Rustlers Roost and Quest 29 Open-Cut Mine Redevelopment

Draft Environmental Impact Statement (EIS)

Section 7.3 - Hydrological Processes

Prepared pursuant to the Environment Protection Act 2019

October 2021

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Key Project Terms

Term	Definition
Adaptive Management	Systematic process for incrementally improving management practices by learning from the outcomes of past and current practices.
Carbon in Leach	This process uses a dilute alkaline cyanide solution to leach (dissolve) gold from the ore material. Activated carbon removes gold out of dilute cyanide solution by adsorption (sticking). The leaching agent and activated carbon are added together in a slurry of ore and water.
Development Envelope	Defined as the maximum area within which the Project footprint could occur. The development envelope for the Project encompasses 790 ha, inclusive of Rustlers Roost, Quest 29, the accommodation camp and haul road.
Environmental Aspect	An element of the Primary Gold's activities, products or services that can interact with the environment.
Environmental Impact	Change to the environment whether adverse or beneficial, wholly or partially resulting from the Primary Gold's environmental aspects. Environmental impacts can be caused directly or indirectly from a Project activity or cumulatively with other non-Project related activities in a set area.
Environmental Factor	The NT EPA listed environmental objectives to identify environmental matters that have value to the Northern Territory and that need to be protected; and to state the objective to be achieved for each matter. The NT EPA has prepared these environmental objectives and organised these in structured divisions of the environment, called environmental factors.
Existing Disturbance Footprint	Defined as the direct disturbance area from known historical activities associated with the Rustlers Roost, Quest 29, accommodation camp and haul road areas. For Rustlers Roost and Quest 29 this is taken from the existing Mine Management Plans. The existing direct disturbance footprint encompasses 169.4ha within the development envelope.
Heap Leach Pad	Existing areas where historic mining placed ore for processing via a leaching solution to dissolve and capture the mineral. The pads contain the remaining material.
Maximum Vegetation Clearing Extent	The maximum extent of native vegetation clearing proposed for the Project based on mapped vegetation extent layers which account for historic anthropogenic disturbances to the development envelope (e.g. historic mining and pastoral activities). This area constitutes a total of 368.86 ha.
Project	The Project includes the expansion of existing pits, waste rock landforms, water storage dams and internal roads in both the Rustlers Roost and Quest 29 MLs. Two new pits will be constructed at Rustlers Roost and new infrastructure includes an onsite processing plant, a tailings storage facility, a landfill, laydown area, magazine, administration office, accommodation camp and groundwater bores for water supply. The Project is inclusive of an expanded connecting haul road between the non-contiguous extraction areas and an accommodation camp.
Project Area	The Project area is defined as wholly including ML1083 (Rustlers Roost), ML 29783 (Quest 29), ML 29814 (accommodation camp) and the connecting haul road. The entire Project area covers 1,143.25 ha.
Direct Disturbance Footprint	Defined as the direct disturbance area based on the current proposed infrastructure and material placement inclusive of Rustlers Roost, Quest 29, the accommodation camp and haul road. This area covers both historically disturbed and undisturbed areas. The disturbance footprint encompasses 532.84 ha within the Project area.
Significant Impact	A significant impact of an action is an impact of major consequence having regard to: (a) the context and intensity of the impact; and (b) the sensitivity, value and quality of the environment impacted on and the duration, magnitude and geographic extent of the impact.
Study Area	Refers to the area of survey or investigation for a specific study. This area may be beyond the Project area or development envelope.
Tailings Storage Facility	A specially engineered and constructed impoundment into which tailings (residue) from the ore processing plant is deposited for placement in perpetuity. The storage facility is constructed with confining embankments consisting of earthen material (e.g. rock and soil) and capped following closure.
Waste Rock Dump	An engineered and constructed impoundment into which overburden from the mining process is placed for safe storage in perpetuity.

Acronyms, Abbreviations and Units

Abbreviation, Acronym or Unit	Definition
$m	Million dollars
%	Percentage
+ve	Assessment of positive
µS	Microsiemens
4WD	Four-wheel drive
AADT	Average Annual Daily Traffic
AAS	Atomic Absorption Spectrophotometer
AAPA	Aboriginal Areas Protection Authority
AARL	Anglo American Research Laboratory
ABS	Australian Bureau of Statistics
AE	Aquatic Ecosystems
AEP	Annual Exceedance Probability
AFANT	Amateur Fishermen's Association of the Northern Territory
AHD	Australian Height Datum
ALA	Atlas of Living Australia
ALARP	As Low As Reasonably Practicable
AMD	Acid and Metalliferous Drainage
ANC	Acid Neutralising Capacity
ANCOLD	Australian National Committee on Large Dams
ANFO	Ammonium Nitrate
ANZG	Australia and New Zealand Government
ARI	Average Recurrence Interval
ARPANSA	Australian Radiation Protection and Nuclear Safety Agency
AS	Australian Standard
ASRIS	Australian Soil Resource Information System
ASX	Australian Stock Exchange
AS/NZS	Australian/New Zealand Standards
AUSRIVAS	Australian River Assessment System
BESS	Battery Energy Storage System
BoM	Bureau of Meteorology
BOO	Build-Own-Operate
BOOT	Build-Own-Operate-Transfer
Bq	Becquerel
BUD	Beneficial Use Declaration
CAD	Computer-Aided Design
CAPEX	Capital Expenditure
CCTV	Closed Circuit Television
CE	Community and Economy
CEO	Chief Operating Officer
CH_4	Methane

Abbreviation, Acronym or Unit	Definition
CIL	Carbon in Leach
CO_2	Carbon Dioxide
CO_2-e	Carbon Dioxide Equivalent
COPC	Contaminant of Potential Concern
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSL	Compact Soil Liner
CSM	Conceptual Site Model
C&D	Construction and Demolition
C&I	Commercial and Industrial
DAWE	Department of Agriculture, Water and Environment (Cth) (current)
DEPWS	Department of Environment, Parks and Water Security (NT) (current)
DGV	Default Guideline Value
DIDO	Drive-in Drive-out
DITT	Department of Industry, Tourism and Trade (NT) (current)
DIWA	Directory of Important Wetlands of Australia
DO	Dissolved Oxygen
DotE	Department of the Environment (Cth) (former)
DotEE	Department of the Environment and Energy (Cth) (former)
EC	Electrical Conductivity
EH&S	Environment, Health and Safety
EIS	Environmental Impact Statement
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Environment Protection Authority
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
EPL	Environment Protection Licence
EP Act	*Environment Protection Act 2019*
ERA	Energy Resources of Australia
ERP	Emergency Response Plan
ESCP	Erosion and Sediment Control Plan
ESD	Ecologically Sustainable Development
GDE	Groundwater Dependent Ecosystem
GGAP	Greenhouse Gas Abatement Plan
GHG	Greenhouse Gas
GJ	Gigajoule
GL	Gigalitre (1,000 Megalitres)
GPS	Global Positioning System
GRP	Gross Regional Product
GST	Goods and Services Tax
g/t	Grams Per Tonne
GV	Guideline Value
GWP	Global Warming Potential
ha	Hectare

