Northparkes Mines

Groundwater Management Plan

October 2014

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Glossary

Alluvial	Deposition from running waters.
Baseflow	The component of streamflow that originates from groundwater.
Block cave mining	A mining method in which an ore body is undercut by drilling and blasting and allowed to fall.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream and tributary streams to a particular location.
Dewatering	Transfer of water from underground workings to the surface.
Drawdown	A reduction in piezometric head within an aquifer.
Electricity conductivity	A measure of the concentration of dissolved salts in water.
Groundwater	Water in a saturated zone, stratum or aquifer beneath the surface of the land.
Groundwater dependant ecosystem	Communities of plants, animals and other organisms whose extent and life processes are dependent on groundwater. A GDE may either be entirely dependent on groundwater for survival or it may use groundwater opportunistically or for a supplementary source of water.
Groundwater extraction	For the purposes of this study, groundwater extraction has been defined as the removal of groundwater from a groundwater source or aquifer, either via direct removal for use via a production bore or via incidental flow of groundwater from the aquifer into the mine workings during and after mining. Groundwater extraction includes the pumping of underground water from flooded mine workings in equilibrium with the surrounding strata as well as the removal of water from perched aquifers recharged directly from rainfall infiltration.
Guideline	Numerical concentration or narrative statement that provides appropriate guidance for a designated water use or impact.
Hardness	The concentration of multivalent cations present in water. Generally hardness is a measure of the concentration of calcium and magnesium ions in water and is expressed in units of calcium carbonate ($CaCO3$) equivalent. Hardness may influence the toxicity and bioavailability of substances in water.
Hydrogeology	The area of geology that deals with the distribution and movement of groundwater in soils and rocks.
Infiltration	Natural flow of surface water through ground surfaces as a result of rainfall events.

Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80 percent of values are found.
pH	Value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Riparian	Pertaining to, or situated on the bank of a river of other water body.
Runoff	Amount of rainfall that ends up as streamflow.
SILO	An enhanced climate data bank based on historical climate data from 1889 provided by the Bureau of Meteorology. Records are mainly based on observed data, with interpolation where there are data gaps.
Strata	Geological layers below the surface.
Subsidence	Mining-induced movements and deformations at the ground surface.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Tailings	The by-product resulting from the processing of ore.
Trigger value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.

Abbreviations

ADWG	Australian Drinking Water Guidelines
BOM	Bureau of Meteorology
CRD	Cumulative rainfall departure
EC	Electrical conductivity
EIS	Environmental Impact Statement
EPL	Environment protection licence
GDE	Groundwater dependant ecosystem
GHD	GHD Pty Ltd
GWMP	Groundwater Management Plan
ha	Hectare
kL	Kilolitre
km	Kilometre
MDB	Murray Darling Basin
mg/L	Milligram per litre
ML/year	Megalitre per year
mm	Millimetre
Mtpa	Million tonnes per annum
NOW	NSW Office of Water
NPM	Northparkes Mines
PSC	Parkes Shire Council
TARP	Trigger Action Response Plan
TSF	Tailings Storage Facility
WAL	Water access licence
Water Act	Water Act 1912
WM Act	Water Management Act 2000
WSP	Water Sharing Plan
µS/cm	Microsiemens per centimetre

1. Introduction

Northparkes Mines (NPM) is a copper and gold mine located approximately 27 km north-west of Parkes in the central west region of NSW, as shown in Figure 1-1. NPM is a joint venture between China Molybdenum Co., Ltd (80%), Sumitomo Metal Oceania Pty Ltd (13.3%) and Sumitomo Corporation (6.7%). NPM consists of underground mines, an ore processing plant and associated activities including exploration and farming.

NPM commenced operations in 1993 following an extensive exploration program and has included open cut and underground mining operations. Currently NPM operates under development consent DC 11_0060, which allows for the processing of 8.5 million tonnes per annum (Mtpa) of ore and transportation of product by rail to Port Kembla for the export market. Approval for the Step Change Project (the Project) was granted in July 2014, which involves the construction of an additional tailings storage facility (TSF) and an extended mine life to 2032.

GHD Pty Ltd (GHD) was commissioned by NPM to prepare a Groundwater Management Plan (GWMP) as part of the Water Management Plan for the mine. The GWMP applies to all operations at NPM and includes the existing and approved mining operations and associated infrastructure within the site boundary, shown in Figure 1-2, which encompasses the mining leases 1247, 1367 and 1641 as shown in Figure 1-3. The management plan has been prepared to satisfy Clause 23, Schedule 3 of development consent DC 11_0060 which was granted under the *Environmental Planning and Assessment Act 1979*.

1.1 Report Objectives

The GWMP has been developed to address the requirements of development consent DC 11_0060 through the completion of the following scope elements:

- Review available background hydrogeological and mining data.
- Identify and describe the groundwater sources within the site boundary as well as the regional groundwater sources.
- Search of the NSW Groundwater Bore Database to identify licensed groundwater users within the expected area of groundwater drawdown.
- Identify of potential groundwater dependent ecosystems (GDEs) based on available information.
- Assess of existing groundwater data (levels and quality) to establish baseline groundwater conditions.
- Develop groundwater assessment criteria for investigating any potentially adverse groundwater impacts.
- Review and develop groundwater monitoring requirements.
- Identify the reporting, responsibilities and training requirements for the GWMP.

Specifically, the GWMP will consider the construction and commissioning of TSF 3 (also referred to as Rosedale TSF) where the plan will be required to be updated to include the addition of bores to monitor the potential seepage or leachate from TSF 3.

The specific requirements of the GWMP content are outlined in Table 1-1, along with the sections of the GWMP report where these have been addressed.

