the co-disposal of waste rock and tailings produced as a by-product of the CIL processing plant. Tailings will be deposited into the dedicated storage cell within the IWL with a 4 m-wide low permeability layer. NAF and PAF-low capacity (PAF-LC) waste rock will be placed to form a ‘doughnut’ shaped structure within which the tailings will be placed.

The approach to tailings management will include:

- Floor and foundation of the embankments of the IWL will comprise of a 1.5 m thick layer of clay material overlying phyllite bedrock to provide low permeability.
- One decant well within the tailings cell to capture infiltration and runoff and the water will be pumped to the process plant.
- Underdrainage system will be placed beneath the IWL to capture seepage from the clay liner. The water will run to two sumps prior to being pumped to the process plant.
- Use of a water tanker during the dry season to prevent the exposed tailings from drying out and blowing out of the IWL tailings cell.
- At closure the IWL will be capped with 0.5 m of compacted clay and 1.5 m of waste rock to minimise infiltrating water through the IWL and reduce the risk of mobilising metals. The waste rock cover will store excess water during the wet season which will subsequently evaporate during the dry season. The IWL will also be shaped into a concave landform to encourage runoff. Further detail is provided in the Mine Closure Plan (ERIAS, 2021).

The IWL will have final batter slopes of approximately 10°, 15° and 20° on the lower, middle and upper slopes respectively, with no berms.

3.2.3 Project Water Demand

Water use during construction will be for dust suppression, moisture conditioning of pavements and foundations only and will be sourced from the Fountain Head pit, but the total consumption will be minimal.

Potable water will initially be trucked to site and stored in sealed water tanks. Once operations are established, if suitable water is available from the Fountain Head Lake then this water will be utilised for potable use. A skid mounted UV treatment and filtration system will be used to treat the water prior to use.

The potable water requirements on site are limited to drinking water, safety showers, pump gland seals, Knelson concentrators and explosive manufacture, total consumption will peak at around 5,500 L/hr.

The Project requires approximately 27t/hr of non-potable water which will be sourced from the Fountain Head pit (predominantly) or evaporation pond.

3.3 Site Water Balance

3.3.1 Overview

An assessment of hydrology was undertaken by CDM Smith (2021a) and CDM Smith (2022b) to:

- Estimate dewatering requirements for life of mine (LOM).
- Demonstrate that the planned water storage capacity and evaporators will be sufficient to enable dewatering of the pit for mining, and storage of water on site.
- Estimate the seepage rates from the evaporation pond.
- Predict groundwater contours during pre-mine, mining and closure stages.
- Assess the ongoing frequency and volume of overflow/flush at Fountain Head Lake.
- Determine the pit water level recovery rate post-closure.

The site water balance includes three stages:

- Stage 1: Dewatering.
- Stage 2: Mining.
- Stage 3: Post-mining.

Stage 1 is being undertaken via a separate approval process; however, it is included in this section as it is an important component of the overall site water balance.

The site water balance components considered in the model included the Fountain Head pit, the evaporation pond and the Fountain Head Lake, which are described in the following section.

The site water balance aligns with the approach of the Minerals Council of Australia Water Accounting Framework, which describes how to report on a mass balance, i.e., present the input, output and storage components, how they relate, whether they are measured/estimated/simulated, their solute concentrations, units of measurement, background and context of the site conditions.

3.3.2 Conceptualisation

In Stage 1, PNX will dewater the Fountain Head pit using three evaporators located within the pit. Mining will commence in early 2023 and the mining operations will work around the three in-pit evaporators for three months before they are removed and relocated to the evaporation pond.

In Stage 2, once the three evaporators are relocated to the evaporation pond the in-pit dewatering pumps will continue to draw the pit water down to maintain a water level in advance of the vertical mining rate. Once the pit is dewatered, sump pumps will be required to maintain a dry pit for mining and this water will also be pumped to the evaporation pond. The three evaporators will be utilised in the evaporation pond to reduce the water volume stored in the pond, which will aid in maintaining available storage capacity. Once mining is complete use of the evaporators will cease.

Note the modelling assessment has not included the use of dewatering wells or considered the volume of in-pit sumps to achieve or buffer dewatering efforts, respectively. Pit inflows (groundwater, rainfall, runoff) will be balanced by natural evaporation and forced evaporation from the evaporators until they are re-positioned around the perimeter of the evaporation pond late 2022. The modelling considers three distinct stages (pre-mining dewatering, mining and post-mining), even though there will be some overlap in the timing of some operations in practice (e.g., mining would begin prior to full dewatering).

3.3.2.1 Fountain Head Pit

The evaporators will operate in the pit for six to nine months prior to the commencement of mining and for a further three months once mining begins. After such time they will be moved to the evaporation pond and water will be pumped from the pit to the evaporation pond to maintain dry working conditions during mining. Pit groundwater inflow is expected to be 2 ML/day and pumping will occur at a maximum rate of 9 ML/d (with variation depending on seasonal factors) to achieve the required levels of dewatering. Pit dewatering rates will be controlled by the capacity of the evaporation pond. The dewatering rate will be adjusted to maintain the evaporation pond water level beneath the operational trigger water level of 97.4 m Australian Height Datum (AHD). The trigger level provides a 365 ML buffer before an evaporation pond overflow event.

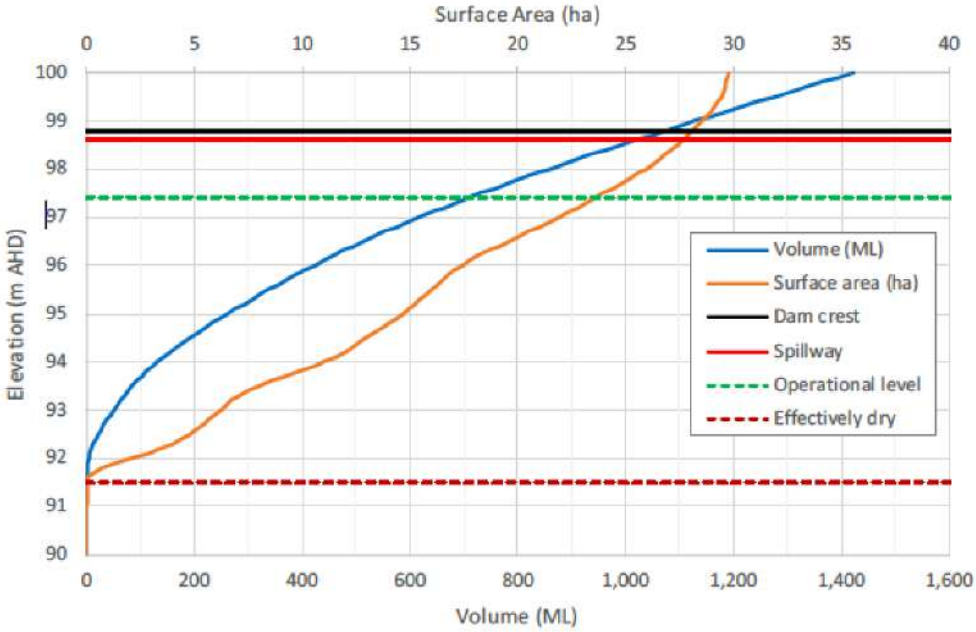
For the model, the Fountain Head pit conceptualisation has considered the transition from the existing void dimensions to the final mined dimensions, modelled as occurring instantaneously which provides a conservative estimate of pit inflow and pumping requirements (i.e., maximum groundwater inflow rate that can be expected within the constraints of model parameter assumptions).

3.3.2.2 Evaporation Pond

The evaporation pond modelling balances the inflows (direct rainfall, runoff and contribution from the Fountain Head pit dewatering) and outflows (evaporation, both natural and mechanically forced by evaporators, and groundwater infiltration/seepage).

Satellite imagery shows that the existing dam has had a residual water body present for most years, from at least 1987 to present. For modelling purposes, this residual volume is assumed to be permanent and therefore is not accounted for in the storage capacity of the evaporation pond. The existing water volume is considered as separate to the base of the evaporation pond, with the total additional capacity amounting to 1,074 ML for a dam wall height of 98.8 m AHD (Figure 3.1). The proposed spillway level is 98.6 m AHD with a capacity of 1,019 ML. However, the evaporation pond will mainly operate between a minimum level of 93 m AHD and a maximum operational level specified by PNX of 97.4 m AHD, which allows for approximately 1.2 m freeboard from the spillway at 98.6 m AHD. The operational volume defined by these thresholds amount to 660 ML. The lower threshold aims at keeping a 50 ML reserve of water to meet site water demand. The upper threshold aims at keeping a sufficient storage capacity in the evaporation pond to prevent a 1% AEP 72-hour rainfall event from reaching the spillway level.

Figure 3.1 – Evaporation Pond Level-volume-surface Area Relationship with Operational and Other Levels



Source: CDM Smith (2021a).

Once operating in the evaporation pond, the three evaporators will remove around 2 to 4.5 ML/day depending on evaporation efficiency and assuming they are operating 20.3 hours per day. Monthly evaporation efficiencies considering seasonal climatic conditions including rainfall, potential evaporation and wind adopted by the model are shown in Table 3.1.

Table 3.1 – Monthly Evaporators Efficiency

Month	Evaporation Efficiency (%)
January	27%
February	24%
March	33%
April	42%
May	48%
June	50%
July	52%
August	55%
September	54%
October	50%
November	42%
December	33%

Natural evaporation from the pond is not expected to be impacted by the use of the evaporators. As the evaporation pond fills, groundwater infiltration (seepage) will progressively increase as the wetted area and the water level in the evaporation pond increase.

At the end of mining the evaporators will cease operation and the evaporation pond storage will evolve back to its previous natural rainfall-runoff input, evaporation and groundwater infiltration dynamics.

3.3.2.3 Fountain Head Lake

The Fountain Head Lake is a man-made surface water feature and is the void remaining from historical alluvial mining. The lake exists due to the mine site haul road downstream of the lake which forms a barrier and dams the water in the lake.

Runoff from the hardstand areas including the ROM, CIL plant and contractor yard as well as the western side of the IWL will drain to the Fountain Head Lake, either directly or via sediment dams (W2, W3 and E3). The sediment dams are discussed in Section 3.4.2 and are shown in Figure 3.6.

The model accounts for water inflows from direct rainfall and from runoff, as well as losses of water to evaporation and through downstream overflow to the north. The surface level of the Fountain Head Lake is assumed to be comparative with the water table elevation (i.e., it is possibly a surface expression of the water table) based on nearby groundwater levels and satellite imagery showing the frequent presence of water in the lake. However, the available data is not sufficient to quantify the surface water and groundwater interaction status or changes over time. As a result, losses from the Fountain Head Lake to groundwater during high water levels and the potential groundwater inflow during low water levels were not included in the modelling.

3.3.3 Model Approach

The water balance model simulates the water management of the mine site from the existing pit dewatering stage (Stage 1), the mining stage (Stage 2) and up to 500 years post-mining (Stage 3). The physical structure of the site comprises three main components:

- The Fountain Head pit – during the dewatering period the pit shape used in the mass balance is the historical pit shape but, from the start of the proposed mining operation, the pit shape and associated bathymetry is swapped to the planned final pit shape at the end of mining.
- The evaporation pond – has a volume to level relationship based on the upgrade works proposed for the site.
- The Fountain Head Lake – has bathymetry defined by the latest digital elevation models available and includes the proposed CIL plant and other catchments related to proposed sediment dams.

The water balance model concurrently simulates the Fountain Head pit, the evaporation pond and the Fountain Head Lake to allow for a seamless transfer of water from the three sub-systems when applicable.

The site water balance was modelled using GoldSim software, and included both a deterministic approach and a probabilistic approach using a Monte Carlo analysis. The whole water management system and the structure of the GoldSim model is illustrated in Figure 3.3. Further detail on the water balance modelling methods are provided in CDM Smith (2021a). The results of the modelling are summarised in the following sections.

3.3.4 Water Balance Modelling Results

3.3.4.1 Fountain Head Pit Dewatering and Recovery Model Results

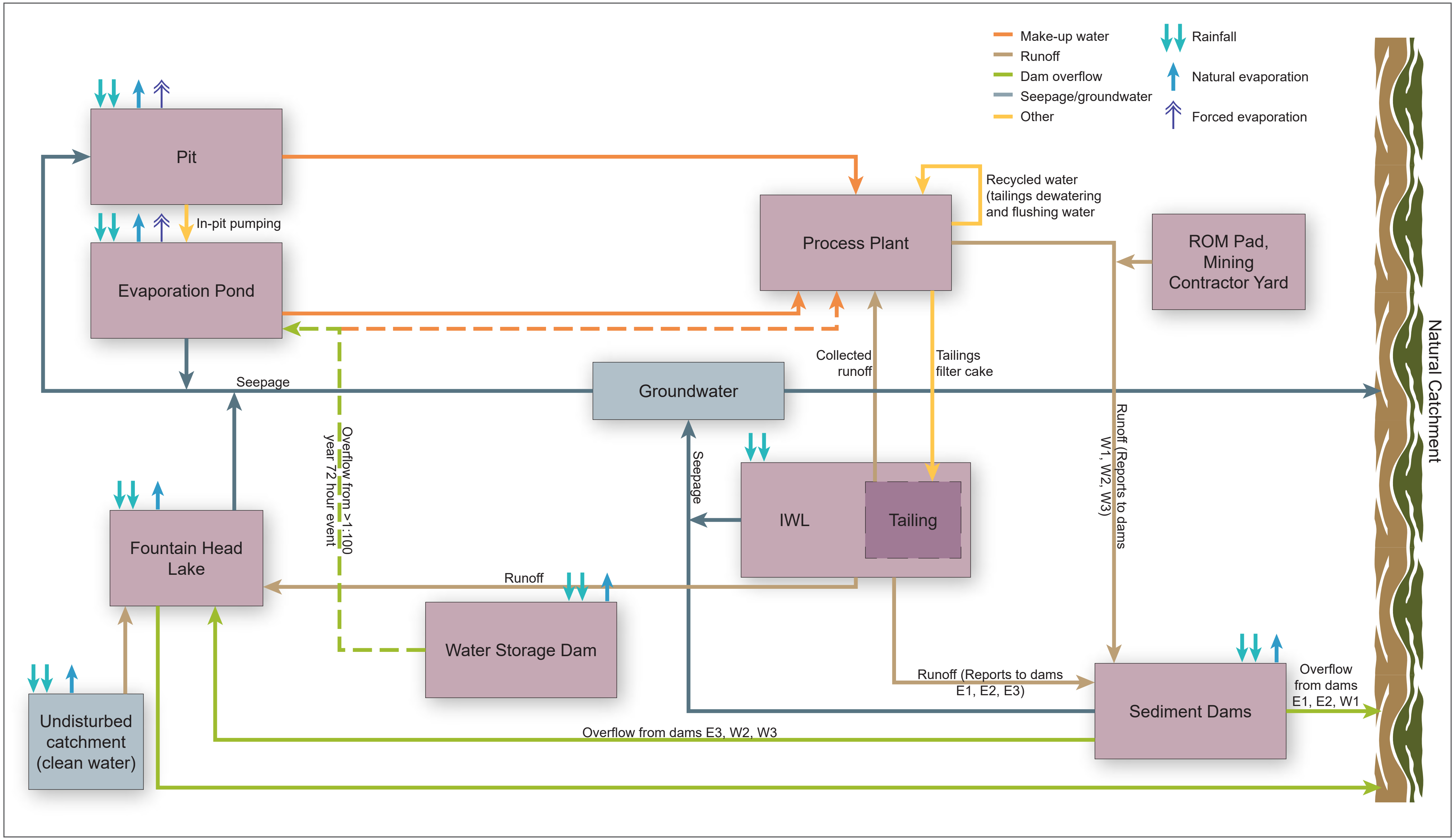
The recovered pit water level is predicted to stabilise after around 50 years post-mining at an average level of 93.5 m AHD with seasonal variation of 2 m.

Using Monte Carlo analysis, there is a 59% likelihood that pit water levels will be maintained at dry conditions without interruption to in-pit dewatering pumps for the entire mining (considering the model assumptions). Conversely, there is 41% likelihood that the operational water level trigger in the evaporation pond (97.4 m AHD) will be exceeded at some point due to a lack of storage capacity and that pumping within the pit will be interrupted to manage evaporation pond operational levels. While in-pit pumping is interrupted, the evaporation pond level is at the operational water level trigger, relying on forced evaporation and infiltration to reduce the water level to balance the inputs from the in-pit pumps. At this time, mining will continue on available higher benches. It is not envisaged that mining will have to stop, except possibly late in the mine life when alternative mining areas may not be available. To decrease the likelihood of mining activities being interrupted, the operational water level trigger in the evaporation pond could be increased.

FOUNTAIN HEAD SITE WATER BALANCE SCHEMATIC

Fountain Head Gold Project | Water Management Plan

FIGURE 3.2



Source: CDM Smith

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Using an operational water level trigger of 97.4 m, there is 0% likelihood of water exceeding the evaporation pond spillway at 98.6 m AHD. Increasing the operational water level trigger (to reduce the likelihood of interruptions to mining) would increase this likelihood. Another alternative is to divert some rainfall runoff from the evaporation pond, to reduce the catchment area.

The predicted Fountain Head pit water balance summary is shown in Table 3.2, based on average conditions over the mining phase (Phase 2) as described in CDM Smith (2022b). As indicated, pit inflows are dominated by groundwater while pit outflow will initially be dominated by forced evaporation and pumping. The volume of water to be removed from the Fountain Head pit to achieve dry conditions is just below 6 GL.

Table 3.2 – Fountain Head Pit Water Balance Summary

Component	Volume (ML)
Inflows	
Rainfall	92
Runoff	465
Groundwater inflow	3,222
Initial water storage	2,060
Total	**5,840**
Outflows	
Forced evaporation	1,270
Natural evaporation	127
Pumping	4,443
Total	**5,840**

To aid the recovery of water in the Fountain Head pit, water could be pumped back to the pit from the evaporation pond once mining is completed. Monte Carlo uncertainty analysis indicates this would take an average of five days, to pump an average volume of 50 ML. There is limited benefit to this option given the small volume of water compared to the volume required to fill the mine pit void and this is unlikely to reduce the time required for pit stabilisation to occur. Of note, at the end of mining, PAF material will be pushed into the pit to ensure groundwater inflows can adequately submerge PAF material. An alternative option is to divert natural catchment runoff to the pit. This option is described in Section 3.3.5.1.

3.3.4.2 Evaporation Pond Water Balance and Seepage Results

If the operational water level trigger of 97.4 m AHD is reached in the evaporation pond, the pit pumps will cease operating. Based on this operational water trigger level and considering all rainfall events that have occurred since 1890, the evaporation pond is not predicted to overflow. The predicted evaporation pond water balance is shown in Table 3.3, based on average conditions over the mining phase (Phase 2) as described in CDM Smith (2022b).

Table 3.3 – Evaporation Pond Water Balance Summary

Component	Volume (ML)
Inflows	
Rainfall	605
Runoff	886
Pumping	3,106
Total	**4,579**
Outflows	
Groundwater infiltration	858
Forced evaporation	2,809
Natural evaporation	734
Supply to site water demand	161
Remaining water in pond	15
Total	**4,578**

3.3.4.3 Fountain Head Lake

Based on the conceptualisation (Section 3.3.2.3) and model assumptions, the Fountain Head Lake is predicted to overflow and discharge over the haul road to the downslope catchment annually, as is currently experienced at the site. There is a 30 cm average fluctuation in the lake water level between the wet and dry season, but limited bathymetry data is available for the lake. The predicted Fountain Head Lake water balance summary is shown in Table 3.4, based on average conditions.

Table 3.4 – Evaporation Pond Water Balance Summary

Component	Volume (ML)
Inflows	
Runoff on natural catchment area	10,020
Direct rainfall	906
IWL runoff and overflow from sediment dam E3	523
Overflow from sediment dams W2 and W3	813
Total	**12,261**
Outflows	
Lake overflow	11,107
Natural evaporation	1,149
Total	**12,261**

3.3.4.4 Modelling Predictive Uncertainty

The Monte Carlo analysis produces probabilistic predictions that reflect the current understanding of the uncertainty residing within each of the water balance input parameters and is useful for understanding the likelihood of certain events occurring, e.g., operational water level triggers being reached, disruptions to dewatering and overflow in the lake. This predictive uncertainty could be further refined with an improved understanding of:

- The hydraulic conductivity value of the deeper part of the aquifer below the existing mine void.
- Groundwater inflow predictions to the pit, as the model does not account for the storage properties of the aquifer.
- The hydraulic properties of the materials beneath and adjacent the evaporation pond.
- The efficiency of the evaporators.

3.3.5 Solute Balance Results

A non-reactive balance was paired with the water balance model to estimate the concentrations of potential contaminants in the pit, pond and lake considering two solute balance scenarios:

- Salinity as total dissolved solids, to provide a relative rather than absolute prediction of TDS concentrations.
- A normalised approach that can be applied to any potential contaminant assuming that the natural surface water environment has no background concentration of that contaminant, whereby the concentration of a contaminant can be predicted by multiplying the normalised concentration by the estimate of the source concentration.

Predictive modelling of arsenic concentrations in the Fountain Head Lake, considering runoff from ore and waste rock and results of geochemical leach tasting, was also undertaken to understand the potential risk from runoff of stockpiled ore and waste rock. A further study of long term pit and evaporation pond water quality was also undertaken considering the input from PAF waste rock in the pit and the pit walls. The results of these models are described in the following sections.

3.3.5.1 Fountain Head Pit and the Evaporation Pond

A pit water quality assessment was undertaken (CDM Smith, 2022a) to support the preparation of the supplement to the EIS considering the storage of PAF material within the pit. This study was completed to understand the long term water quality of the Fountain Head pit, to assess the risk to the environment and to determine the best options to manage this water. A conservative modelling approach was adopted, whereby no decay or transformation of the source water components into other compounds or precipitation was assumed.

The solute balance scenario modelled assumed the Fountain Head pit is closed once mining ceases, the evaporation pond remains and no further pumping of water from the pit occurs.

CDM Smith (2022a) modelled the water quality predictions for the complete submersion of all PAF material at the end of mining (as all PAF material will be pushed into the pit at the end of mining to ensure complete submersion). The modelling also considered the pit wall rock contributions to water quality, by modelling the progressive reduction leachate contribution to the pit lake as the wall rock is progressively submerged in water.

The model assumed that dewatering activities will occur until end of mining in April 2025, at which time the PAF material from Pod 1 will be pushed further into the pit leading to full submersion of PAF material from the pods and partial submersion of PAF rock associated with the exposed pit walls (similar to existing conditions), which will oxidise with time.

Under this assessment, the source term, defined as the suite of elements with a propensity to leach from the source material, was derived by screening the concentrations measured from the leachate generated from the kinetic tests and pit lake water with the relevant water quality guidelines (i.e., stock water guidelines). This process identified which elements may pose a threat to receptors and informed the elements targeted by the assessment. Such that, rather than modelling all elemental concentrations, the source term was used to narrow the suite modelled. This approach ensures the assessment is risk focused towards the elements that have potential for environmental harm.

Using this methodology, the source term was expanded to include acidity, arsenic, cobalt and copper. Predictions of the Fountain Head pit lake concentrations for the source term constituents are presented in Table 3.5 and as Figure 3.3 for arsenic exclusively. Figure 3.4 presents the arsenic concentration within the EP, where arsenic was used as a conservative proxy in place of other elements due to its independent relationship to pH (CDM Smith, 2022b; Appendix 5).