Abbreviation, Acronym or Unit	Definition
HDPE	High Density Polyethylene
HEC-HMS	Hydrologic Modelling System
HFC	Hydrofluorocarbons
HP	Hydrological Processes
HSE	Health, Safety and Environment
IAP2	International Association for Public Participation
IBC	Intermediate Bulk Container
ID	Identification
IECA	International Erosion Control Association
IFC	International Finance Corporation
IPCC	Intergovernmental Panel on Climate Change
IPP	Independent Power Provider
ISO	International Organisation for Standardisation
IWEQ	Inland Water Environmental Quality
JORC	Joint Ore Reserve Committee
kL	Kilolitre
km	Kilometre
km^2	Square Kilometre
kV	Kilovolt
L	Litre
L/s	Litre Per Second
LED	Light Emitting Diode
LiDAR	Light Detection and Ranging
LNG	Liquefied Natural Gas
LOM	Life-of-Mine
LPG	Liquefied Petroleum Gas
M	Million
m	Metre
m^2	Metre squared
m^3	Cubic metre
mAHD	Metres Australian Height Datum
mBGL	Metres Below Ground Level
MCP	Mine Closure Plan
MEDLI	Model for Effluent Disposal Using Land
mg	Milligram
ML	Mining Lease (Granted)
MLA	Mining Lease Application
mm	Millimetre
MMP	Mining Management Plan
MNES	Matter of National Environmental Significance
MP	Management Plan
mRL	Metres Reduced Level
Mt	Million Tonnes

Abbreviation, Acronym or Unit	Definition
Mtpa	Million Tonnes Per Annum
MW	Megawatt
N_2O	Nitrous Oxide
NAF	Non-Acid Forming
NAPP	Net Acid Producing Potential
N/A	Not Applicable
NGER Act	*National Greenhouse Energy Reporting Act 2007*
NLC	Northern Land Council
NMD	Neutral Mine Drainage
NORM	Naturally Occurring Radioactive Material
NOI	Notice of Intent
NO_2	Nitrogen Dioxide
NSESD	National Strategy for Ecologically Sustainable Development
NT	Northern Territory
NTG	Northern Territory Government
NTU	Nephelometric Turbidity Unit
NT Act	*Native Title Act 1993*
NVIS	National Vegetation Information System
OPEX	Operational Expenditure
PAF	Potentially Acid Forming
PASS	Potential Acid Sulfate Soil
PER	Public Environmental Report
PET	Plecoptera, Ephemeroptera and Trichoptera
PFC	Perfluorocarbon
PGO	Primary Gold Limited, a wholly owned subsidiary of Hanking Australia Investment Pty Ltd
PMF	Probable Maximum Flood
PMLU	Post Mining Land Use
PMST	Protected Matter Search Tool
PPL	Perpetual Pastoral Lease
Q	Quarter
RL	Reduced Level
RMP	Risk Management Plan
RO	Reverse Osmosis
ROM	Run of Mine
RRMPL	Rustlers Roost Mining Pty Ltd
RSWL	Reduced Standing Water Level
SA	Statistical Area
SD	Saline Drainage
SDS	Safety Data Sheet
SEP	Stakeholder Engagement Plan
SEIFA	Socio-Economic Indexes for Areas
SF_6	Sulfur Hexafluoride
SGV	Site-Specific Guideline Value

Abbreviation, Acronym or Unit	Definition
SIGNAL	Stream Invertebrate Grade Number – Average Level
SoBS	Site of Botanical Significance
SoCS	Site of Conservation Significance
SSAN	Security Sensitive Ammonium Nitrate
SSC	State Suburb Code
SSTV	Site-Specific Trigger Values
STP	Sewage Treatment Plant
SWGs	Stock Water Drinking Guidelines
SWL	Standing Water Level
t	Tonne
TAMS	Territory Asset Management Services
TARP	Trigger Action Response Plan
TBD	To Be Determined
TE	Terrestrial Ecosystems
TEC	Threatened Ecological Community
TEQ	Terrestrial Environmental Quality
Th	Thorium
TN	Total Nitrogen
ToR	Terms of Reference
TP	Total Phosphorus
TPWC Act	*Territory Parks and Wildlife Conservation Act 1976*
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
TSSC	Threatened Species Scientific Committee
U	Uranium
UC	Uncertain
V	Volt
UNESCO	United Nations Educational, Scientific and Cultural Organisation
UNFCCC	United Nations Framework Convention on Climate Change
WCD	Water Control District
WDL	Waste Discharge Licence
WMP	Water Management Plan
WONS	Weed of National Significance
WRD	Waste Rock Dump
WTP	Water Treatment Plant
WWTP	Wastewater Treatment Plant

7.3 Hydrological Processes

NT EPA Environmental Factor	Hydrological Processes
NT EPA Environmental Objective	*Protect the hydrological regimes of groundwater and surface water so that environmental values including ecological health, land uses and the welfare and amenity of people are maintained.*
Relevant Policy and Guidance	▪ Northern Territory Water Allocation Planning Framework (Policy) (Northern Territory Government 2020); ▪ Guidelines on the Consequence Categories for Dams (ANCOLD 2012); ▪ *Water Act 1992*; and ▪ Water Stewardship, Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016a).

7.3.1 Environmental Values – Surface Water

The Rustlers Roost site is located on a catchment divide (Figure 7-21). The eastern portion of surface water flows drain into the Mary River catchment via Mount Bundey Creek; and the western portion of flows drain into the Adelaide River via an unnamed tributary of Marrakai Creek.

The Rustlers Roost catchment is comprised of a series of ridges and dissected hills, which are drained by small steep rivulets. These systems converge into a single creek channel in the south-east of the site. The mining area has a small external catchment area of approximately 2.2 km^2.

The Quest 29 Project area is located on the boundary of two upper sub-catchments within the Mary River regional catchment. The main catchment encompasses two drainage lines flowing south through the site, converging into one drainage line that flows south-east off the tenement boundary and in an easterly direction towards the McKinlay River.

All waterways within the Project area are ephemeral. Flows are intermittent and occur in direct response to rainfall. Stream flows predominantly occur during the wet season months from late November (first-flush) to April (recessional flows), with sustained creek flows for approximately four months (December to March). There are no permanent pools located within the Project areas during the dry season; however, isolated pools remain during early dry season further downstream in the catchments. Catchment boundaries and drainage lines are shown in Figure 7-35.

