CALIDUS
RESOURCES LIMITED

Groundwater Monitoring Procedure

CRL-ENV-PRO-021-19

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This document has been prepared based on assumptions as reported throughout and upon information and data supplied by others.

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1 Introduction

The groundwater management procedure has been prepared as part of the environmental management of Calidus Resources Limited's Warrawoona Gold Project (WGP).

1.1 Purpose

The purpose of this procedure is to identify the potential direct and indirect impacts on groundwater flows and/or quality and develop management/monitoring measures that maximise the ongoing protection of groundwater dependent systems to be retained from disturbance within and adjacent to the WGP.

1.2 Scope

This procedure applies to all Calidus controlled sites and their activities, employees, contractors and visitors, and is subject to the requirements of the Calidus Health, Safety and Environment (HSE) Standards and applicable environmental legislation.

1.3 Context

The environmental risks associated with groundwater management at the WGP include:

- Groundwater abstraction for mine dewatering and water supply;
- Groundwater abstraction drawdown resulting in impacts to groundwater dependent ecosystems;
- Groundwater drawdown and alteration of hydrological processes as a result of mine dewatering and water supply abstraction;
- Altered hydrogeology and water balance associated with the creation of permanent and episodic mining void water bodies.

1.4 Definitions

Term	Definition
Aquifer	A saturated geological unit that is permeable enough to yield economic quantities of water
Aquitard	A geological unit that is permeable enough to transmit water but not sufficient to yield economic quantities
Drawdown	The change in hydraulic head observed at a well in an aquifer typically due to pumping
Hydraulic Conductivity	The volume of water that will flow in a time unit under a hydraulic gradient through a unit area. Analogous to the permeability with respect to fresh water

2 Responsibilities

All Calidus employees and contractors are required to comply with the requirements of this procedure.

Accountability for fulfilling the requirements of this procedure is dependent on the stage of Project development (exploration, construction, operations, decommissioning).

During exploration, the Exploration Manager will be accountable for ensuring the requirements of the procedure are met.

During construction stages, whether activities are undertaken by an external service provider or internal Calidus personnel, the Project Manager / Registered Manager will be accountable for ensuring the requirements of this procedure are met.

During operational, decommissioning and closure stages, the General Manager (Registered Manager) will be accountable for ensuring the requirements of this procedure are met

Table 1: Responsibilities

Role	Responsibility
Exploration Manager/ Project Manager / Registered Manager/ General Manager	Accountable for ensuring the requirements of the procedure are met dependent on the stage of project development.
Senior Environmental Advisor	Implement and maintain the Groundwater Management Procedure Review the Groundwater Management Procedures Annual Audit of Compliance. Organised the review and update, of this surface water management procedure annually Deliver monitoring/reporting data to the appropriate regulatory authority

Role	Responsibility
Warrawoona Environmental Advisor	Implement monitoring programs. Maintain monitoring records. Implement and deliver awareness training programs to personnel, contactors and visitors.
Construction and Operation Managers	Endorse implementation of the surface water management procedures by Project personnel and contractors.
All personnel, contractors and visitors	Participate in awareness training prior to commencing duties. Implement Surface Water Management Procedures in daily activities, where relevant.

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3 Hydrogeology

The WGP is located along the Warrawoona range which forms a local surface water and groundwater divide, with fractured rock aquifers the most significant aquifers to develop in the project area.

Runoff from the range reports to the Brockman Hay Cutting/Sandy/Camel Creek system located to the south of the range and the Brockman Creek to the north. Groundwater recharge in the Klondyke area is likely to be significant but episodic and mostly as a result of cyclonic events. Recharge will likely be direct infiltration through exposed outcrop, with secondary infiltration through the base of the local creek systems during runoff events.

The WGP area has a number of intruded dolerite dykes of various sizes and orientations. The dykes may have enhanced permeability along their margins in some places.

A hydrogeological map of the WGP is shown in Figure 1.