Figure 1-1 Locality Plan

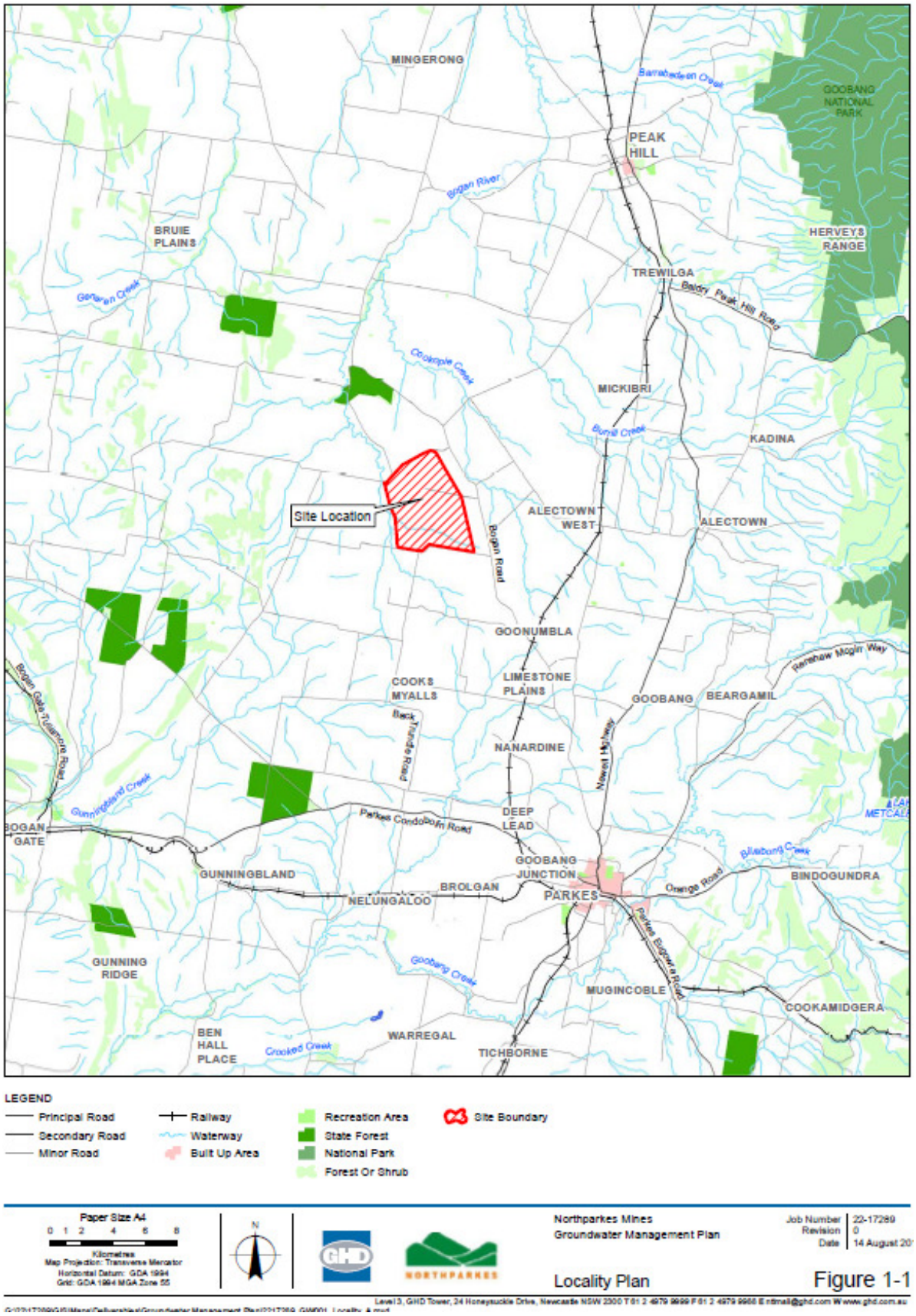


Figure 1-2 Site Boundary

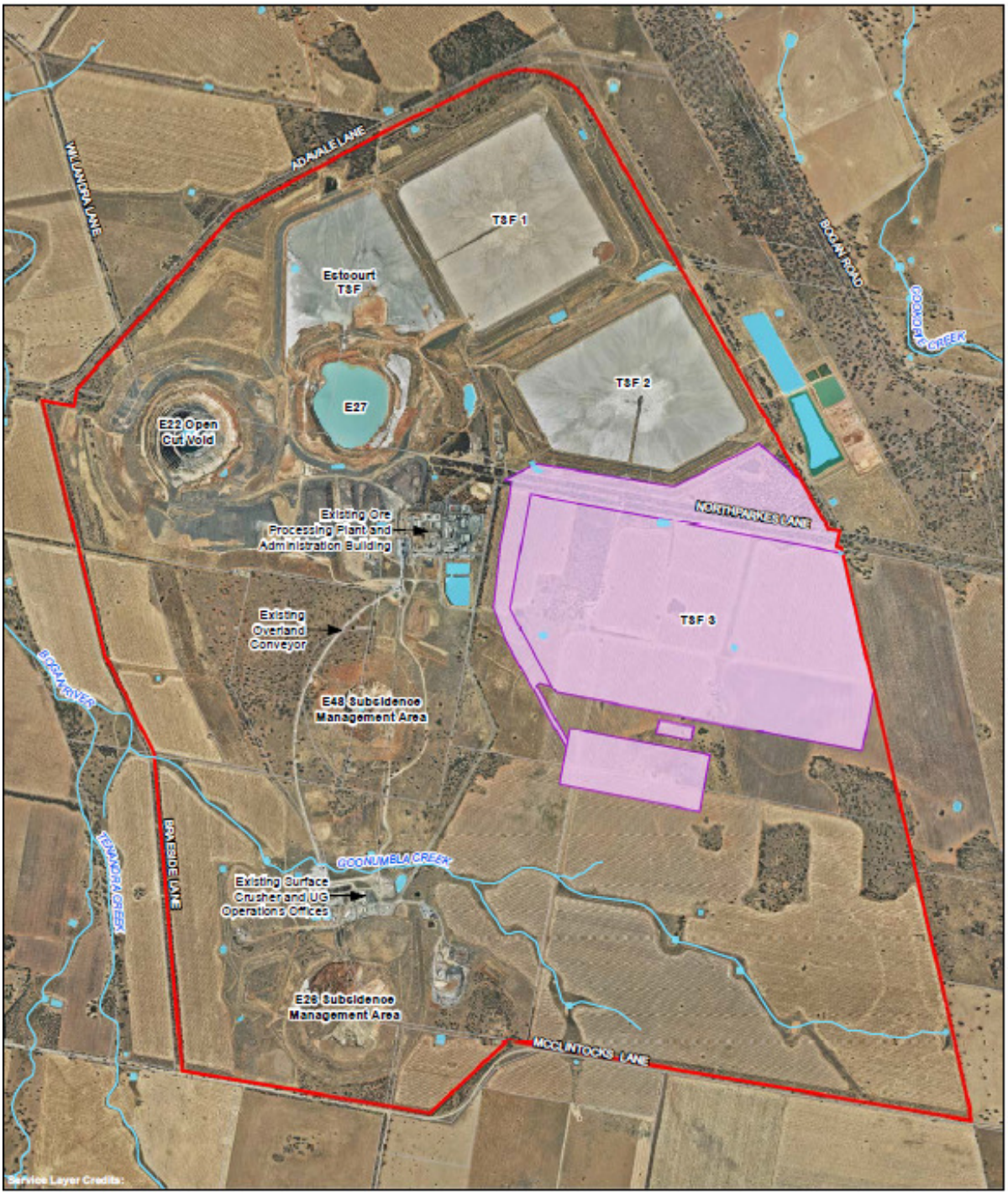


Figure 1-3 Mineral Titles

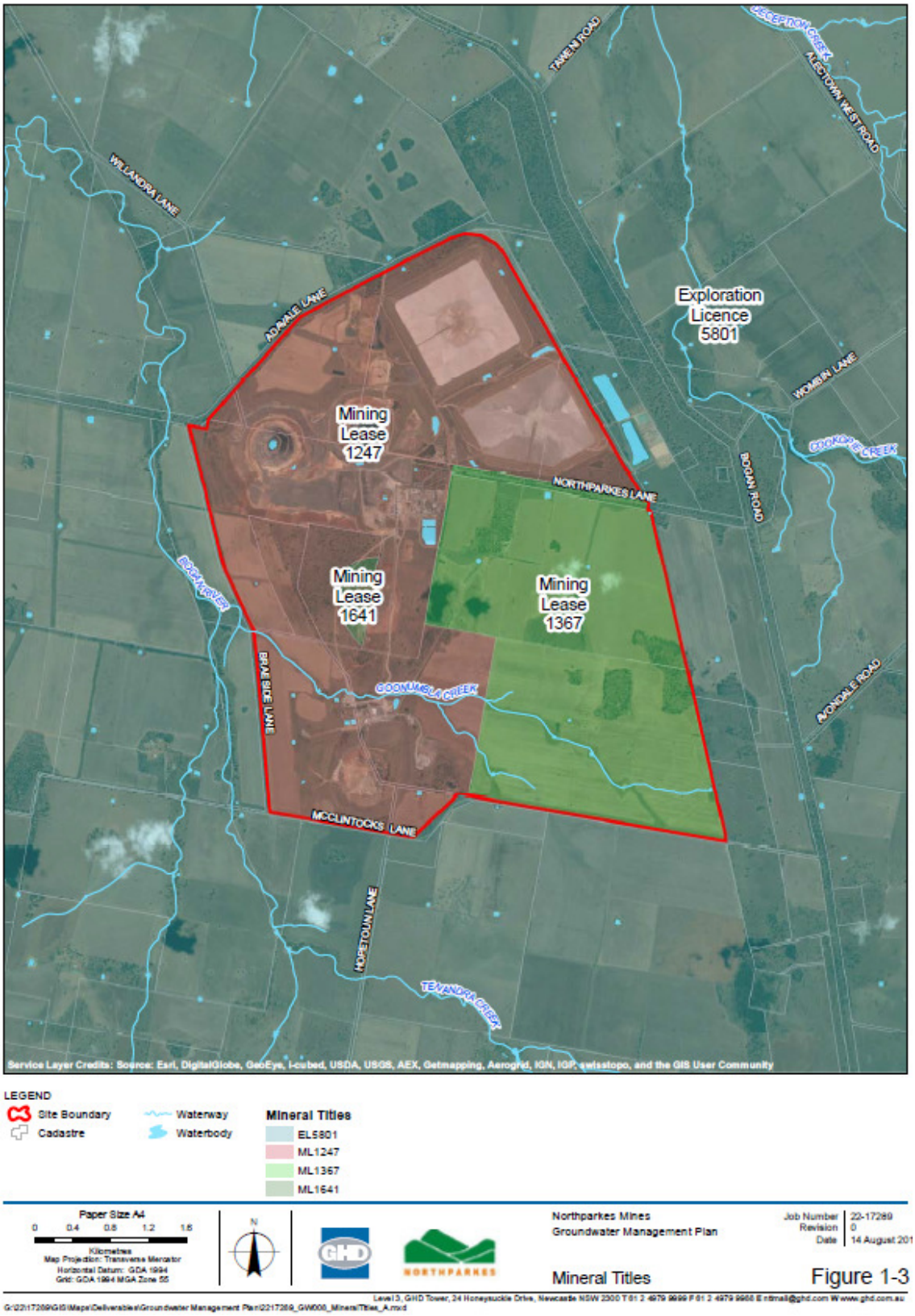


Table 1-1 Relevant Management Plan Conditions

Element	Where Addressed in this Report
Conditions of Approval (DC 11_0060)	
Detailed baseline data on groundwater levels, yield and quality in the region and privately-owned groundwater bores that could be affected by the Project.	Section 3.2
Groundwater assessment criteria, including trigger levels for investigating any potentially adverse groundwater impacts.	Section 4
A program to monitor and report on: • Groundwater inflows to the block cave and open cut mining operations. • The seepage/leachate from water storages, emplacement and final voids. • Background changes in groundwater yield/quality against mine-induced changes. • Impacts of the Project on: – Regional and local (including alluvial) aquifers. – Groundwater supply of potentially affected landowners. – Riparian vegetation. • A program to validate the groundwater model for the Project and comparison of monitoring results with modelled predictions.	Sections 4, 5 and 6.1 Site Water Balance (GHD, 2014a)
A plan to respond to any exceedances of the groundwater assessment criteria.	Section 4.2 and Appendix E
Statement of Commitments for Step Change Project (Umwelt, 2013a)	
NPM commit to the continuation of the existing approved groundwater monitoring program as part of the Project.	Section 5
NPM commit to the following additional groundwater monitoring and management measures: • The extent of dewatering, impacts on current users and future resources will be monitored throughout the life of the Project. • Monitor dewatering volumes to verify that volumes are within licenced allocations. • Trigger levels, regarding declines in groundwater levels and the degradation of groundwater quality, will be reviewed to manage the potential impacts as part of updated monitoring program. Where monitoring results indicate levels in excess of the trigger values, an investigation appropriate for the situation will be conducted to assess the need to implement management/mitigation/remedial measures.	Sections 4 and 5 Appendix E Site Water Balance (GHD; 2014a)

1.2 Overview of Site Operations

The following sections provide a brief overview of the site operations under existing, approved and proposed conditions. A summary of the operations at NPM is provided in Table 1-2.

1.2.1 Existing Conditions

NPM currently has approval to extract up to 8.5 Mtpa of ore under DC 11_0060. Open cut mining ceased in 2010 as the open cut mines were economically exhausted. Two copper sulphide porphyry ore bodies, E26 and E48, are mined using the block cave method. Ore is transported to the surface via conveyor systems where it processed through a semi-autogenous grinding circuit and associated flotation process. Copper concentrate slurry is then filtered through ceramic discs and loaded into sealed containers for transportation to Port Kembla from the Goonumbla Rail Siding. By-products from the ore processing facility are stored in the on-site TSFs. Approximately 6.01 million tonnes of ore were milled in 2013 with 168,282 tonnes of copper concentrate produced.

NPM currently owns approximately 6,481 ha of land, comprising the active operational areas of the mine, as well as agricultural land within the surrounding area, which primarily farms wheat and canola.

The site surface features associated with operations at NPM are provided in Figure 1-2 and includes two former open cut pits (E22 and E27), two underground block cave mines (E26 and E48) and resultant surface subsidence zones, underground mining infrastructure, surface mining-related infrastructure, processing plant and workshop and administration infrastructure.

The water management system at NPM includes the collection of catchment runoff in surface water storages. Water used for activities associated with mining and processing, including underground mining, ore processing, dust suppression and vehicle washdown, is supplied by surface water storages and external sources. External water is supplied to NPM from the Lachlan Valley borefield at Forbes and from the Lachlan River by Parkes Shire Council (PSC). The infrastructure supporting the supply of water was funded jointly by NPM and PSC, with the system operated and maintained by PSC, and services both the township of Parkes and the mine.

1.2.2 Approved Conditions

Approval to construct the Rosedale TSF was granted in 2007 as part of project approval PA 06_0026. The Step Change Project proposed amendments to the configuration of TSFs at NPM, including a new TSF 3 which incorporates the approved Rosedale TSF.

Until late 2011, all tailings generated from ore processing have been deposited in TSF 1 and TSF 2. Since the completion of these TSFs, tailings have been stored in Estcourt TSF and E27 TSF. At the current ore processing rate of 6.5 Mtpa, it is expected that these TSFs will be completed by the end of 2016, with TSF 3 utilised from this time. Construction of TSF 3 is anticipated to commence in early 2015 and be completed within a year.

1.2.3 Proposed Conditions

Approval for the Step Change Project (DC 11_0060) was granted in July 2014. The major components of proposed as part of the project include the continuation of underground block cave mining in the E26 and E48 ore bodies, the development of underground block cave mining of the E22 ore body, additional campaign open cut mining located in existing mining leases and an extended mine life of seven years until 2032.

Table 1-2 Summary of Existing, Approved and Proposed Operations (Umwelt, 2013a)

Component	Existing and Approved Operations	Proposed Operations
Mining areas	Underground block cave mining of E26 and E48 ore bodies. Open cut mining of E22 (ceased in 2010).	Continued block caving of the E26 and E48 ore bodies (as per current approval). Development of block caving mining in the E22 resource (previously subject to open cut mining). Development of open cut mining area in existing mine subsidence zone for E26. Development of four small open cuts to extract ore from E28, E28N, E31 and E31N. All proposed open cut mining areas are located within the existing PA 06_0026 project area and existing mining leases.
Ore processing	Up to 8.5 Mtpa of ore, sourced from underground and open cut mining areas.	Continuation of processing up to 8.5 Mtpa of ore through the existing processing plant sourced from underground and open cut mining areas.
Mine life	Until 2025.	Extension of mining by seven years until end of 2032.
Operating hours	24 hours a day, seven days per week.	No change.
Numbers of employees	Approximately 700 full time equivalents.	No change.
Mining methods	Multiple underground block cave. Campaign open cut mining yielding up to 2 Mtpa for stockpiling and processing as required.	Multiple underground block cave. Campaign open cut mining of up to 7 Mtpa for stockpiling and processing as required.

Component	Existing and Approved Operations	Proposed Operations
Infrastructure	TSF 1–3. Ore processing plant including surface crusher, crushed ore stockpiles, active grinding mills, froth flotation area and concentrate storage. Site offices, training rooms and workshop facilities. Road haulage of concentrate to the Goonumbla rail siding for transport to Port Kembla. An overland conveyor to transport ore from the hoisting shaft to the ore processing plant stockpiles. Operation of four wastewater treatment plants.	Tailings storage facilities to be augmented to connect existing and approved tailings facilities, through the development of TSF 3 southward from the existing southern embankment of TSF 2. The proposed TSF 3 will substantially include the approved TSF 3 (known as Rosedale). Establishment of new waste stockpiles to store waste material generated during open cut mining campaigns, including a vehicle washdown area. Continued operation of existing processing plant, site offices, underground access, water supply infrastructure and logistics connections. Continued road haulage of concentrate to Goonumbla rail siding for transport to Port Kembla Closure of the existing site access road through the development of TSF 3. Provision of an upgraded site access road along a new alignment from McClintocks Lane. Development of an access control and visitor's car parking at the intersection of the proposed site access and McClintocks Lane. Upgrade/sealing of McClintocks Land between the NPM access road and Bogan Road. Upgrades as required to the intersection of McClintocks Lane and Bogan Road.

1.3 Relevant Legislation, Policies and Guidelines

1.3.1 *Water Act 1912*

The *Water Act 1912* (Water Act) is administered by the NSW Office of Water (NOW) and has historically been the main legislation for managing water resources in NSW. The Water Act governs access, trading and allocation of licences associated with both surface water and groundwater sources and is currently being progressively phased out and replaced by water sharing plans (WSPs) under the *Water Management Act 2000* (WM Act). The elements to which the *Water Act 1912* applies include extraction of water from a river, extraction of water from groundwater sources, aquifer interference (less than 3 ML/year) and diversion works of surface water runoff for capture (of a capacity less than basic landholder rights).

As the NSW Murray Darling Basin Fractured Rock Groundwater Sources WSP is in place for the area within the site boundary, the Water Act does not apply for the installation of bores for the extraction of groundwater. Several licences are held by NPM under the Water Act for groundwater monitoring bores, summarised in Table 1-3.

Table 1-3 Existing *Water Act 1912* Licences

Licence number	Issue Date	Expiry Date
80BL244990	16 July 2008	Perpetuity
80BL244991	16 July 2008	Perpetuity
80BL244992	17 July 2008	Perpetuity
80BL620200	7 September 2011	Perpetuity
80BL620201	9 September 2011	Perpetuity
80BL620202	9 September 2011	Perpetuity
80BL620405	22 May 2014	Perpetuity
80BL620406	22 May 2014	Perpetuity
80BL620407	22 May 2014	Perpetuity
80BL620408	22 May 2014	Perpetuity

1.3.2 *Water Management Act 2000*

The WM Act, also administered by NOW, is progressively being implemented throughout NSW to manage water resources, superseding the Water Act. The aim of the WM Act is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and their in-stream uses as well as to provide for protection of catchment conditions. Fresh water sources throughout NSW are managed via WSPs under the WM Act. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

An amendment to the WM Act (Section 60I) came into effect on 1 March 2013. This amendment provides that it is an offence for a person without an access licence to take, remove or divert water from a water source or relocate water from one part of an aquifer to another part of an aquifer in the course of carrying out a mining activity. Various activities are captured by the provisions of the amendment including mining, mineral exploration and petroleum exploration.

The area within the site boundary is covered by the NSW Murray Darling Basin (MDB) Fractured Rock Groundwater Sources WSP which regulates extractions from the saprock, saprolite and fractured bedrock aquifers. As defined by this WSP the site is within the Lachlan Fold Belt MDB Groundwater Source.

The Lachlan Unregulated and Alluvial Water Sources WSP regulates extraction of alluvial groundwater within the site boundary. As defined under this WSP the site is within the Upper Lachlan Alluvial Groundwater Source.. Table 1-4 identifies the water access licences (WALs) currently held by NPM under the WM Act, the annual extraction limit and the WSP covering the WAL.

It is recommended that NPM review their WALs held under the WM Act. NPM must ensure they have sufficient WALs for the predicted groundwater extractions from both the alluvial and fractured rock groundwater sources.

Table 1-4 Existing *Water Management Act 2000* Licences

Water Access Licence Number	Extraction Limit (ML/year)	Water Sharing Plan	Description
31850	500	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
31863	634	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
31930	600	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
31963	700	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
31969	1,728	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
32004	1,600	Lachlan Unregulated and Alluvial Water Sources	High security licence (Avondale Bores 6 and 7).
32120	1,050	Lachlan Unregulated and Alluvial Water Sources	High security licence (Dawes Bore 8).
32138	1,110	Lachlan Unregulated and Alluvial Water Sources	Aquifer.
34955	232	NSW Murray Darling Basin Fractured Rock Groundwater Sources	Dewatering of E22, E26, E27 and E48 underground and open cut mining areas.