7.3.1.1 Mount Bundey Creek

Surface hydrological regimes in Mount Bundey Creek are not significantly altered by any existing land use in the catchment, which is limited to pastoral grazing and the Mary River National Park. Past mining activities are unlikely to have significantly altered flows in any of the creeks downstream because those activities affect relatively small areas of land in the upper parts of the catchment that are a relatively minor contributor to stream flows.

A total of 66% (or 4.9 km^2) of the Rustlers Roost ML 1083 and all of the accommodation camp is located within the headwaters of the Mount Bundey Creek catchment. Approximately 3.5% (or 0.1 km^2) of Quest 29 ML 29783 (northern area heap leach infrastructure) drains north into Charlies Creek, a tributary of the upper Mount Bundey Creek, upstream of the Rustlers Roost portion of the Project area. The Project area covers 3.5% (or 5.8 km^2) of the total ~170 km^2 catchment area of the Mount Bundey Creek.

Mount Bundey Creek is currently used as stock drinking water during the wet season, and the wet season flows and dry season pools support riparian and aquatic ecosystems. The nearest permanent billabong thought capable of providing suitable habitat for aquatic fauna is situated approximately 4 km directly north-east of the Rustlers Roost Project area (Figure 7-42).

7.3.1.2 Marrakai Creek

A total of 34% (or 2.6 km^2) of Rustlers Roost ML 1083 (the western portion) is located within the headwaters of the Marrakai Creek catchment. The main ephemeral drainage line that receives surface water flows from the Project area has been dammed to create Annie's Dam, previously built as a pastoralist dam. The dam has a surface area of approximately 11 ha and without extraction, retains water throughout the dry season.

Surface water flows from this area, flow west into minor unnamed ephemeral drainage lines, which during the wet season flow into Marrakai Creek proper approximately 6 km downstream. Marrakai Creek discharges into the upper tidal reaches of the Adelaide River approximately 35 km downstream of the Project area.

7.3.1.3 McKinlay River

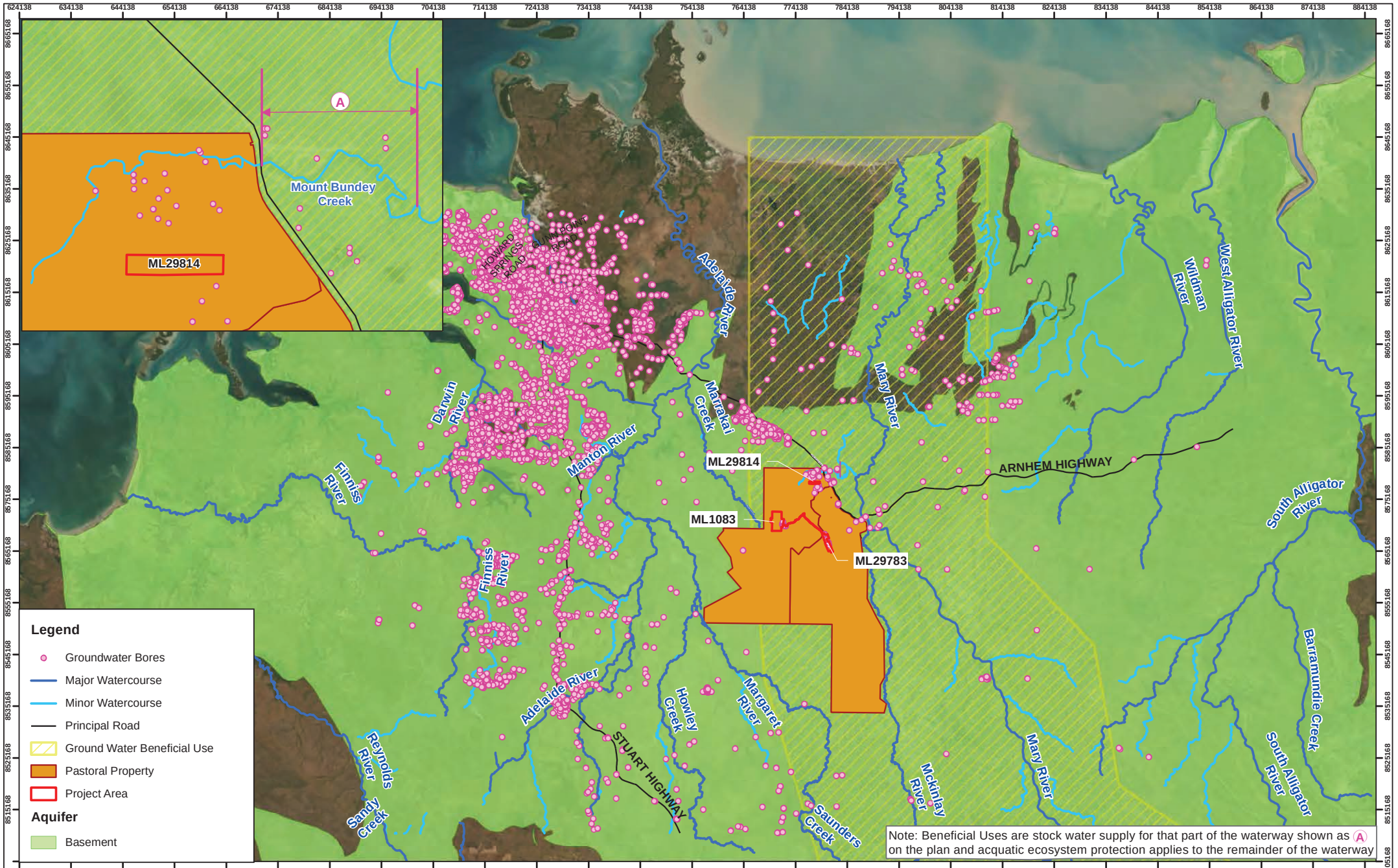
The remaining 96.5% (or 2.75 km^2) of the Quest 29 ML 29783 falls within the McKinlay River catchment. Unnamed ephemeral drainage lines downstream of the site discharge to the east through floodplains towards the McKinlay River main branch, which is approximately 15 km downstream of the Project area. From this location, the McKinlay River flows north and discharges into the Mary River.

7.3.1.4 Project Area Catchment Stream Flows

There are no stream flow data for the tributaries and relevant creeks in the Project area. However, a hydrologic model was developed for each of the catchments at Rustlers Roost and Quest 29 to assess baseline environmental flows and future flows by application of a climate change scenario with changed catchment conditions resulting from mining (Primary Gold 2021a, Primary Gold 2021b). Overall, there was little difference between the baseline discharge and the modelled future scenario discharge, as well as the baseline peak flow (Qp) and the modelled future mean flow for all connected catchments (Table 7-21).