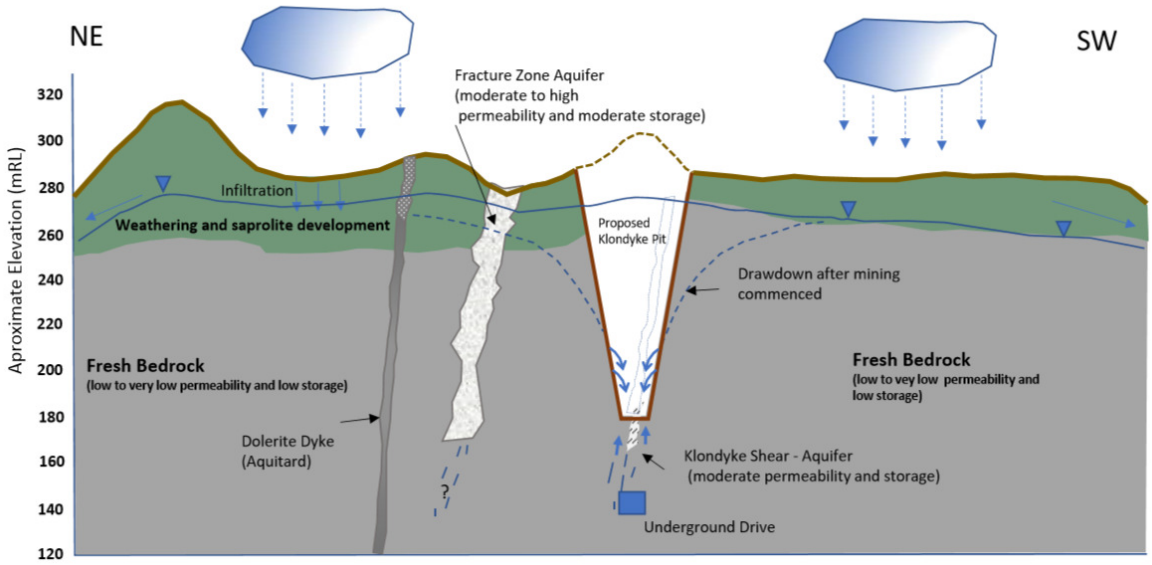

Figure 1 - Local Hydrology

3.1 Baseline Modelling

Initial groundwater studies have been completed for the WGP. The studies involved field investigations, data analysis, numerical groundwater flow modelling and separate post-closure modelling for the Klondyke pit lake recovery.

The groundwater quality in the project area is fresh to slightly brackish and slightly alkaline. Dissolved metal concentrations in the groundwater were generally low apart from arsenic and iron. Arsenic was above the Australian Drinking Water Guideline (ANZECC,2000) for human consumption, however the concentrations were below the Australian Drinking Water Guideline (ANZECC,2000) limits for livestock watering in all samples analysed.

The key findings of the hydrogeological assessment are as follows:

- Groundwater inflows will potentially range from 20-35L/s after the first few months of mining up until around mid-way through year 5;
- From about mid Year 5 until the end of mining, combined open pit and underground mine dewatering rates could potentially increase up to around 50L/s;
- At the end of mining (currently anticipated to be around 6 years), the drawdown impact could extend up to around 4km northwest and southeast along the strike of the Warrawoona Range, and around 3km laterally to the northeast and southwest from Klondyke. However given the frequency of large seasonal recharge events, it is likely the final drawdown impact will be smaller than that predicted;
- Mine dewatering will develop a strong local hydraulic gradient towards the Klondyke pit over time, such that any potential seepage from the TSF, which reaches the water table will migrate towards it;
- Post closure, the Klondyke pit will form a groundwater sink for the 100 years modelled;
- At the end of project mining the historic Klondyke Queen, Dawson City and Criterion workings could have dewatered. However the Bow Bells underground workings should still have a significant saturated thickness (Section 3.3).

The WGP groundwater model will be recalibrated after 12 months of project operation when significant pumping and monitoring data are available. The recalibrated flow model can then assist Calidus with development of an adaptive management plan.

3.2 Post Closure Modelling

The final mined depth will be well below the ambient groundwater level. At mine closure pumping will cease and the groundwater level will recover forming a pit lake.

Pit Lake modelling was undertaken which showed that the Klondyke pit will remain a local groundwater sink over the 100 year predictive period, with the pit lake level remaining well below the average groundwater level, with no discharge of lake water to the surrounding groundwater environment. This is important as the current site closure plan proposes that runoff from the waste rock dump be directed into the pit post closure.

3.3 Bat Roost Impacts

Dewatering of the Klondyke mine will depress the local groundwater level in the historic Klondyke Queen workings, a known Ghost Bat maternity roost and a permanent diurnal roost for Pilbara Leaf Nose Bats. The maternity roost for Pilbara Leaf nosed Bats in the region is located at Bow Bells south (Biologic, 2019a).

The Klondyke Queen workings will likely fully dewater within two years of the commencement of mining. Modelling suggests the Klondyke Queen workings may not begin to re-saturate for at least a decade after mine closure.