1.3.3 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy was finalised in September 2012 and clarifies the water licencing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer in the course of carrying out mining. Many aspects of this policy will be given legal effect in the future through an Aquifer Interference Regulation. Stage 1 of the Aquifer Interference Regulation commenced on 30 June 2011.

The NSW Aquifer Interference Policy outlines the water licensing requirements under the Water Act and WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void) even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The water access licence must hold sufficient share component and water allocation to account for the take of water from the relevant water source at all times.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source as a result of an aquifer interference activity, both for the life of the activity and after the activity has ceased. Many mining operations continue to take water from groundwater sources after operations have ceased. This take of water continues until an aquifer system reaches equilibrium and must be licensed.

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The minimal impact considerations relevant to the Project are outlined in Section 4.1.

1.3.4 NSW State Groundwater Policy

The objective of the NSW State Groundwater Policy Framework Document (NSW Government, 1997) is to manage the State's groundwater resources so that they can sustain environmental, social and economic uses for the people of NSW. NSW groundwater policy has three component parts:

- NSW Groundwater Quantity Protection Policy.
- NSW Groundwater Quality Protection Policy.
- NSW Groundwater Dependent Ecosystems Policy.

NSW Groundwater Quantity Protection Policy

The principles of this policy include:

- Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn.
- Groundwater extraction shall be managed to prevent unacceptable local impacts.
- All groundwater extraction for water supply is to be licensed. Transfers of licensed entitlements may be allowed depending on the physical constraints of the groundwater system.

The criteria and management plan developed as part of this Project will seek to follow the principles of this policy.

NSW Groundwater Quality Protection Policy

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

- Slow and halt, or reverse any degradation in groundwater resources.
- Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater.
- Establish a methodology for reviewing new developments with respect to their potential impact on water resources that will provide protection to the resource commensurate with both the threat that the development poses and the value of the resource.
- Establish triggers for the use of more advanced groundwater protection tools such as groundwater vulnerability maps or groundwater protection zones.

Groundwater triggers will be developed as part of this management plan where they will seek to follow the objectives of this policy.

NSW Groundwater Dependent Ecosystems Policy

This policy was designed to protect ecosystems which rely on groundwater for survival so that, wherever possible, the ecological processes and biodiversity of these dependent ecosystems are maintained or restored for the benefit of present and future generations.

Analysis of the application of the NSW Groundwater Dependent Ecosystems Policy to the area within the site boundary is outlined in Section 2.3.

1.4 Consultation

This GWMP has been prepared in consultation with the NOW and NSW Environment Protection Authority, as required by conditions provided within the development consent DC 11_0060.

2. Site Overview

2.1 Climate

Daily rainfall data was obtained as SILO Patched Point Data from the Queensland Climate Change Centre of Excellence. SILO Patched Point Data is based on historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations. For this assessment, SILO data was obtained for the Goonumbla (Coradgery) Station (station number 50016), which is located approximately 6 km south of the site. This station was chosen based on the length and quality of the data record and proximity to the mine site.

The period of rainfall data used for this assessment extended from January 1900 to December 2013 and is summarised as annual totals in Figure 2-1. The statistics for this rainfall data set are:

- Minimum annual rainfall – 149 mm in 2006
- Average annual rainfall – 522 mm
- Median annual rainfall – 514 mm
- Maximum annual rainfall – 1,192 mm in 1950

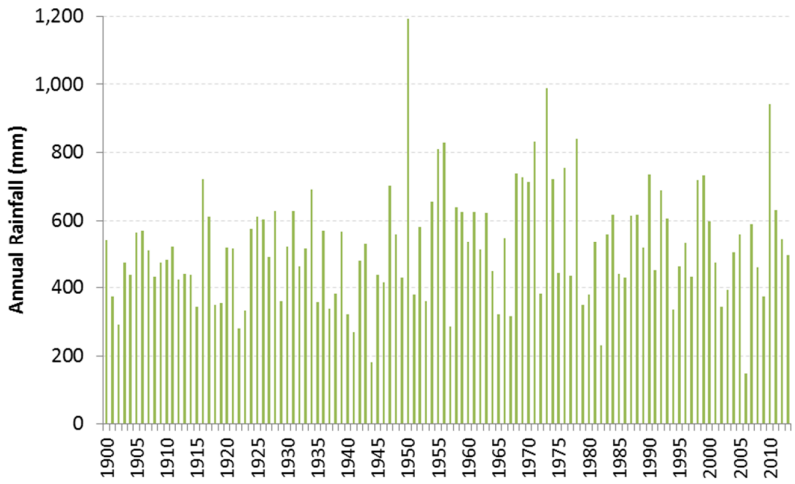


Figure 2-1 Annual Rainfall Recorded at Goonumbla (Coradgery) Station

The average monthly rainfall was observed to vary from a low of approximately 36 mm in September to a high of approximately 52 mm in January. The rainfall record showed a significant variation in the maximum recorded monthly rainfall with the largest monthly value being approximately 323 mm in April and the least monthly value being approximately 106 mm in August. The minimum recorded monthly rainfall was 0 mm for all months, expect for May, which has a minimum of 0.5 mm.

The SILO Patched Point Data from the Goonumbla (Coradgery) Station was also used to generate a cumulative rainfall departure (CRD) curve over the period from 1900 to 2013, presented in Figure 2-2. A CRD curve is a monthly accumulation of the difference between the observed monthly rainfall and long-term average monthly rainfall. Any increase in the CRD curve reflects above average rainfall while a decrease in CRD curve reflects below average rainfall. The CRD curve only deviates from zero due to a typical (above and below average) rainfall.

Figure 2-2 Cumulative Rainfall Departure Curve for Goonumbla (Coradgery) Station

As shown in Figure 2-2, the CRD curve indicates the region generally experienced below average rainfall during the period extending from 1900 to 1946, with the most significant below average rainfall period occurring between 1936 and 1946. Following this, above average rainfall was recorded, indicated by the increase in CRD curve between 1946 and 1978. Since this time, the CRD curve generally shows a decreasing trend, indicating below average rainfall.

2.2 Geology

The geology of the site is shown in Figure 2-3. A cross-section of the site showing the geology and groundwater monitoring bores is shown in Figure 2-4.

NPM is located in an area that is covered by unconsolidated colluvium and alluvium of a Tertiary-Quaternary age. This is underlain by Ordovician-Devonian age rocks of the Lachlan Fold Belt (LFB) which covers the majority of NSW and Victoria. The LFB consists of metamorphosed sedimentary and volcanic rocks, forming the regional bedrock. The LFB forms the basement of large alluvial basins, such as the Murray Darling Basin.

The Late Ordovician Goonumbla Volcanic Group is part of a volcanic group within the LFB and contains the deposits targeted by mining at NPM. The ore bodies are typical porphyry copper systems that are oriented vertically and surrounded by mineralised zones. The porphyries form narrow (typically less than 50 m in diameter) but vertically extensive (greater than 900 m) pipes (Golder Associates, 2013). Above the mineralised bedrock lies an upper oxidised zone of bedrock, referred to as saprock, which is distinguished from the overlying regolith by its greater rock strength.

Saprolite overlies the bedrock within the area, which is a highly chemically altered unit of upper bedrock and is typically comprised of clays and sediments. The deeper sections of the regolith unit consist of highly weathered sediments of the upper bedrock strata. The regolith unit varies in thickness from 5 m to more than 40 m (MER, 2006) and is overlain by transported alluvium and colluvium to depths of 30 m or more (Golder Associates, 2013).

Figure 2-3 Regional Geology

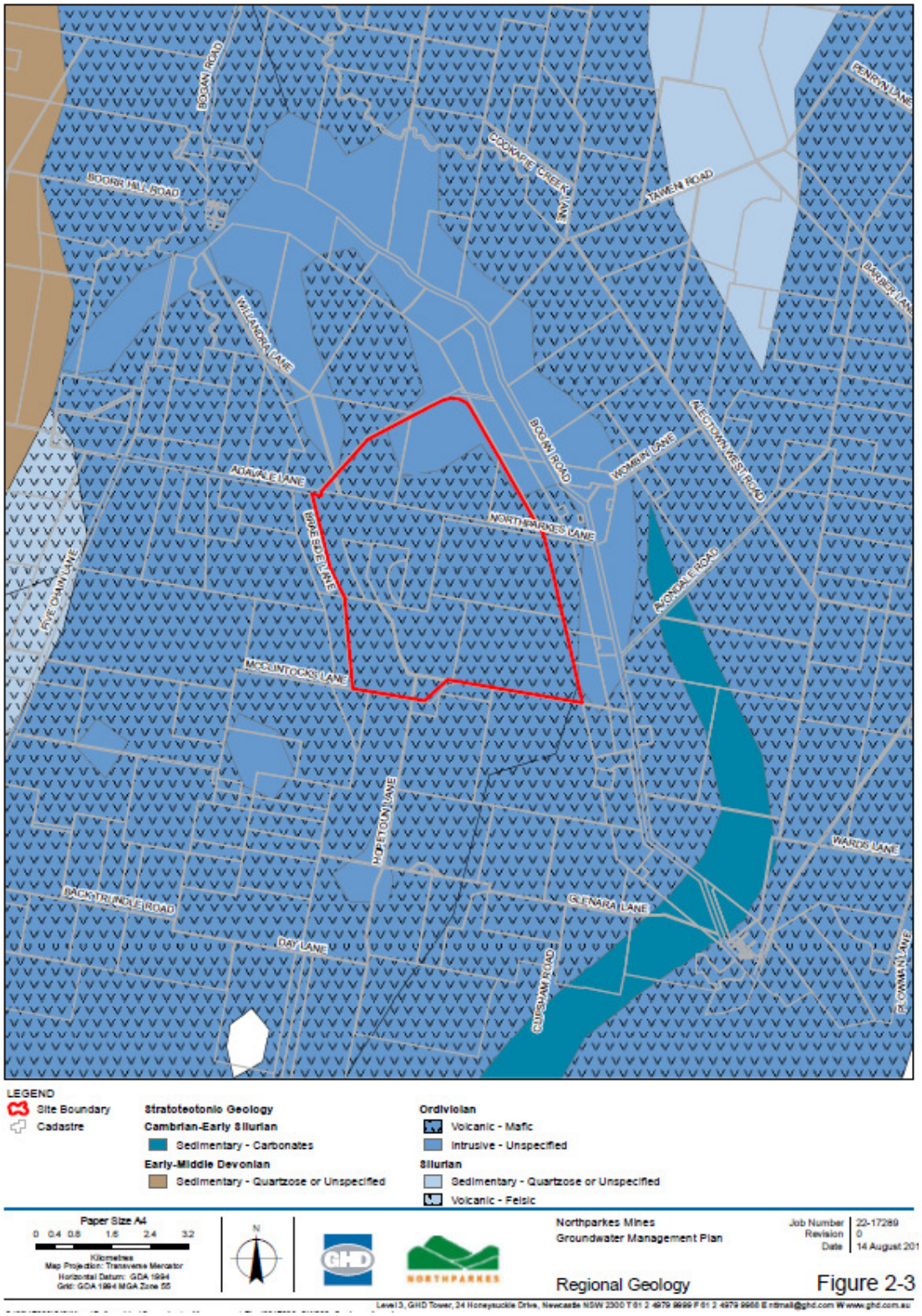
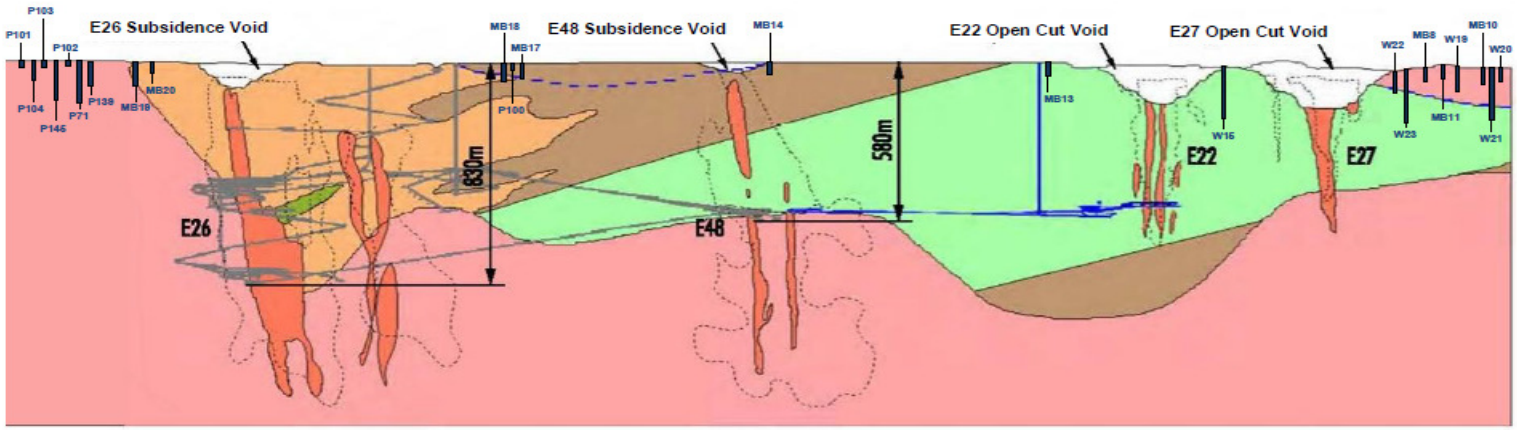


Figure 2-4 Groundwater Monitoring Bores and Geological Cross Section (Golder Associates, 2013)



LEGEND

Quartz Monzonite Porphry
Monzonite Stocks
AltonaFault
Monzodiorite
Lattic dominant volcanics
0.5% Cu
Lattic Sediments
Trachytic Sediments
U/G Drives
Proposed U/G Drives

LOCATION	Northparkes
DRAWN	SM
CHECKED	IG
APPROVED	SG
SCALE	NTS

Northparkes Mines
Groundwater Management Plan

Groundwater Monitoring Bores and Geological Cross Section (Golder Associates; 2013)

NORTHPARKES

DATE August 2014 | Figure 2-4

G:\22\17289\Visio\Groundwater Management Plan\2217289_FIG2-4_Mine Monitoring Bores and Geological Cross Section.vsd

2.3 Hydrogeology

The groundwater source that is typically intercepted by mining at NPM occurs within the fractured rock aquifers of the LFB and associated alluvium. Prior to mining operations at NPM, groundwater flow was found to occur typically in a north to north-west direction across the region which was consistent with surface drainage. Generally this flow direction is maintained, however with the development of some open cut voids and borrow pits, localised areas of drawdown have occurred. Groundwater resources in the region are limited due to the low potential for rainfall infiltration through surface clays and poor storage and transmission characteristics of the deeper strata.