Table 7-21 Rustlers Roost and Quest 29 Surface Water Catchments, Modelled Baseline, and Future Discharge

Catchment	Mean Baseline Annual Discharge (GL)	Mean Scenario Annual Discharge (GL)	Baseline Peak Flow (Qp) (m^3s^{-1})	Mean Scenario Peak Flow (Qp) (m^3s^{-1})
Rustlers Roost east (Mount Bundey Creek)	3.7	3.8	2.4	2.3
Rustlers Roost west (Marrakai Creek)	1.9	2.5	0.7	0.8
Quest 29 north (Mount Bundey Creek)	0.5	0.5	1.6	1.7
Quest 29 south (McKinlay River)	1.7	1.7	5.0	5.8



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1	Final	30/08/21
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DESIGNED	SS	CHECKED	TK
DRAWN	SS	CHECKED	TK
APPROVED	TK	DATE	30/08/21

Notes:

N

0 7,000 14,000 28,000

Meters

1 cm = 6,693 meters

GCS GDA 1994 MGA Zone 52

DATA SOURCE
NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 7-21

Regional Hydrogeological Features

DRG Ref: 1001087-EIS-07-7.35

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Chapter 7\Figure 7-35.mxd

7.3.1.5 Inundation and Flood Occurrence

There are no records of significant flood events within the Project area. Hydrodynamic flood models have been used to assess the potential occurrence and impacts of flood and inundation events at Rustlers Roost (CDM Smith 2019a, Appendix N).

Due to previous mining activities the catchment area has been highly disturbed. This led to numerous areas, especially in the eastern section around the WRD, being prone to shallow ponding (< 0.2m). Rainfall would be likely to pond at these locations for a short time before either seeping into the soil or evaporating away. Furthermore, there is reasonable separation between disturbed and undisturbed areas of the site. The Rustlers Roost pit void acts as a terminal sink for a large portion of the catchment, including the WRD and previous mine infrastructure area. In addition, the gullies to the west of the heap leach pad and ponds drain freely to the outlet (i.e. site boundary), separated from the disturbed areas by bunds. Overall the site is unlikely to be adversely affected by flooding, as the undisturbed sections are largely free draining, and the disturbed sections drain mostly to the pit.

7.3.1.6 Beneficial Uses

The Mary River regional catchment has declared 'beneficial uses' under the *Water Act 1992*. The Mary River beneficial uses declaration (BUD) covers Rustlers Roost (with the exception of the western catchment encompassing Annie's dam) and the Quest 29 Project area. The declared beneficial uses for the Mary River surface water catchment are environment, riparian and cultural. These uses rely on the maintenance of stream flows and good water quality. The potential impact of mining activity on declared beneficial uses is taken into consideration by the NT Government when making decisions in relation to project approvals.

The Project areas are not directly covered by the Mount Bundey Creek BUD. The BUD commences approximately 13 km downstream of the Project areas. The declared beneficial uses for Mount Bundey Creek are aquatic ecosystem protection (for the upper and lower creek sections), and stock water supply for the middle 7.8 km section of the creek (downstream of Toms Gully Mine east of the Arnhem Highway).

7.3.1.7 Surface water Users

The Project area is located on pastoral leases with existing pits and dams that may be accessed by stock and fauna for drinking water. Flows in watercourses or permanent waterholes downstream of the mine sites, may also be accessed by stock and fauna. There are no know direct surface water users within the 5 km radius of the Project area.

7.3.2 Environmental Values – Groundwater

Groundwater information available for the Project area is limited to regional-scale aquifer information available from Tickell 2019 and historical site-specific information from previous operators of Rustlers Roost, Valdora (1994) and Greenbase (1997). In general, the regional groundwater system comprises of intermediate-scale aquifers associated with unconsolidated sediments and local-scale aquifers associated with fractured and weathered rocks. The Project area is situated near the northern flank of the Pine Creek Geosyncline. Aquifers, where they occur, are typically associated with increased structural deformation of the metasediments.

Groundwater Enterprises (2020) was commissioned to prepare a groundwater investigation plan, including aquifer hydraulic properties testing, for the Project area. A network of groundwater monitoring bores, as recommended by Groundwater Enterprises (2020), was installed during October 2020. Baseline groundwater monitoring will be undertaken on these investigation bores, which will provide site-specific data on groundwater levels, flow directions, connectivity with surface water and water quality.

7.3.2.1 Rustlers Roost

Aquifers beneath the Rustlers Roost lease are associated with fracturing/structural permeability within the metasediments of the South Alligator Group and Burrell Creek Formation (Appendix H). These aquifers are mapped at a local scale (Tickell 2019). Regional data suggests typical bore yields in the Mount Bonnie Formation range from 0.5 – 2 L/s away from major structural features and 0.5 – 5 L/s along major faults or shear zones (Valdora 1994).

A potentiometric surface developed using surveyed water levels in mineral holes pre-mining in 1993, indicates the regional groundwater flow direction is towards the east/north-east and the Mary River with the local flow directions following the natural surface gradient (Valdora 1994). The aquifer response from a short-term (26 hour) pumping test completed prior to mining (Valdora 1994) showed, confined to semi- confined conditions with a transmissivity range of 71 – 107 m^2/day and a storativity range of 2 x 10^{-3} – 10^{-5}. Further investigations at the Rustlers Roost site reported a hydraulic conductivity range from 0.8 — 12.5 m/day with a geometric mean of 4.1 m/day (Appendix H).

NR Maps indicate that seven registered bores were drilled along the eastern boundary of ML 1083 for Valdora Mining during 1994. A bore search undertaken during 2016 could not locate any of the historical registered bores. Bore completion depths ranged from 61 to 86 m; SWL ranged between 11 to 23 metres below ground level (mBGL) and yield ranged from 1.5 L/s to 20 L/s. Desktop assessment of the groundwater by CDM Smith (2019b) identified one existing groundwater sampling point (MB1), located downstream of the heap leach pad. The MB1 bore is not a registered bore and there is no bore development report available. There are no other bores located within 5 km of the Rustlers Roost portion of the Project area.

Available records of groundwater level monitoring conducted between 2020 and early 2021 at Rustlers Roost are summarised in Table 7-22.

Table 7-22 Rustlers Roost Groundwater Levels

Bore ID	Lat	Long	Mean RSWL [mAHD]	Max RSWL [mAHD]	Min RSWL [mAHD]
RRMB01	-12.926872	131.500677	54.46	55.25	52.78
RRMB02	-12.928138	131.501481	51.85	53.73	49.95
RRMB03	-12.931479	131.492211	54.48	57.05	52.18
RRMB04	-12.923166	131.487615	55.39	57.51	53.18
RRMB05	-12.918846	131.49531	57.7	59.92	55.71
RRMB06	-12.915522	131.502737	56.48	58.69	54.61
RRMB07	-12.908878	131.498342	57.31	59.76	55.33
RRMB08	-12.903331	131.492669	51.47	54.96	49.4

Groundwater flow direction inferred from observations at Rustlers Roost is consistent with topographic relief indicated that the water table resemble a subdued representation of ground surface elevation.