The results show the contaminants within the Fountain Head pit are predicted to be less than the current pit water quality following mining with the water quality in the EP becoming dominated by rainfall and falling below the background concentration for arsenic by early 2027. As stated:

- The Fountain Head pit will act as a groundwater sink during and post mining for a period of at least 50 years after which a minor throughflow component may develop based on the understanding of current groundwater flow and groundwater gradients regionally.
- Seepage from the EP will be captured by the Fountain Head pit for around 5 years post mining before groundwater is predicted to begin to flow northeast starting from the northeast most corner of the facility. Full recovery of water levels under the EP will take up to 40 years meaning groundwater flow will occur both towards the Fountain Head pit and to the northeast during this period.

Under current conditions, where a minor throughflow component is thought to occur, solutes are mostly constrained within the pit lake with the arsenic concentration of groundwater significantly lower than the pit lake. This suggests under current conditions, the pit lake acts predominantly as an evaporative sink, which is further evidenced by higher water levels in groundwater bores surrounding the pit. Given the concentration of arsenic within the Fountain Head pit is predicted to be well below the current pit lake water quality (0.567 mg/L) and stock water guidelines (0.5 mg/L) upon near-full recovery in 2061 (D, Table 3.5) and prior to any potential for throughflow to the environment, it is reasonable to assume the concentrations of contaminants downstream of the site are unlikely to be higher than current background levels, therefore, no further assessment regarding water quality in groundwater inside and outside the Project area is warranted. This statement remains true also regarding the EP where the arsenic concentration is predicted to be below the background groundwater level (0.056 mg/L) by the time groundwater below this facility could be expected to flow towards the northeast.

Table 3.5 – GSS mixing model predictions summary - Fountain Head pit lake (CDM Smith, 2022b)

Parameter	Stock water guideline (ANZECC, 2000) (mg/L)	Leachate concentration [1]		Predicted pit lake concentration - S1 and S2 combined leachate mixed with groundwater inflow (ML)			
		S1 – 0.15 Mt PAF material	S2 – Pit walls	500 (A) – 2026	3,500 (B) - 2031	6,000 (C) - 2044	7,500 (D) - 2061
Acidity (mg/L) (HCO_3-) [2]	-	-	129	-	114	114	114
Arsenic (mg/L)	0.5	0.44	3.8	0.41	0.10	0.07	0.06
Cobalt (mg/L)	1	1.32	15.2	1.3	0.05	0.02	0.001
Copper (mg/L)	1	2.52	26.6	3.3	0.1	0.08	0.003

Notes: 1. Assuming 116 ML runoff and 92 ML rainfall
2. Predicted pit lake acidity for >2 years post mining.
All concentrations reported have an applied CSF of 0.4 and used mean concentrations for rainfall and groundwater to represent the mixing volumes
'-' denotes not calculated

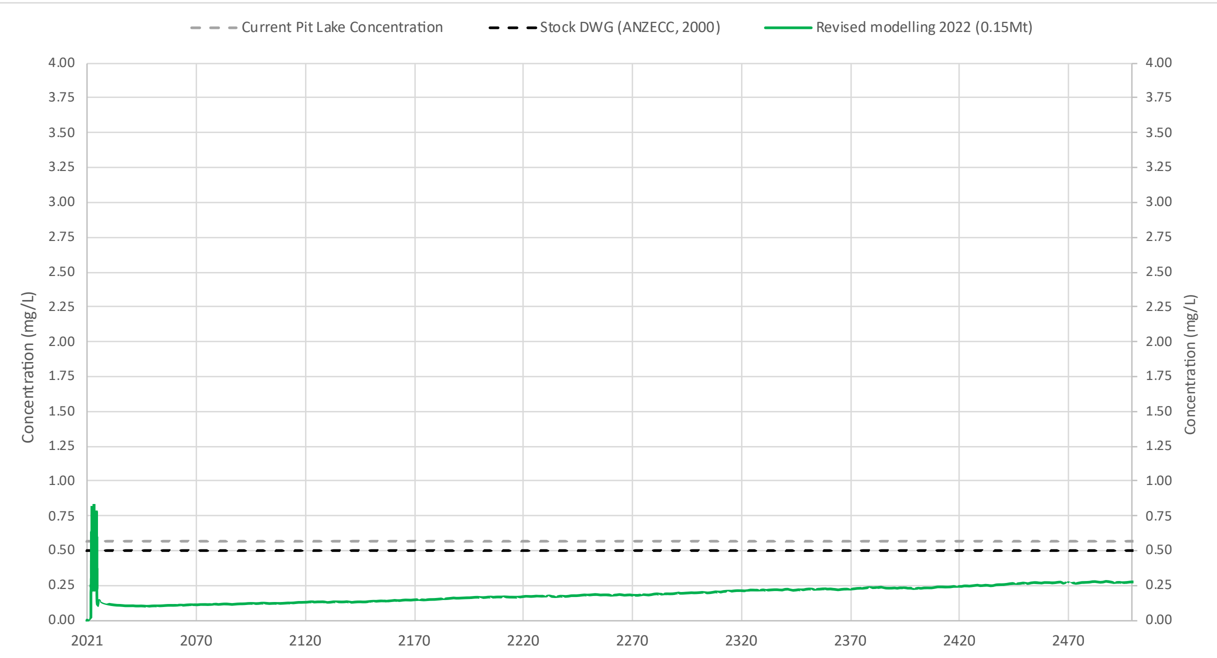


Figure 3.3 – Predicted Dissolved Arsenic Concentration of the Fountain Head Pit Lake Over 500 Years Post Mining (CDM Smith, 2022b)

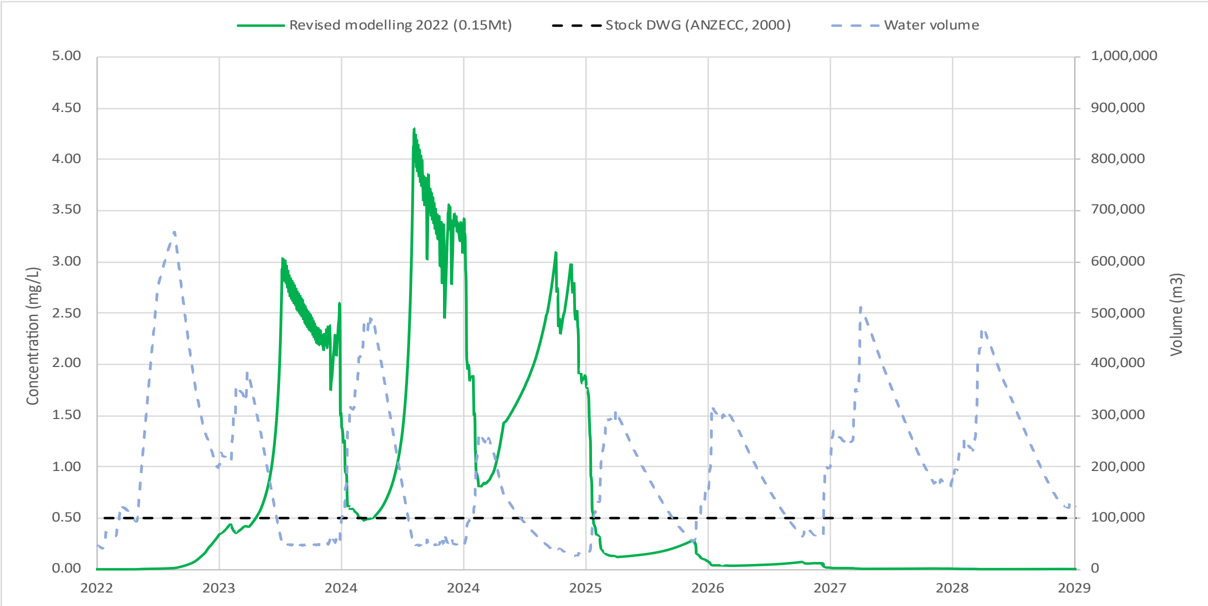


Figure 3.4 – Predicted Dissolved Arsenic Concentration of the Evaporation Pond 2022 to 2029 (CDM Smith, 2022b)

Water quality modelling predicts the contaminant concentrations within the Fountain Head pit lake will be lower than current levels and the long-term evaporation pond chemistry will be dominated by rainfall.

3.3.5.4 Fountain Head Lake

Salinity in the lake will fluctuate on a seasonal basis, increasing during the dry season (due to the effects of evapoconcentration) and decreasing during the wet when there is increased dilution and flushing.

The normalised prediction assumes that runoff from the IWL and overflow from sediment dams E3, W2 and W3 are the sources of solutes. The scenario assumes that no attenuation occurs post-mining and that solutes are continued to be released post-mining. Maximum solute concentrations are predicted to reach up to 26% of the source concentration and usually around 13% of the concentration that would be found in the IWL or sediment dams E3, W2 and W3. The annual flushing of the lake is predicted to reduce concentrations to around 7% of the source concentration.

Predictive modelling of arsenic concentrations in the Fountain Head Lake, which will receive runoff from sediment dams E3, W2 and W3, were made using highly conservative assumptions considering leach testing results. Using an arsenic runoff concentration of 150 µg/L for waste rock and ore (a conservative over-estimate of realistic concentrations), it is predicted that arsenic concentrations in the Fountain Head Lake will remain below the 80% aquatic ecosystems protection limit of 140 µg/L for As (V), with a flow-weighted average concentration of approximately 11 µg/L, which is below the 95% aquatic ecosystems protection limit of 13 µg/L for As(V). Given uncertainties associated with the predictions due to a lack of time-series water level or flow data from the Fountain Head Lake to calibrate the rainfall-runoff model used to make the predictions, conservative values were used in this modelling. Water from the Fountain Head Lake (which will receive runoff from the industrial hardstand areas and the IWL) is expected to pose minimal risk to the downstream catchment during overflow events.

3.3.6 Groundwater Dynamics

A predictive groundwater numerical modelling was used to interface with the GoldSim water balance modelling to generate water table surfaces that represent the flow patterns at different stages of the operation including current status, end of mining and post-mining (CDM Smith, 2021a). The MODFLOW model was subsequently updated (CDM Smith, 2022b) to improve the existing model and confidence in assessing the results.

The groundwater water balance is shown in Table 3.6. As indicated, the system inflow and outflow are dominated by rainfall recharge and evapotranspiration respectively. For the long-term recovery stage, groundwater outflow to the pit decreases notably, but is predicted to be higher than current conditions.

Table 3.6 – Groundwater Water Balance Model

Stage	Component	Net Inflow (ML/yr)	Net Outflow (ML/yr)
Current Condition	Regional flow	0	768
	Fountain Head pit	0	19
	Rainfall recharge	2,955	0
	Evapotranspiration	0	2,136
	Margaret River	0	33
	Total	**2,995**	**2,956**
End of Mining	Regional flow	0	767
	Fountain Head pit	0	1,073
	Evaporation pond	237	0
	Rainfall recharge	2,953	0
	Evapotranspiration	0	1,394
	Margaret River	0	33
	Changes in storage	77	0
	Total	**3,267**	**3,267**
Long-term Recovery (June 2065)	Regional flow	0	768
	Fountain Head pit	0	72
	Evaporation pond	186	0
	Rainfall recharge	2,953	0
	Evapotranspiration	0	2,239
	Margaret River	0	33
	Changes in storage	0	27
	Total	**3,139**	**3,139**

Drawdown of greater than 100 m at the base of the pit is predicted at the end of mining but is relatively steep, with the cone of depression largely restricted to the near vicinity of the pit

(Figure 3.5). Groundwater drawdown is predicted to be less than 0.1 m within 2 km of the pit (to the southeast).

Following completion of mining and cessation of dewatering, water levels in Fountain Head pit are predicted to stabilise at around 93 m AHD 40 years post-mining (Figure 3.6). The predicted drawdown of groundwater associated with the pit void at this stage is shown in Figure 3.5. Groundwater levels in the vicinity of the pit are predicted to recover to less than 5 m below existing groundwater levels. The pit lake is therefore expected to act for the most part as a groundwater sink due to the local depression in groundwater levels in the vicinity of the pit, but following full recovery there is predicted to be a throughflow component, where the outflow flux to the groundwater system is approximately 20% of the inflow.

3.3.6.1 Groundwater Mounding

A groundwater mounding assessment was undertaken (CDM Smith, 2021c and CDM Smith, 2022b) to support the preparation of the supplement to the EIS. This study was completed to understand potential mounding effects related to the storage of water in the evaporation pond. A conservative modelling approach which overestimates the potential mounding effects was adopted.

The model suggests temporary mounding of groundwater levels beneath the evaporation pond might occur during the beginning of mining as the Fountain Head pit is dewatered and mine water discharged to the evaporation pond.

The mounding, however, is expected to be encompassed by the greater drawdown extent (Figure 3.8) and therefore, would flow downgradient towards the Fountain Head pit during dewatering until operations cease and groundwater levels under the evaporation pond recover. Recovery of groundwater levels under this facility are expected to be gradual, occurring first from the northeast corner of the evaporation pond at 5 years post mining and progressively reducing before full recovery is reached within 40 years end of mine (Figure 3.7). Therefore, the flow of seepage from the evaporation pond from five years following mining will likely occur both towards the pit (where a downward gradient exists) as well as to the northeast until full recovery is reached and quasi-steady state flow conditions to the northeast resume.

At the end of operations, model predictions indicate a residual drawdown of around 0.1 m to greater than 5 m exists around the pit and evaporation pond at 10 years post mining, with groundwater levels predicted to fully recover within 40 years following mining.

The probability of solutes from the EP exceeding a maximum travel distance of 3,500 m is predicted to be low at 20% and no direct interaction of groundwater flow paths from the FHGP with aquatic groundwater dependent ecosystems (GDEs) is predicted. However, as already stated and as evidenced by the water quality modelling in CDM Smith (2022b; Appendix 5) should groundwater flow from the Fountain Head pit and EP occur, this will not negatively impact the receiving environment.

3.4 Surface Water Management Strategy

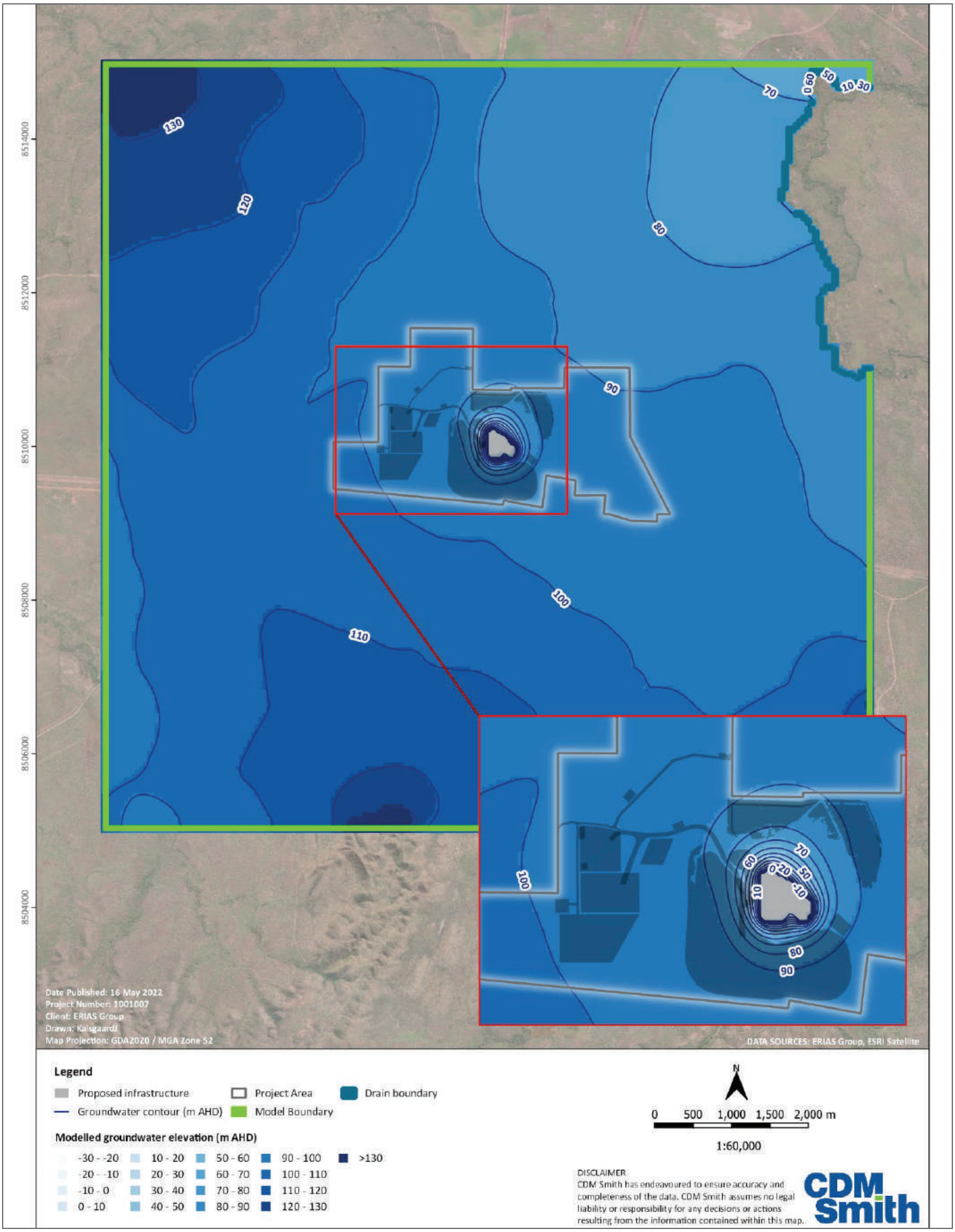
This section provides a summary of the proposed strategy (CDM Smith, 2021d) for management of surface water and is illustrated in Figure 3.9. The water management approach includes the evaporation pond, sediment dams, runoff drains, diversion channels and erosion protection.

Internal runoff from the CIL plant will be contained and managed within the plant footprint through drainage or bunding with sumps, and will be returned to the process plant (i.e., the CIL plant will be a closed system).

3.4.1 Evaporation Pond

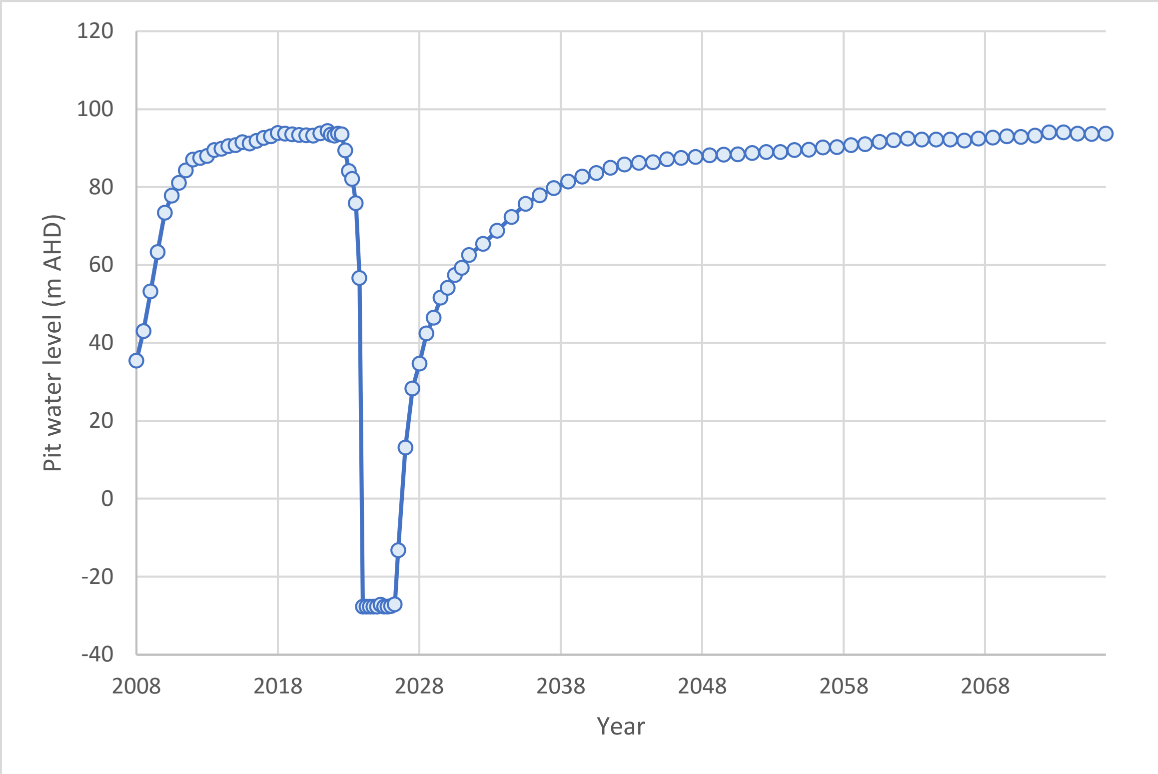
The existing water storage dam is located immediately to the northeast of the Fountain Head pit (Figure 3.9). To increase the existing on-site storage capacity, proposed works plan to increase the height and extend the northern dam wall further to the west. This will create a relatively large and connected surface water storage, i.e., the evaporation pond. The proposed design includes a wall crest at 98.8 m AHD (approximately 1,074 ML capacity) with a proposed operational water level at 97.4 m AHD to account for a 1% AEP rainfall event and freeboard. The evaporation pond is effectively dry (less than around 0.1 ML) at a level of 91.5 m AHD.