Groundwater interactions at NPM within and surrounding the site have occurred since the commencement of mining operations. Extensive dewatering of the site aquifers was undertaken prior to mining to lower the groundwater table and allow ore extraction. Minimal volumes of groundwater that seep into the underground workings or open cut mines is captured and transferred to the water management system for reuse. Mine dewatering has been maintained by pumping groundwater seepage from sumps located at the base levels of the mine to keep working areas dry and to provide water for mineral processing.

Parsons Brinkerhoff (2012) have previously defined the three main aquifers across the site as being the regolith, mineralised zones which include the quartz monzonite porphyries and their associated mineralised halos and the bedrock.

2.3.1 Regolith

The regolith is not used as a water source and as such there are no bores that access the regolith in the region. The permeability of the upper regolith varies due to the variability in the shallower transported regolith (Golder Associates, 2013). Generally the permeability of the regolith decreases with depth (Parsons Brinkerhoff, 2012).

2.3.2 Mineralised Zones

Workings in the mineralised zones have had some impact on the local hydrogeology, with fracturing of the mineralised halos creating a pathway for groundwater flow. However, these pathways have little effect on regional groundwater movement due to their low fracture connectivity and poor hydraulic connection with regional groundwater flow (Golder Associates, 2013).

2.3.3 Bedrock

The oxidised shallow bedrock known as saprock is the main aquifer exploited for water supply in the area, due to its size and accessibility. The permeability of the bedrock is due to fracturing which decreases with depth (Parsons Brinkerhoff, 2012).

2.1 Activities Impacting Groundwater

A number of mining-related activities have the potential to impact groundwater levels and quality. Underground mining operations, open cut mining pits, waste rock dumps and TSFs all have the ability to affect groundwater levels and quality.

2.1.1 Underground Mining

Underground mining results in drawdown of groundwater levels as the underground workings intercept deeper aquifers and groundwater is pumped to the surface. Continuation of underground mining in E26 and E48 and the commencement of underground mining in E22 will result in a drawdown in groundwater pressure in the vicinity of the workings.

2.1.2 Open Cut Mining

Open cut mining results in drawdown of groundwater levels as mining intercepts shallow aquifers that are pumped out of the open cut workings. Development of any open cut mining in E28, E28N, E31 and E31N or E26 will likely result in groundwater drawdown in the vicinity of the workings. Drawdown will continue as long as open cut areas continue to be dewatered. As dewatering ceases it is anticipated groundwater levels will slowly re-stabilise.

Open cut mining ceased in 2010 with the completion of the E22 open cut pit.

2.1.3 Tailings Storage Facilities

Analysis of groundwater levels near the TSFs as part of the Environmental Impact Statement (EIS) for the Project showed an increase in groundwater levels at regolith bores MB1 to MB6 inclusive and regolith and or bedrock bores W14 and MB8 (Golder Associates, 2013).

Estcourt TSF was approved in October 2009 and was excavated to provide construction material for TSF 1 and TSF 2. Groundwater monitoring bores W19, W20 and W21 to the north of Estcourt TSF have generally shown an increase in groundwater levels since their monitoring began in 2012. The increase in groundwater levels in these bores has occurred concurrently with an increase in groundwater levels in the existing adjacent bore MB10. Groundwater levels in MB10 had been increasing consistently since monitoring began in 2008.

Groundwater bores up-gradient of Estcourt TSF have not shown the same uniform trend as bores located to the north. Since monitoring of W23 (to the east of Estcourt TSF) began in 2012 groundwater levels have increased. In the deeper bore W22 (adjacent to W23) groundwater levels decreased three months after monitoring began and have stayed at this level since. W22 screens fresh bedrock and may be influenced by a range of factors including dewatering of E27 pit or underground workings in the E48 ore body. In W24 and W25 groundwater levels have fluctuated since monitoring began in 2012.

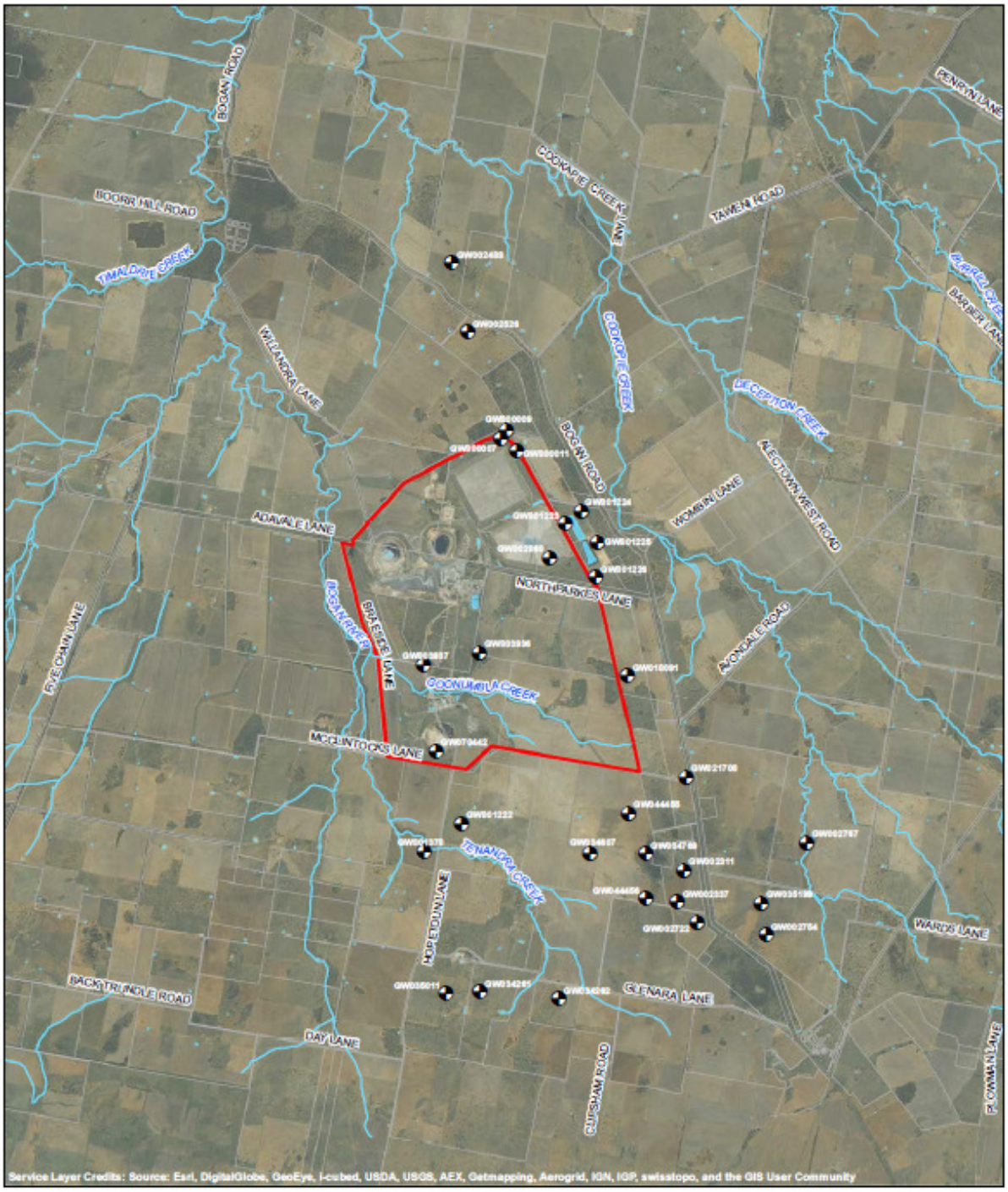
The EIS for the Project raised a number of potential causes of the observed increase in groundwater levels associated with TSFs. Potential causes were related to enhanced recharge due to thinning or removal of the regolith near the tailings dams, pore squeezing due to the weight of tailings on the ground surface and actual leakage from the tailings dams (Golder Associates, 2013).

2.2 NSW Groundwater Bore Database

As shown in Appendix A, a search of the NSW Groundwater Bore Database identified 32 registered bores within the 4.5 km radius predicted by Golder Associates (2013) to be the extent of drawdown due to mining, which are shown in Figure 2-5. Golder Associates (2013) reports that bore GW002860 is decommissioned. A number of the bores identified are NPM monitoring bores, however several NPM bores do not appear on the list. A full list of NPM monitoring bores is found in Section 3.1.

Based on groundwater modelling all private bores are outside the predicted 1 m drawdown area (Golder Associates, 2013).

Figure 2-5 NSW Groundwater Bore Database Search Results



LEGEND

- Site Boundary
- Cadastre
- Waterway
- Waterbody
- Groundwater Monitoring Bore

Paper Size A4

0 0.4 0.8 1.6 2.4 3.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

Northparkes Mines
Groundwater Management Plan

NSW Groundwater Bore Database Search Results

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Revision 0
Date 14 August 201

Figure 2-5

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9966 E nmail@ghd.com W www.ghd.com.au

2.3 Groundwater Dependant Ecosystems

The closest high priority GDE is Lambert Springs located greater than 50 km south-east of the site boundary. This is outside the modelled 4.5 km radius of dewatering predicted by Golder Associates (2013). Areas of River Red Gum Woodland, which is a potential GDE, occur within 7.5 km of the site boundary, however are outside of the proposed disturbance area. The River Red Gum Woodland has an area of approximately 2.1 ha and an additional number of small areas along the Bogan River (Umwelt, 2013a).

Dewatering from mining operations is not expected to impact surface flow in the Bogan River or its tributaries through a reduction in baseflow contribution to these creeks. Umwelt (2013a) indicated that due to the presence of perched aquifers within the shallow groundwater environment, the connectivity between alluvial areas of the creeks and rivers and the groundwater environment within the site boundary is expected to be low.

3. Existing Baseline Data

3.1 NPM Groundwater Monitoring Bores

The existing groundwater monitoring program at NPM involves sampling of groundwater bores and monitoring of groundwater levels. A number of bores are no longer monitored or were found to have inadequate data. The details of the groundwater monitoring bores are provided in Appendix B and the locations of the bore currently monitored are shown in Figure 3-1.

Data has been taken from available drilling logs and from *Step Change Project Response to Submissions* (Umwelt, 2013b). Data available from drilling logs has been prioritised. Monitoring start and end dates were determined from a review of historical monitoring data and have been interpreted from the start and end dates provided from NPM monitoring level data.

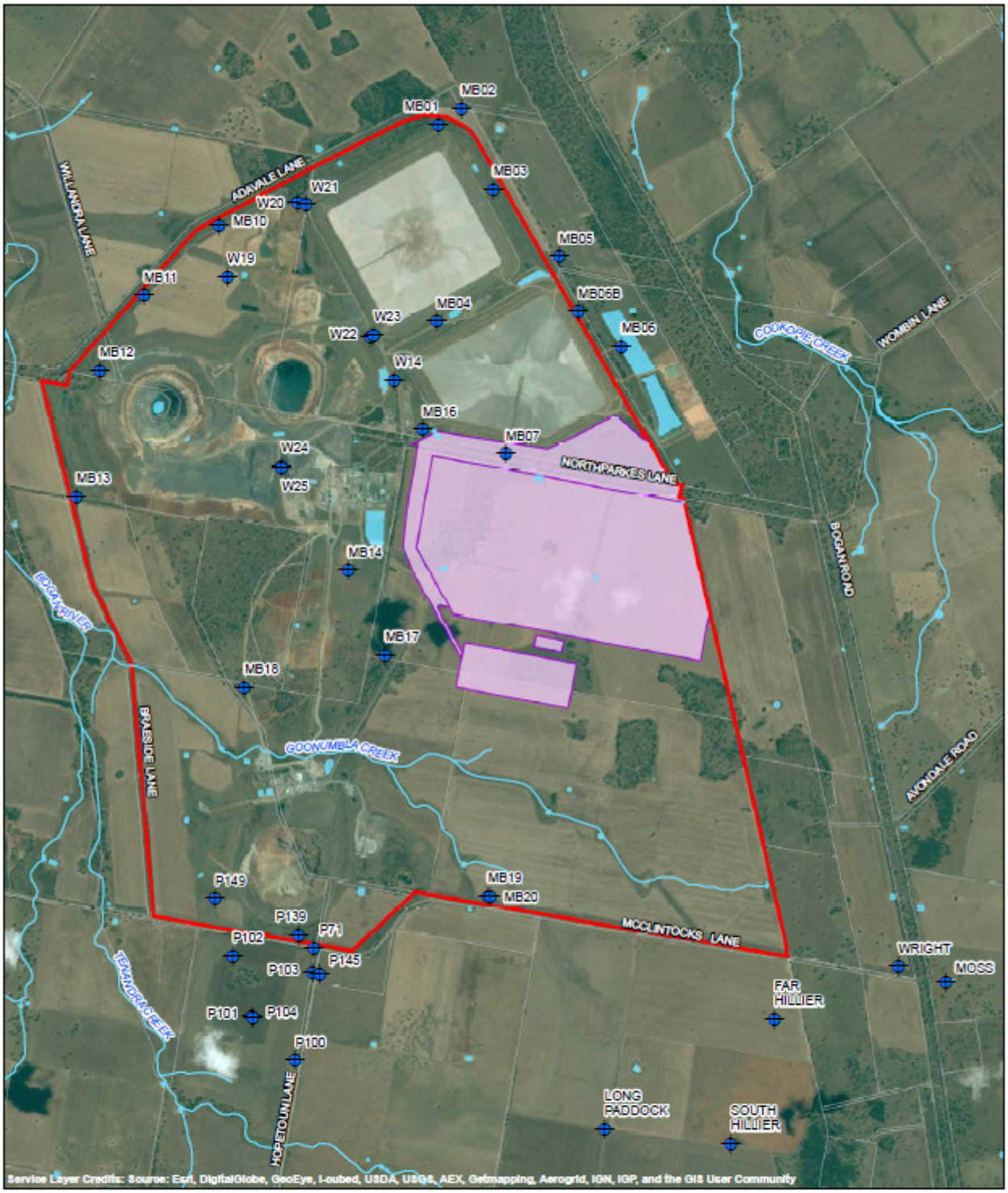
3.2 Background Data

3.2.1 Groundwater Levels

There was a lack of long term pre-mining background data. To determine baseline groundwater levels, bores outside the modelled 2 m drawdown contour at the base of the saprock at the end of mining in 2032 were used. The modelled 2 m drawdown contour was digitised from data provided in *Step Change Project Response to Submissions* (Umwelt, 2013b). It was assumed that at these locations groundwater levels have not been greatly impacted by mining activities and that these bores would provide appropriate background data. The 2 m drawdown contour and the background monitoring bores utilised are shown in Figure 3-2.