7.3.2.2 Quest 29

Groundwater Enterprises (2020) indicates that there is limited groundwater information available onsite or in the immediate vicinity of the lease. Regional scale mapping suggests aquifers across the lease are local scale systems in fractured and weathered rocks with expected bore yields of 1-3 L/s in the metasediments and <0.75 L/s in the Mount Bundey Granite (Tickell 2019). Higher permeabilities are likely associated with structural deformation within the metasediments/dolerite (Sirocco 1999) and at local scale (Appendix H). Slug testing on site undertaken by Groundwater Enterprises (2020) has shown hydraulic conductivity ranges from 0.3 — 38.8 m/day with geometric mean of 5.2 m/day.

NR Maps records show four registered bores within the Quest 29 ML were historically drilled for mining purposes. Three of these bores (drilled in 1976) were not located during a bore audit undertaken in 2016. The fourth bore, drilled during 1999 for Sirocco Resources, was located immediately north-west of the existing heap leach ponds, and is monitored as part of the Quest 29 groundwater monitoring program (GWB01). Bore completion depths ranged from 17 to 27 m; SWL is artesian to 10 mBGL and yield ranged from 0.25 L/s to 10 L/s. An unregistered bore (GWB02) located to the south-west of the heap leach ponds is also included in the Quest 29 groundwater monitoring plan.

There are five registered bores within a 5 km radius of the Quest 29 portion of the Project area, all bores are associated with mining activities and are either historical investigation holes or monitoring sites. The closest registered bores not associated with mining is a pastoral bore (RN036401) located 6 km north-east of the lease (Appendix H).

Available records of groundwater level monitoring conducted between 2020 and early 2021 at Rustlers Roost are summarised in Table 7-23.

Table 7-23 Quest 29 Groundwater Levels

Bore ID	Lat	Long	Mean RSWL [mAHD]	Max RSWL [mAHD]	Min RSWL [mAHD]
Q29MB01	-12.93731	131.577287	68.91	71.65	66.65
Q29MB02	-12.939042	131.577692	68.9	71.69	66.61
Q29MB03	-12.962217	131.587492	31.93	33.32	30.43
Q29MB04	-12.957727	131.584775	36.06	37.24	34.7
Q29MB05	-12.954557	131.585617	44.38	45.07	43.8
Q29MB06	-12.952175	131.579835	46.14	48.62	44.53
Q29MB07	-12.949718	131.58156	49.09	50.61	47.48
Q29MB08	-12.940141	131.581646	78.97	82.75	76.43
Q29MB09	-12.936416	131.574607	62.81	64.17	61.55

There is no groundwater flow information available, however it is assumed to broadly reflect the topographic gradient and surface flows, flowing towards Charlies Creek in the north and the remainder of the site flowing south.

A number of shallow historic mining pits present at Quest 29 hold water from a combination of rainfall, surface water runoff and potentially groundwater.

7.3.2.3 Groundwater Interaction with Existing Mine Pits

Investigation has shown that the existing pit lakes at Rustlers Roost and Quest 29 may act as groundwater sinks or trough flow depending on location and depth of the pit (Appendix H):

- Rustlers Roost pit: Groundwater level observed at nearby RRMB05 (57.7 mAHD[13] on average) and RRMB06 (56.5 mAHD on average) were within one meter of the Rustler Roost pit lake water level (56.9 mAHD), indicating that the gradient between groundwater and surrounding aquifer is small. The behaviour of the pit lake is not clearly defined as a sink and may be behaving as a through flow with the

[13] Reference elevation for calculating the reduced standing water levels (RSWL) of the pits was sourced from the digital elevation model (DEM) with 0.5m uncertainty, assuming the datum point at the ground elevation.

lake receiving groundwater from the western side (RRMB05) and recharging the aquifer on the eastern side (RRMB06);

- Quest 29 Zamu pit: the lake level (37.5 mAHD) is standing approximately 7 m below Q29MB05 average groundwater level (44.4mAHD) and 1.4 m above Q29MB04 groundwater level (36.1 mAHD) suggesting that the pit lake may act as a through flow lake receiving groundwater from the northern side and losing to groundwater on the southern side. The pit is not bounded, and its catchment is not limited to the pit suggesting a larger runoff contribution than if the pit were bounded and pit catchment limited to the strict pit area;

- Quest 29 Taipan pit: the lake level (39 mAHD) is standing approximately 3 m above groundwater level at Q29MB04 (36.1 mAHD) suggesting that the pit lake is leaking to the groundwater aquifer at least on the north-east side of the pit. The pit lake may possibly be working also as a through flow lake as the higher ground elevation on the southern side may suggest higher groundwater level on this side;

- Quest 29 South Koolpin pit: the lake level (40 mAHD) is standing approximately 4 m above groundwater level at Q29MB04 (36.1 mAHD) suggesting infiltration on the southern end of the pit. Furthermore, higher ground surface elevation on the other sides of the pit also suggest likely groundwater seepage to the pit;

- Quest 29 North Koolpin pit: the lake level (52.50 mAHD) is standing above groundwater level at Q29MB07 (49.1 mAHD) and Q29MB06 (46.1 mAHD), suggesting that the lake is losing to groundwater. However, the location of the pit along a ridge may indicates that groundwater along the ridge may be flowing toward the pit; and

- Quest 20 BHS pit: the lake level (70.5 mAHD) is standing above the monitoring groundwater level at Q29B01 (68.9 mAHD) and Q29B02 (68.9 mAHD) suggesting that the pit lake is recharging the aquifer. The standing water level in the BHS pit may result from rainfall runoff across the catchment as the historical pit is not bunded.

7.3.2.4 Beneficial Uses

The Mary River groundwater management zone (encompassing the eastern portion of Rustlers Roost and the entirety of Quest 29) has declared 'beneficial uses' under the *Water Act 1992*. The defined beneficial uses are environment, riparian and agriculture.