FIGURE 3.5



Source: CDM Smith

Figure 3.6 – Predicted Recovery in Fountain Head Pit Water Levels



PREDICTED GROUNDWATER DRAWDOWN 50 YEARS POST-CLOSURE

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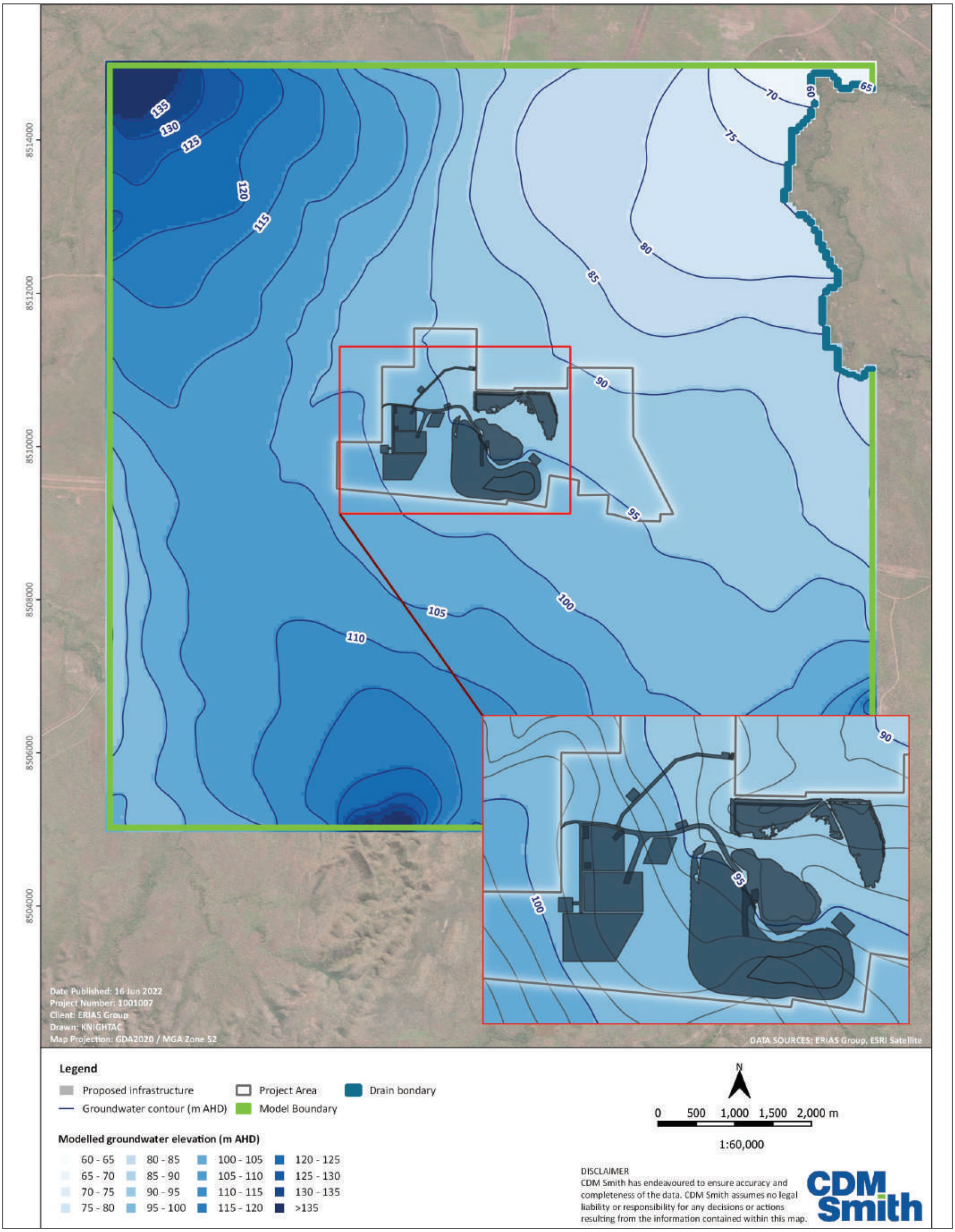
FIGURE 3.7



Source: CDM Smith

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PREDICTED MEAN DRAWDOWN AT END OF OPERATIONS (YEAR 3)

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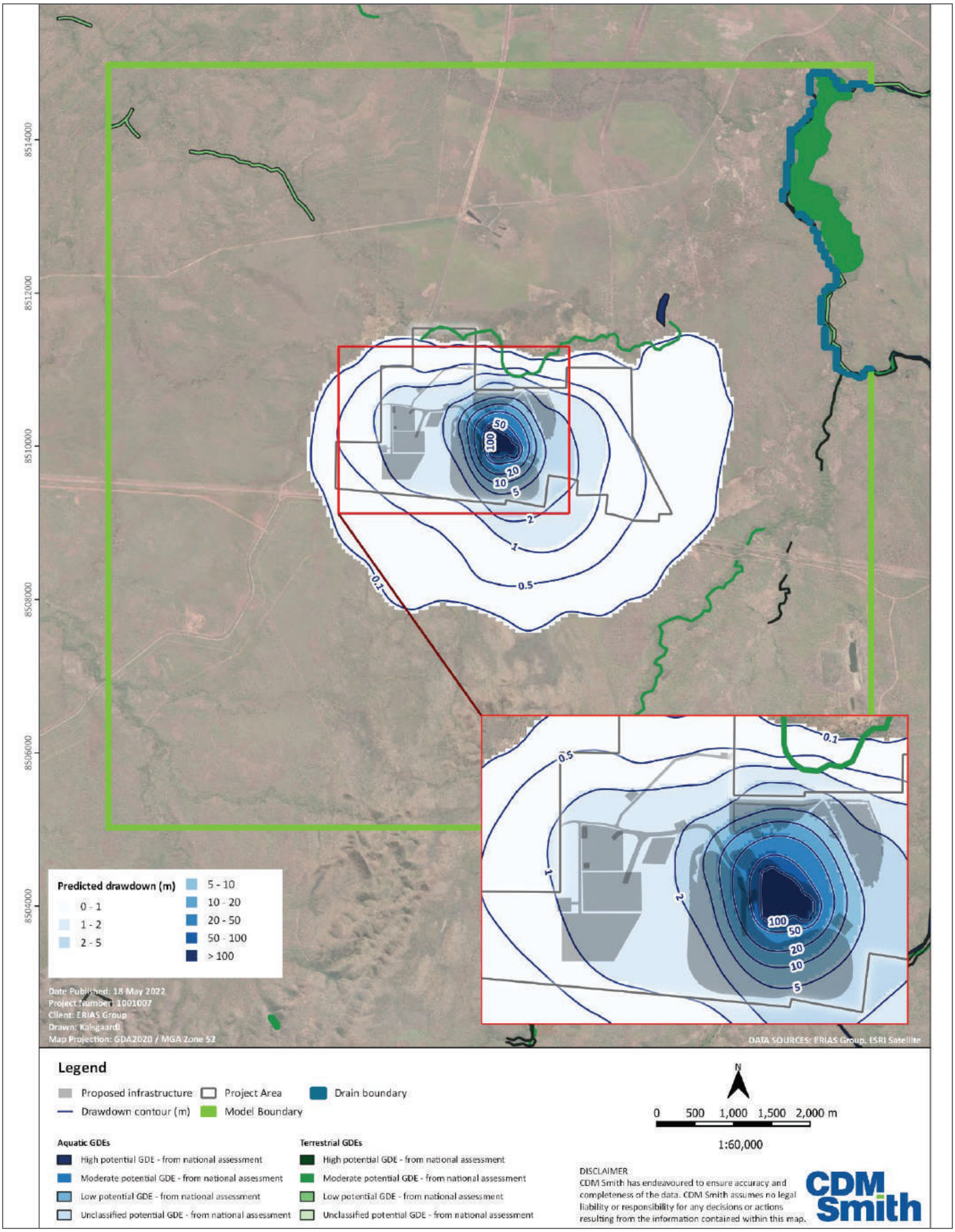
FIGURE 3.8



Source: CDM Smith

2022.07.13 | 01238D_4_ILL007 | 01238D_4_F03-8_ILL_v5-e_es

3.4.2 Sediment Dams

Six sediment dams are proposed for the operation (E1, E2, E3, W1, W2 and W3) as shown in Figure 3.7 with runoff from the IWL and process plant area to be directed to these dams before being released to the environment.

Sediments in water passing through these dams will be allowed to settle. As the surface runoff from these areas are relatively benign, the sediment dams will operate with decanted overflow directly into the environment after the settlement of suspended solids. The sediment dams will operate with decanted overflow into the environment after the settlement of suspended sediments. Water quality of runoff from the IWL and ROM areas will be captured in the sediment dams and monitored and tested; however, based on the results of predictive modelling described in Section 3.3.5.3, runoff from these areas is not expected to pose a risk to the downstream catchment. As such, water within sediment dams is not proposed to be pumped back to the site water balance system for reuse. The sediment dams have been sized in accordance with the Best Practice Erosion and Sediment Control guidelines (IECA, 2008).

3.4.3 Proposed Runoff Drains

Proposed minor runoff drains are shown in Figure 3.9 and include:

- ‘Mine impacted’ runoff drains to divert surface runoff from disturbed areas (such as IWL and mine infrastructure areas) to the sediment dams to capture and settle sediment.
- ‘Clean’ runoff drains to divert clean/natural catchment runoff from undisturbed areas away from disturbed areas. The majority of clean water from natural or undisturbed areas will generally be diverted to flow directly to the Unnamed Creek, bypassing mine infrastructure. The natural catchment south of the Project site will flow past the proposed mine infrastructure into the Fountain Head Lake before overflowing the causeway to the north, similar to the existing situation.

‘Dirty impacted’ runoff drains are proposed around the perimeter of the IWL and the proposed mine infrastructure areas to divert the ‘mine impacted’ runoff to the sediment dams, as shown in Figure 3.7. A ‘clean’ runoff drain is proposed to the west of the mine infrastructure area to divert the natural catchment runoff away from the site to minimise contact water generation. A second ‘clean’ runoff drain is proposed along the eastern toe of the IWL, draining to the surrounding environment (Figure 3.9).

PROPOSED SURFACE WATER MANAGEMENT

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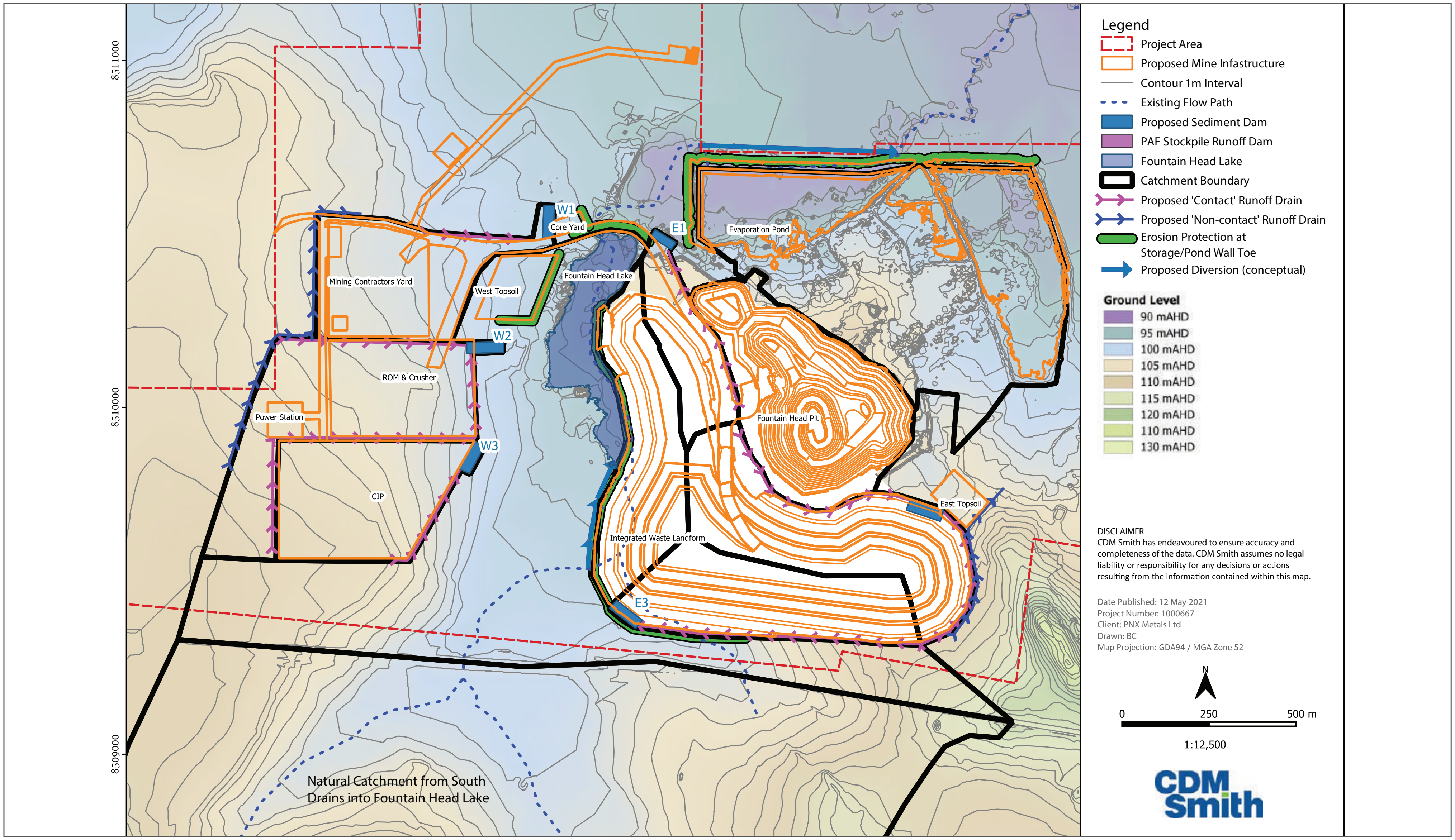
FIGURE 3.9



Source: CDM Smith

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3.4.4 Proposed Diversions

A diversion channel will be constructed along the western side of the IWL to reinstate the natural flow path and to divert the natural catchment runoff into the existing Fountain Head Lake. A diversion is also proposed along the northern side of the proposed evaporation pond as the western portion of the proposed pond is located on an existing flow path. Figure 3.9 shows the locations of these two diversions.

3.4.5 Erosion Protection

Erosion protection, such as rock armour protection, will be installed on the western and northern toes of the evaporation pond (Figure 3.9). It is understood that the existing haul road is subject to erosion issues during overtopping events from the Fountain Head Lake and hence culverts will be installed and erosion protection installed on the haul road batters.

3.5 Flood Modelling

A hydrological assessment (CDM Smith, 2021d) of the Fountain Head mine site included modelling to investigate the probability and extent of flooding, to inform operational constraints for mining operations and develop mitigation options to manage water and avoid environmental impacts. The TUFLOW hydraulic model was used to simulate flood behaviour in the vicinity of Fountain Head Mine for the 10%, 5%, 2%, 1% and 0.1% annual exceedance probability (AEP) design events. This modelling characterised flood extent, depths and velocities for the existing conditions, and was also used to assess the potential flood impact from the proposed mine infrastructure of the Fountain Head Project. Modelled peak flood depths for a 1% AEP (i.e., 1 in 100 years) flood event are shown in Figure 3.10, which shows the mine infrastructure footprint (not considering in the output) overlaying the predicted flood levels. Most of the proposed mining infrastructure is located outside the 0.1% AEP flood extent. A few components of proposed infrastructure (such as the core yard and west topsoil stockpile) will be raised or protected by bunds to achieve the required flood immunity and reduce erosion potential.

Modelling was also undertaken to assess the impact of Project infrastructure on flooding (CDM Smith, 2021d). As shown in Figure 3.11, for a 1% AEP event, the modelling predicts there to be up to a 0.1 m increase in the water level of Fountain Head Lake compared to existing conditions. No increase in flood level is expected to occur along the existing railway line to the south of the site. The modelling shows that, under existing conditions (and with no culverts in the causeway), Fountain Head Lake overflows and discharges over the causeway to the north of the lake every year during the wet season. Flood water levels downstream of Fountain Head Lake, west of the evaporation pond, are predicted to increase by up to 0.9 m during a 1% AEP (without culverts in the causeway). This is due to the proposed extension to the evaporation pond (which is located on the existing flow path) restricting the flow conveyance. Only very minor flood impacts are expected north of the evaporation pond compared to existing conditions, increasing up to 0.05 m.

Flow velocities are predicted to increase along the western toe of the IWL and north of the evaporation pond where erosion control measures are proposed to be installed to provide protection from scouring. Similar protection would also be installed as required at any other susceptible locations such as bends and outlets of diversion channels.

MODELLED PEAK FLOOD DEPTHS (1% AEP) IN FOUNTAIN HEAD MINE AREA

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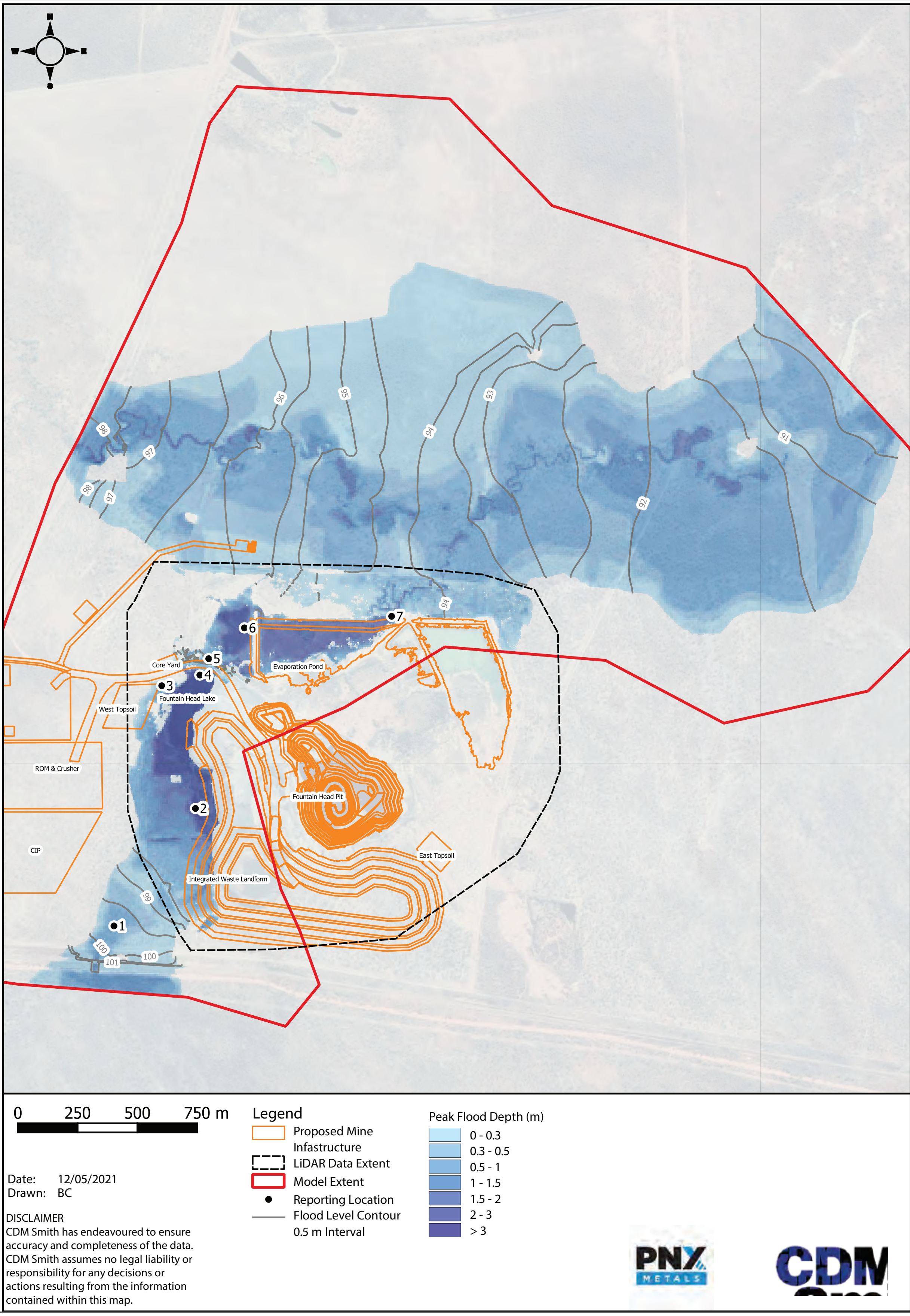
FIGURE 3.10



Source: CDM Smith

MODELLED PEAK FLOOD LEVEL DIFFERENCE FOR 1% AEP EVENT

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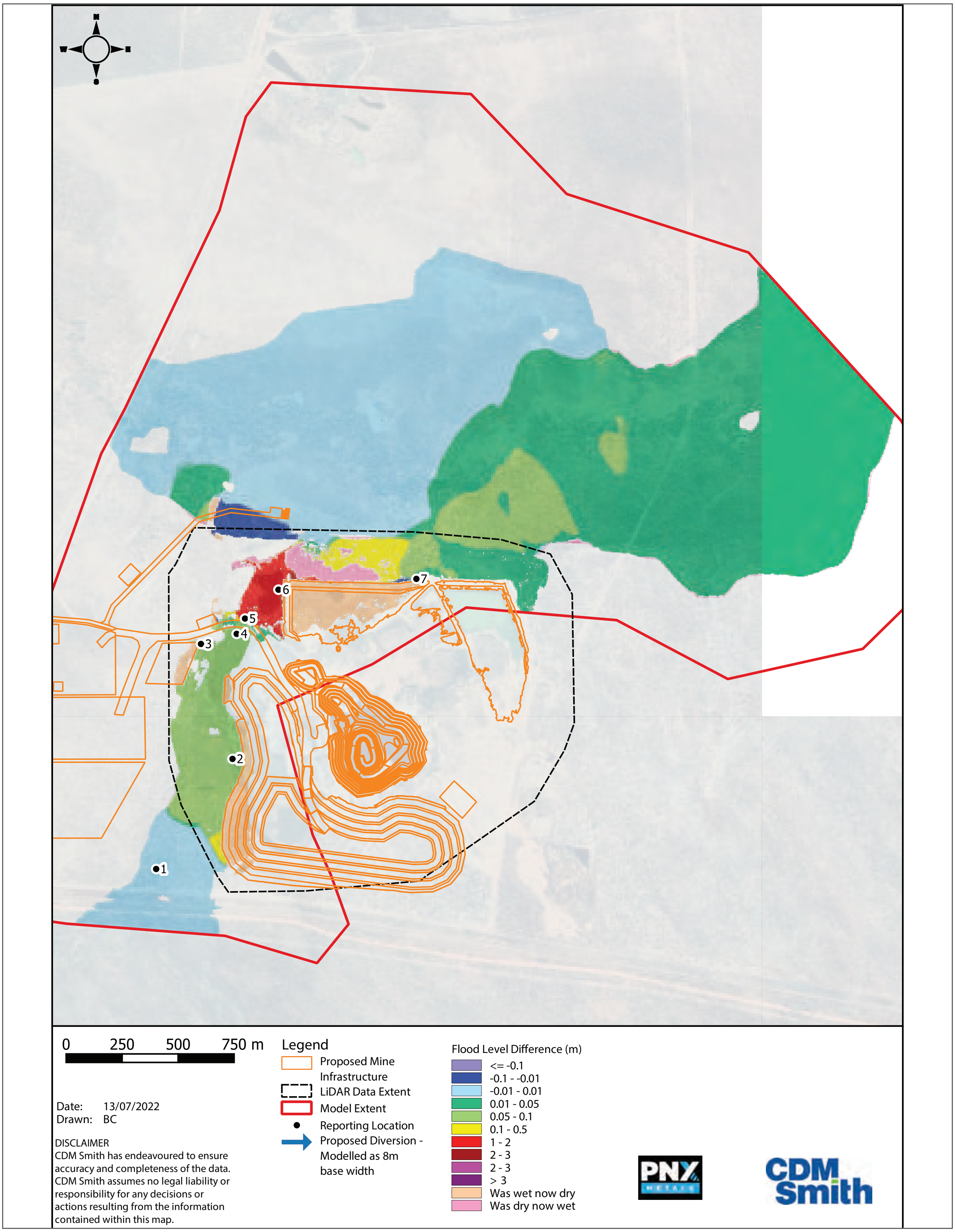
FIGURE 3.11



4. Current Conditions

4.1 Hydrology

4.1.1 Regional Hydrology

The Project lies in the Adelaide Basin surface water management area of the Timor Sea Drainage Division, as defined by the Australian Water Resources Council (AWRC) (Petheram et al., 2009). This drainage division encompasses an area of around 564,647 km^2, with streams tending to run west towards the Indian Ocean or north to the Timor Sea. Considering streamflow per area, it is the second wettest drainage division in Australia (CSIRO, 2009). Within this drainage division, the Project is located in the upper catchment of the Margaret River, which is a tributary of the Adelaide River. The Adelaide River flows through extensive coastal and marine floodplains east of Darwin into the Arafura Sea and has a total basin area of approximately 7,700 km^2 (Pusey et al., 2017). Along with the Finniss, Mary and Wildman rivers, the Adelaide River is part of the Darwin catchments (also known as the Van Dieman region). The Darwin catchment covers an area of approximately 30,000 km^2 (CSIRO, 2018) (Figure 4.1).