The diurnal bat roosts identified in the project area are shown in relation to the model predicted drawdowns at the end of Klondyke mining in Figure 2. This shows that at the end of mining, water tables may have propagated along the Warrawoona Range from Klondyke to impact all of the diurnal bat roosts. However, given the frequency of large seasonal recharge events, it is likely

the final drawdown impact will be smaller than that predicted and the groundwater model will be recalibrated after 12 months of project operation and annually thereafter when pumping and monitoring data are available.

Based on plans of the historic mine workings at Bow Bells, the underground could extend 30m or more below the current water table. Therefore, if drawdown impacts result from Klondyke mine dewatering the majority of the Bow Bells underground workings are predicted to remain saturated.

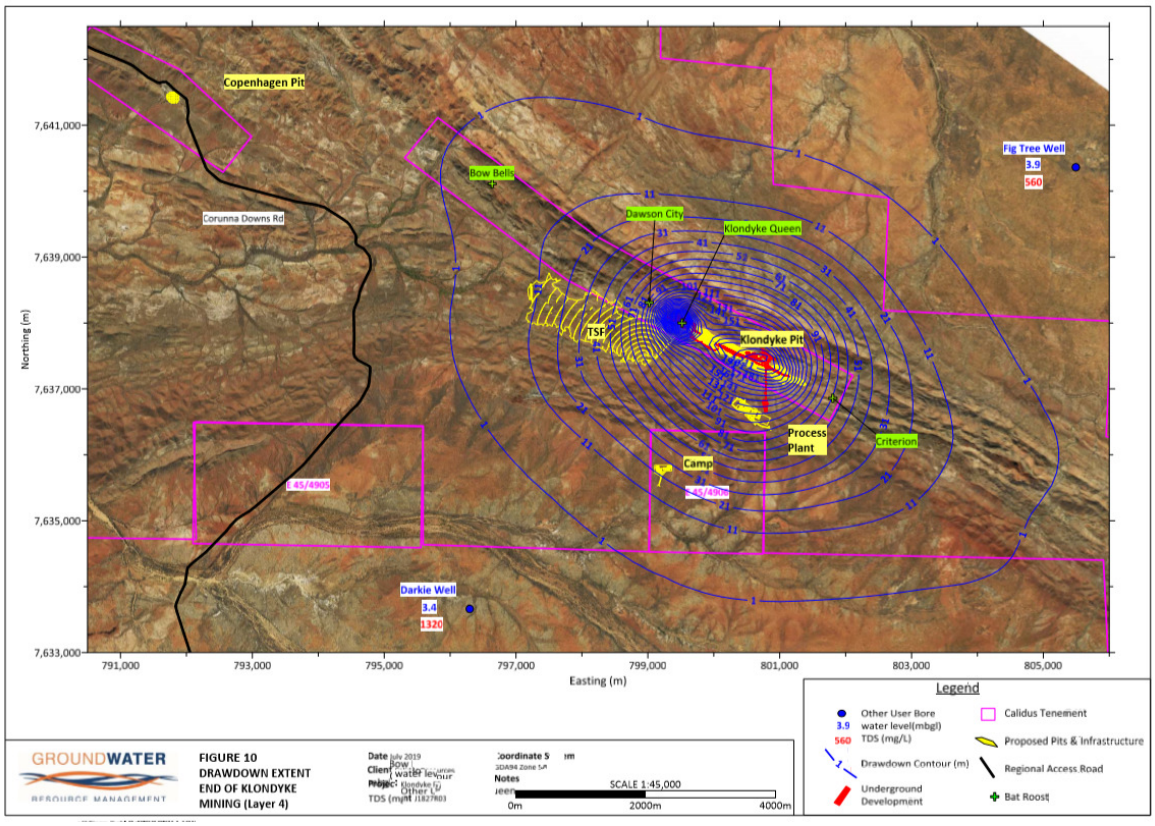

Figure 2 - Drawdown extent and local Bat Roosts

This is important in the context of the impact on the respective Bat Roosts. Firstly, dewatering the Klondyke Queen is not anticipated to impact the Ghost Bat colony In the Pilbara, Ghost bats have been recorded roosting and reproducing in caves that have low humidity levels (R. Bullen pers comm). Further, at both Klondyke Queen and Comet mines and elsewhere, large numbers of Ghost bats have been observed roosting in chambers well above and not directly connected to the water table with close to ambient conditions present (R. Bullen pers comm).

However, as the Pilbara Leaf-nosed Bat is dependent on humid microclimates (Baudinette et al. 2000) this may lead to the Pilbara Leaf-nosed Bat abandoning the non-permanent diurnal roost inside the Klondyke Queen workings and returning the main permanent maternity roost at Bow Bells South. This will not be a significant impact to the species as the monitoring has found that the main Pilbara Leaf-nosed Bat roost proximal to the Warrawoona Gold Project is Bow Bells (Biologic 2019a).