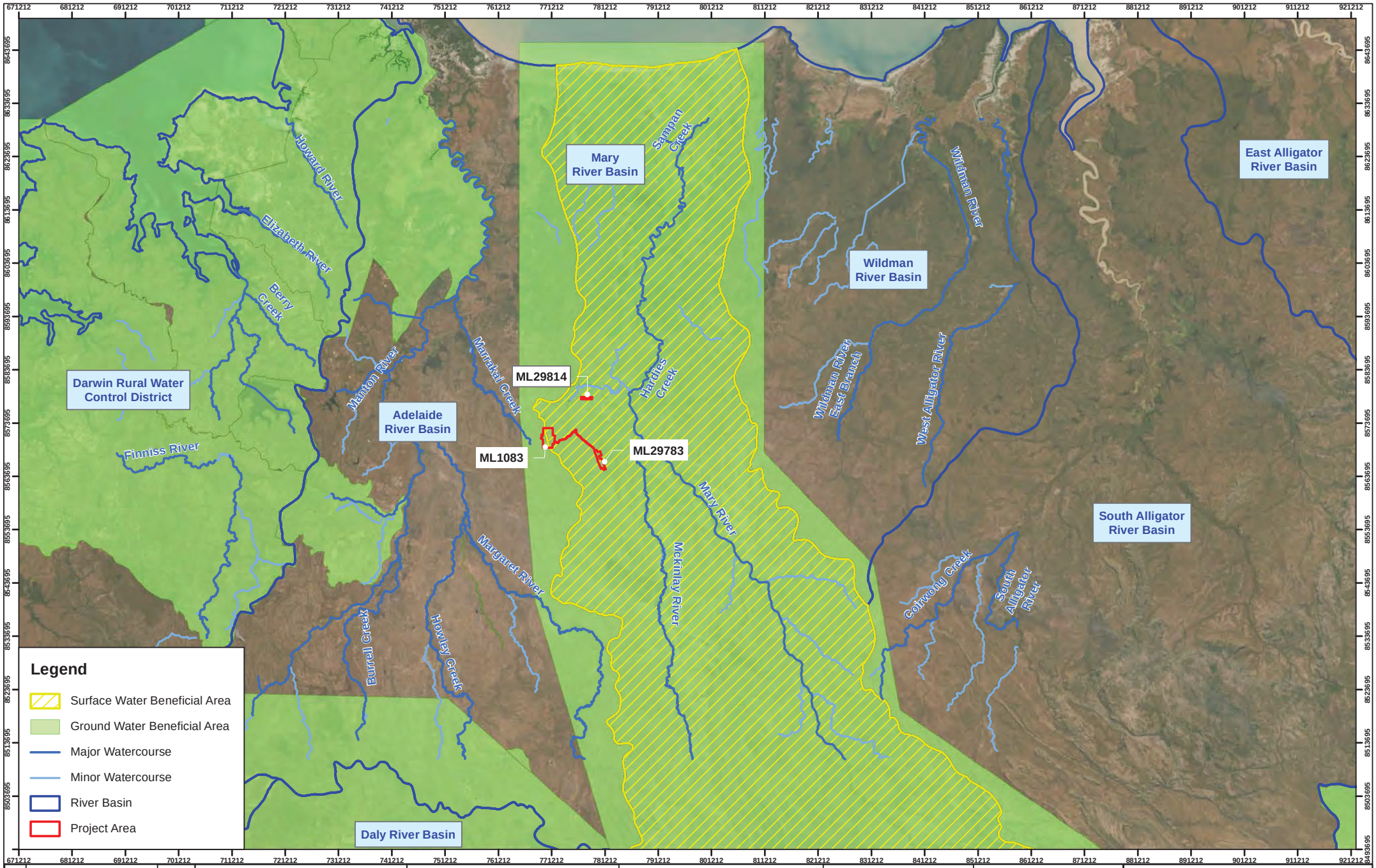
7.3.2.5 Groundwater Users

The nearest identified groundwater users include the Old Mount Bundey Station and quarry, Goanna Park and McKinlay River Station. All of these users are located greater than 5 km in distance from the Project area and therefore their groundwater supplies are unlikely to be affected by the Project activities.

7.3.2.6 Groundwater Dependent Ecosystems

There are no recorded GDE's within the Quest 29 Project area. The GDE atlas (BOM 2021) maps a low-moderate potential for terrestrial GDEs at two locations on ephemeral watercourses that drain north of the lease (ML 29783) between 2 km to 3 km downstream from the Project area (Appendix H).

There are no recorded GDE's within the Rustlers Roost Project area. The GDE atlas (BOM 2021) maps a moderate potential for terrestrial GDEs along watercourses that drain north of the Project area. These occur approximately 1 km to 2 km downstream from the Project area (Appendix H).



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APPROVED	TK	DATE	26/08/21

Notes:

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Meters

1 cm = 6,407 meters

GCS GDA 1994 MGA Zone 52

DISCLAIMER
CDM Smith has endeavoured to ensure accuracy and completeness of the data. CDM Smith assumes no legal liability or responsibility for any decisions or actions resulting from the information contained within this map.

DATA SOURCE
NT Government Open Source Data

DESIGNER

CDM Smith

CLIENT

PRIMARY GOLD

FIGURE 7-22

Mary River Groundwater and Surface Water Beneficial Use Areas

DRG Ref: 1001087-EIS-07-7.22

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7.3.3 Potential Impacts and Risks

This section identifies, describes, and assesses the potential impacts and risks to hydrological processes from disruption to the natural alignment of creek lines and drainage features, dewatering and groundwater abstraction to the water table and discharge of surface water from pit dewatering. The environmental risk assessment discussed in Section 6 and presented in Appendix B identified and considered potential sources of impacts to hydrological processes. A summary of the identified sources and the associated potential impacts is presented in Table 7-24.

Table 7-24 Potential sources of impacts to hydrological processes

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
HP-1	Vegetation clearing for the Project	Construction Operation	**Direct** - Disturbing an additional 333.4 ha of land for the Rustlers Roost, 26.16 ha for Quest 29, 7.3 ha for the accommodation camp and 2 ha for the haul road. Loss of 368.86 ha of habitat. Resulting in potential decreased infiltration during precipitation, increased runoff (quantities and velocities) resulting alterations to drainage line (including scouring and incising). Disruption to the natural alignment of creeks and streams reducing or presenting flows downstream. **Indirect or Cumulative** - Increased disturbance and lost productivity of surface water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and the nearby Mount Bundey Training Area. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation.
HP-2	Overtopping, embankment failure or seepage from the new TSF at Rustlers Roost leading to uncontrolled release of tailings material to surrounding environment.	Construction, Operation, Decommissioning or Closure	**Direct -** Direct alteration of the hydrological regime including potential influx that causes significant destruction to existing drainage lines on and off site. Potential for persistent alteration of the local groundwater regime through seepage and mounding. Potential alteration of the water table that would impact features of the natural environment that are reliant on existing conditions (e.g. GDEs). Impact on structural integrity of engineered embankments threatening additional failures and contaminant releases (e.g. adjacent decommissioned heap leach pad). Groundwater interaction with contaminants from TSF seepage. **Indirect or Cumulative -** Contribution of overtopping flows of embankment failures to discharges from Toms Gully Mine into the Mount Bundey catchment resulting in increased water levels, flooding of area typically not susceptible to inundation, higher watercourse velocities, scouring and downstream deposition. Negative implications on the riparian environment and capacity to naturally accommodate wet season events.
HP-3	Overtopping, embankment failure or seepage from the process water storage at Rustlers Roost	Operation, Decommissioning and Closure	**Direct -** Direct alteration of the hydrological regime including potential influx that causes significant destruction to existing drainage lines on and off site. Potential for persistent alteration of the local groundwater regime through seepage and mounding. Potential alteration of the water table that would impact features of the natural