The Darwin catchments include both highly modified urban and agricultural landscapes, operational and legacy mines, and large areas of relatively intact landscapes. More than half of the population of the Northern Territory lives in the Darwin catchments, yet 53% of the total area is retained as conservation lands and other natural environments, much of it relatively undisturbed. These landscapes are important for the wide range of ecosystem services they provide, including Darwin's water supply, recreational activities, tourism, cattle grazing on native pastures, and varied conservation and environmental values (CSIRO, 2018).

Approximately 82% of runoff in the Darwin catchments occurs during the period between January and March, with the highest monthly totals occurring during March (CSIRO, 2018). There is little rainfall during the dry season to sustain continuous flows in many of the surface waters of the Timor Sea Drainage Division, except where substantial groundwater input is received which maintains baseflows during the dry season (e.g., Daly, Roper, Jardine and Gregory rivers) (Pusey et al., 2017). Most streams throughout the region can be considered seasonally flowing, i.e., have no flow during most of the dry season.

The freshwater coastal floodplains of the Darwin catchments provide a mosaic of highly productive wetland habitats and contain 5 of the 33 Northern territory wetlands of national significance, including the Adelaide River coastal floodplain (Figure 4.1) within the Adelaide River Basin (CSIRO, 2018). This floodplain extends from the junction of the Margaret River in the south to the mouth of the Adelaide River at the coast and is a large seasonally inundated freshwater floodplain that is traversed by a permanent tidal section of the Adelaide River.

4.1.2 Project Area Hydrology

Surface water streams in the area of the Fountain Head Project include both intermittent streams, which have flowing water for all or most of the wet season but are dry during the drier months, and ephemeral streams such as tributaries to the Margaret River, which flow briefly following

DARWIN CATCHMENTS AND REGIONAL FEATURES

Fountain Head Gold Project | Water Management Plan

FIGURE 4.1

SCALE: 1:1,500,000 @ A4

0 5 10 20 KM

GDA2020 MGA Zone 52

Fountain Head Project	Watercourse
Populated place	Darwin catchments
Roads	Adelaide River coastal floodplain
Railway	

ERIAS, 13-25 Church Street
Hawthorn VIC 3122, Australia

Issue Date: 07.05.2021

Map ID: 01238D_4_GIS003_v0-a

Figure Number: 01238D_4_F04.1_GIS_v0-a

DATA SOURCE:
Project data from PNX Metals, 2021.
Base data from Geoscience Australia & GEODATA 250K, 2006.
Adelaide River coastal floodplain, DLRM (Sites of Conservation Sig.), 2012.
Catchments from Bureau of Meteorology Geofabric System V2, 2018.
Imagery © ESRI, DigitalGlobe and Partners, 2021.

rainfall and are dry for most of the year. There are no perennial streams in the study area; however, there is a perennial billabong and small waterhole located downstream of the site, approximately 550 m northeast of the Project area. The presence of other water pools in the dry season is likely dependent on the previous wet season's rainfall and subsequent groundwater recharge. All flow paths at the Project site are ephemeral and experience surface runoff only after rainfall events in the catchment. Surface runoff discharges are highly variable and most flow paths are likely to dry out during dry seasons when rainfall is low, although some pools hold water for extended periods.

The key surface waters within the Project area include:

- 'Southern Flow Path' and Fountain Head Lake.
- Unnamed creek.
- An existing water storage dam (to become the evaporation pond for pit dewatering).
- Flooded mine pit (to be dewatered).

The Fountain Head Project area is in the upper Margaret River catchment. The Project area is mostly within the catchment of an unnamed waterway, which is termed the 'Southern Flow Path' that drains into Fountain Head Lake before overflowing into an unnamed creek (Figure 4.2). The unnamed creek drains in an easterly direction on the northern side of the Project area into the Margaret River approximately 7 km downstream. The catchment area of the 'Southern Flow Path' to the south of the Project site is approximately 6 km^2 and the catchment area of the unnamed creek north of the Project site is approximately 33 km^2. The total catchment of the Margaret River to the confluence of the unnamed creek is approximately 374 km^2 (including the unnamed creek).

The Fountain Head Lake (Plate 4.1) has formed within historical alluvial workings due to the construction of a causeway for a haul road by the previous mine operators. Water contained within the lake surface flows along the 'Southern Flow Path' following rainfall events and is possibly a surface expression of groundwater within the water table. Fountain Head Lake overflows and discharges over the causeway to the north of the site.

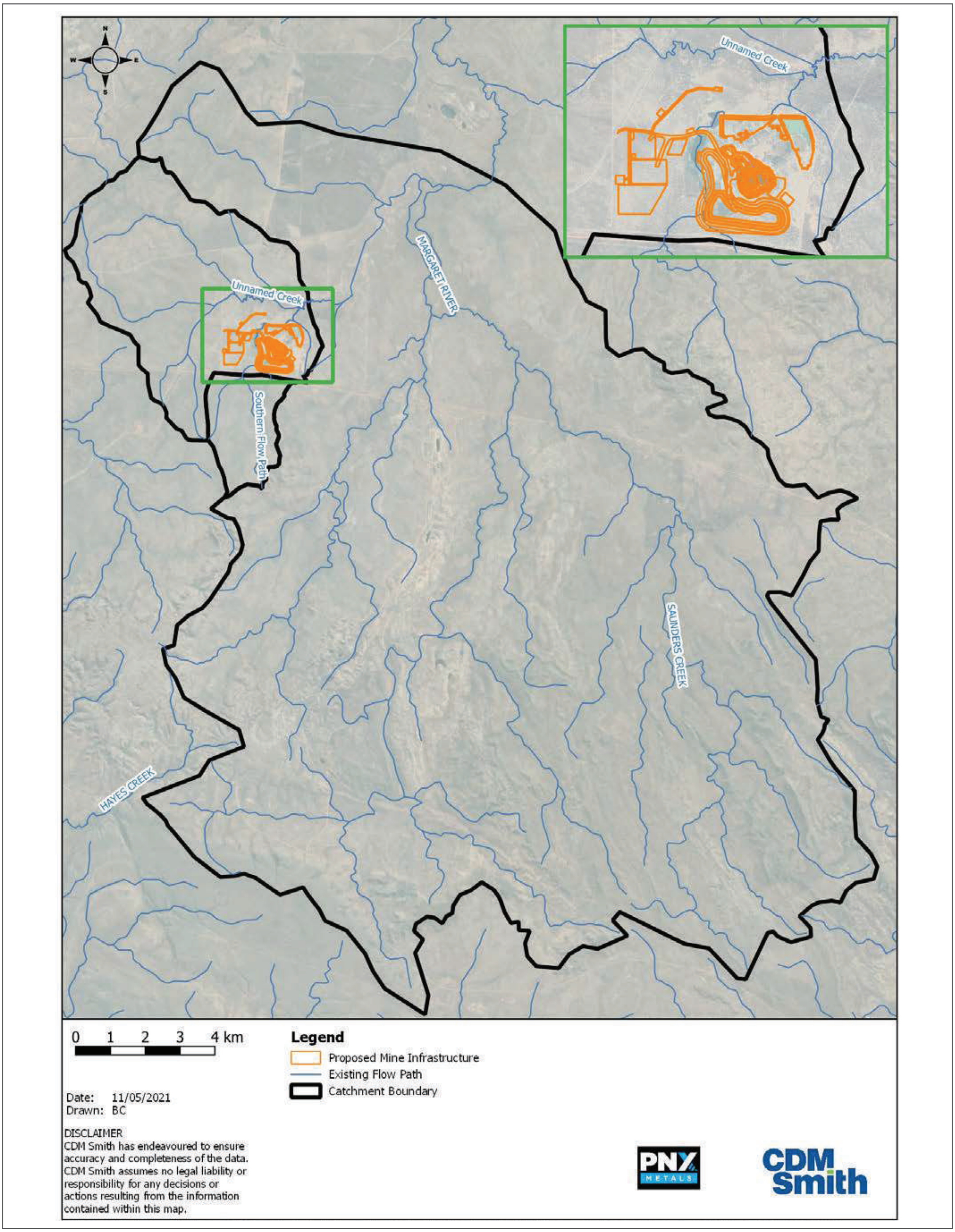
Plate 4.1 – Fountain Head Lake

Source: L&MGSPL (2019).

CATCHMENTS AND WATERWAYS IN THE FOUNTAIN HEAD PROJECT AREA

Fountain Head Gold Project | Water Management Plan

FIGURE 4.2



Source: Appendix A003

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The existing water storage dam from previous mining operations is located immediately to the northeast of the Fountain Head Pit. It is proposed to remediate and extend this dam to provide a facility for dewatering of the pit and provide a water supply for mine operations.

4.2 Surface Water

As described in Section 4.1.1, the Project is located within the Adelaide River catchment. There are currently no declared/gazetted beneficial uses for the surface waters of this catchment. Notwithstanding, the beneficial uses identified for the adjacent Mary River surface water catchment (riparian and cultural for surface water) are relevant to the unnamed tributary creek and downstream Margaret River. The objectives for these beneficial uses are defined as those provided in Chapters 2 (protection of aquatic ecosystems), Chapter 3 (recreational water quality and aesthetics) and Chapter 5 (agricultural water uses) of the Australian Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 1992).These guidelines have since been superseded by the ANZG (2018) or where no update has been provided in ANZG (2018), e.g., for livestock drinking water, more recent objectives are provided ANZECC/ARMCANZ (2000a). In the case of managing risks to recreational water, NHMRC (2008) provides the most current guidelines.

There is a known sacred site located approximately 550 m from the nearest boundary of the Project area, which is approximately 2.5 km northeast of the Fountain Head pit. This site is a perennial billabong and small waterhole and is located downstream of the Project area.

4.2.1 Local Surface Waters

This section describes the quality of local surface waters (i.e., Margaret River and nearby tributary creeks). This description combines data available from care and maintenance monitoring conducted for the previous mine operators between 2012 and 2016 and since 2019 for PNX in line with the Fountain Head Dewatering Mining Management Plan Amendment (PNX Metals, 2021). Additional data was also collected during aquatic field surveys conducted by ERIAS in April 2019 (ERIAS, 2020).

Sampling conducted for previous and current care and maintenance operations includes locations in close proximity to Fountain Head as well as the broader region. Sample locations are provided in Table 4.1 and shown in Figure 4.3. The historic water quality data is discussed in the following sections.

Table 4.1 – Care and Maintenance Surface Water Monitoring Locations

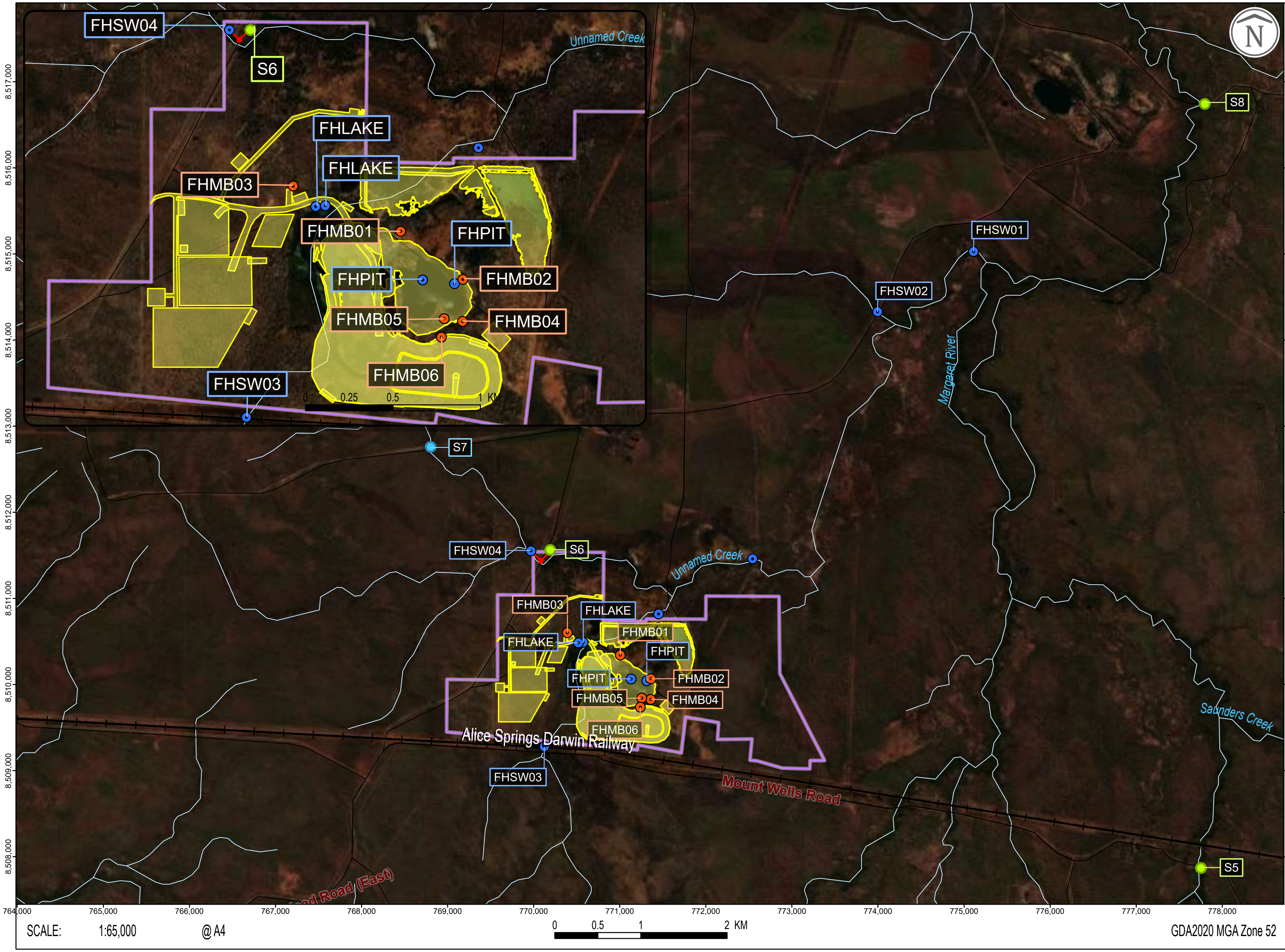
Sampling Location	Description	Easting	Northing
FHSW01	Fountain Head, downstream of Fountain Head deposit, near confluence of Margaret River	775109	8515026
FHSW02	Fountain Head, upstream control for FHSW01	773994	8514327
FHSW03	Fountain Head, upstream control for FHLAKE	770123	8509278
FHSW04	Fountain Head, upstream control for all sites	770082	8511436

Coordinates are in WGS84 Zone 52 L.

EXISTING SURFACE WATER AND GROUNDWATER MONITORING LOCATIONS

Fountain Head Gold Project | Water Management Plan

FIGURE 4.3



Care and maintenance monitoring location
- Surface water
- Groundwater

ERIAS survey location
- Water quality
- Water quality and aquatic ecology
- Road
- Railway
- Watercourse
- Project area
- Infrastructure layout

Issue Date: 2022.07.13

Map ID: 01238D_4_GIS004

Figure Number: 01238D_4_F04-3_GIS_v5-d_es

ERIAS

ERIAS, 13-25 Church Street
Hawthorn VIC 3122, Australia

DATA SOURCES:
Project data from PNX Metals, 2021.
Imagery © ESRI, DigitalGlobe and Partners, 2021.

General Water Quality Parameters

Results for general water quality parameters in surface water are available from 2012 to 2016 and from 2019 to 2021. The following observations are made from the data:

- With the exception of two results from June 2012 at FHSW02, electrical conductivity results were within the Australian and New Zealand Environment and Conservation Council/Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) default trigger values for upland and lowland rivers[3] in tropical Australia of 20 to 250 µS/cm. Electrical conductivity has generally been lower in more recent years compared to 2012 to 2014.

- pH values were close to neutral and within the ANZECC/ARMCANZ (2000) default trigger value range of pH 6.0 to 8.0 for lowland rivers in tropical Australia.

- Water hardness is classified as soft, with average hardness being less than 55 mg $CaCO_3$/L, with lower water hardness at FHSW03 and FHSW04 compared to FHSW01 and FHSW02.

- The average concentrations of major ions were generally low and below 10 mg/L for each individual ion, with the exception of sulphate at FHSW01 which had an average concentration of 17 mg/L and a maximum concentration of 170 mg/L in February 2013; however, aside from this result, all other sulphate concentrations were below 10 mg/L at this site.

- Average total suspended solids (TSS) concentrations ranged from 14 to 34 mg/L, and has been particularly variable at site FHSW01, where a maximum concentration of 140 mg/L was recorded in January 2014. The maximum TSS concentrations for the remaining sites were between 28 and 68 mg/L.

These results indicate that water quality between sites FHSW01 and FHSW02, located close to the Margaret River and between sites FHSW03 and FHSW04, located in the tributary creeks around the Fountain Head site have been similar, but there are notable differences between these two groups of sites. Electrical conductivity, pH, hardness, alkalinity and concentrations of major ions have been previously higher at sites FHSW01 and FHSW02. Total suspended solids concentrations have been comparable between sites FHSW02, FHSW03 and FHSW04 and higher and variable at site FHSW01.

In situ measurements of dissolved oxygen and turbidity have also been included during sampling conducted since 2019. Results indicate that dissolved oxygen saturation is variable between sites and sampling events, but generally below the lower limit of the default trigger value range of 85%. Low levels of dissolved oxygen are not uncommon in ephemeral inland freshwater systems, where there is intermittent, low or no flow. Turbidity was only recorded in April 2019 and February 2021, but during both sampling events, turbidity was elevated at all sites, except site FHSW03 in

[3] While the Australian and New Zealand Government (ANZG) 2018 guidelines replace the previous ANZECC/ARMCANZ (2000) guidelines, default guideline values for the Timor Sea drainage division where the Project is located have not yet been published; therefore, the regional default guidelines values from ANZECC/ARMCANZ (2000) have been used.

February 2021. All other results were above the upper limit of the default trigger value range of 15 NTU, ranging from 42 to 228 NTU.

Heavy Metals and Metalloids

Results for dissolved metal and metalloid concentrations in surface water samples are compared to the ANZECC/ARMCANZ (2000a) trigger values for slightly to moderately disturbed ecosystems, given the long history of mining and agriculture in the study area. The following observations are made from the data:

- The majority of individual results and all average and median values for aluminium concentrations from all sampling locations exceeded the ANZECC/ARMCANZ (2000) trigger value of 55 µg/L.
- Chromium concentrations were mostly below the laboratory limit of reporting of 1 µg/L at all sites for all sampling events with the exception of concentrations between 1 and 2 µg/L at site FHSW01 in 2012, 2013, 2014 and 2021 and a concentration of 5 µg/L at site FHSW04 in January 2013. These results were equal to or above the ANZECC/ARMCANZ (2000) trigger value of 1 µg/L. This trigger value is however for chromium (VI) whereas the results reported include chromium species Cr (VI) and Cr (III). It is unknown if the Cr(VI) fraction of the chromium result exceeded 1 µg/L; however, for the purpose of this assessment an exceedance of this value has been assumed. In addition, chromium was notably elevated in February 2020 with a concentration of 40 µg/L at site FHSW01 and 22 µg/L at site FHSW04 reported, both well above the default trigger value. It is noted that concentrations were however within typical levels for subsequent sampling events in March 2020, and February and April 2021.
- Individual results for cobalt and nickel were generally below the limit of reporting of 1 µg/L and below the trigger value of 1.4 µg/L for cobalt and 11 µg/L for nickel. In February 2020, cobalt was recorded at a concentration of 8 µg/L at sites FHSW01(downstream of Fountain Head) and FHSW04 (upstream of Fountain Head) and was above the trigger value, while nickel also exceeded the trigger value at these same sites. Subsequent results indicate cobalt and nickel were below or close to the limit of reporting of 1 µg/L, consistent with historical trends.
- There were some individual exceedances of the ANZECC/ARMCANZ (2000) trigger value for copper of 1.4 µg/L at sites FHSW01 and FHSW04 in 2013 and again in April 2019 and February 2020 at site FHSW01 (the site furthest downstream from Fountain Head), with concentrations of 2 and 22 µg/L recorded respectively while there was also one minor exceedance at site FHSW02 in February 2021 (2 µg/L).
- Individual results for concentrations of zinc were generally below the ANZECC/ARMCANZ (2000) trigger value of 8 µg/L; however, elevated zinc levels were found during some sampling events in 2012, 2013, 2014 and 2020 which has resulted in the average zinc concentrations at all sites except FHSW03 being above 8 µg/L. The most recent data from February and April 2021 indicates that concentrations of zinc were below the limit of reporting of 5 µg/L at all sites.

- All other metal concentrations were below the applicable ANZECC/ARMCANZ (2000) trigger values for slightly to moderately disturbed ecosystems.
- Concentrations of metals in February 2020 were substantially higher at site FHSW01 (the furthest downstream site) and FHSW02 (upstream control for all sites) for all metals (except cadmium and zinc) compared to all other results, with higher concentrations generally recorded at FHSW01. These results indicate there was a potential source of metals in the unnamed tributary creek upstream of Fountain Head, but metal concentrations increased further downstream from Fountain Head. Concentrations of metals at FHSW02, the control for FHSW01, did not show the same trend, with results consistent with previous findings for this site.
- Results for site FHSW01 and the upstream control site FHSW02 indicate that metal concentrations are generally comparable, but concentrations of aluminium, arsenic, chromium, copper, iron and zinc have been slightly higher at FHSW01. The results for sites FHSW03 (upstream of Fountain Head) and FHSW04 (upstream control for all sites) indicate that metal concentrations are generally higher at FHSW04 compared to FHSW03 for aluminium, chromium, copper, iron, manganese, nickel and zinc.

Overall, the results from 2012 to 2021 indicate that aluminium regularly exceeds the default trigger value at all sites, while other metals such as chromium, chromium, copper and zinc have exceeded default trigger values on a number of occasions, particularly at site FHSW01 and FHWS04. With the exception of results from February 2020, the data collected from 2019 to 2021 is generally comparable to results from 2012 to 2016. The results indicate existing elevated background concentrations of these metals both upstream and downstream of Fountain Head.

Additional Analytes

In addition to the available data from care and maintenance monitoring described in the previous sections, ERIAS conducted an aquatic field survey in April 2019 investigating a variety of surface water environments close to Fountain Head and in the broader region. Figure 4.3 shows the location of relevant survey sites. Site S6 aligns with care and maintenance sampling site FHSW04 while the remaining sites have not been previously sampled. Additional analytical parameters not included in the care and maintenance monitoring program included nutrients, hydrocarbons and microbes.

Nutrients were only analysed in samples collected by ERIAS in 2019. Nutrient concentrations were generally low and below the default trigger values, with the exception of total nitrogen at sites S7 (downstream of Fountain Head) and S8 (downstream in the Margaret River).

Total recoverable hydrocarbons and benzene, toluene, ethylbenzene, xylenes and naphthalene concentrations were below the laboratory limits of reporting in all samples, indicating no evidence of existing hydrocarbon contamination.

E. coli was detected at all sites and ranged from 81 MPN/100 mL at S8 in the Margaret River to 435 MPN/100 mL at S7, in the tributary creek downstream of Fountain Head. Total coliforms were above 2,400 MPN/100mL at all sites, while faecal coliforms ranged from 163 MPN/100mL at site S5 to 980 MPN/100 mL at site S6. Manure from cattle and buffalo present in the Project area is likely the major source of coliforms.