Calidus will install a regional groundwater monitoring bore between the Klondyke Pit and the Bow Bells workings to monitor long-term groundwater trends, and any drawdown impacts from Klondyke dewatering and regional water supply.

There will be no production bores proximal to the Bow Bells South location.

3.4 Subterranean Habitat Connectivity

From Biologic (2019b)

The Klondyke shear which strikes northwest through the centre of the deposit provides a zone of preferential flow and permeability (fractured rock habitats), which is the most likely habitat for troglofauna in the area of the deposit. The Klondyke shear zone runs for approximately 40 km throughout and beyond the Klondyke deposit to the north, north-west and south-east. The Klondyke shear is paralleled by several other shears, including the St. George and Coronation shears.

Hydrological testing showed that at least two vertical fracture zones and faults cross the Klondyke Shear within and near the deposit although it is very likely that they are more numerous throughout the area. Such fracture zones and faults support enhanced permeability and are likely to comprise highly suitable habitat for troglofauna. Therefore, it is likely that a network of habitable rock fractures may occur to the north, north-west and south-east of the proposed pit via the Klondyke shear, and into the west via transverse/vertical fractures and faults. Potential connectivity between fractured rock habitats and superficial detrital habitats may also occur in the vicinity of weathered saprolite valley fill and alluvials near drainage lines.

Suitable hydrogeological habitat for stygofauna at Klondyke comprises fractured rock aquifers which have developed within the Klondyke shear zone throughout the proposed pit and beyond. These moderately to highly permeable aquifers are constrained by massive/fresh geologies with very low porosity. The fractured rock aquifers extend beyond the Study Area to the west along fracture zones and faults, potentially connecting to a network of other fractured rock aquifers to the north, north-west and south-east throughout the Klondyke shear zone.

Overall, the current geological and hydrogeological information suggests that the potential habitats for troglofauna and stygofauna species found in the proposed Klondyke pit are likely to extend beyond the pit boundaries, particularly to the north, north-west and south-east via shear zones and to the west via faults and fractures.

3.5 Water Licensing

A licence to construct and test up to eight groundwater production bores was granted to Calidus on 5th March 2019 by DWER and is valid for two years. Calidus intends on constructing the bores in H1 2020 and then applying for the abstraction licence.

It is likely that around six to eight groundwater production bores (including mine dewatering bores) may be required to meet the water demands for the WGP in the early years of mining.

4 Groundwater Monitoring

A set of preliminary monitoring parameters have been selected to provide broad coverage of different mining related impacts and it is anticipated that monitoring procedures will be refined over the life of the mine and into closure.

Monitoring will utilise baseline/ambient water quality as the guidelines for trigger values and will be applied at ground water monitoring points specified in this procedure. The monitoring will utilise baseline/ambient water quality as the guidelines for trigger values. Where these trigger values are exceeded an investigation will be undertaken and remedial action initiated.

The monitoring program will be adaptive, dependent on flow events and the quality and quantity of data collected with innovations in monitoring techniques and methodologies incorporated into program design over time.

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Field Analysis

Field Analysis will comprise field instrument measurement of physicochemical properties (EC, pH, DO, temperature and salinity).

Hydrochemistry

The following general groups of water quality parameters will be measured at WCP groundwater monitoring sites,:

- major cations;
- major anions;
- nutrients (Camp WWTP);
- metals and metalloids; and
- Total and WAD Cyanide (TSF sampling areas – as per Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19) and
- hydrocarbons (process plant, landfill, bioremediation areas only).

Water sampling to be conducted as per:

- Groundwater sampling should be conducted in accordance with the requirements of AS/NZS 5667.11:1998 Water Quality – Sampling - Guidance on Sampling of Groundwater
- Laboratory analysis to occur at an appropriate NATA accredited laboratory.

The objectives of the groundwater monitoring programme is to:

- Determine whether the levels and water quality in groundwater dependent systems potentially impacted by operational activities are significantly different from baseline modelling;

- Monitor and measure the success of management measures to inform an adaptive management approach.

Baseline and operational monitoring will be informed by the findings of the monitoring itself as they become available. These findings may similarly lead to ongoing refinements to this procedure and its management strategies to ensure an adaptive management approach is undertaken.