After reviewing the historical data for each of these bores it was decided that the baseline level for each of these bores would be taken as the maximum recorded level in the 12 months post the commencement of the WSP. This value was determined to not be significantly different to the mean groundwater level over the past 10 years.

Figure 3-1 Site Groundwater Monitoring Bores



LEGEND

- Site Boundary
- Tailings Footprint
- Cadastre
- Waterway
- Waterbody
- Groundwater Monitoring Bore

Paper Size A4

0 0.3 0.6 0.9 1.2

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Northparkes Mines
Groundwater Management Plan

Site Groundwater Monitoring Bores

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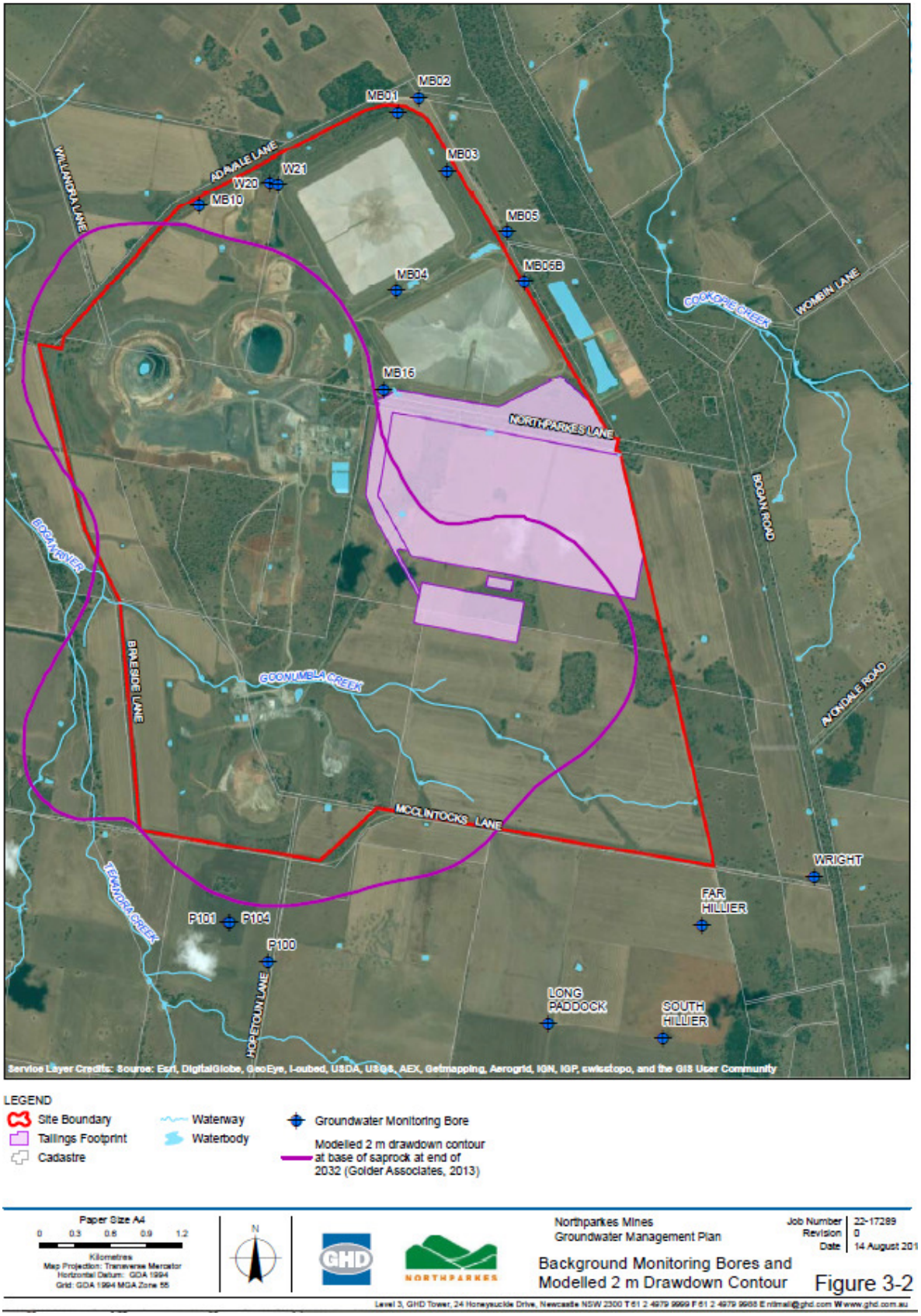
Figure 3-1

Figure 3-2 Background Monitoring Bores and Modelled 2 m Drawdown Contour



LEGEND

- Site Boundary
- Tailings Footprint
- Cadastre
- Waterway
- Waterbody
- Groundwater Monitoring Bore
- Modelled 2 m drawdown contour at base of saprock at end of 2032 (Golder Associates, 2013)

Paper Size A4
0 0.3 0.6 0.9 1.2
Kilometres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Northparkes Mines
Groundwater Management Plan

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Background Monitoring Bores and Modelled 2 m Drawdown Contour

Figure 3-2

Level 3, GHD Tower, 24 Honeysuckle Drive, Newcastle NSW 2300 T 61 2 4979 9999 F 61 2 4979 9988 E nlmail@ghd.com W www.ghd.com.au

Up-Gradient Bores

Historical groundwater levels have been plotted as shown in Figure 3-3 for each bore outside the 2 m drawdown contour that is located up-gradient of mining.

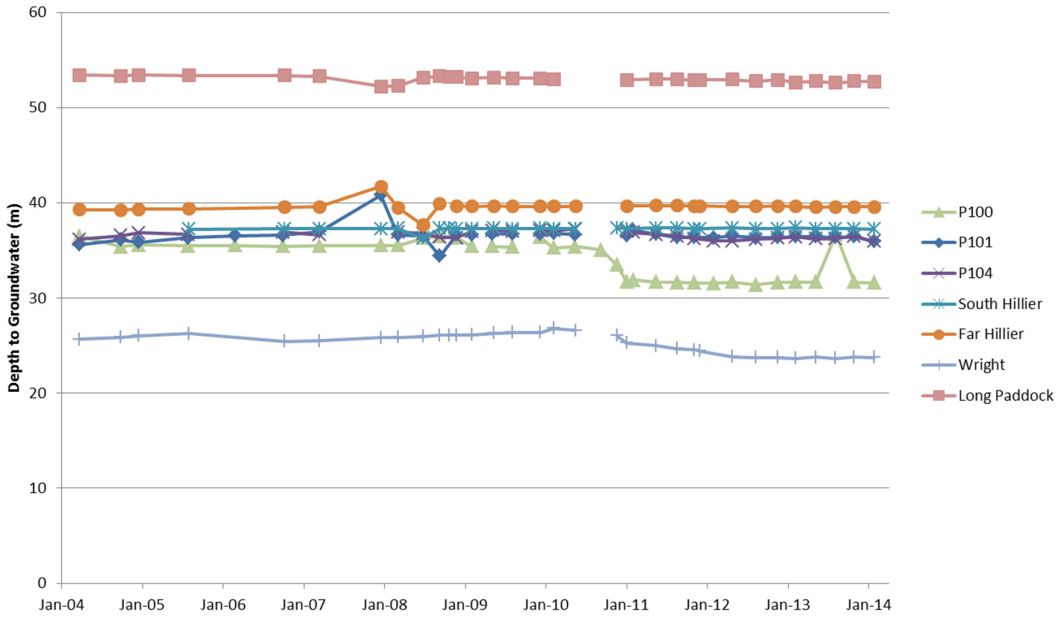


Figure 3-3 Historical Groundwater Levels of Up-Gradient Bores

A statistical analysis of the levels in Figure 3-3 has been undertaken, with the results provided in Table 3-1.

Table 3-1 Analysis of Historical Groundwater Levels for Up-Gradient Bores

Monitoring Bore	Historical Maximum Depth to Groundwater (m)	Historical Minimum Depth to Groundwater (m)	Historical Mean Depth to Groundwater (m)	Maximum Depth to Groundwater in 12 Months Post 16/01/12 (m)
P100	36.68	31.4	34.11	31.4
P101	40.84	34.43	36.57	36.35
P104	37.28	35.97	36.61	36
South Hilliers	37.42	36.3	37.27	37.27
Far Hilliers	41.74	37.69	39.61	39.63
Wright	26.85	23.67	25.30	23.74
Long Paddock	53.43	52.23	53.00	52.8

Down-Gradient Bores

Figure 3-4 presents the historical groundwater levels for each bore outside the 2 m drawdown contour that is located down-gradient of mining. The bores all display a similar trend of groundwater levels increasing over the life of the mine. The higher groundwater levels at monitoring bores M21, W20, MB4 and MB1 is likely due to their proximity to TSF 1 and TSF 2.

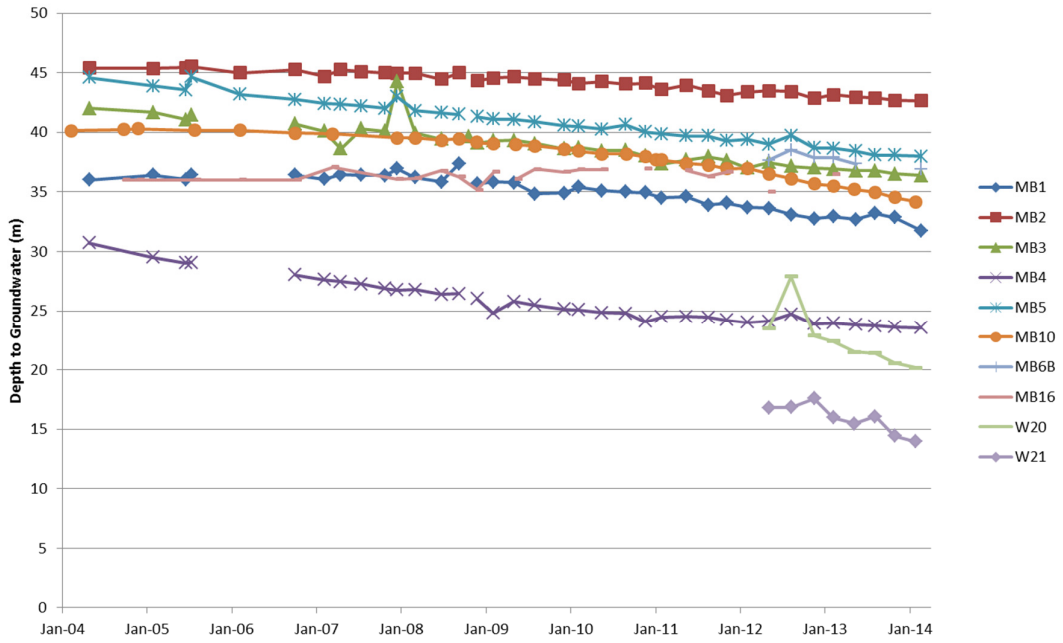


Figure 3-4 Historical Groundwater Levels of Down-Gradient Bores

A statistical analysis of the levels in Figure 3-4 has been undertaken, with the results provided in Table 3-2.

Table 3-2 Analysis of Historical Groundwater Levels

Monitoring Location	Historical Maximum Depth to Groundwater (m)	Historical Minimum Depth to Groundwater (m)	Historical Mean Depth to Groundwater (m)	Maximum Depth to Groundwater in 12 Months Post 16/01/12 (m)
MB1	37.36	31.75	34.98	32.75
MB2	45.53	42.65	44.23	42.86
MB3	44.25	36.38	38.89	37.01
MB4	30.70	23.55	25.74	23.89
MB5	44.66	38.00	40.91	38.70
MB6B	38.53	36.89	37.71	37.67
MB10	40.29	34.16	38.02	35.67
MB16	37.10	35.00	36.35	35.00
W20	27.90	20.15	22.54	22.87
W21	17.57	13.97	15.89	16.80

3.2.2 Groundwater Quality

Due to the lack of pre-mining data, background groundwater quality was taken from bores located up-gradient of the site boundary. For these bores, a statistical analysis of water quality has been undertaken, as shown in Table 3-3. The analysis found that water quality is very variable across the up-gradient bores, with electrical conductivity (EC) appearing to be higher in bores closer to the ore bodies.