4.2.2 Mine Water Quality

4.2.2.1 Pit Water

Water quality data for Fountain Head pit water was collected between 2009 and 2016 by previous mine operators and has been collected since 2019 on behalf of PNX (see sampling locations in Figure 4.3). Samples were collected of surface water except during October 2016 when sampling was undertaken at 10 m depth intervals to a maximum depth of 50 m below surface at two separate locations in the pit. Results from the sampling conducted since 2019 are consistent with results from previous sampling events undertaken from 2009 to 2016. Profile sampling of the pit water column in October 2016 showed that water quality is generally similar with depth, with the exception of higher pH in the surface 10 m and notably higher concentrations of a number of metals (aluminium, cobalt, copper, iron, lead, nickel and zinc) in the bottom profile at one of the two sampling locations in the pit.

General Water Quality Parameters

Comparison is made to the following ANZECC/ARMCANZ (2000)[4] guideline values:

- Short-term trigger value (STV) for use of water for irrigation for less than a 20-year period.
- Trigger values for slightly to moderately disturbed ecosystems. While comparison to these values is not strictly applicable to the pit water, comparison to these criteria provides an indication of the level of risk posed if pit water is discharged to the receiving environment, although does not consider mixing that would occur in receiving waters (where the guidelines would be applicable).
- Livestock drinking water quality guidelines.

With the exception of electrical conductivity and pH, the average, median and maximum concentrations of general parameters and major ions were below applicable guideline values considering irrigation, livestock drinking water and aquatic ecosystem protection.

The electrical conductivity of pit water has been consistently higher than the default trigger value for slightly disturbed rivers in tropical Australia, with an average and standard deviation of 420±77 µS/cm. The salinity of the pit water would; however, be considered 'very low' by irrigation standards and is suitable for use on salinity sensitive crops and as stock drinking water.

The pH and hardness of the pit water indicates it is unlikely to cause corrosion or scaling issues in pumping equipment or pipelines. The alkaline pH of the pit water (average pH of 8.1) indicates the influence of carbonate minerals in host rocks of the pit, and the absence of acid and metalliferous drainage (AMD) from pit walls. This is supported by the relatively high alkalinity measured in the pit water (average concentration of 138±15 mg $CaCO_3$/L from 32

[4] While the ANZG (2018) replace the previous ANZECC/ARMCANZ (2000) guidelines, there have been no updates to the trigger values for irrigation and general water use and the revised livestock drinking water guidelines are yet to be published. Default guideline values for the Timor Sea drainage division where the Project is located have not yet been published; therefore, the regional default guidelines values from ANZECC/ARMCANZ (2000) have been used.

measurements), which provides considerable buffering capacity. The pH of pit water has generally exceeded the default trigger values of 6.0 to 8.0.

Considering concentrations of chloride and sodium, the pit water is suitable for irrigation use on sensitive crops. Concentrations of sulphate in pit water are low (average concentration of 67±8 mg/L), indicating that the occurrence of AMD, or neutral metalliferous drainage (NMD), from pit walls is not problematic. The sodium adsorption ration (SAR) is an indicator of the suitability of water for use in agricultural irrigation and considers concentrations of sodium, calcium and magnesium. The SAR value is calculated to be 1.1 based on average concentrations of the alkaline ions in pit water, indicating water quality is good with no major concerns for irrigation use.

Metals and Metalloids

Average, median and maximum concentrations of all metals and metalloids were well below the irrigation STVs, indicating that phytotoxic effects would not be expected if pit water is used for irrigation.

Arsenic concentrations have consistently exceeded the livestock drinking water guideline value of 500 µg/L with the average and median values above this, indicating that pit water poses some risk to livestock if consumed. All remaining total metal concentrations were below the livestock drinking water guidelines.

There were some exceedances of applicable trigger values for aquatic ecosystem protection for arsenic, copper and chromium with results for the remaining metals below trigger values. Arsenic has consistently exceeded the trigger value for slightly to moderately disturbed aquatic ecosystems of 13 µg/L (for As(V)) with an average and standard deviation of 599±141 µg/L. This indicates the influence of arsenic from the mineralised area of the pit. Arsenic can be naturally elevated in the vicinity of gold deposits due to their geological association, as both are hosted in iron-sulphide minerals such as pyrite, marcasite and arsenopyrite (Xing et al., 2019).

Concentrations of copper were generally below the adjusted trigger value for slightly to moderately disturbed aquatic ecosystems (5.5 µg/L) but were above in February 2009 at site FHPITW and FHPITE (12.5 µg/L, 7.1 µg/L) and February 2015 (28 µg/L), which was the most recent exceedance. Results from 2019 to 2021 for dissolved copper were all below the laboratory limit of reporting of 1 µg/L.

Concentrations of chromium have generally been below the laboratory limit of reporting, which has ranged from <0.1 to <1 µg/L, but exceeded the default trigger value of 1 µg/L for Cr(VI) in two samples, one being from February 2009 (3 µg/L) and the other from January 2014 (5 µg/L). All results since January 2014 have been less than 1 µg/L.

4.2.2.2 Existing Dam Water Quality

Three surface water samples were collected from the edge of the existing dam in March 2020 for laboratory analysis.

General Water Quality Parameters

The results show that the water in the existing dam has low hardness (i.e., is soft water) and very low salinity and is suitable for use on sensitive crops.

The chloride concentration (17 to 37 mg/L) is higher than measured in pit water but is less than the trigger value for chloride causing foliar injury. The groundwater is therefore suitable for irrigation of chloride sensitive crops. Sodium concentrations in the evaporation pond are less than measured in pit water, and less than the trigger value for sodium causing foliar injury.

The SAR value was calculated to be less than 1 indicating water quality is good with no major concerns for irrigation use.

Metals and Metalloids

Average, median and maximum total concentrations of all metals and metalloids were well below the irrigation STVs and livestock drinking water quality guidelines, indicating that phytotoxic effects would not be expected if the existing dam water is used for irrigation and that the water poses no risk to livestock if consumed.

Dissolved metal concentrations were all below the trigger values for slightly to moderately disturbed ecosystems with the majority of metals below the laboratory limit of reporting. There were detections of dissolved arsenic and manganese, but concentrations were well below the trigger values.

4.2.2.3 Fountain Head Lake

Water quality data for the Fountain Head Lake was collected between 2009 and 2016 by previous mine operators and since 2019 on behalf of PNX. Results from the conducted since 2019 are consistent with results from previous sampling events undertaken from 2009 to 2016.

General water quality parameters and metal concentrations vary throughout the year, with major ions and water hardness and some metals increasing in concentration during the dry season due to the effects of evapoconcentration and decreasing at the onset of the wet season from the effects of dilution.

General Water Quality Parameters

The lake pH values are within the irrigation and general water use guidelines and livestock drinking water guidelines (with the exception of April 2021 when pH was 9.7) and have generally been within the aquatic ecosystem guidelines for tropical Australia, but have been just outside this range on some occasions with lake water moderately alkaline at times.

The average electrical conductivity of the Fountain Head Lake is above the trigger value for slightly disturbed rivers in tropical Australia, and at times has exceeded the STV for irrigation of sensitive crop species. Electrical conductivity has fluctuated considerably over time and in some years has had a tendency to increase towards the end of the dry season/beginning of the wet season (e.g., in 2014), which can be attributed to evaporation leading to decreased water volume in the lake and higher salt concentrations.

The results show that water hardness in the Fountain Head Lake varies seasonally, varying between moderate to very hard water, with water hardness generally increasing during the dry season due to evapoconcentration.

Major ion concentrations indicate the water is predominantly a magnesium–sulphate type water with some spread towards magnesium-bicarbonate type.

Average values for general water quality parameters in Fountain Head Lake are similar to pit water; however, parameters vary considerably more seasonally in the lake compared to the pit where water quality parameters have been more stable over time.

While the SAR value was calculated to be less than one, indicating water quality is good with no major concerns for irrigation use, parameters fluctuate during the year and at times electrical conductivity has exceeded the STV for irrigation of sensitive crops.

Metals and Metalloids

With the exception of aluminium and iron, total metal and metalloid concentrations were well below the irrigation STVs and livestock drinking water quality guidelines. Maximum total concentrations of aluminium and iron exceeded the applicable guidelines on some occasions, but average values were below. Total aluminium was equal to the irrigation STV of 20,000 µg/L (February 2013) on one occasion and also exceeded the livestock drinking water guidelines on this occasion and during one other sampling event (February 2014). Total iron concentrations were also uncharacteristically high in February 2013, with a total concentration of 26,000 µg/L. All other individual results for these two metals were below the irrigation and general water use and livestock drinking water trigger values indicating the water is generally acceptable for these uses.

With the exception of aluminium, all average dissolved metal and metalloid concentrations were below the applicable trigger values for aquatic ecosystem protection. Dissolved aluminium concentrations fluctuated considerably during the monitoring period and have exceeded the trigger value around 30% of the time. In most years' aluminium concentrations have been highest in January or February, during the peak of the wet season, but in 2015 concentrations were highest in July, in the middle of the dry season.

There are also some individual exceedances of applicable trigger values for aquatic ecosystem protection for arsenic, chromium, cobalt, copper and zinc, but the majority of results for these metals and metalloids have been below. All results for the remaining metals were below trigger values.

4.3 Groundwater

4.3.1 Project Area Hydrogeology

The Project is located within the Pine Creek Geosyncline geological province where there are the following four Proterozoic hydrostratigraphic units:

- Alluvial sediments (alluvial aquifer where saturated).
- Burrel Creek Formation (fractured rock aquifer).
- Mt Bonnie Formation (fractured rock aquifer).
- Gerowie Tuff (fractured rock aquifer).

The Pine Creek Geosyncline is bounded by the Hayes Creek Fault to the south, the Pine Creek Shear Zone to the east and the Shoobridge Fault to the west. Surface geology at Fountain Head is dominated by weathering products of the Burrell Creek Formation.

4.3.2 Groundwater Beneficial Uses

Groundwater is the Darwin catchments' most important consumptive water resource. Aquifers in the Darwin Rural Water Control District (DRWCD) currently provide an estimated 25 gigalitres (GL) for the purpose of irrigated agriculture, horticulture, public water supplies and local domestic use. Groundwater supplies in the Darwin rural area are currently fully allocated.

Within the Darwin catchment, the Project is located within the Adelaide River groundwater and surface water catchment. There are currently no declared/gazetted beneficial uses for the groundwater of this catchment. Notwithstanding, the beneficial uses identified for the adjacent Mary River groundwater catchment (environment, riparian and agriculture) are relevant to the groundwaters of the Project area. As described in Section 4.2, the objectives for these beneficial uses are defined in ANZG (2018) and ANZECC/ARMCANZ (2000a).

A search of the Australian Groundwater Explorer (BOM, 2020) indicates that there are 62 groundwater bores located within 10 km of Fountain Head. Thirty of these are no longer in use, 11 are listed as, or known to be, functional while the status of the remaining 21 bores is unknown. Identified uses for groundwater bores includes stock and domestic water, commercial and industrial water, and exploration.

There is a bore registered for stock and domestic water use located within the mine lease approximately 500 m south of the pit, but it is not in use and is within the footprint of the proposed expanded IWL. Another bore located outside the mine lease approximately 800 m northeast of the pit is periodically used by Ban Ban Springs Station for stock watering. The remaining known functional bores within 10 km of Fountain Head are located at Grove Hill, North Point and Princess Louise.

Aside from human uses of groundwater resources, groundwater in the Darwin catchment can be important for groundwater dependent ecosystems. A search of the Bureau of Meteorology Groundwater Dependent Ecosystems Atlas (BOM, 2021) indicates that the perennial billabong and waterhole located 550 m downstream to the northeast of the Project area and the Margaret River have a high potential as being aquatic groundwater dependent ecosystems, i.e., high likelihood of a reliance of surface expressions of groundwater. The riparian vegetation along the unnamed tributary creek to the north of the Project area as well as the Margaret River are classified as having a moderate potential as being terrestrial groundwater dependent ecosystems, i.e., moderate likelihood of a reliance of subsurface presence of groundwater. One such groundwater dependent ecosystem known to the Darwin catchment is monsoon vine forest. Monsoon vine forests require permanent water availability and can be found where water is trapped, or the water table is close to the surface (CSIRO, 2018). The majority of monsoon vine forest habitat found in the Darwin catchment are located in the coastal and sub-coastal belts rather than in inland areas such as the Project area (CSIRO, 2018). No monsoon vine forests are located close to the Project area. The nearest monsoon vine forest habitat is located around 15 km to the northwest (Barber et al., 2018).

4.3.3 Hydrogeological Conceptual Model

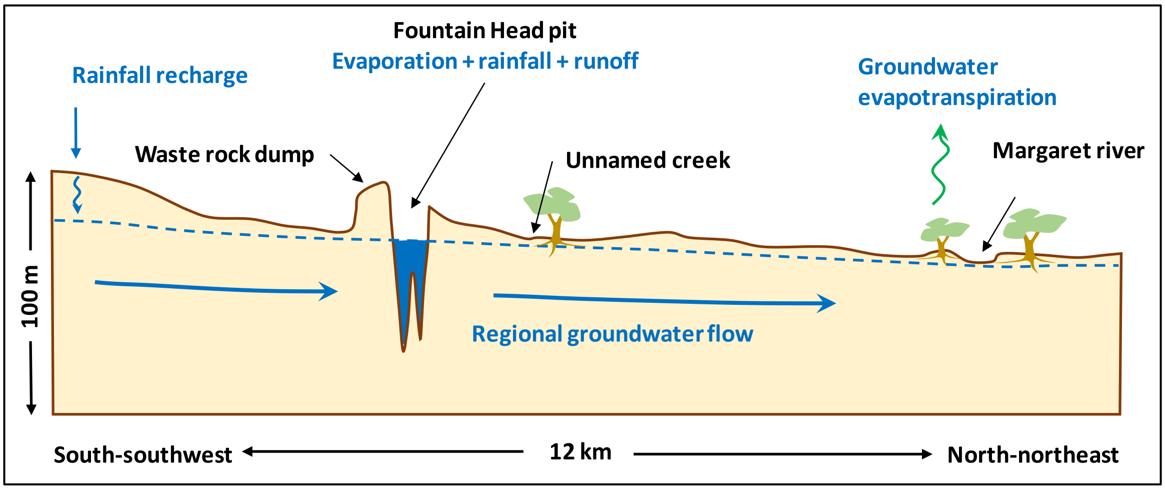
A conceptual model of the hydrogeological conditions at the Fountain Head site has been developed based on available data and characteristics of the area (CDM Smith, 2021a).

Groundwater flow within alluvial sediments is likely to follow a subdued form of the topography and to be structurally controlled in deeper formations due to the presence of fractured rock aquifers (i.e., flow through networks of connected fractures). Regional groundwater flow is assumed, based on topography, to be in a northeast direction. Groundwater discharge is expected along ephemeral creek lines as groundwater evapotranspiration from riparian vegetation and as direct groundwater discharge when groundwater heads are higher than those in the ephemeral creeks. An unnamed creek is located approximately 1 km north of the Fountain Head pit while the Margaret River is approximately 5 km to the northeast. End of wet season baseflow may occur but this is unclear due to a lack of flow information or groundwater measurements in the vicinity of the surface water features.

The Fountain Head pit may be drawing groundwater from the aquifer, but it may also be acting as a throughflow feature given it is likely to have fully recovered from previous dewatering. Based on the time for the pit to fill since cessation of previous mining and water balance modelling, the hydraulic conductivity of rocks hosting the Fountain Head pit is estimated to be approximately 0.2 m/day (CDM Smith, 2021a).

This simplified hydrogeological conceptual model is shown in a cross-section from the top of the surface water catchment (south of the site) through the Fountain Head Pit and to the Margaret River in Figure 4.4. Regional groundwater flows from southwest to northeast.

Figure 4.4 – Simplified Hydrogeological Conceptual Model



Source: CDM Smith, 2021a.

4.3.4 Groundwater Levels and Flow

The natural water table level in the vicinity of the pit is estimated to be about 95 m AHD, ranging between 93 and 97 m AHD, with the water table sitting within 5 to 10 metres below ground surface (mbgs).

A three-dimensional numerical groundwater model, using the USGS MODFLOW, has been developed to generate steady state water table surfaces in the Project area (CDM Smith, 2021a). The 2021 MODFLOW groundwater model was updated to allow for improvements and documented by CDM Smith (2022a). Results are shown in Figure 4.5 for existing conditions and indicates groundwater flow direction is generally to the northeast towards Margaret River. The modelling indicates the pit lake acts as a throughflow feature where regional groundwater flows in from the southwest and out towards the northeast. However, the Fountain Head Pit is likely to be acting as a local groundwater discharge zone, with minor throughflow due to the overall deficit between evaporation and rainfall (i.e., lower pit water levels due to evaporation exceeding rainfall draws surrounding groundwater into the pit).

4.4 Groundwater Water Quality

The Fountain Head site is approximately 50 km from Pine Creek, which has been previously described as naturally having irregularly high arsenic concentrations occurring in groundwater and surface waters (Tickell, 2008). The elevated arsenic concentrations in groundwater are associated with the regional geology (Section 4.2.1).

The Fountain Head site has six monitoring bores in various condition (Figure 4.3) from which water quality data has been collected between 2011 to 2016 by previous mine operators, and since 2019 on behalf of PNX. Generally, results from the 2019 to 2021 sampling are consistent with results from previous sampling undertaken from 2011 to 2016. Results from groundwater monitoring are described in the following sections.

4.4.1 General Water Quality Parameters

The groundwater has an average electrical conductivity of 372±163 µS/cm. Electrical conductivity less than 650 µS/cm is considered suitable for irrigation use on sensitive crops and as livestock drinking water. The average electrical conductivity of groundwater is above the range for slightly disturbed rivers in tropical Australia and is higher than surface waters in the nearby area, which generally have an electrical conductivity between 60 and 180 µS/cm, but lower than pit water, which has had an average electrical conductivity of 420 µS/cm.

The pH of groundwater is circumneutral with the average and median values within applicable guideline values, with the exception of two sampling occasions (April 2012 and November 2015) where pH values were slightly above the upper limit for rivers in tropical Australia, and in April 2012 pH was also just above the STV for irrigation and general water use and the drinking water guidelines.

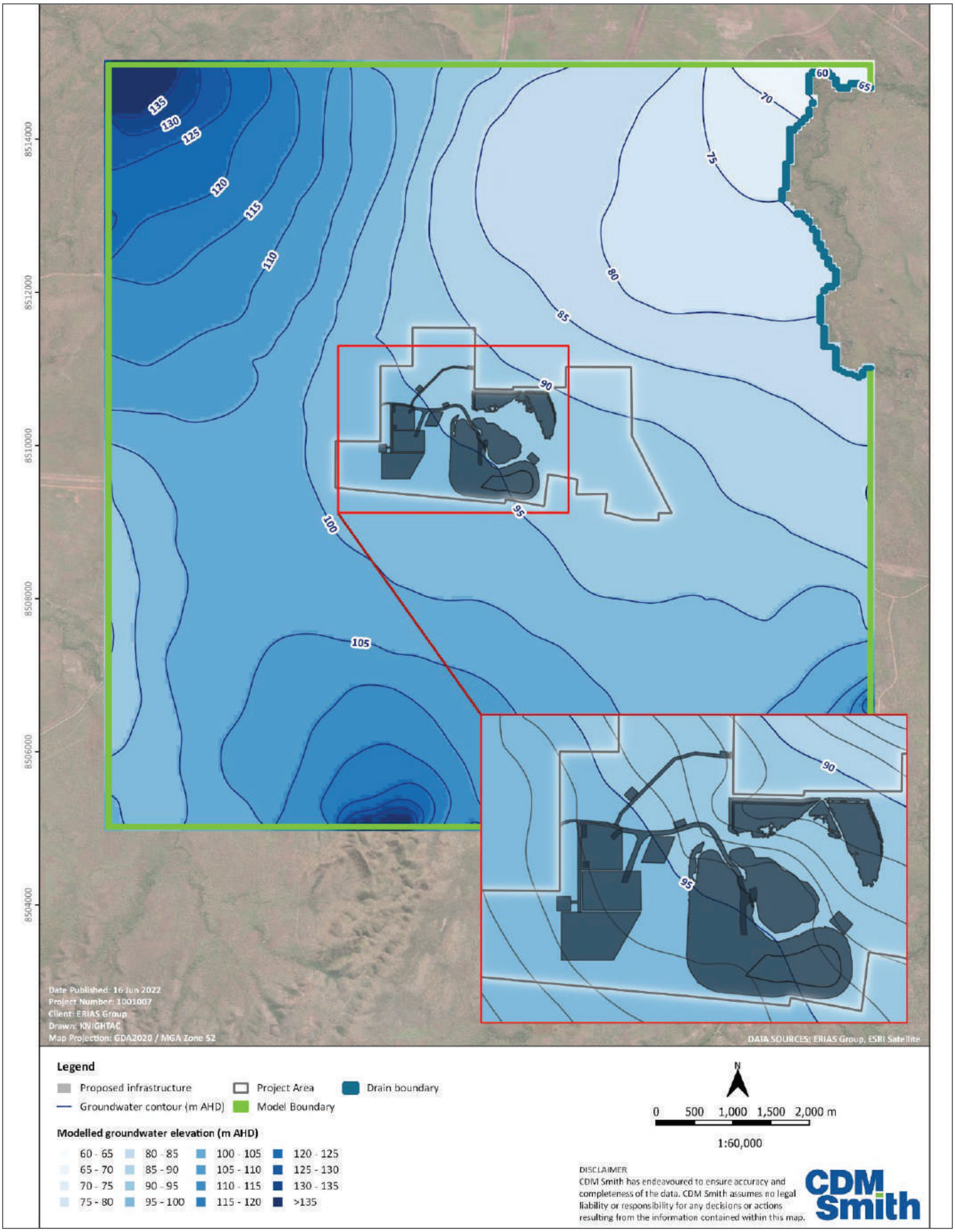
Groundwater is moderately hard, with an average hardness of 108±60 mg $CaCO_3$/L. The pH and hardness of groundwater indicates it is unlikely to cause corrosion or scaling issues in pumping equipment or pipelines. While the average water hardness is below the human drinking water guidelines based on aesthetic considerations, the maximum is slightly above.

Concentrations of major ions are all below applicable guidelines for irrigation use and livestock drinking water. No guidelines are provided for major ions for the protection of aquatic ecosystems or for human drinking water. The SAR value is calculated to be 1.1 based on average concentrations of the alkaline ions in groundwater, indicating water quality is good with no major concerns for irrigation use.

MODELLED EXISTING GROUNDWATER LEVELS IN THE PROJECT AREA

Fountain Head Gold Project | Water Management Plan

FIGURE 4.5



Source: CDM Smith

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4.4.2 Metals and Metalloids

The average and median concentrations of total metals and metalloids are well below the applicable guidelines for irrigation and general water use and livestock drinking water. There have been some exceedances of the Australian drinking water guidelines for arsenic, iron and manganese.

The maximum total aluminium concentration in groundwater exceeded the livestock drinking water guidelines on one occasion at FHMB05 in February 2012 (13,000 µg/L) and was equal to the guideline value of 5,000 µg/L at FHMB06 in April 2016. All other results were below irrigation and livestock drinking water guidelines.

The average total iron concentration in groundwater (from all bores) is less than the short-term trigger value (STV); however, 7 of the 13 results from bore FHMB01 and 8 of the 11 results from bore FHMB02 exceed the STV. This indicates that crops may potentially be impacted by the phytotoxic effects of iron if groundwater from bores FHMB01 and FHMB02 is exclusively used for irrigation for a lengthy period (i.e., 20 years). These two bores are located to the north (FHMB01) and northeast of the pit (FHMB02).