4.1 Groundwater Monitoring Network

Table 2: Monitoring Summary

Area / Aspect	Location	Parameter	Collection Method	Frequency	Comment
Rainfall	Upper Reaches of catchments	Rainfall	Rain Gauge	Event based	
TSF	Down Gradient	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	Refer to Cyanide Monitoring Procedure (CRL-ENV-PRO-019-19)
Camp	WWTP on-site irrigation area	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	Refer to WWTP Management Plan (CRL-ENV-PLN-002-19).
Plant	Select bores near bulk Fuel Farm	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	Refer to WWTP Management Plan (CRL-ENV-PLN-002-19).
Pit	Pit Dewatering Monitoring Bores	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	Field measurement and Laboratory Analysis) Quarterly	
St George Pits (Back fill area for NAZ waste)	Down Gradient	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	Field measurement and Laboratory Analysis) Quarterly	Refer Metalliferous Drainage Plan (CRL-ENV-PLN-005-19).

Area / Aspect	Location	Parameter	Collection Method	Frequency	Comment
Abstraction	Monitoring Bores associated with bore field within development Envelope	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	
Land Fill	Development Envelope	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	
Bioremediation Area	Klondyke Waste Rock Dump	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	As per DWER Licence likely quarterly Field measurement and Laboratory Analysis)	
Waste Dump	Select bores near Klondyke and Copenhagen WRD	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	Field measurement and Laboratory Analysis) Quarterly	
Significant Bat Roosts (Klondyke Queen and Bow Bells)	In between Klondyke and Bow Bells	Water Quality and level	Field measurement using calibrated instrument and hydrochemistry laboratory analysis	Field measurement and Laboratory Analysis) Quarterly	Refer CRL-ENV-PLN-006-19 Significant Species Management Plan
Klondyke Queen Shaft	Adjacent to the KQ shaft	Level	Field measurement using calibrated instrument	Quarterly	As above

Table 3: Monitoring Parameters and Methods

Monitoring Parameter	Method
Rainfall	Gauge
Hydrochemistry	Sample Collection (Field/Analysis (Lab)

Monitoring Parameter	Method
Field EC and pH	Water quality metre (field)
Water Levels	Water level indicator (field)

4.2 Adaptive Management

Calidus will implement adaptive management practices to learn from the implementation of mitigation measures, monitoring and evaluation against management targets, to more effectively meet any conditioned environmental objective.

The WGP groundwater flow model will be recalibrated after 12 months of project operation when pumping and monitoring data are available. The recalibrated flow model can then assist Calidus with development of an adaptive management plan.

5 Reporting

Monitoring reports will be provided to the State and Commonwealth Governments as annual reporting requirements.

5.1 Annual Review

An Annual Monitoring Report will be developed with the results of the monitoring programs across the WGP. This report will outline the monitoring data captured during the reporting period and the analysis required to report compliance against management targets and conditioned environmental objectives.

5.2 Annual Environment Monitoring Report

An Annual Monitoring Report will be developed with the results of the monitoring programs across the WGP. This report will outline the monitoring data captured during the reporting period and the analysis required to report compliance against management targets and conditioned environmental objectives.

6 Related Documentation:

CRL-ENV-PRO-006-19 Bioremediation Management Procedure

CRL-ENV-PRO-004-19 Hydrocarbon Management Procedure

CRL-ENV-PRO-019-19 TSF and Cyanide Monitoring Procedure

CRL-ENV-PRO-022 -19 Metalliferous Drainage Procedure

CRL-ENV-PLN-002-19 Wastewater (WWTP) Management Plan

CRL-ENV-PRO-005-19 Hydrocarbon (and Chemical) Spill Management Procedure

CRL-ENV-PLN-006-19 Significant Species Management Plan

7 References

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment and Conservation Council (ANZECC) 2000.

Australian guidelines for water quality monitoring and reporting. National Water Quality Management Strategy paper No 7, Australian and New Zealand Environment and Conservation Council & Agriculture and Resource Management Council of Australia and New Zealand, Canberra.

Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) and Australian and New Zealand Environment and Conservation Council (ANZECC) 2000,

Baudinette, R.V., Churchill, S.K., Christian, K.A., Nelson, J.E. and Hudson, P.J. (2000) Energy, water balance and the roost microenvironment in three Australian cave-dwelling bats (Microchiroptera). Journal of Comparative Physiology 170, 439–446

Biologic (2019a). Warrawoona Gold Project: Conservation Significant Bat Species Impact Assessment

Biologic (2019b). Warrawoona Gold Project: Subterranean Fauna Study

Groundwater Resource Management (2019). Warrawoona Gold Project 2mtpa Pre-Feasibility Hydrogeological Investigations Report