Table 3-3 Mean Concentration of Historical Water Quality Indicators

Location	EC (µS/cm)	pH	Sulfate (mg/L)	Sodium (mg/L)	Aluminium (mg/L)	Copper (mg/L)	Manganese (mg/L)	Zinc (mg/L)	Iron (mg/L)
P100	16,235	7.0	1,076	7	0.58	0.0145	0.4378	0.0618	1.9633
P101	10,641	7.3	3,232.5	1,640	7.8	0.0688	4.76	0.1543	16.0833
P104	10,327	8.9	34.5	2,430	0.05	0.0022	0.158	0.0120	0.7500
Far Hilliers	777	6.2	1	35	0.035	0.0055	0.8396	0.0588	36.2875
South Hilliers	985	8.2	–	–	–	0.0081	0.1987	0.0086	1.3250
Long Paddock	1,033	8.4	7	119	0.01	0.0069	0.0125	0.0098	0.4050
Wright	809	6.6	39	59	0.19	0.0218	0.3748	6.5697	4.4862

4. Groundwater Impact Assessment Criteria

4.1 Groundwater Trigger Values

The NSW Aquifer Interference Policy requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the policy. If the predicted impacts are less than the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The Level 1 minimal impact considerations for Less Productive Fractured Rock Groundwater Sources have been adopted for this GWMP and are as follows:

- A cumulative pressure head decline of not more than a 2 m decline, at any water supply work.
- If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
- Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.
- If the above condition is not met then appropriate studies will need to demonstrate that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

4.1.1 Groundwater Levels

Trigger values have been developed for all bores outside the modelled 2 m drawdown contour at the base of the saprock at the end of mining in 2032 (Umwelt, 2013b).

The Stage 1 trigger would be exceeded if the monitored levels indicate an increase in depth to groundwater of 1 m compared to the adopted baseline value. The baseline value has been determined to be the maximum value in the 12 months following the commencement of the WSP. The Stage 2 trigger value would be exceeded if the monitored levels indicate a total increase in depth to groundwater of 2 m compared to the adopted baseline value. Adopted baseline levels and Stage 1 and Stage 2 trigger values for bores outside the modelled 2 m drawdown contour are outlined in Appendix C.

For bores inside the predicted 2 m drawdown contour no trigger values are recommended. Bores within this area should continue to be monitored and levels compared to predicted groundwater drawdown.

Groundwater levels have increased over time at a number of monitoring locations. It is expected that this increase in levels is due to the influence of the TSFs. To monitor the influence of the TSFs on groundwater levels, an increase in groundwater level by 1 m at any bore over two monitoring rounds has been adopted as a Stage 1 trigger. An increase in groundwater level by 1 m at any bore over four monitoring rounds has been adopted as a Stage 2 trigger.

4.1.2 Groundwater Quality

As outlined in Section 4.1, under the NSW Aquifer Interference Policy the impact on groundwater quality from NPM operations should not reduce the beneficial use category beyond 40 m from the activity.

Taking into account the surrounding bore usage based on data available from the NSW Groundwater Bore Database, there were 18 private bores within a 4.5 km radius from the mine. The majority (10) of the surrounding private bores are listed as stock bores. Three of the bores are listed as general use; one is listed as monitoring and one as domestic stock. Three bores were listed as having an 'unknown' purpose.

As shown in Figure 3-1 bores being monitored to the south east include Far Hilliers, South Hilliers, Long Paddock and Wright. Based on the search of the NSW Groundwater Bore Database bores to the south-east of the site boundary were generally stock bores. Table 4-1 presents the analysis of historical water quality of background bores. This analysis showed that based on the Australian Drinking Water Guidelines (ADWG) (NHMRC, 2011), with the exception of the Far Hilliers bore, EC of the bores to the south-east was generally fair. The historical analysis also identified that the ADWG for manganese, lead and iron were regularly exceeded. Based on this it was determined that the usefulness of this groundwater source was for stock.

Table 4-1 Background Water Quality

Parameter	ADWG guideline (mg/L unless otherwise noted)	Long Paddock		Far Hilliers		South Hilliers		Wright	
		No. of Exceedences	% of Samples Exceeding	No of Exceedences	% of Samples Exceeding	No of Exceedences	% of Samples Exceeding	No of Exceedences	% of Samples Exceeding
Lead	0.01	0	0	2	33.3	2	50	4	57
Manganese	0.1	0	0	5	100	2	100	5	100
Iron	0.3	1	25	4	100	1	50	3	60
EC	1,350 µS/cm (poor quality)	2	11.1	1	5.3	2	16.67	1	5
	900 µS/cm (fair quality)	10	55.56	1	5.3	8	66.67	10	50

Analysis of other bores across the site identified great variability in water quality across the site and surrounds. EC was very variable depending on location and was found to be a key value in limiting the useful of the groundwater resource. Bores located both up- and down-gradient of the workings showed very high EC values greater than 7,500 µS/cm, which would exceed the ANZECC and ARMCANZ (2000) livestock drinking water quality guidelines.

Analysis identified that bores MB01, MB06B, MB14, MB17, W19 (MB21), W24 (MB26) and W25 (MB27) displayed EC value less than 7,500 µS/cm. The usefulness of these bores was considered to potentially be for stock watering. It is recommended that for these bores and for Far Hilliers, South Hilliers, Long Paddock and Wright bores the ANZECC and ARMCANZ (2000) livestock triggers be adopted. These trigger values are shown in Table 4-2.

Table 4-2 Livestock Water Quality Trigger Values (ANZECC and ARMCANZ, 2000)

Parameter	Units	Default Trigger Values for Livestock
Aluminium	mg/L	5
Arsenic	mg/L	0.5
Cadmium	mg/L	0.01
Calcium	mg/L	1,000
Copper	mg/L	0.4 (guideline for sheep)
Lead	mg/L	0.1
Magnesium	mg/L	2,000
Molybdenum	mg/L	0.15
Nickel	mg/L	1
Selenium	mg/L	0.02
Sulfate	mg/L	1,000
TDS	mg/L	5,000
Zinc	mg/L	20
Alkalinity ($CaCO_3$)	mg/L	60–350
EC	µS/cm	7,500 µS/cm

In developing trigger values for all bores located down-gradient of the TSFs, it was determined that the trigger values must detect a release of water from the TSF. Bores located down-gradient of the TSFs include MB01, MB02, MB03, MB04, MB05, MB06B, W20 and W21. Water quality monitoring of TSF has not been undertaken. Monitoring point TSF 1 and the Return Water Dam were determined to be the best indicator of water quality within TSFs. The Return Water Dam receives water from the TSFs and from the Caloola Dams, so the water quality of Return Water Dam is diluted and is not completely reflective of water quality within TSFs. Monitoring point TSF 1 is the decant location for TSF 1. In developing water quality of all surrounding bores, the contaminants in the Return Water Dam and TSF 1 (and hence the TSFs) have been considered.

Table 4-3 shows water quality of major contaminants of the return water dam and TSF 1. The analysis of water quality of TSF 1 was limited by the range of contaminants monitored.

Table 4-3 Key Contaminants of Return Water Dam

Parameter	Return Water Dam Mean Concentration (mg/L Unless Otherwise Noted)	TSF1 Mean Concentration (mg/L Unless Otherwise Noted)
EC	4,450.4 µS/cm	–

Parameter	Return Water Dam Mean Concentration (mg/L Unless Otherwise Noted)	TSF1 Mean Concentration (mg/L Unless Otherwise Noted)
pH	–	7.4
Sulfate	2,220	2,364.5
Copper	8.6*	177.9**
Aluminium	1.55	–
Selenium	0.03	–
Molybdenum	0.1915	–

* Median value is 0.06 mg/L.

** Median value is 20 mg/L.

It should be noted that the predicted level of contamination within the Return Water Dam and TSF 1 are within the ANZECC and ARMCANZ (2000) livestock trigger values for EC, copper and aluminium. Sulfate, selenium and molybdenum are high and would exceed trigger values if detected in groundwater.

Selenium levels in W24 (MB26) and W25 (MB27) have triggered ANZECC and ARMCANZ (2000) livestock trigger values in both monitoring samples taken at each bore (two exceedences each).

For all other monitoring bores the trigger values have been determined from statistical analysis of historical water quality data. Groundwater quality objectives were set for the purposes of maintaining the existing quality of the groundwater resource present currently and mitigating any potential degradation of groundwater quality on site. The adopted Stage 1 trigger was the 95th percentile for the last two year of groundwater monitoring data for each parameter. The 99th percentile for the last two years of groundwater monitoring data was adopted as the Stage 2 trigger. Recommended trigger values are provided in Appendix D.

4.2 Response Plan

4.2.1 Groundwater Quality and Levels

The appropriate response to a trigger being exceeded is outlined in the Trigger Action Response Plan (TARP) in Appendix E. The response to a trigger being exceeded generally involves undertaking analysis to determine if a change in groundwater quality or level is due to natural variation or mining activity and informing the site manager that a trigger value has been exceeded.

4.2.2 Update and Verification of Hydrogeological Predictions

NPM will undertake an annual review of hydrogeological groundwater level predictions against the monitored data. A review should also be undertaken if the operations timeline or site development varies from what was predicted as part of the most recent revision of the hydrogeological modelling. Opportunities for hydrogeological model verification exist through using the transfer data metered from E26 Underground to the Process Water Dam. This data is metered daily along with the volume of water transferred into the E26 Underground.

5. Groundwater Monitoring

5.1 Monitoring Program Objective

The purpose of this GWMP is to provide a framework for monitoring and management of groundwater quality and levels. The aim of groundwater monitoring is to ensure groundwater drawdown is within the predictions of the groundwater modelling undertaken as part of the EIS for the Project (Umwelt, 2013a), to detect any potential impact on surrounding groundwater users and to ensure that requirements of the NSW Aquifer Interference Policy are met. The GWMP outlines the locations, parameter, frequency and methodology of monitoring.

5.2 Monitoring Methodology

As specified by DIPNR (2003), groundwater monitoring should be undertaken in general accordance with *A Practical Guide to Groundwater Sampling* (Jiwan and Gates, 1992), although it is recommended that low flow sampling techniques be used for purging and sampling (rather than bailers or submersible pumps) to minimise aquifer disturbance and reduce the volume of groundwater extracted during sampling.

In general, the groundwater monitoring methodology should include the following:

- Gauging of groundwater levels prior to purging.
- Purging of monitoring bores using a low flow peristaltic pump. To limit the disturbance of possible sediments in the base of each bore, the sample tubing at each bore should be lowered to approximately the middle of the screened interval for purging and sample collection.
- Measurement of groundwater field parameters (pH, EC) using a calibrated water quality meter and a flow cell during purging. The pH and EC readings should be recorded in the field once they have stabilised.
- If groundwater samples are to be collected, they are to be transferred into suitably preserved laboratory supplied sample containers once field parameters have stabilised. Samples to be analysed for dissolved metals are to be filtered in the field using 0.45 µm filters. All sample containers are to be clearly labelled with sample number, sample location, sample depth and sample date. The sample containers are to be transferred to a chilled esky for sample preservation prior to and during shipment to the testing laboratory. A Chain-of-Custody form should be forwarded with the samples to the testing laboratory.
- Decontamination of all non-dedicated sampling equipment between monitoring locations.

5.3 Monitoring Network

The NPM monitoring network is shown in Figure 3-1. A list of all known NPM bores is given in Appendix B.

GHD (2014b) has recently completed a specification for the installation of new monitoring bores assessment and identified the groundwater monitoring bore specifications for the construction of TSF 3. The location of these bores is shown in Figure 5-1. These bores should be incorporated into the NPM groundwater monitoring program. GHD (2014b) also recommended that MB16 be decommissioned. Additionally it is anticipated that bores MB07 and MB04 will be lost due to the construction of the TSF 3 and infilling between TSF 1 and TSF 2. It is recommended that bores MB16, MB07 and MB04 are removed from the groundwater monitoring network.

The bores should be decommissioned prior to relevant construction commencing in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (ADIA, 2012), which would include:

- If possible, removal of above ground steel casing or monuments.
- Injection of a 5% cement bentonite grout from the base of the bore to the surface with a tremie pipe.

5.3.1 Surface and Groundwater Transfer Metering

To monitor and assess the operational water cycle at NPM, a number of volumetric meters are positioned around the site. These meters allow for definitive annual reporting of water usage, inputs and outputs of the operational water cycle and provide a point of verification for the water balance representations of the site. These existing volumetric metering locations will continue to be monitored daily for the life of the mine. The locations of the volumetric meters are:

- Transfers from Parkes Shire Council groundwater bores and river supply to the Raw Water Tank.
- Raw Water Tank outflows to the Water Treatment Plant.
- Potable Water Tank to contractor's yard, E26 Underground, truck wash and administration facilities.
- TSF 1 and TSF 2 to the Process Water Dam.
- E26 Underground to the Process Water Dam.
- Transfers from the Return Water Dam to the Process Water Tank, Caloola Dams and Process Water Dam.

The Site Water Balance (GHD, 2014a) considers the historical data of these metering locations as well predicted future annual transfer volumes.

5.3.2 Upgrading Network

It is recommended that prior to commencement of block cave mining in the E22 ore body, the groundwater monitoring network is reviewed to determine the need for installation of a monitoring bore down-gradient of the workings in the bedrock to monitor bedrock depressurisation and any changes in groundwater quality.

Prior to commencing open cut mining in E28, E28N, E31 and E31N ore bodies it is recommended that the groundwater monitoring network be reviewed to ensure it is capable of detecting potential impacts of mining in these resources.