Groundwater would not be suitable for human drinking water based on regular exceedances of arsenic, iron and manganese drinking water guideline values. Average concentrations of arsenic and iron have been over an order of magnitude above respective guideline values. The average manganese concentration has exceeded the aesthetic-based guideline value of 100 µg/L on a number of occasions but has rarely exceeded the health-based guideline value of 500 µg/L.

Other notable observations from the monitoring data are as follows:

- There is a wide range in aluminium results with a standard deviation nearly four times the average value; however, concentrations in groundwater are generally similar to pit water excluding outlier results.
- Arsenic concentrations are lower in groundwater than in pit water, and there is considerable variation in concentrations between different bores.
- Iron concentrations are higher in groundwater than in pit water, and there is considerable variation in concentrations between different bores.

Dissolved cadmium, chromium, cobalt and lead concentrations were generally below or very close to the respective laboratory limits of reporting at all monitoring bores and for all sampling events. The average, median and maximum dissolved concentrations of cadmium, chromium, cobalt, manganese, lead, nickel and zinc are below the adjusted trigger values for slightly to moderately disturbed aquatic ecosystems. There are exceedances of aquatic ecosystem guidelines for aluminium, arsenic and copper at some or all of the groundwater monitoring bores.

Although maximum concentrations of dissolved aluminium are above the trigger value for slightly to moderately disturbed aquatic ecosystems at all monitoring bores except FHMB02, 53 of the 67 results were below the laboratory limit of reporting of 10 µg/L indicating that the maximum results are outliers for the monitoring period.

Maximum concentrations of dissolved arsenic are above the guideline for slightly to moderately disturbed aquatic ecosystems (13 µg/L for As(V)) at all monitoring bores, and average concentrations are also above these guidelines at all monitoring bores except FHMB04. Arsenic concentrations have been highest at FHMB01 (located to the north) with an average concentration of 189±171 µg/L compared to average concentrations of between 8 and 141 µg/L for the remaining bores. As previously described, groundwater in the region is known to have naturally elevated arsenic levels due to the regional geology.

Dissolved copper concentrations are generally below the laboratory limit of reporting of 1 µg/L for all monitoring bores and sampling events; however, there were 2 results out of a total of 69, where concentrations were 4 µg/L and marginally exceeded the adjusted trigger value of 3.5 µg/L.

Overall, the results for total and dissolved metals indicate that groundwater is not suitable for drinking water based on elevated levels of arsenic, iron and manganese but is generally suitable for irrigation use and livestock drinking water; however, groundwater from FHMB01 and FHMB02 has elevated levels of iron above irrigation guidelines and aluminium has exceeded livestock drinking water guidelines at FHMB05 and FHMB06. Concentrations of dissolved aluminium, arsenic and copper have also exceeded trigger values for slightly to moderately disturbed aquatic ecosystems on some occasions.

Historical and recent results for surface waters in the nearby area show widespread elevated aluminium concentrations above trigger values for slightly to moderately disturbed aquatic ecosystems. Groundwater may therefore be a contributing source of aluminium reporting to these environments where there is connectivity.

5. Information and Knowledge Gaps

5.1 Existing Environment Knowledge Gaps

Monitoring of surface water and groundwater was undertaken from 2011 to 2016 by previous mine operators and has been conducted regularly since 2019 on behalf of PNX. This data provides sufficient information to understand and characterise the existing surface water and groundwater quality relevant to the Project. There is however limited hydrological data (e.g., volumes and flow frequency) available regarding surface water flows in the unnamed tributary creek and the upper reaches of the Margaret River (Figure 4.2). Given there is no surface water extraction or discharge to surface water proposed, this information is not critical to being able to assess potential impacts of the Project and to determine appropriate mitigation and management measures.

Other information and knowledge gaps relevant to water management identified are listed in Table 5.1. These gaps were considered when assessing the potential impacts of the Project and where these gaps created uncertainty, this was reflected in the assessment of residual impacts described in the EIS and Section 6 of this WMP. Considering the proposed actions listed in Table 5.1, the identified knowledge and information gaps are not considered to pose a significant risk to the environment as appropriate measures will be in place to manage these risks. In addition to these knowledge gaps identified during preparation of the Draft EIS and Draft WMP, additional uncertainties were identified when undertaking the supplementary studies for the supplement to the EIS (e.g., CDM Smith 2021c). These are also included in Table 5.1.

Table 5.1 – Information and Knowledge Gaps and Proposed Actions

Information/Knowledge Gap	Proposed Actions
Hydraulic properties of the material beneath the evaporation pond and seepage.	Regular groundwater level monitoring. Drilling of monitoring bores and pump tests to further determine the hydraulic properties. Modelling to be updated if required.
Quality of runoff water to be captured from the tailings storage cell in the IWL (during operations).	Water will be captured in two sumps and pumped to the process plant for reuse.
Quality of runoff water from the ROM pad (given the select number of samples with low sulphur content that have been tested).	Routine monitoring of water in the sediment dams collecting runoff from the ROM to assess risk to downstream receiving surface waters.
The influence of faults or fault zones and unsaturated zones on groundwater flow dynamics is unknown. These could act as recharge or discharge boundaries and influence drawdown.	The proposed groundwater monitoring network is designed to validate the numerical model and the trigger action plan will be implemented as required.

6. Impact Assessment and Mitigation and Management Measures

6.1 Impact Assessment Method

For the EIS, a significance assessment approach was used to assess potential environmental impacts associated with the Project. The method is based on understanding the vulnerability of an environmental value, resource or sensitive receptor to determine the potential severity of impacts. The method assesses credible impacts that are expected to occur during the Project's life cycle.

6.1.1 Sensitivity of Environmental Values and Receptors

The sensitivity of an environmental value is determined on the basis of its intrinsic value as well as its susceptibility or vulnerability to threatening processes. In order to reflect the specific focus of each technical study, key attributes that define sensitivity were reviewed, including:

- **Intactness**: a measure of the existing condition of the environmental value, including its representativeness and how intact it is.
- **Formal status**: this may be assigned by statutory or regulatory authorities or by appropriately recognised national or international organisations. This may involve legislation, regulations or international conventions or other mechanisms that attribute a particular status to a value or receptor.
- **Rarity or uniqueness**: as assessment of an environmental value's incidence, abundance and distribution within and beyond its bioregion.
- **Replacement potential**: an assessment of the potential for any losses of the environmental value to be replaced by an equivalent or representative example.
- **Resilience to change**: an assessment of the capacity of an environmental value to adapt to change without adversely affecting its intactness, conservation status, rarity or uniqueness.
- **Importance**: it's worth to local communities and society, its iconic or symbolic importance to cultural value systems.

Applying these elements enables the sensitivity of an environmental value to be ranked as high, moderate, or low, as described by the model criteria in Table 6.1.

Table 6.1 – Sensitivity Criteria

Sensitivity	Description
High	• The environmental value is listed as being of conservation significance on a statutory or recognised international, national or state register. • The environmental value is unique to the environment in which it occurs. It is isolated to the affected area or system, and is poorly represented in the region, territory, country or the world. • The environmental value has not been exposed to threatening processes, or there has not been a noticeable impact on the integrity of the environmental value.
Medium	• The environmental value is recognised as being important at a regional level, and may have been nominated for listing on recognised or statutory registers. • The environmental value is in a moderate to good condition despite it being exposed to previous impacts or threatening processes. It retains many of its key characteristics and structural elements. • The environmental value is relatively well represented in the areas/systems in which it occurs, but its distribution and abundance are limited by threatening processes.
Low	• The environmental value is not listed on any recognised or statutory register. It might be recognised locally by relevant and suitably qualified experts or organisations. • The environmental value is in a poor to moderate condition as a result of previous impact or threatening processes, which have degraded its intrinsic value. • The environmental value is not rare or unique, and numerous representative examples exist throughout the area/system.

6.1.2 Magnitude of Potential Impacts

The magnitude of a potential impact reflects the predicted size and nature of change based on several elements. For the purposes of this assessment these elements are defined as follows:

- **Duration**: the timescale of the effect, whether short, medium (i.e., reversible) or long term (i.e., effectively permanent).
- **Geographical extent**: the spatial extent of the impact where this is defined as site, local, regional or widespread (provincial, national or trans-boundary).
- **Severity**: the scale or degree of change (both positive and negative) from the existing condition, as a result of the environmental impact.

Applying the above elements enables the magnitude of an impact to be ranked as high, moderate, low, negligible or positive as described in Table 6.2.

Table 6.2 – Magnitude Criteria

Magnitude	Description
High	• An impact that is long lasting (i.e., more than 15 years), widespread, and leads to substantial and possibly irreversible change to the environmental and/or social value. • To address the impact, avoidance of the value through appropriate design responses and/or implementation of site-specific environmental and/or social management controls are required.

Magnitude	Description
Medium	• An impact that is medium term (i.e., lasting 5 to 15 years), is contained within the region where the Project is being developed and/or where the intensity and frequency of the impact is outside the range of natural variability or environmental/social value is supported in a moderately modified condition. • It is possible to reduce or largely reverse the impacts/changes via specific environmental and/or social management controls.
Low	• An impact that is short term (i.e., less than 5 years) and localised in extent and/or the intensity and frequency of the impact is detectable with respect to natural variability or the environmental/social value is only slightly impacted. • The change can be effectively mitigated and reversed through routine environmental and/or social management controls.
Negligible	• An impact that is unlikely to be detectable or completely reversed with respect to natural and social variability.
Positive	• A beneficial impact on an environmental and/or social value.

6.1.3 Residual Impact Significance

The significance of an impact on a value or receptor was determined using the significance matrix presented in Table 6.3 which combines the likely magnitude of an impact with the sensitivity of the value or receptor. The magnitude of an impact was assessed considering the application of mitigation measures which were expected to reduce the impact's severity, geographic extent or duration. The result is a significance rating for the residual impact.

Table 6.3 – Significance Assessment Matrix

		Sensitivity of Value		
		High	*Medium*	*Low*
Magnitude of Impact	*High*	Severe	Major	Moderate
	Medium	Major	Moderate	Minor
	Low	Moderate	Minor	Negligible
	Negligible	Negligible	Negligible	Negligible
	Positive	Positive	Positive	Positive

The classifications (severe, major, moderate, low, negligible and positive) for significance of an impact are defined as follows:

- **Severe**: when an impact will potentially cause widespread or irreversible harm to an environmental value that is irreplaceable because of its rarity or uniqueness. Avoidance of the value/impact through appropriate design responses is the only effective mitigation.
- **Major**: when proposed activities are likely to worsen threatening processes affecting the core characteristics or structural elements of an environmental value. Although replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred in order to preserve the environmental value's conservation status or intactness.

- **Moderate**: where an environmental value is somewhat resilient to change but would be further degraded due to the scale of the impact or its susceptibility to further change. The abundance and/or distribution of the environmental value ensures that it is adequately represented in the region, and that replacement, if required, is achievable.
- **Low**: where an environmental value is of local importance, but temporary changes will not adversely affect its viability, provided that routine environmental management controls are implemented.
- **Negligible**: where impact to an environmental value will not result in any noticeable change in its intrinsic value, and as such, the proposed activities will have negligible effect on its viability.
- **Positive**: where a Project activity will have a beneficial impact on an environmental value that enhances its resilience to change.

6.2 Hydrological Processes

A summary of the impact assessment provided in the EIS for hydrological processes is provided in the following sections.

6.2.1 Sensitivity

The sensitivity of surface water in the Project area with regard to hydrological processes is categorised as ***Low***, considering the location high in the upper catchment where surface runoff only occurs intermittently after rainfall events. Such hydrological regimes are not rare or unique, and numerous representative examples exist throughout the Adelaide River basin. Additionally, modification of the natural regime has occurred from previous mining operations by the installation of a causeway, forming Fountain Head Lake.

The sensitivity of groundwater in the Project area with regard to hydrological processes is also categorised as ***Low***. This categorisation is based on there being no groundwater dependent ecosystems (such as monsoon vine forest habitat) in the area of the mine, high levels of arsenic and iron make it unsuitable for use as human drinking water and groundwater also has been subject to considerable variation in levels and influences from previous mining activities. Notwithstanding that a bore located adjacent the mine lease boundary is periodically used by Ban Ban Springs Station, groundwater availability is quite extensive in the broader region.

6.2.2 Potential Impacts

A summary of the potential impacts to hydrological processes due to the Project considered in the impact assessment are summarised in Table 6.4.

Table 6.4 – Summary of Potential Impacts on Hydrological Processes

Project Phase	Activity/Aspect	Project Component	Potential Impact
Operations and closure.	Project infrastructure footprint.	Process plant; ROM pad, mining contractors yard, access roads; evaporation pond; IWL.	Altered surface water hydrological regime.

Project Phase	Activity/Aspect	Project Component	Potential Impact
Construction, operations and closure.	Pit dewatering.	Open pit.	Groundwater drawdown.
Construction, operations and closure.	Evaporation pond seepage.	Evaporation pond.	Groundwater mounding.

6.2.3 Mitigation and Management Measures

The potential impacts with regards to water management for this project are to be mitigated and managed by the embedded design controls outlined below.

Most of the proposed mining infrastructure is located outside the 0.1% AEP flood extent. To reduce the flood risk, a few components of proposed infrastructure (such as the core yard and west topsoil stockpile) are proposed to be raised or protected by bunds to achieve the required flood immunity and reduce erosion potential.

To reduce potential flood impacts, a diversion channel will be constructed along the western side of the existing waste rock dump to reinstate the natural flow path and divert the natural catchment runoff into the existing Fountain Head Lake (Figure 3.7). A diversion is also proposed along the northern side of the evaporation pond as the proposed pond extension is located on the existing flow path connecting Fountain Head Lake to the unnamed tributary creek. Surface water runoff from upgradient of the process plant site and ROM pad will also be diverted to flow to the unnamed tributary creek. Given these surface flow diversions, no significant change in the hydrological regime of surface waters downstream of Project infrastructure is expected.

Six sediment dams are proposed to be constructed to capture surface runoff from the IWL and mining infrastructure areas (CIL plant, power station, ROM pad and mining contractors yard) (Figure 3.7), with decant allowed to overflow to the downslope catchment.

To prevent impacts from scouring due to high water velocities, erosion protection such as rock armour protection will be as required e.g., along the evaporation pond. Scour protection will also be undertaken along the Fountain Head Lake causeway and culverts will be installed in the causeway to provide drainage from the lake rather than overflow over the haul road.

6.2.4 Residual Impacts

A summary of the residual hydrological processes impact assessment, including proposed mitigation and management measures to minimise impacts, is provided in Table 6.5.

Table 6.5 – Hydrological Processes Impact Assessment

Environmental Value	Potential Impact	Activity/Aspect	Mitigation Measures	Project Phase	Sensitivity/ Magnitude	Residual Impact Significance
Surface water	Altered surface water hydrological regime.	Project infrastructure footprint.	Embedded design controls will include: • HED01. • HED02. • HED03. • HED04.	Operations and closure.	Low/Low	Negligible
Groundwater	Groundwater drawdown.	Pit dewatering.	None proposed.	Construction, operations and closure.	Low/Low	Negligible
	Groundwater mounding.	Evaporation pond seepage.	None proposed.	Construction, and operations.	Low/Low	Negligible
				Closure.	Low/Negligible	Negligible

6.3 Surface Water Quality

6.3.1 Sensitivity

The impact assessment addresses potential impacts to surface water quality outside of the mine lease (e.g., surface water environments described in Section 4.2.1). While there are surface waters within the mine lease, e.g., the Fountain Head Lake and the existing dam/proposed evaporation pond, these man-made mine waterbodies are associated with past mining activities. Impacts to the water quality of these waterbodies are not considered in the EIS; however, potential impacts from these man-made water bodies on downstream surface water quality have been considered.

Surface water quality in the unnamed tributary creek, to the north of the mine lease, and the Margaret River is generally typical of ephemeral freshwater systems of northern Australia but with widespread microbial contamination and elevated concentrations of some metals (aluminium, chromium, copper and zinc) observed at sites both upstream and downstream of the Project area. Considering this, surface waters that may be potentially impacted by the Project, including the Margaret River and its tributary creeks are considered to have a ***Medium*** sensitivity, given the long history of mining and agricultural activities in the area and because surface waters are considered to be moderately disturbed.

6.3.2 Potential Impacts

Potential impacts to surface water quality due to the Project considered in the impact assessment are summarised in Table 6.6.

Table 6.6 – Summary of Potential Impacts on Surface Water Quality

Project Phase	Activity/Aspect	Project Component	Potential Impact
Construction, operations and closure.	Earthworks/ ground disturbance, topsoil stripping and stockpiling.	Pit expansion; IWL expansion; construction of process plant, power station, laydown areas, access roads and infrastructure; ROM pads; topsoil stockpiles.	Increased turbidity/sedimentation in downstream surface waters due to erosion of soils/exposed surfaces.
Operations and closure.	Mining and processing.	ROM pads; IWL.	Increased turbidity/sedimentation in downstream surface waters due to rainfall runoff from ore, tailings and waste rock.
Construction, operations and closure.	Mining and processing.	ROM pads; IWL.	Contamination of downstream surface waters from rainfall runoff of ore, tailings and waste rock.
Construction, operations and closure.	Chemical and fuel storage and use.	Mine machinery, plant, vehicles and equipment; explosive magazine, chemical silos, reagent storage area.	Contamination of downstream surface waters due to accidental release of hydrocarbons and chemicals.

6.3.3 Mitigation and Management Measures

6.3.3.1 Suspended Sediment and Turbidity

A number of embedded design controls address impacts on surface water from increased suspended sediment and turbidity. Such design controls will include:

- Installing approximately six appropriately sized sediment dams according to the best practice erosion and sediment control guidelines (IECA, 2008) to capture surface runoff from the IWL, processing plant, ROM pad, mining contractor yard and hardstand areas to allow suspended sediment to settle out prior to overflowing to the downslope catchment (Figure 3.7). Prior to the installation of the sediment dams (i.e., during the construction phase), rainfall runoff will flow through existing drainage lines either into Fountain Head Lake or towards the unnamed tributary creek to the north. [SWED01]

- Diverting natural catchment runoff from upstream of the processing area, diverting the existing drainage line around the north of the evaporation pond (which is located on the existing flow path) and installing a bund around the Fountain Head pit to direct surface water away from operational areas (Figure 3.7). [SWED02]

- Installing erosion protection, e.g., rock armour around the western soil stockpile, adjacent the haul road at the northern extent of Fountain Head Lake and along the western and northern toes of the evaporation pond to minimise scour from surface water drainage (Figure 3.7). [SWED04]

- Installing culverts under the haul road to provide direct drainage from the lake and to reduce the frequency of flooding of the haul road. [SWED05]

- Constructing the core yard and western soil stockpile on raised pads above the 1% AEP peak flood levels with appropriate freeboard or flood protection structures. [SWED06]

The presence of the Fountain Head Lake will also restrict transport of sediment to downstream surface waters by acting as a sediment retention basin. Fountain Head Lake will receive natural catchment runoff from the southern part of the site adjacent the processing area and the western extent of the IWL. While the lake currently overflows during the wet season, culverts will be installed in the causeway to provide drainage and to reduce the frequency of flooding of the haul road. Once the lake reaches capacity, overflow water will discharge to the downslope catchment via the culverts; however, some suspended sediment is likely to have settled out prior.

Additional measures to minimise impacts to surface water quality from increased suspended sediment and turbidity will include:

- If deemed appropriate, using hay bales, geotextile silt fencing, or silt socks to contain sediment runoff during construction and closure earthworks and ground disturbance activities. [SW01]

- Rehabilitating disturbed areas as soon as practicable to minimise areas of potentially erodible soil. [SW02]

- Controlling sediment runoff from stockpiles by installing sediment control structures to intercept sediment laden-surface runoff to reduce sediment delivery to watercourses. [SW03]

- Avoiding stockpiling spoil and/or topsoil close to existing and proposed drainage lines, maintaining a minimum distance of approximately 50 m, where practicable. [SW04]

- Undertaking earthworks and ground disturbance activities during the drier months, wherever practicable, when exposed surfaces will be less prone to rainfall erosion. [SW05]

6.3.3.2 Surface Water Contamination from Waste Rock, Ore and Tailings

Embedded design control measures that will mitigate impacts on surface water due to runoff from stockpiled ore, waste rock and tailings will include:

- Placing the tailings within a lined cell within the IWL and capturing rainfall runoff that has been in contact with the tailings (during operations) for use at the process plant or directing it to the evaporation pond via decant wells. [SWED08]

- Installing finger drains or excavated trenches below the IWL to capture seepage from the clay liner. The water will be collected in two sumps and will be pumped to the process plant. [SWED12].

- Washing of tailings filter cake to remove residual cyanide prior to placement in IWL, and return of wash water to processing plant circuit. [SWED09]

- Capping the tailings with a 0.5 m layer of clay and 1.5 m layer of NAF waste rock to prevent rainfall infiltrating the tailings following closure. [SWED10]

Additional measures to minimise impacts on surface water from waste rock, ore and tailings will include:

- Validating the assumption that operational blending of non-acid forming (NAF) and potentially acid-forming low capacity (PAF-LC) material will buffer the acid forming potential of PAF-LC and conducting column leach testing to further understand the potential for acidic drainage from PAF-LC material placed in the IWL. [SW07]

- Testing the sulphur content of waste rock and placing PAF waste rock in the pit perimeter, using a <=0.4% Total S cut-off for NAF material and pushing PAF material further into the pit at completion of mining for permanent submersion. [SW08]

- Routine monitoring of water quality in the sediment dams that overflow to the downslope catchment to confirm that runoff from the operational areas is of suitable quality in line with downstream receiving environmental objectives. Where water in the sediment dams does not meet relevant receiving water quality criteria, it will be directed to the evaporation pond or process plant. [SW21]

- Monitoring of surface water quality in the unnamed tributary creek and Margaret River to detect potential contamination and to initiate remedial action. [SW09]

6.3.3.3 Contamination from Chemical Releases

Measures to mitigate impacts to surface water from hydrocarbon and chemical releases will include:

- Implementation of standard international cyanide management codes. [SW10]
- Storing fuels, lubricants and process reagents in covered areas or in bunded and lined areas. Bunding will be implemented in accordance with relevant standards and guidelines including *AS 1940 Storage and handling of flammable and combustible liquids* and the *Australian Dangerous Goods Code*. [SW11]
- Collection of oil waste from the wash bay at the vehicle maintenance workshop with an oil separator and water underflow reporting to a soakage or storage pit for reuse. Waste oil will be collected and stored in drums in bunded and lined area for removal off site by a licensed contractor. [SW12]
- Refuelling on impermeable hardstand areas with spill prevention and spill containment kits available in close proximity. [SW13]
- Providing spill kits appropriate to the spill risk at the Project site and within vehicles as necessary. All fuel tankers and those tankers transporting hazardous materials shall carry appropriate spill kits. [SW14]
- Inspecting, maintaining and repairing fittings, pipes and hoses regularly. [SW15]
- Training personnel in the handling, transportation and storage of hazardous materials and providing training to an appropriate number of staff in the handling of emergency response and release scenarios. [SW16]
- Clearly labelling vessels with name or description of hazardous material with accompanying material safety data sheets (MSDS) to be stored in close proximity and readily available in case of a spill or leak. [SW17]
- Use of bunds and sumps to collect and return any spills from the CIL plant internally. [SW18]
- Testing permanent storage vessels and enclosures intended for hazardous materials storage for leaks prior to installation and operation. [SW19]
- Routinely inspecting vessels, tanks and secondary containment for leaks. If a leak is identified activate appropriate actions as per the Spill Response Plan (or similar). [SW20]
- Developing and implementing a service and maintenance schedule according to manufacturer's specifications [SW22]

6.3.4 Residual Impacts

A summary of the residual surface water quality impact assessment, including proposed mitigation and management measures to minimise impacts, is provided in Table 6.7.