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	leading to uncontrolled release of process water to surrounding environment.		environment that are reliant on existing conditions (e.g. GDEs). Impact on structural integrity of engineered embankments threatening additional failures and contaminant releases (e.g. adjacent decommissioned heap leach pad). Groundwater interaction with contaminants from process water storage dam. **Indirect or Cumulative -** Contribution of overtopping flows of embankment failures to discharges from Toms Gully Mine into the Mount Bundey catchment resulting in increased water levels, flooding of area typically not susceptible to inundation, higher watercourse velocities, scouring and downstream deposition. Negative implications on the riparian environment and capacity to naturally accommodate wet season events.
HP-4	Embankment failure or seepages from the new WRDs at Rustlers Roost and Quest 29 to surrounding environment.	Operation, Decommissioning and Closure	**Direct -** Direct alteration of the hydrological regime including potential influx that causes significant destruction to existing drainage lines on and off site. Potential for persistent alteration of the local groundwater regime through seepage and mounding. Potential alteration of the water table that would impact features of the natural environment that are reliant on existing conditions (e.g. GDEs). Impact on structural integrity of engineered embankments threatening additional failures and contaminant releases (e.g. adjacent decommissioned heap leach pad). Groundwater interaction with contaminants from WRDs. **Indirect or Cumulative -** Contribution of overtopping flows of embankment failures to discharges from Toms Gully Mine into the Mount Bundey catchment resulting in increased water levels, flooding of area typically not susceptible to inundation, higher watercourse velocities, scouring and downstream deposition. Negative implications on the riparian environment and capacity to naturally accommodate wet season events.
HP-5	Embankment failure of Annie's Dam water storage or process water ponds and uncontrolled water and sediment release.	Construction, Operation	**Direct -** Adverse impacts to Marrakai Creek including potential influx surface water that causes significant destruction to existing drainage lines on and off site. Direct disturbance of the hydrological regime of Marrakai Creek and alteration of the riparian environment. Localised severe scouring of the topsoils in the area surrounding the breach and exposure of subsoils to erosive factors which could lead to further impact to surface water features. Impact on structural integrity of engineered embankments. **Indirect or Cumulative** - Addition of affected drainage lines to the Adelaide River catchment contributing to minor but cumulative catchment runoff, higher watercourse velocities, scouring and downstream deposition. Potential contribution to the formation of anthropogenic induced depositions, damming and backflow lagoons downstream. This could result in inundation of areas not previously subject to flooding and thus alteration of ecological conditions in those areas.

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
HP-6	Groundwater drawdown.	Construction, Operation	**Direct -** Reduced water table elevation due to dewatering has the potential to reduce access to groundwater by riparian vegetation (including GDEs). Impact to any groundwater dependent ecosystems including aquatic ecosystems that are dependent on groundwater to provide dry season refugee. Potential change to surface water quality due to dewatering activity. **Indirect and Cumulative** - Cumulative drawdown of groundwater across three relatively close sites (Rustlers Roost, Quest 29 and Toms Gully) resulting in drawdown across the upper Mount Bundey Creek catchment. Potential to impact any localised GDE species and recharge of the local tributaries. Cumulative impacts could also occur with drawdown associated with nearby quarries. Potential increase in cumulative impact on groundwater level in conjunction with Toms Gully Mine and nearby quarries.
HP-7	Indiscriminate use of existing waste rock for construction. Storage of waste rock outside of pit footprint for too long.	Construction Operation Decommissioning Closure	**Direct** - Diversion of existing runoff pathways, whether this be overland flow within drainage lines. This would likely result in scouring and incision causing altered flow paths leading to loss of topsoil, sedimentation of waterways and altered upper-catchment hydrological regime. This would adversely affect the biological processes that depend on water quality. Groundwater interaction with contaminants from incorrect storage of waste rock. **Indirect or Cumulative** - Increased disturbance and lost productivity of surface water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and the nearby Mount Bundey Training Area. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation. Indirect biological and human health implications in the immediate location of the placement and areas subject to seepage or runoff.
HP-8	Pit and groundwater dewatering exposing PAF and causing AMD.	Construction Operation Decommissioning Closure	**Direct** - Reduction of onsite water quality and potential exceedance of SSTVs, if discharged. Adverse impacts on downstream water quality, aquatic environment, and downstream users. Groundwater interaction with PAF. **Indirect and Cumulative** - Potential transportation of PAF material, with potential to cause contamination, throughout the Project area and external. With specific relevance to hydrological processes this would have the potential to lead to dieback of riparian vegetation exposing sediments, reducing infiltration and waterway roughening, thus resulting in higher instream velocities, scouring and downstream sedimentation. Indirect biological and human health implications in the immediate location of the PAF material and areas subject to seepage or runoff.
HP-9	Planned pit over topping or release to surface water	Construction Operation	**Direct -** Contamination of surrounding water features and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	features during extreme rainfall and flooding events.		affecting the biological processes that depend on water quality (pyrite, pyrrhotite and arsenopyrite are expected to be present in tailings in quantities that will be Potentially Acid Forming). **Indirect and Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminant of concern being cyanide). Contamination of downstream environments resulting in human health risks that would necessitate the closure of watercourse to extraction of drinking water, recreation, and fishing.
HP-10	Unplanned pit overtopping or release to surface water features during extreme rainfall and flooding events.	Construction Operation Decommissioning Closure	**Direct** - Direct alteration of the hydrological regime including potential influx that causes significant destruction to existing drainage lines on and off site. Potential for persistent alteration of the local groundwater regime through seepage and mounding. Potential alteration of the water table that would impact features of the natural environment that are reliant on existing conditions (e.g. GDEs). Impact on structural integrity of engineered embankments threatening additional failures and contaminant releases (e.g. adjacent decommissioned heap leach pad). **Indirect or Cumulative -** Contribution of overtopping flows of embankment failures to discharges from Toms Gully Mine into the Mount Bundey catchment resulting in increased water levels, flooding of area typically not susceptible to inundation, higher watercourse velocities, scouring and downstream deposition. Negative implications on the riparian environment and capacity to naturally accommodate wet season events.
HP-11	Erosion of site infrastructure leading to sedimentation	Operation, Decommissioning Closure	**Direct** - Potential direct alteration of flow paths onsite and decreased structural integrity of the impacted infrastructure. Movement of soil or rock material from site infrastructure (e.g. WRD or TSF embankments) contributing to sedimentation and blockage of natural drainage lines leading to localised flooding and erosion. **Indirect or Cumulative** - Contribution to exposed ground in the Project area and general locality. Thus, contributions to the surface water runoff in the wider area.
HP-12	Release of hazardous chemicals or materials during storage and handling onsite.	Construction, Operation, Decommissioning	**Direct** - Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the riparian flora if the contaminants reach drainage lines and leading to vegetation dieback. **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation.
HP-13	Poor handling and management of	Operation, Decommissioning	**Direct** - Diversion of existing runoff pathways, whether this be overland flow within drainage lines. This would likely result in scouring and incision causing altered flow paths