5.4 Monitoring Parameters and Frequency

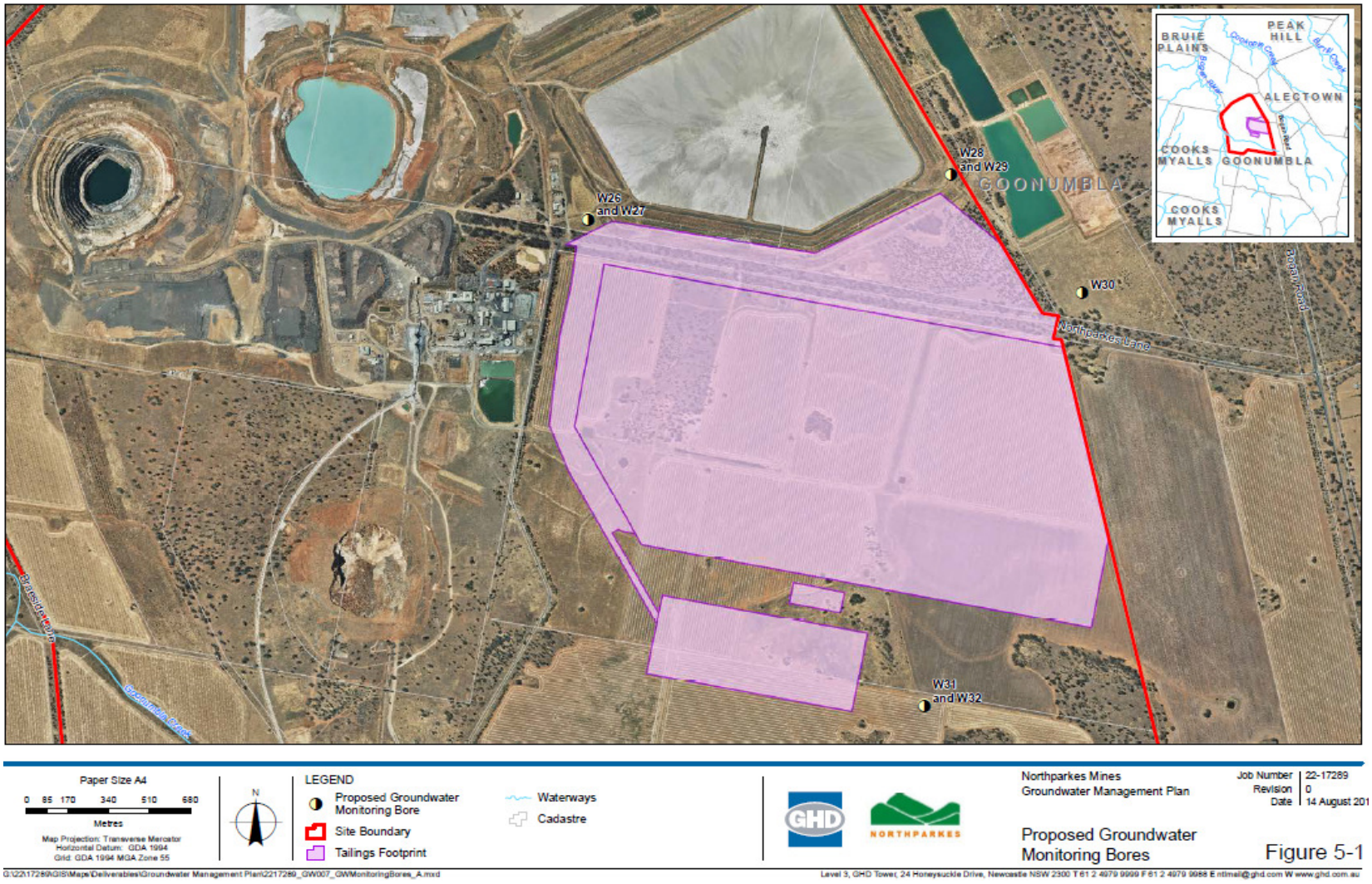
The groundwater monitoring of levels and quality is to continue as part of the Project. The frequency and parameters to be monitored have been provided in Table 5-1.

The NPM groundwater monitoring network is shown in Figure 3-1. Details regarding all actively monitored bores are provided in Appendix B. It is recommended that monitoring continue at all currently monitored bores. Details regarding proposed bores recommended for inclusion in the groundwater monitoring network and bores recommended for future removal are outlined in Section 5.3.

Table 5-1 Groundwater Monitoring Parameters and Frequency

Frequency	Parameter
Quarterly	Water level
Quarterly	pH, EC, total dissolved solids, hydroxide alkalinity, carbonate alkalinity, bicarbonate alkalinity, total alkalinity, sulfate, chloride, calcium, magnesium, sodium, potassium, aluminium, antimony, arsenic, beryllium, barium, cadmium, chromium, cobalt, copper, lead, manganese, molybdenum, nickel, selenium, zinc, nitrate, strontium, thallium, thorium, uranium, iron and mercury.

Figure 5-1 Proposed Groundwater Monitoring Bores



6. Reporting and Responsibility

6.1 Data Review

Upon receipt of monitoring results, the following review processes will be undertaken:

- Data will be compared to the specified trigger values where applicable.
- If any results do not meet specified trigger values, further investigation will be required at the respective location.

Groundwater levels should be compared to the predicted groundwater modelling on an annual basis. Any large discrepancies or variances from predicted groundwater level should be investigated. If the cause of the variance is determined to be due to mining-related activities, then the groundwater model will require updating. NPM will undertake groundwater modelling on an annual basis after commissioning of the Rosedale Tailings Facility for the first three years and once every three years after the initial three year period.

6.2 Reporting

6.2.1 Environment Protection Licence 4784

The monitoring requirements under this GWMP are part of NPM's Environment Protection Licence (EPL) 4784 and therefore the monitoring results need to be reported in accordance with the requirements of the EPL.

The conditions of EPL 4784 require groundwater monitoring to be undertaken at the following locations: W14, MB21, MB23, MB25, MB27 and MB22. The parameters requiring reporting and the frequency of reporting are shown in Table 6-1.

Table 6-1 EPL 4784 Groundwater Monitoring Requirements

Parameter	Units	Frequency	Sampling Method
Aluminium	mg/L	Yearly	Representative sample
Arsenic	mg/L	Yearly	Representative sample
Barium	mg/L	Yearly	Representative sample
Beryllium	mg/L	Yearly	Representative sample
Bicarbonate	mg/L	Yearly	Representative sample
Cadmium	mg/L	Yearly	Representative sample
Calcium	mg/L	Yearly	Representative sample
Chloride	mg/L	Yearly	Representative sample
Chromium	mg/L	Yearly	Representative sample
Cobalt	mg/L	Yearly	Representative sample
Conductivity	µS/cm	Quarterly	Representative sample
Copper	mg/L	Quarterly	Representative sample

Parameter	Units	Frequency	Sampling Method
Lead	mg/L	Yearly	Representative sample
Magnesium	mg/L	Yearly	Representative sample
Molybdenum	mg/L	Yearly	Representative sample
Nickel	mg/L	Yearly	Representative sample
pH	pH units	Quarterly	Representative sample
Potassium	mg/L	Yearly	Representative sample
Selenium	mg/L	Yearly	Representative sample
Sodium	mg/L	Yearly	Representative sample
Standing water level	m	Quarterly	In situ
Sulfate	mg/L	Yearly	Representative sample
Total dissolved solids	mg/L	Yearly	Representative sample
Zinc	mg/L	Yearly	Representative sample

6.2.2 Annual Environment Monitoring Report

NPM will prepare and Annual Review (previously an Annual Environmental Management Report) that reviews the performance of operations at NPM against the requirements of the Water Management Plan, provides an overview of environmental management actions taken and summarises the monitoring results over the 12 month reporting period. The Annual Review typically includes the following elements specific to water management:

- Any amendments to licensing or statutory approvals.
- A summary of any complaints or incidents relating to the performance of the water management system over the reporting period.
- A summary of the monitoring results collected over the reporting period and assessment against any relevant criteria.
- An evaluation of any trends in the monitoring results occurring across the site over the life of the project.
- Any non-compliance recorded during the reporting period and the actions taken to ensure compliance.
- Identification of any discrepancies between the predicted and actual impacts of the Project and an analysis of the potential cause of any significant discrepancies.
- An evaluation of the site water balance.
- A summary of management actions to be implemented over the next year to improve the environmental performance of the project.

Management actions identified in the Annual Review relating to the water management system may include:

- Refinements to performance criteria and objectives.
- Changes to monitoring frequency, parameters or locations.
- The initiation of any remedial actions.

6.2.3 WM Act

It is recommended that as part of the Annual Review NPM identify the predicted groundwater make of the open cut and underground block caving mining areas for alluvial groundwater and saprock, saprolite and fractured bedrock groundwater sources for the upcoming water year. NPM must compare the predicted extraction from each of these groundwater sources to the extraction licences held under the WM Act. A summary of the licences currently held by NPM under the WM Act is shown in Table 1-4. If the review determines that insufficient licences are held NPM must apply for additional licences.

6.3 Roles and Responsibilities

Personnel carrying out work under this water management plan must be familiar with the requirements of this document and comply with it in full. Table 6-2 outlines key roles and responsibilities regarding water management.

Table 6-2 Roles and Responsibilities Summary

Role	Responsibility
Water Champion	• The principal point of contact in relation to the GWMP. • Coordinate the Water Team and delegate tasks and water enquiries at NPM.
Water Team	• Review or arrange a review of activities associated with the GWMP on a regular basis. • Maintain a record of water monitoring results. • Investigate GWMP non-conformances in accordance with relevant TARPs. • Determine appropriate management strategies and implement contingency measures in consultation with relevant departments. • Complete all internal and external reports required by the GWMP. • Investigate and report on all incidents and complaints relevant to the GWMP. • Maintain a record of all incidents and complaints relevant to the GWMP.

Role	Responsibility
Operations and engineering managers	• Installation, maintenance and operation of water management infrastructure. • Consult with the Water Team to determine appropriate environmental management strategies and contingency measures required by the GWMP. • Consult with the Water Team with respect to the management of any contractor activities that may affect the effectiveness of the GWMP.
All employees and contractors	• Undertake activities in accordance with relevant NPM policies, procedures and management plans and statutory and contract requirements. • Implement appropriate environmental management measures in accordance with the GWMP. • Report all environmental incidents to the Water Champion.

6.4 Management Plan Review

The GWMP will be reviewed and revised every year or as a result of:

- Any regulatory or statutory requirements.
- Any significant change to water management practices.
- Construction of additional surface water storages.
- Development of new open cut or underground mining areas.
- Continual exceedances of any trigger values.
- Any incident that requires reporting.

A review of the GWMP will be undertaken by a suitably qualified person and also should consider consultation with the appropriate local and state government authorities.

7. References

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Appendices

Appendix A – NSW Bore Database Search

Results of NSW Groundwater Bore Database Search

Bore Number	Licence Number	Owner Type	Purpose	Depth (m)	Screened/ Slotted Depth (m bgl)	Completion Date	Salinity	Yield (kL)	Standing Water Level (m)	Draw Down Level (m)
GW034261	–	Private	Stock	61	–	1/01/1937	(Unknown)	–	–	–
GW034607	80BL027626	Private	Domestic stock	70.1	–	1/01/1940	(Unknown)	–	–	–
GW002311	–	Private	General use	23.2	–	1/03/1928	(Unknown)	–	–	–
GW002337	–	Private	General use	11.6	–	1/04/1928	(Unknown)	–	–	–
GW002526	–	Private	Unknown	108.5	–	1/01/1928	Over 14,000 ppm	–	51.6	–
GW002722	–	Private	Stock	37.5	–	1/08/1929	Fresh	–	–	–
GW002754	–	Private	Stock	44.8	–	1/10/1929	Fresh	0.09	32.3	–
GW002860	–	Private	Unknown	47.5	–	1/02/1930	Fresh	0.91	38.4	–
GW035011	–	Private	Stock	54.8	–	1/01/1937	(Unknown)	–	–	–
GW018091	–	Private	Stock	48.8	–	1/02/1959	1,001-3,000 ppm	0.46	39	–
GW021708	80BL014017	Private	Stock	36.6	–	1/03/1964	Good	0.1	29	–
GW070442	–	Mines	Test bore	215.6	54 – 204	17/01/1993	30,000	7.7	47.34	80.53
GW800009	80BL236023	Private	Monitoring bore	60	6 – 60	17/04/1994	–	–	–	–
GW044455	80BL103781	Private	Stock	49.1	–	1/04/1975	(Unknown)	–	–	–
GW801222	80BL155193	Mines	Monitoring bore	250	39 – 205	5/08/1994	20,000	0.4	74.7	119.8

Bore Number	Licence Number	Owner Type	Purpose	Depth (m)	Screened/ Slotted Depth (m bgl)	Completion Date	Salinity	Yield (kL)	Standing Water Level (m)	Draw Down Level (m)
GW801224	80BL237290	Mines	Monitoring bore	60	6 – 60	16/04/1997	–	–	–	–
GW801225	80BL237290	Mines	Monitoring bore	43	5 – 43	17/04/1997	–	–	–	–
GW801226	80BL237290	Mines	Monitoring bore	24	5 – 24	18/04/1997	–	–	–	–
GW801378	80BL155192	Mines	Monitoring bore	250	60 – 246	9/08/1994	–	–	–	–
GW800007	80BL236021	Mines	Monitoring bore	36.5	6 – 36.5	17/04/1994	–	–	–	–
GW002488	–	Private	Unknown	76.2	–	1/10/1928	–	0.11	50.3	–
GW035199	80BL027965	Private	Stock	42.6	–	1/01/1927	(Unknown)	–	–	–
GW034769	80BL025843	Private	Stock	42.6	–	1/01/1970	(Unknown)	–	–	–
GW002767	–	Private	General use	59.7	–	1/01/1929	Fresh	0.01	51.8	–
GW044456	80BL103782	Private	Stock	57.9	–	1/01/1975	Unknown	0.51	27.4	–
GW801223	80BL237290	Mines	Monitoring bore	60	6 – 60	15/04/1997	–	–	–	–
GW800011	80BL236022	Mines	Monitoring bore	66	6 – 66	16/04/1994	–	–	–	–
GW803934	80BL244990	Mines	Monitoring bore	102	99 – 102	25/11/2009	–	–	–	–
GW803935	80BL244990	Mines	Monitoring bore	54	–	27/07/2008	–	–	–	–
GW803936	80BL244991	Mines	Monitoring bore	66	60 – 63	24/07/2008	–	–	–	–
GW803937	80BL244992	Mines	Monitoring bore	90	87 – 90	25/07/2008	–	–	–	–
GW034262	80BL027634	Private	–	58.5	–	1/01/1937	–	–	–	–