Table 6.7 – Surface Water Quality Impact Assessment

Environmental Value	Potential Impact	Activity/Aspect	Mitigation Measures	Project Phase	Sensitivity/ Magnitude	Residual Impact Significance
Surface water	Increased suspended sediment and turbidity.	Earthworks/ground disturbance, topsoil stripping and stockpiling.	Embedded design controls will include: • SWED01. • SWED02. • SWED04. • SWED05. • SWED06. • SWED11. Mitigation measures will include: • SW01. • SW02. • SW03. • SW04. • SW05.	Construction.	Medium/Low	Minor
		Ore stockpiling and processing; IWL; diversion channels, Project infrastructure.		Operations.	Medium/Negligible	Negligible
		Earthworks, rehabilitation.		Closure.	Medium/Negligible	Negligible
Surface water	Surface water contamination from waste rock, ore and tailings.	Waste rock stockpiling/use of NAF material.	Embedded design controls will include: • SWED08. • SWED09. • SWED10. • SWED11. Mitigation measures will include: • SW07. • SW08. • SW09. • SW21.	Construction, operations and closure.	Medium/Negligible	Negligible
		Waste rock stockpiling (NAF and PAF-LC material)		Operations and closure	Medium/Low	Minor
		Waste rock stockpiling (PAF material).		Operations and closure.	Medium/Negligible	Negligible
		Ore stockpiling.		Operations.	Medium/Low	Minor

Environmental Value	Potential Impact	Activity/Aspect	Mitigation Measures	Project Phase	Sensitivity/ Magnitude	Residual Impact Significance
		Tailings.		Operations and closure.	Medium/Negligible	Negligible
Surface water	Surface water contamination from accidental release of hydrocarbons and chemicals.	Use of chemical reagents, vehicles, plant and equipment, fuel and chemical handling and storage.	• SW10. • SW11. • SW12. • SW13. • SW14. • SW15. • SW16. • SW17. • SW18. • SW19. • SW20. • SW22.	Construction and operations.	Medium/Low	Minor
				Closure.	Medium/Negligible	Negligible

6.4 Groundwater Quality

6.4.1 Sensitivity

Groundwater quality in the region has natural high arsenic concentrations due to the regional geology. As such, groundwater is unsuitable for use as human drinking water. Monitoring bores from the Project site indicate that groundwater also has iron and manganese concentrations elevated above drinking water guidelines, aluminium concentrations elevated above livestock drinking water guidelines and iron concentrations elevated above irrigation guidelines. Arsenic, aluminium, chromium and copper concentrations have also been above ecological guideline values for slightly to moderately disturbed surface waters. Considering this, groundwater that may be potentially impacted by the Project, is considered to have a ***Low*** sensitivity, given it has been subject to influences from previous mining activities, is unsuitable for human drinking water, livestock drinking water and irrigation and does not meet surface water guidelines for slightly to moderately disturbed ecosystems and groundwater availability is quite extensive in the broader region.

6.4.2 Potential Impacts

Potential impacts to groundwater quality due to the Project that considered in the impact assessment are summarised in Table 6.8.

Table 6.8 – Summary of Potential Impacts on Groundwater Quality

Project Phase	Activity/Aspect	Project Component	Potential Impact
Construction, operations and closure.	Pit dewatering.	Evaporation pond.	Contamination of groundwater from seepage of evaporation pond water.
Operations and closure.	Mining and processing.	ROM pad; IWL.	Contamination of groundwater from waste rock, ore and tailings.
Construction and operations.	Chemical and fuel storage and use.	Mine machinery, plant, vehicles and equipment; explosive magazine, chemical silos, reagent storage area.	Contamination of groundwater due to accidental release of hydrocarbons and chemicals.
Closure.	Mining.	Final pit lake.	Contamination of groundwater from interaction with final pit water.

6.4.3 Mitigation and Management Measures

6.4.3.1 Groundwater Contamination from Seepage from the Evaporation Pond

Based on the groundwater drawdown modelling results (CDM Smith, 2021a) which shows that groundwater from the area of the evaporation pond is expected to be drawn to back to the pit, no management measures are proposed to mitigate groundwater contamination from evaporation pond seepage.

6.4.3.2 Groundwater Contamination from Waste Rock, Ore and Tailings

The measures embedded in Project design described Section 6.2.3.2 to mitigate impacts to surface water quality will also mitigate impacts to groundwater quality from waste rock, ore and tailings.

6.4.3.3 Groundwater Contamination from Accidental Hydrocarbon or Chemical Releases

The management measures listed in Section 6.2.3.3 to mitigate impacts to surface water quality from hydrocarbon and chemical releases will also mitigate impacts to groundwater quality. No additional measures are proposed.

6.4.3.4 Groundwater Contamination from Septic Systems

Measures to minimise impacts on groundwater from septic systems will include:

- Locating, constructing and using septic systems according to the Northern Territory Code of Practice for Onsite Wastewater Management. [GW02]
- Regularly pumping solids from the septic tank to prevent blockages. [GW03]

6.4.3.5 Groundwater Contamination from Final Pit Water

No management measures are proposed to mitigate final pit water interacting with surrounding groundwater.

6.4.4 Residual Impacts

A summary of the residual groundwater quality impact assessment, including proposed mitigation and management measures to minimise impacts, is provided in Table 6.9.

Table 6.9 – Groundwater Quality Impact Assessment

Environmental Value	Potential Impact	Activity/Aspect	Mitigation Measures	Project Phase	Sensitivity/ Magnitude	Residual Impact Significance
Groundwater	Groundwater contamination from seepage from the evaporation pond.	Pit dewatering.	None proposed	Construction, operations and closure.	Low/Medium	Minor
Groundwater	Groundwater contamination from waste rock, ore and tailings.	Waste rock stockpiling/use of NAF material and ore stockpiling.	Embedded design controls will include: • SWED08. • SWED09. • SWED10. • SWED12. Mitigation measures will include: • SW07. • SW08. • SW21.	Construction, operations, closure.	Low/Negligible	Negligible
		Waste rock stockpiling (PAF-LC)		Operations and Closure	Low/Low	Negligible
		Waste rock stockpiling (PAF material).		Operations.	Low/Low	Negligible
		Waste rock stockpiling (PAF material).		Closure.	Low/Negligible	Negligible
		Tailings.		Operations and Closure.	Low/Negligible	Negligible
Groundwater	Groundwater contamination from accidental hydrocarbon or chemical releases.	Use of chemical reagents, vehicles, plant and equipment, fuel and chemical handling and storage.	• SW10. • SW11. • SW12. • SW13. • SW14. • SW15. • SW16. • SW17.	Construction, operations and closure.	Low/Negligible	Negligible

Environmental Value	Potential Impact	Activity/Aspect	Mitigation Measures	Project Phase	Sensitivity/ Magnitude	Residual Impact Significance
			• SW18. • SW19. • SW20. • SW22.			
Groundwater	Groundwater contamination from septic system.	Wastewater management.	• GW02. • GW03.	Construction and Operations	Low/Negligible	Negligible
Groundwater	Groundwater contamination from final pit water quality.	Refilling of Fountain Head pit.	None proposed.	Closure	Low/Negligible	Negligible

7. Monitoring, Management and Reporting

7.1 Monitoring

The monitoring program is designed to assist in identifying changes over time and determining the success of the various water management measures provided in Section 6.

7.1.1 Performance Objectives, Targets and Monitoring

Table 7.1 describes the key performance objectives, targets and monitoring that PNX will use to manage impacts related to hydrological processes, surface water quality, groundwater quality and aquatic ecosystems. Further detail on the monitoring program is provided in Section 7.2.

Table 7.1 – Processes Objectives, Targets and Monitoring

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
Hydrology					
Altered surface water hydrological regime.	• Avoid flooding or erosion of Project infrastructure. • Minimise impacts on flows to downstream surface waters. • Avoid impacts to beneficial uses including sacred sites.	• No flood damage to Project (or other) infrastructure. • No impacts on downstream flows.	• Visual inspection of infrastructure, diversion channels and downstream flow behaviour following rainfall events.	• Install additional or alternative hydrological/erosion controls.	• Visual inspection of infrastructure, diversion channels and downstream flow behaviour following rainfall events.
Groundwater drawdown.	• Minimise impacts on other groundwater users. • Avoid impacts to sacred sites.	• No exceedances of trigger levels provided in Section 7.1.3.	• Groundwater level monitoring as per Section 7.1.3.	• Investigate cause of reduced groundwater availability and provide alternative water source if mine-related. • Follow the trigger action plan in Section 7.1.3.	• Annual reporting as required for the mine management plan.
Groundwater mounding.	• Avoid waterlogging of soil and surface expression of evaporation pond seepage.	• No exceedances of trigger levels provided in Section 7.1.3.	• Groundwater level monitoring as per Section 7.1.3.	• Action measures to prevent seepage to the downstream catchment (e.g., interception trenches/ bores). • Follow the trigger action plan in Section 7.1.3.	• Annual reporting as required for the mine management plan.

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
Surface Water					
Increased suspended sediment and turbidity from rainfall runoff.	• Minimise impacts from rainfall runoff, erosion and scouring on surface water quality. • Avoid impacts to beneficial uses including sacred sites.	• No detectable change from background conditions in downstream water quality beyond the unnamed tributary creek.	• Surface water monitoring as per Section 7.1.2. • Verification that sediment control structures are installed during construction and as required for closure (i.e., once sediment dams have been removed). • Monitoring the success of rehabilitation works in accordance with the Rehabilitation Management Plan.	• Investigate potential sources of excess sediment, inspect for signs of erosion and implement corrective actions to reduce sediment loads. • Install additional or alternative sediment control structures. • Inspections of unsuccessful rehabilitation site to identify root cause.	• Annual reporting as required for the mine management plan.
Surface water contamination from waste rock, ore and tailings.	• Prevent impacts to surface water quality from NAF waste rock and ore at the ROM pad. • Avoid impacts to beneficial uses including sacred sites.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in downstream surface waters (i.e., the unnamed tributary creek or Margaret River).	• Surface water monitoring as per Section 7.1.2.	• Where testing shows operational blending is unable to buffer the acid forming potential of PAF-LC, implement appropriate management measures to reduce potential acidic drainage from PAF-LC (e.g., temporary segregation and subsequent submersion).	• Annual reporting as required by the mine management plan.
	• Minimise impacts to surface water	• Placement of PAF rock into the pit rather than	• Surface water monitoring as per Section 7.1.2.	• Review PAF management procedures	• Annual reporting as required by the mine

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
	quality from PAF waste rock. • Avoid impacts to beneficial uses including sacred sites.	temporary above ground storage. • No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in downstream surface waters (i.e., the unnamed tributary creek or Margaret River).	• Verify PAF material distribution in accordance with the Waste Rock Management Plan. • Verify that testing of sulphur the content of waste rock is being conducted and PAF material is segregated.	and implement corrective action. • Should pit water quality monitoring events (post mining) be materially different from the modelling: – investigate possible source of pollution i.e., is it from within the pit (PAF rock storage or walls) or external to the pit (i.e., drainage from the IWL). – Update groundwater model to determine if the decline in pit water quality would impact downstream aquatic ecosystems. – If the results of the updated groundwater model was that the risk to downstream aquatic ecosystems was high then PNX would commit to treating the pit water to reduce the source of contaminants.	management plan.

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
	• Minimise impacts to surface water quality from tailings. • Avoid impacts to beneficial uses including sacred sites.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in downstream surface waters (i.e., the unnamed tributary creek or Margaret River).	• Surface water monitoring as per Section 7.1.2.	• Investigate sources of contamination and implement remedial action. • Develop appropriate long-term management strategy (if required).	• Annual reporting as required by the mine management plan.
Surface water contamination from accidental release of hydrocarbons and chemicals.	• Prevent or minimise contamination of surface water from the accidental release of hydrocarbons and chemicals. • Avoid impacts to beneficial uses including sacred sites.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in downstream surface waters (i.e., the unnamed tributary creek or Margaret River). • No undetected or uncontained release of hydrocarbons or chemicals.	• Surface water monitoring as per Section 7.1.2. • Incident-triggered surface water monitoring where release of hydrocarbon or chemicals occurs and may impact downstream surface water either due to the size of the release or the time taken to contain/remediate it. • Visual monitoring for signs of leaks or spills from vehicles, plant and machinery. • Inspect bunds, sumps and storage pits designed to contain hydrocarbons or chemicals and remove water and dispose offsite	• Investigate potential source of hydrocarbon or chemical releases (if unknown). • Investigate potential environmental impacts of a known release (if considered a reportable incident). • Review management measures and procedures, and implement corrective actions to reduce likelihood of incident recurrence. • Remove from use vehicles, plant or machinery which have not been serviced in accordance with the	• Incident reporting and investigation of release of hydrocarbons or chemicals as required by the NT EPA and PNX procedures. • Maintain service and repair records of vehicles, plant and machinery. • Maintain personnel training records. • Annual reporting as required by the mine management plan.

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
			using a licensed contractor where operational limits are reached. • Verify spill containment kits are located on site at required locations (e.g., at refuelling areas) within vehicles (as necessary) and within tankers transporting fuel or hazardous materials. • Verify personnel have received appropriate training in handling, transportation and storage of hazardous materials and emergency response and spill response procedures. • Inspect vessels, tanks and secondary containment for leaks and activate appropriate actions as per the Spill Response Plan (or similar). • Verify service and maintenance schedule developed and adhered to.	service and maintenance schedule and only return to service once servicing has been completed. • Provide training to untrained personnel in handling, storage and transport of hydrocarbons and chemicals and spill response and containment measures.	

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
Groundwater					
Groundwater contamination from seepage from the evaporation pond.	• Minimise impacts to groundwater quality from evaporation pond seepage. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in groundwater monitoring bores, or detectable change from background concentrations (e.g., for arsenic, aluminium and other already elevated metals and metalloids).	• Groundwater monitoring as per Section 7.1.3.	• Investigate extent of potential contamination. • Follow the trigger action plan in Section 7.1.3.	• Annual reporting as required by the mine management plan.
Groundwater contamination from waste rock, ore and tailings.	• Prevent impacts to groundwater quality from NAF waste rock and ore at the ROM pad. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in groundwater monitoring bores, or detectable change from background concentrations (e.g., for arsenic, aluminium and	• Groundwater monitoring as per Section 7.1.3.	• Where testing shows operational blending is unable to buffer the acid forming potential of PAF-LC, implement appropriate management measures to reduce potential acidic drainage from PAF-LC (e.g., temporary segregation and subsequent submersion).	• Annual reporting as required by the mine management plan.

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
		other already elevated metals and metalloids).		• Follow the trigger action plan in Section 7.1.3.	
	• Minimise impacts to groundwater quality from PAF waste rock. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in groundwater monitoring bores, or detectable change from background concentrations (e.g., for arsenic, aluminium and other already elevated metals and metalloids).	• Groundwater monitoring as per Section 7.1.3.	• If testing estimates larger quantity of PAF material than expected (i.e., >5%), review PAF material management strategy to ensure adequacy. • Investigate sources of contamination and implement remedial action. • Follow trigger action plan in Section 7.1.3.	• Annual reporting as required by the mine management plan.
Groundwater contamination from accidental release of hydrocarbons and chemicals.	• Prevent or minimise contamination of groundwater from the accidental release of hydrocarbons and chemicals. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in groundwater monitoring bores, or detectable change from background concentrations	• Groundwater monitoring as per Section 7.1.3. • Visual monitoring for signs of leaks or spills from vehicles, plant and machinery. • Inspect bunds, sumps and storage pits designed to contain hydrocarbons or chemicals and remove water and dispose offsite	• Follow the trigger action plan in Section 7.1.3. • Investigate potential source of hydrocarbon or chemical releases (if unknown). • Investigate potential environmental impacts of a known release (if considered a reportable incident).	• Incident reporting and investigation of release of hydrocarbons or chemicals as required by the NT EPA and PNX procedures. • Maintain service and repair records of

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
		(e.g., for arsenic, aluminium and other already elevated metals and metalloids). • No undetected or uncontained release of hydrocarbons or chemicals.	using a licensed contractor where operational limits are reached. • Verify spill containment kits are located on site at required locations (e.g., at refuelling areas) within vehicles (as necessary) and within tankers transporting fuel or hazardous materials. • Verify personnel have received appropriate training in handling, transportation and storage of hazardous materials and emergency response and spill response procedures. • Inspect vessels, tanks and secondary containment for leaks and activate appropriate actions as per the Spill Response Plan (or similar). • Verify service and maintenance schedule developed and adhered to.	• Review management measures and procedures, and implement corrective actions to reduce likelihood of incident recurrence. • Remove from use vehicles, plant or machinery which have not been serviced in accordance with the service and maintenance schedule and only return to service once servicing has been completed. • Provide training to untrained personnel in handling, storage and transport of hydrocarbons and chemicals and spill response and containment measures.	vehicles, plant and machinery. • Maintain personnel training records. • Annual reporting as required by the mine management plan.

Environmental Impact	Environmental Performance Objective	Environmental Performance Target	Monitoring	Contingency	Reporting and Record Keeping
Groundwater contamination from septic system.	• Prevent contamination of groundwater from septic system. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Trigger Values for nutrients and dissolved oxygen.	• Groundwater monitoring as per Section 7.1.3. • Visual/odour monitoring for signs of septic leaks.	• Investigate potential source of septic leak. • Follow the trigger action plan in Section 7.1.3.	• Annual reporting as required by the mine management plan. • Maintain records of septic pumping and repairs (if required).
Groundwater contamination from final pit water quality.	• Minimise impacts to groundwater quality from final pit water. • Avoid impacts to beneficial uses.	• No exceedances of the applicable ANZG (2018) Australian Water Quality Guideline Trigger Values in groundwater monitoring bores, or detectable change from background concentrations (e.g., for arsenic, aluminium and other already elevated metals and metalloids).	• Groundwater monitoring as per Section 7.1.3.	• Investigate extent of potential contamination. • Follow the trigger action plan in Section 7.1.3.	• Annual reporting as required by the mine management plan.

7.1.2 Surface Water

The surface water monitoring program is outlined in this section and is designed to assist in identifying changes in surface water quality over time and determining the success of the various surface water management measures.

7.1.2.1 Locations and Frequency

Proposed surface water monitoring locations are shown in Figure 7.1 with coordinates provided in Table 7.2, which also indicates the monitoring frequency.

Table 7.2 – Surface Water Monitoring Locations and Frequency

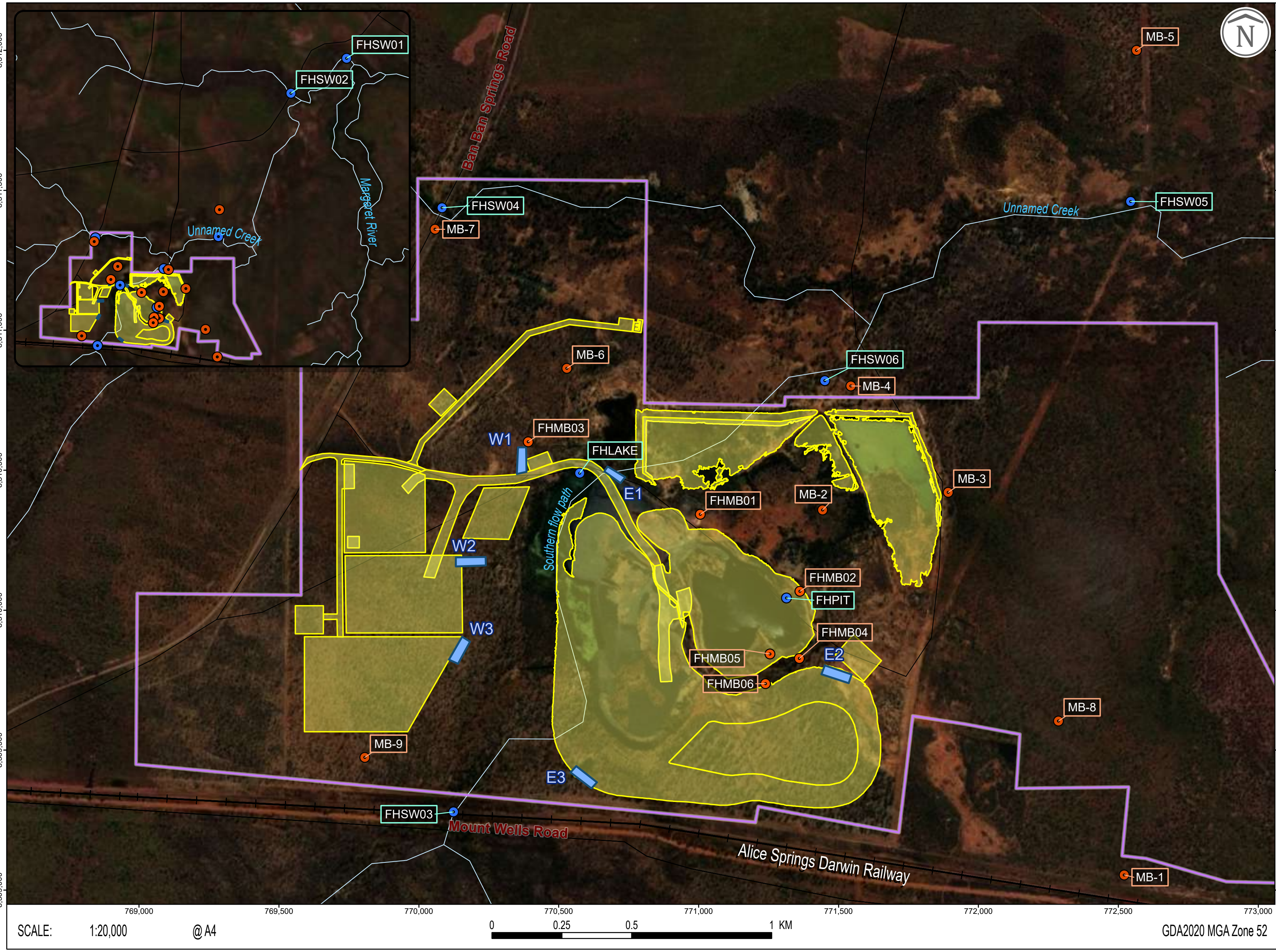
Site Code	Sample Location/Description	Coordinates (Zone 52L, GDA94)		Monitoring Frequency
		Easting	*Northing*	
FHSW01	Downstream of Fountain Head deposit near confluence of Margaret River.	775109	8515026	Tri-annual (early, mid and late wet season).
FHSW02	Upstream control for FHSW01.	773994	8514327	Tri-annual (early, mid and late wet season).
FHSW03	Upstream control for FH Lake.	770123	8509278	Tri-annual (early, mid and late wet season).
FHSW04	Upstream control for all sites.	770082	8511436	Tri-annual (early, mid and late wet season).
FHSW05	Downstream of Fountain Head deposit and FHSW01 and upstream of the perennial billabong and waterhole.	772544	8511460	Tri-annual (early, mid and late wet season).
FHSW06	Upstream of site FHSW05. Site representative of water quality leaving the site.	771451	8510820	Tri-annual (early, mid and late wet season).
FH PIT	In pit sumps/surface water collection points.	771313	8510042	Tri-annual (early, mid and late wet season).
FH PIT	In pit sumps/surface water collection points.	771313	8510042	Monthly – first year post mining
FH LAKE	Water body between waste rock and Go-line.	770574	8510488	Tri-annual (early, mid and late wet season).
FH EVAP POND	Evaporation Pond.	TBD	TBD	Tri-annual (early, mid and late wet season).
E1, E2, E3, W1, W2 and W3	Sediment dams.	TBD	TBD	Monthly during the wet season for the first operational year and tri-annually (early mid and late wet season) thereafter.