Appendix B – Current Groundwater Monitoring Bores Details

Current Groundwater Monitoring Bores

Name	Northings	Eastings	Drill date	Monitoring Start Date	Monitoring End Date	Bore Depth (m)	Slotted/Screened Depth (m bgl)	Screened Geology
MB06B	600106	6359043	20/01/2012	9/05/2012	Ongoing	50	16 – 46	Saprolite/saprock/biotite quartz monzonite
MB21/W19	597482	6359201	23/01/2012	8/05/2012	Ongoing	154	69 – 154	Porphyritic andesite
MB22/W20	598037	6359766	17/01/2012	8/05/2012	Ongoing	60	32 – 47	Saprock
MB23/W21	598093	6359783	18/01/2012	8/05/2012	Ongoing	154	51 – 150	Brecciated andesite
MB24/W22	598581	6358743	13/01/2012	8/05/2012	Decommissioned	60	31 – 55	Saprolite/saprock/volcaniclastic andesite
MB24A/W22	598581	6358743	31/01/2012	8/05/2012	Ongoing	55	30 – 51	Saprolite/saprock
MB25/W23	598617	6358770	13/01/2012	8/05/2012	Ongoing	154	54 – 150	Saprock/volcaniclastic andesite
MB26/W24	597904	6357762	23/01/2012	8/05/2012	Ongoing	25	11 – 21	Saprolite/saprock
MB27/W25	597905	6357751	25/01/2012	8/05/2012	Ongoing	154	24 – 150	Porphyritic andesite/brecciated andesite
MB14	598413	6356964	27/08/2002	4/08/2009	Ongoing	50.5	30 – 42	Andesite
MB16	599000	6358040	29/08/2002	4/08/2009	Recommended for decommission	40.3	23 – 35	Clay/weathered andesite
MB17	598582.9	6356141.7	24/07/2008	2/02/2009	Ongoing	66	60 – 63	Latite
MB18	597513.6	6355890.2	25/07/2008	2/02/2009	Ongoing	90	87 – 90	Volcanic sandstone
MB06	600952	6358439	17/04/1997	27/04/2004	6/02/2012	43	5 – 43	Clay/ weathered volcanics

Name	Northings	Eastings	Drill date	Monitoring Start Date	Monitoring End Date	Bore Depth (m)	Slotted/Screened Depth (m bgl)	Screened Geology
MB05	600647	6359027	16/04/1997	27/04/2004	Ongoing	60	6 – 60	Clay/weathered volcanics/fresh volcanics
MB04	600332	6358784	15/04/1997	27/04/2004	Ongoing	60	6 – 60	Volcanics, Weathered and Fresh
MB01	599101	6360398	17/04/1994	27/04/2004	Ongoing	36.5	6 -36.5	Weathered monzonite/monzonite
MB02	599411	6360179	17/04/1994	27/04/2004	Ongoing	60	6 – 60	Clay/weathered monzonite/monzonite
MB07			18/04/1997	27/04/2004	Recommended for decommission	24	5 – 24	Weathered volcanics
MB10	597434	6359586	22/09/2002	4/08/2009	Ongoing	44.6	31.6 – 43.6	Clay/andesite breccia
MB08	598322	6359016	6/09/2002	4/08/2009	10/11/2011	59.6	39.6 – 51.6	Monzonite
MB12			28/09/2002	4/08/2009	Ongoing	45.2	29.6 – 41.6	Saprock/diorite
MB13	596348	6357524	2/10/2002	4/08/2009	Ongoing	60.15	43.8 – 55.8	Saprock
MB19	599481	6354484	27/07/2008	2/02/2009	Ongoing	102	99 – 102	Latite
MB20	599498	6354474	27/07/2008	2/02/2009	Ongoing	54	51 – 54	Saprock
W1	–	–	9/09/1995	–	Assumed decommissioned as part of Estcourt TSF construction	100	–	Clay/moderately weathered siliceous tuff/crystalline trachyandesite tuff
W2	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	100	–	Bedrock (OTZ)

Name	Northings	Eastings	Drill date	Monitoring Start Date	Monitoring End Date	Bore Depth (m)	Slotted/Screened Depth (m bgl)	Screened Geology
W3	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	100	–	Regolith/bedrock
W4	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	120	–	Regolith/bedrock
W5	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	102	–	Regolith/bedrock
W6	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	108	–	Bedrock (OTZ)
W11	–	–	–	–	–	150	–	Bedrock (OTZ)
W12	–	–	–	–	–	150	–	Bedrock (OTZ)
W13	–	–	–	–	–	150	–	Bedrock (OTZ)
W14	598561	6358433	–	4/08/2009	Ongoing	150	–	Regolith and Bedrock
W15	597337	6358523	–	4/08/2009	2/02/2011	150	–	Regolith and Bedrock
W16	598094	6357979	–	4/08/2009	22/08/2011	100	–	Bedrock
W17	598094	6357972	–	4/08/2009	22/08/2011	60	–	Bedrock

Name	Northings	Eastings	Drill date	Monitoring Start Date	Monitoring End Date	Bore Depth (m)	Slotted/Screened Depth (m bgl)	Screened Geology
W18	598123	6358299	–	4/08/2009	6/02/2012	100	–	Regolith/bedrock
MB03	599207	6360582	–	27/04/2004	Ongoing	60	–	Monzonite, weathered
MB08A	–	–	–	–	–	62.6	–	Regolith/bedrock
MB11	596862	6359066	–	4/08/2009	Ongoing	57	–	Andesite, weathered
P71	598154	6354079	–	2/02/2009	Ongoing	130	–	Bedrock
P100	598014	6356234	–	2/02/2009	Ongoing	30	–	Bedrock
P101	597683	6352566	–	2/02/2009	Ongoing	24	–	Bedrock
P102	597536	6354028	–	2/02/2009	Ongoing	18	–	Bedrock
P103	598150	6353898	–	2/02/2009	Ongoing	24	–	Bedrock
P104	597692	6353563	–	2/02/2009	Ongoing	97	–	Bedrock
P139	598039	6354188	–	2/02/2009	Ongoing	108	–	Bedrock
P145	598196	6353888	–	2/02/2009	Ongoing	120	–	Bedrock
P149	597410	6355150	–	2/02/2009	Ongoing	90	–	Bedrock
Far Hillers	601656	6353541	–	19/03/2004	Ongoing	–	–	Alluvial and regolith
Long Paddock	600370	6352695	–	19/03/2004	Ongoing	–	–	Alluvial and regolith
South Hillers	601315	6352587	–	1/08/2005	Ongoing	–	–	Alluvial and regolith
Wright	602600	6353946	–	19/03/2004	Ongoing	–	–	Alluvial and regolith
Moss	–	–	–	1/08/2005	Ongoing/unable to be sampled since	–	–	Alluvial and regolith

Name	Northings	Eastings	Drill date	Monitoring Start Date	Monitoring End Date	Bore Depth (m)	Slotted/Screened Depth (m bgl)	Screened Geology
					22/10/2008			
PDH-29	–	–	–	–	Assumed decommissioned as part of Estcourt TSF construction	>200	–	Bedrock

Appendix C – Groundwater Level Trigger Values

Monitoring Location	Maximum Depth to Groundwater in 12 Months Post 16/01/12 (m)	Stage 1 Trigger (m)	Stage 2 Trigger (m)
P100	31.4	32.4	33.4
P101	36.35	37.35	38.35
P104	36	37	38
South Hilliers	37.27	38.27	39.27
Far Hilliers	39.63	40.63	41.63
Wright	23.74	24.74	25.74
Long Paddock	52.8	53.8	54.8
MB01	32.75	33.75	34.75
MB02	42.86	43.86	44.86
MB03	37.01	38.01	39.01
MB04	23.89	24.89	25.89
MB05	38.7	39.7	40.7
MB06B	37.67	38.67	39.67
MB10	35.67	36.67	37.67
MB16	35	36	37
W20	37.74	38.74	39.74
W21	16.8	17.8	18.8

Appendix D – Trigger Values for Monitoring Bores with Elevated Salinity

Parameter	Units	Stage 1 trigger (95%)	Stage 2 trigger (99%)
EC	µS/cm	26,700	32,843
pH	pH units	5.905–9.825	5.6–11.519
Total dissolved solids (TDS)	mg/L	23,575	24,252
Suspended solids	mg/L	456	471.2
Turbidity	NTU	620.85	1,696.8
Hydroxide alkalinity as $CaCO_3$	mg/L	30.85	60.08
Carbonate alkalinity as $CaCO_3$	mg/L	49.5	87.35
Bicarbonate alkalinity	mg/L	818.7	1,123.7
Total alkalinity as $CaCO_3$	mg/L	843.6	1,166.7
Sulfate	mg/L	3,134	3,830.6
Chloride	mg/L	10,490	11,424
Calcium	mg/L	1,159	1,637
Magnesium	mg/L	1,143	1,294
Sodium	mg/L	6,054	6,331.8
Potassium	mg/L	58.9	255.52
Copper (dissolved)	mg/L	0.0344	0.26602
Aluminium	mg/L	6.388	7.496
Antimony	mg/L	0.001	0.00685
Arsenic	mg/L	0.0107	0.01824
Beryllium	mg/L	0.0024	0.00848
Barium	mg/L	0.3069	0.46696
Cadmium	mg/L	0.00144	0.002824
Chromium	mg/L	0.0394	0.04548
Cobalt	mg/L	0.5086	0.61174
Copper (total)	mg/L	0.0862	0.25171
Lead	mg/L	0.0905	0.19586

Parameter	Units	Stage 1 trigger (95%)	Stage 2 trigger (99%)
Manganese	mg/L	9.075	12.372
Molybdenum	mg/L	0.039	0.04148
Nickel	mg/L	0.0104	0.01648
Selenium	mg/L	0.02	0.0262
Strontium	mg/L	28.825	38.541
Thallium	mg/L	0.0016	0.00815
Thorium	mg/L	0.0087	0.01469
Uranium	mg/L	0.05865	0.07435
Zinc	mg/L	0.5472	1.05136
Iron	mg/L	33.24	44.146
Mercury	mg/L	0.00043	0.000762

Appendix E – Groundwater Levels and Quality Trigger Action Response Plan (TARP)

Monitoring Parameter	Normal	Stage 1	Stage 2
Groundwater Quality	**Normal Trigger:** Groundwater quality is within typical range of historical average. **Response:** *Continue to monitor on a quarterly basis.*	**Stage 1 Trigger:** For monitoring locations MB01, MB06B, MB14, MB17, W19 (MB21), W24 (MB26), W25 (MB27), Far Hilliers, South Hilliers, Long Paddock and Wright groundwater quality is outside the typical range of historical averages or exceeds Livestock Trigger Values (Appendix C) for at least one parameter for more than 2 monitoring rounds. **Response:** *Investigate if change in groundwater quality is due to mining related activity. Alert site manager.* **Stage 1 Trigger:** For all monitoring locations groundwater quality is outside the typical range of historical averages or exceed Stage 1 Water Quality Trigger Values (Appendix D) for at least one parameter for more than 2 monitoring rounds **Response:** *Investigate if change in groundwater quality is due to mining related activity. Alert site manager.* **Stage 1 Trigger:** Complaint from adjacent bore owner regarding groundwater quantity or quality. **Response:** *Alert site manager. Sample affected bore if possible. Sample surrounding bores if possible. Investigate degradation of groundwater quality.*	**Stage 1 Trigger:** For monitoring locations MB01, MB06B, MB14, MB17, W19 (MB21), W24 (MB26), W25 (MB27), Far Hilliers, South Hilliers, Long Paddock and Wright groundwater quality is outside the typical range of historical averages or exceeds Livestock Trigger Values (Appendix C) for at least one parameter for more than 4 monitoring rounds. **Response:** *Investigate if change in groundwater quality is due to mining related activity. Alert site manager.* **Stage 2 Trigger:** For all monitoring locations groundwater quality is outside the typical range of historical averages or exceed Stage 1 Water Quality Trigger Values (Appendix D) for at least one parameter for more than 4 monitoring rounds **Response:** *Investigate if change in groundwater quality is due to mining related activity. Alert site manager.*

Monitoring Parameter	Normal	Stage 1	Stage 2
Groundwater Level	**Normal Trigger:** Groundwater level is within typical range of historical and climatic average. **Response:** *Continue to monitor on a quarterly basis.*	**Stage 1 Trigger:** Depth to groundwater of background bore (listed in Appendix C) exceeds Stage 1 Groundwater Level Trigger Values (Appendix C). **Response:** *Compare groundwater level to modelled level. Alert site manager.* **Stage 1 Trigger:** Groundwater levels have increased by 1 metre at any bore over 2 monitoring rounds. **Response:** *Compare groundwater level to modelled level. Alert site manager.* **Stage 1 Trigger:** Complaint from adjacent bore owner regarding groundwater level. **Response:** *Alert site manager. Sample affected bore if possible. Sample surrounding bores if possible. Investigate cause of drop in groundwater level.*	**Stage 2 Trigger:** Depth to groundwater of background bore (listed in Appendix C) exceeds Stage 2 Groundwater Level Trigger Values (Appendix C). **Response:** *Compare groundwater level to modelled level. Alert site manager. Investigate if change in groundwater level is due to mining related activity. If drop in groundwater level is due to mining related activity update hydrogeological model.* **Stage 2 Trigger:** Groundwater levels have increased by 1 metre at any bore over 4 monitoring rounds. **Response:** *Compare groundwater level to modelled level. Alert site manager. Investigate if change in groundwater level is due to mining related activity. If drop in groundwater level is due to mining related activity update hydrogeological model.*

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