TBD – to be determined.

PROPOSED SURFACE WATER AND GROUNDWATER MONITORING LOCATIONS

Fountain Head Gold Project | Water Management Plan

FIGURE 7.1



SCALE: 1:20,000 @ A4

GDA2020 MGA Zone 52

Monitoring locations
- Surface water
- Groundwater
- Road
- Railway
- Watercourse
- Project area
- Sediment dam
- Infrastructure layout

Issue Date:	2022.07.11
Map ID:	01238D_4_GIS005
Figure Number:	01238D_4_F07-1_GIS_v5-h_es

ERIAS

ERIAS, 13-25 Church Street
Hawthorn VIC 3122, Australia

DATA SOURCES:
Project data from PNX Metals, 2021.
Imagery © ESRI, DigitalGlobe and Partners, 2021.

7.1.2.2 Monitoring Parameters

Parameters to be monitored in offsite surface waters (FHSW01 to FHSW06) and the Fountain Head Lake are:

- pH, electrical conductivity, dissolved oxygen and turbidity (field measurements).
- Major cations (Ca, K, Na, Mg) and anions (Cl, SO_4).
- Water hardness and alkalinity.
- TSS.
- Cyanide.
- Filtered metals (Al, As, Cd, Cr, Co, Cu, Hg, Pb, Mn, Ni, Zn).
- Total metals (Al, As, Cd, Cr, Co, Cu, Hg, Pb, Mn, Ni, Zn).
- Dissolved organic carbon.
- Total recoverable hydrocarbons (TRH) and benzene, toluene, ethylbenzene, xylenes and naphthalene (BTEXN).

Parameters to be monitored in the sediment dams, evaporation pond and the Fountain Head pit are outlined in Table 7.3.

Table 7.3 – Monitoring Parameters for Mine Site Waterbodies

Analyte	Sediment Dams	Evaporation Pond	Fountain Head Pit
Cyanide	✓(E1, E2 and E3 only)	No	No
Sulphate	✓(E1, E2 and E3 only)	No	No
Total metals	No	✓	✓
Filtered Metals	✓	No	No
pH and EC	✓	✓	✓
TRH and BTEXN	✓	No	No

In addition to the collection of samples from onsite and offsite waterbodies and water storage dams, general monitoring actions to be implemented will include visual inspections and observations and verification monitoring as outlined in Table 7.1. This will include measures such as:

- Conducting visual inspections of water management infrastructure diversion channels, including bunds, sumps storage pits and drainage systems.
- Conducting visual monitoring for signs leaks or spills from vehicles, plant and machinery.
- Monitoring water levels in the sediment dams.

- Verifying that personnel are appropriately trained in handling, transport and storage of fuels, oils and chemicals and spill response and containment measures.
- Verifying that vehicle, plant and machinery service and maintenance schedules are developed and implemented.

7.1.2.3 Guideline Values

While there is a substantial amount of data available from monitoring undertaken between 2011 and 2021, there has been an insufficient frequency of sampling to establish site-specific toxicant guideline values. Further, as discussed in detail by Smith et al. (2020), establishing reference and test sites, from which site-specific values could be derived and valid comparisons made between sites, is highly constrained and rarely valid in temporary waterways.

In lieu of catchment-specific water quality objectives, the ANZG (2018) default trigger values will be adopted for comparison of the monitoring data. The water quality guideline vales for the upstream and downstream tributary creeks, Margaret River and the Fountain Head Lake are provided in Table 7.4. These guideline values are based on the default trigger values for lowland rivers in tropical Australia (for physicochemical parameters) and the default trigger values for slightly to moderately disturbed aquatic ecosystems for toxicants. This level of protection is considered most appropriate for comparison, given the long history of mining and agriculture in the area.

Table 7.4 – Water Quality Guideline Values for Surface Water

Parameter	Guideline Value
In-situ Parameters	
pH	6.0 to 8.0
Electrical conductivity	20 to 250 µS/cm
Dissolved oxygen	85 to 120 % saturation
Turbidity	2 to 15 NTU
General Water Quality Parameters (mg/L)	
Calcium	NA
Chloride	NA
Magnesium	NA
Potassium	NA
Sodium	NA
Sulphate	NA
Total suspended solids	NA
Hardness	NA
Total alkalinity	NA
Dissolved Metals and Metalloids (µg/L)	
Aluminium	55 (pH >6.5)
Arsenic	13 (As(V))
Cadmium	0.2*
Chromium	1 (Cr(VI))

Parameter	Guideline Value
Cobalt	1.4#
Copper	1.4*
Lead	3.4*
Manganese	1,900
Mercury	0.06
Nickel	11*
Zinc	8*
Hydrocarbons (µg/L)	
Total recoverable hydrocarbons	NA
Benzene	950
Toluene	180
Ethylbenzene	80
Xylenes	75
Naphthalene	16
Inorganic Toxicants (µg/L)	
Cyanide	4

* Trigger values should be adjusted for water hardness as per Table 3.4.4 of ANZECC/ARMCANZ (2000a).
# Low reliability trigger value.

It is noted the environmental performance target for downstream surface waters, i.e., the unnamed tributary creek and the Margaret River, is for no exceedances of the applicable ANZG (2018) water quality guideline values, shown in Table 7.4. While these guideline values provide a reference point for comparison of the data, as described in the ANZG (2018), exceedance of the guideline values is intended as an ‘early warning’ mechanism rather than an instrument for assessing compliance. It is noted that aluminium regularly exceeds the proposed guideline value at all offsite surface water monitoring sites, while chromium, copper and zinc have exceeded the guideline values shown in Table 7.4 on a number of occasions, particularly at site FHSW01 and FHSW05. Interpretation and assessment of surface water monitoring results will therefore consider historical trends, particularly where there is an exceedance of the values provided in Table 7.4. It is also noted that temporary waterways naturally experience large fluctuations in water quality throughout the wet and dry season, due to the effects of seasonal runoff and flushing events and evapoconcentration, and water quality will vary inter-annually depending on the characteristics of the wet and dry season. The influence of such conditions presents a number of challenges when monitoring temporary waters to assess environmental performance. As such, a risk-based approach will be applied to data interpretation.

Similarly, it is not proposed that values in Table 7.4 are used as ‘compliance criteria’ for mine waterbodies (i.e., sediment dams, evaporation pond and the pit). Rather, monitoring results will be screened against these values to understand potential risks and inform water management strategies (e.g., directing water from sediment dams to the process plant or evaporation pond where a risk to the downstream environment is identified) and initiating further investigations, as necessary.

7.1.3 Groundwater

The groundwater monitoring program is outlined in this section and is designed to assist in identifying changes in groundwater quality over time and determining the success of the various groundwater management measures. This monitoring program has been developed considering the recommendations provided in CDM Smith (2021c).

7.1.3.1 Monitoring Locations and Frequency

The proposed groundwater monitoring bores are shown in Figure 7.1. A number of the existing groundwater monitoring bores are located within the proposed expanded Project footprint (e.g., FHMB02 and FHMB05). As such, some of these monitoring bores may be removed during Project development. The existing monitoring bores will continue to be utilised where available or until removed and a new network of monitoring bores will also be installed. The coordinates for the existing and newly proposed monitoring bores are provided in Table 7.5. The exact locations of the new monitoring bores will be determined once the Project layout and design has been finalised. The proposed network will enable groundwater level and groundwater quality monitoring over the life of mine and post-closure.

Table 7.5 – Proposed Groundwater Monitoring Locations and Frequency

Site Code	Proposed Sample Location	Coordinates (Zone 52L, GDA94)		Monitoring Frequency
		Easting	*Northing*	
FHMB01	Northwest of Fountain Head pit.	771005	8510340	Biannual (early and late dry season)
FHMB02	North of Fountain Head pit.	771361	8510066	
FHMB04	Southern edge of Fountain Head pit.	771358	8509817	
FHMB05	Southern edge of Fountain Head pit.	771235	8509841	
FHMB06	Southern edge of Fountain Head pit.	771236	8509736	
MB-1	Between the Fountain Head pit and the evaporation pond.	772521	8509054	
MB-2	Eastern edge of the evaporation pond.	771443	8510358	
MB-3	North of the evaporation pond and close to registered bore RN024290.	771892	8510421	

MB-4	Northwest of the evaporation pond.	771544	8510801	
MB-5	Northwest of MB-4 and the evaporation pond.	772565	8512000	
MB-6	Southwest of the Project area and south of the CIL plant.	770529	8510864	
MB-7	Just south of the southeast boundary of the Project area.	770058	8511361	
MB-8	Southeast of the Project area.	772286	8509604	
MB-9	Northeast of the Project area and north of the unnamed tributary creek.	769807	8509474	

7.1.3.2 Monitoring Parameters

Parameters to be monitored in groundwater are:

- Standing water level measurement.
- pH, electrical conductivity, total dissolved solids.
- Water hardness and alkalinity.
- Major cations (Ca, K, Na, Mg) and anions (Cl, SO_4).
- Fluoride, nitrate and nitrite.
- Filtered and total metals (Al, As, B, Be, Cd, Cr, Co, Cu, Fe, Hg, Pb, Mn, Mo, Ni, Se, U and Zn).
- Cyanide.
- TRH and BTEXN.

7.1.3.3 Groundwater Level Measurements

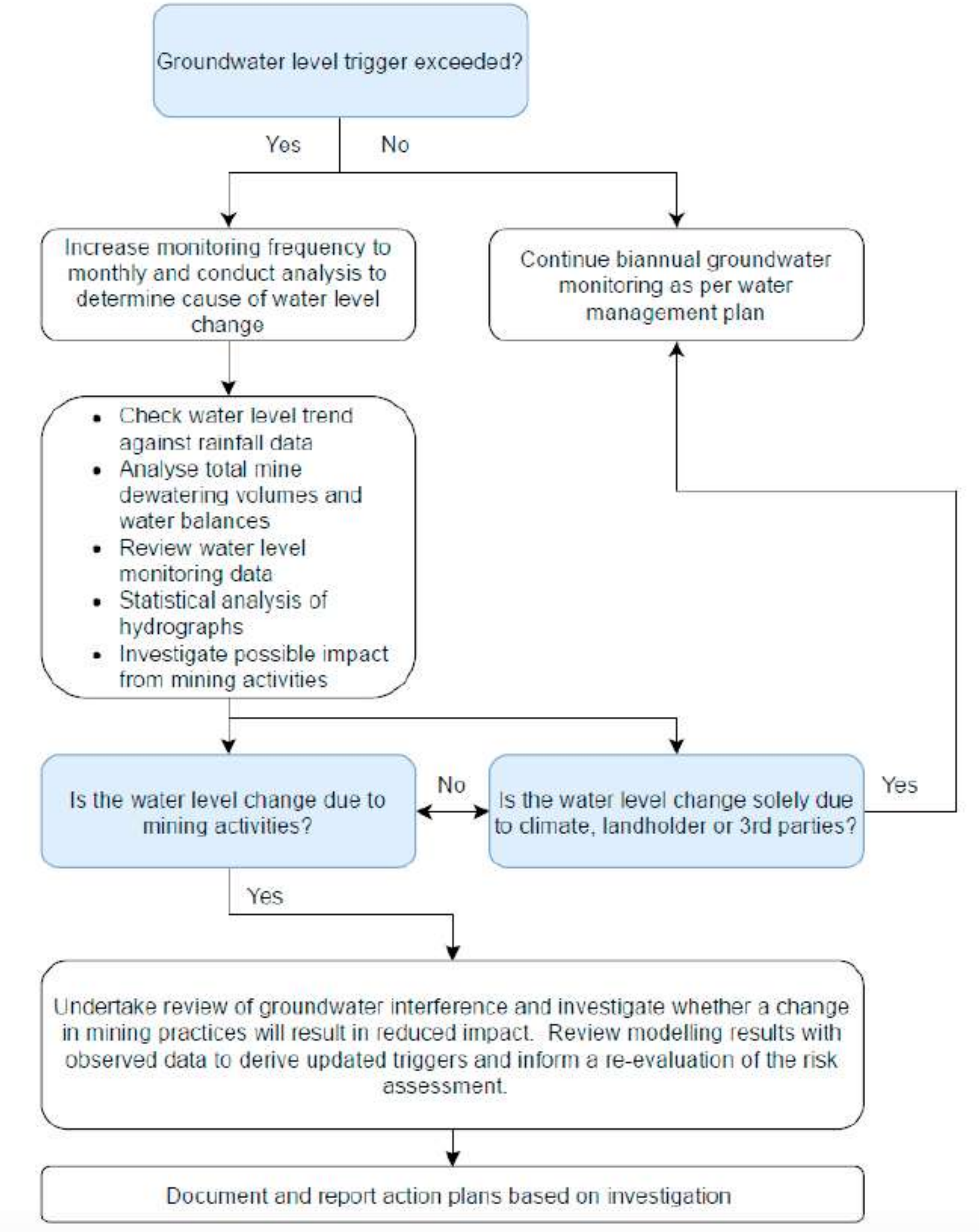
While the pit dewatering is not predicted to effect groundwater availability in nearby bores used by Ban Ban Springs Station, monitoring of groundwater levels will be undertaken to confirm groundwater modelling drawdown and mounding predictions and to calibrate the modelling. Trigger values have been developed for each monitoring bore, based on the numerical modelling and mounding results (CDM Smith, 2021c). These trigger values have been established to be equal to the predicted end of mine groundwater elevation (mAHD) (Figure 3.5). The triggers have been proposed to measure exceedances of predicted drawdown and mounding effects. A trigger action plan (Figure 7.2) has been developed should these trigger values be exceeded.

Table 7.6 – Proposed Groundwater Monitoring Locations and Frequency

Site Code	Monitoring Bore Purpose	Current/Nominal Bore Depth (m)	Estimated Bore Depth (mAHD)	Proposed Groundwater Level Trigger Value (mAHD)
FHMB01	Drawdown	93	9.1	<-5.2
FHMB02	Drawdown	>102	2.2	<-27.6
FHMB04	Drawdown	>102	6.0	<-7.7
FHMB05	Drawdown	>102	6.0	<-27.6
FHMB06	Drawdown	23	81.5	<-3.4
MB-1	Mounding	70	32	>91.2
MB-2	Mounding	40	55	>91.4
MB-3	Mounding	30	64	>87.1
MB-4	Drawdown	40	56	<69.7
MB-5	Drawdown	20	77	<89.8
MB-6	Drawdown	25	82	<90.0
MB-7	Drawdown	25	81	<89.8
MB-8	Drawdown	35	71	<79.9
MB-9	Drawdown	20	75	<90.0

Source: CDM Smith (2021c).

Figure 7.2 – Groundwater Level Trigger Action Plan



Source: CDM Smith (2021c).

7.1.3.3 Groundwater Quality Guideline Values

While the ANZG (2018) and ANZECC/ARMCANZ (2000a) guidelines do not provide trigger values for groundwater ecosystem protection, they do provide values for stock drinking water which has been identified as a potential beneficial use of groundwater. The applicable stock drinking water guideline values for the monitoring parameters listed in Section 7.1.3.2 are provided in Table 7.7. It is also appropriate to consider the connectivity between groundwater and surface water ecosystems and thus groundwater data can be compared to the guidelines for freshwater aquatic ecosystems provided in Table 7.4, while considering background concentrations for naturally elevated metals and metalloids including arsenic and aluminium.

Table 7.7 – Livestock Drinking Water Guideline Values

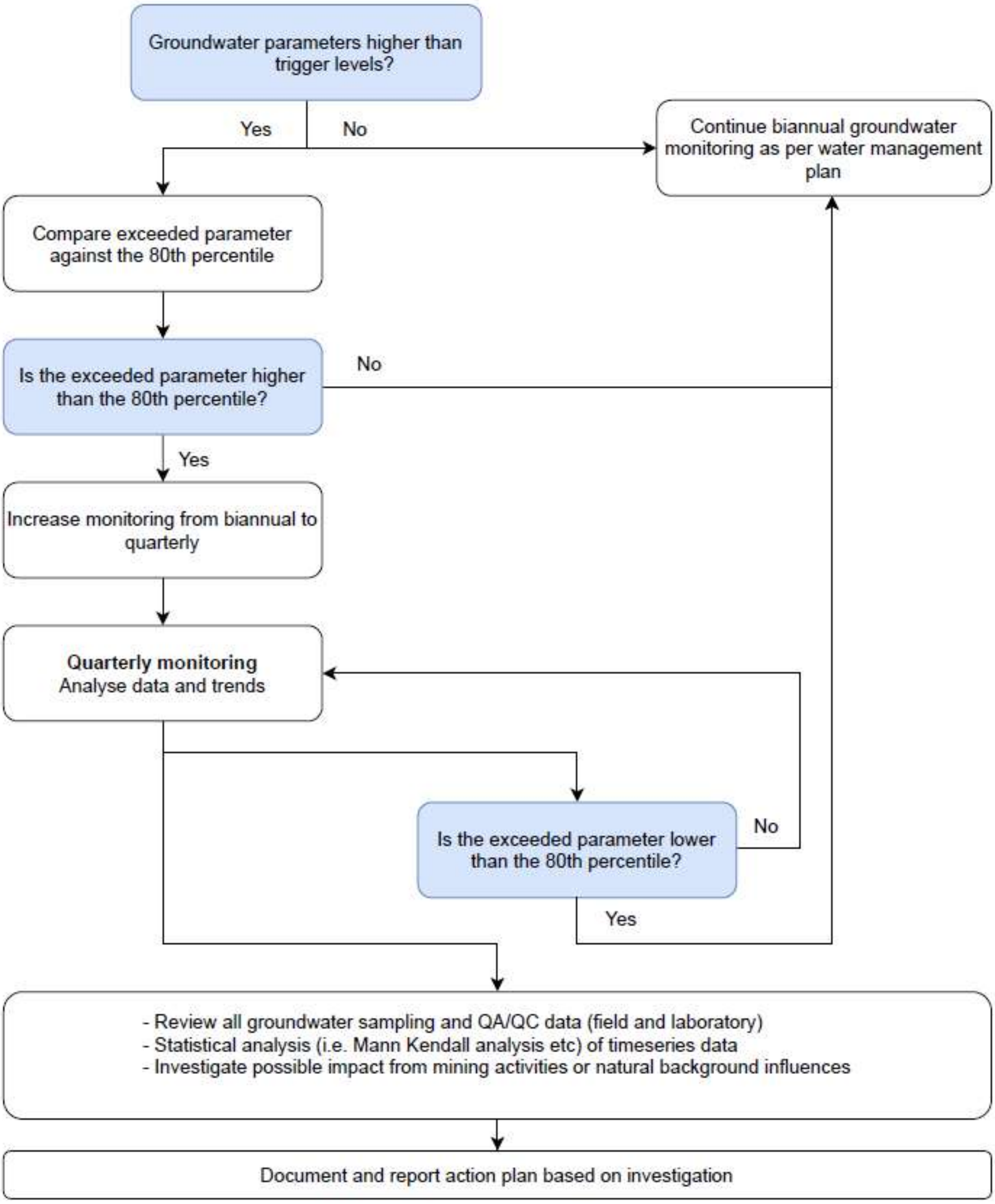
Parameter	Guideline Value
Field Parameters	
pH	NA
Electrical conductivity	0 to 5,970*
General Water Quality Parameter (mg/L)	
Total dissolved solids	4,000 to 5,000 (beef cattle)
Hardness	NA
Total alkalinity	NA
Calcium	1,000
Magnesium	NA
Potassium	NA
Sodium	NA
Sulphate	1,000
Fluoride	2
Nitrate	1,500
Nitrite	30
Total Metals (mg/L)	
Aluminium	5
Arsenic	0.5
Beryllium	NA
Boron	5
Cadmium	0.01
Chromium	1
Cobalt	1
Copper	1 (beef cattle)
Iron	NA
Lead	0.1
Manganese	NA
Mercury	0.002
Molybdenum	0.15
Nickel	1
Selenium	0.02
Uranium	0.2
Zinc	20,000
Hydrocarbons (µg/L)	
Total recoverable hydrocarbons	NA

Parameter	Guideline Value
Benzene	NA
Toluene	NA
Ethylbenzene	NA
Xylenes	NA
Naphthalene	NA
Inorganic Toxicants (µg/L)	
Cyanide	NA

NA: not guideline available.
* For no adverse effects and based on total dissolved solids conversion provided in ANZECC/ARMCANZ (2000a).

A groundwater quality trigger action plan (Figure 7.3) has been developed should the values provided in Table 7.4 and Table 7.7 be exceeded. The trigger action plan is intended to initiate a phased approach to inform an appropriate response. The trigger action plan identifies proposed actions and responses if the groundwater quality guideline values provided in Table 7.4 and 7.7 are exceeded based on 80^{th} percentiles of the baseline datasets for individual monitoring bores. As described in Section 7.1.2.3, exceedance of the guideline values provides an ‘early warning’ mechanism rather than being an instrument for assessing compliance. The trigger action plan provides a framework for assessing change in baseline groundwater quality.

Figure 7.3 – Groundwater Quality Trigger Action Plan



Source: CDM Smith (2021c).

7.1.4 Quality Assurance and Quality Control

A quality assurance and quality control (QA/QC) program will be implemented as part of the monitoring program. This will include:

- Collecting field duplicates to provide an indication of the precision and reproducibility of the field sampling techniques and analytical results. Duplicate samples will be assessed by calculating the relative percent different (RPD) between the primary and duplicate sample, with a target RPD of less than 50%. Duplicates will be collected at a rate of 10% of primary samples.
- Laboratory QA/QC program including laboratory duplicates, method blanks, laboratory controls, matrix spikes, and surrogate spikes.
- Following field quality assurance procedures such as:
  - Wearing 100% powder-free nitrile gloves which will be changed between each sampling site to prevent cross contamination.
  - Using sample containers for chemical analyses that are provided by the analytical laboratory, and appropriate for the required analyses.
  - Avoiding touching the inside of sample containers and lids to prevent the introduction of contaminants from extraneous sources.
  - Placing samples in the dark, on ice packs, immediately after collection and transferring them to a fridge or freezer after the completion of the day's fieldwork and sending samples to the laboratories as soon as possible, accompanied by chain of custody documentation.

7.2 Management and Review

The WMP will be reviewed and updated (if required) annually. A review may occur sooner where there is a material change in risk due to a change in equipment, systems, processes, where there is a change in legal obligations or in response to an incident relevant to water management. Where a material change is proposed, a risk assessment will be undertaken to identify additional mitigation and management measures and any deviations to the monitoring program that may be required.

7.3 Reporting

Raw data will be provided to DITT on an agreed reporting period and in an agreed format in accordance with the requirements of the MMP. An interpretative report will also be prepared considering the raw data collected during the monitoring period. The interpretative report will include discussion of trends over time and performance against the objectives, performance standards and measurement criteria outlined in Table 7.1, Table 7.4 and Table 7.6 to assess overall performance of the management strategies and actions outlined in the WMP. The report will detail any modifications or changes proposed to the monitoring program with justification for approval by DITT. The report will also detail any remedial or corrective action undertaken in response to the results of the monitoring data as well as the visual and verification monitoring. Where the objectives and performance targets outlined in Table 7.1 are not achieved, PNX will undertake further investigation and initiate remedial actions and additional monitoring (if required). The findings of such investigations and the actions implemented will be documented in the report provided to DITT.

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