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
	tailings and waste rock		leading to loss of topsoil, sedimentation of waterways and altered upper-catchment hydrological regime. This would adversely affect the biological processes that depend on water quality. Potential alteration of flow paths resulting in decreased structural integrity of the impacted infrastructure. Movement of soil or rock material from site infrastructure (e.g. WRD or TSF embankments) contributing to sedimentation and blockage of natural drainage lines leading to localised flooding and erosion. Groundwater interaction with contaminants from tailings and waste rock. **Indirect or Cumulative** - Increased disturbance and lost productivity of surface water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and the nearby Mount Bundey Training Area. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation. Indirect biological and human health implications in the immediate location of the placement and areas subject to seepage or runoff.
HP-14	Production of domestic waste and storage of the waste onsite	Construction, Operation, Decommissioning.	**Direct** - Contamination of surface water and groundwater in the area proximal to the domestic waste receptacle where inappropriate storage vessels and management is used. Alteration of water characteristics, including chemical, physical, biological and aesthetic qualities resulting in riparian or GDE impacts that impact hydrological processes (e.g. dieback of vegetation and increase scouring). **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation.
HP-15	Unfinished/ unsuccessful rehabilitation of Project due to inadequate funds or natural disaster (e.g. cyclone).	Construction, Operation, Decommissioning and Closure	**Direct** - Site not rehabilitated to required standards. Increased potential for offsite impacts from AMD, erosion and sedimentation. Degradation of water quality onsite and various forms of erosion (sheet, rill, wind etc.) transporting soils into water features, potentially resulting in sedimentation and backflows (afflux). **Indirect or Cumulative** - Potential transportation of contaminated sediments and material throughout the Project area and external. Biological and human health implications (primary contaminant of concern being cyanide). Contamination of downstream environments resulting in human health risks that would necessitate the closure of watercourse to extraction of drinking water, recreation and fishing. Given PGO is the same proponent for the nearby Toms Gully Mine project it would likely result in unfinished or unsuccessful rehabilitation at both sites. This would result in a large area of disturbed and unrehabilitated land in the Mount Bundey catchment cumulatively resulting in

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
			increased sediment loads to Mount Bundey Creek and the downstream Mary River.
HP-16	Long term positive water balance	Construction, Operation, Decommissioning and Closure	**Direct** - Potential build-up of water onsite and the need for long term treatment and constant discharges of water. Positive water balance could potentially mean surrounding areas (groundwater and surface water) are not receiving typical supply. This has potential to influence an imbalance of the local hydrological regime which could adversely impact ecological features such as GDEs. **Indirect and Cumulative** - Likely result in a constant requirement for ongoing discharges and a regular pulses of site water into the environment rather than a steadier flow that would occur in a natural system. This could indirectly result in scouring and degradation of drainage features that receive the discharged water.
HP-17	Inappropriate management of the decommissioned site, post closure landform.	Closure	**Direct** - Unauthorised access to the site by externals (including public, leaseholders and livestock) negatively affecting rehabilitation potential and contributing to rehabilitation failure. Potential scouring, soil erosion, loss of topsoil and sedimentation resulting in the alteration of on and off site drainage features. **Indirect or Cumulative** - Increased disturbance of soils in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and the nearby Mount Bundey Training Area, resulting in altered hydrological regime (primarily surface water) to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation.
HP-18	Ineffective operational implementation of site environmental management system, plans and procedures.	Construction, Operation, Decommissioning Closure	**Direct -** Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the riparian flora if the contaminants reach drainage lines and leading to vegetation dieback and scouring of surface water features. **Indirect or Cumulative** - Rehabilitation success is affected by inappropriate operational procedures which results in decreased likelihood of achieving rehabilitation goals and closure requirements following decommissioning. Agreed PMLU cannot be achieved due to significant environmental incidents resulting in widespread ongoing contamination of water features. Potential increase in cumulative concentration of sediments within the downstream watercourse as a result of any sediment discharged. Increased downstream depositions and siltation impacts.
HP-19	Inappropriate liquid and solid waste disposal.	Construction, Operation, Decommissioning Closure	**Direct -** Contamination of surface water and groundwater and alteration of water characteristics, including chemical, physical, biological and aesthetic qualities. Adversely affecting the riparian flora if the contaminants reach drainage lines and leading to vegetation dieback and scouring of surface water features. **Indirect or Cumulative** - Rehabilitation success is affected by inappropriate operational procedures which results in decreased likelihood of achieving rehabilitation goals and closure requirements following decommissioning. Agreed

Risk No.	Source of Impact	Project Phase(s)	Summary of Potential Impacts
			PMLU cannot be achieved due to significant environmental incidents resulting in widespread ongoing contamination of water features. Potential increase in cumulative concentration of sediments within the downstream watercourse as a result of any sediment discharged. Increased downstream depositions and siltation impacts.
HP-20	As part of closure and rehabilitation, creeks and drainage alignments are not consistent to the surrounding landforms and catchment area.	Closure	**Direct** - Diversion of existing runoff pathways, whether this be overland flow within drainage lines. This would likely result in scouring and incision causing altered flow paths leading to loss of topsoil, sedimentation of waterways and altered upper-catchment hydrological regime. This would adversely affect the biological processes that depend on water quality. **Indirect or Cumulative -** Increased disturbance and lost productivity of surface water features in the wider Mount Bundey locality coupled with disturbance at Toms Gully Mine and the nearby Mount Bundey Training Area. Resulting in reduced local capacity of surface water features to perform ecological functions and a cumulative increase in erosion contributing to waterway sedimentation. Indirect biological and human health implications in the immediate location of the placement and areas subject to seepage or runoff.

The following sections provide a summary of the potential key impacts on hydrological processes and considers the severity and extent of these impacts and implications for protection of environmental values.

7.3.3.1 Alteration of Surface Flow

To analyse environmental flows for all associated catchments under a post mining scenario, simulations were conducted under the following assumptions (Primary Gold 2021a, Primary Gold 2021b):

- Baseline condition as the site is represented today, using 100-year rainfall records from 1921 to 2021;
- Undisturbed condition for the future 100 year, used the same rainfall record with the climate change scenario applied to simulate the next 100 years; and
- Post-mining Hydrologic Modelling System (HEC-HMS) model with rainfalls as outlined in the second point to assess changes occurring to total flow and peak flow resulting from changed catchment conditions resulting from mining.

A summary of the modelled Project induced changes to surface flows are discussed in the following sub-sections.

Rustlers Roost East (Mount Bundey Creek)

Overall the simulation showed a decline of mean annual flow by 0.5 ML (10%) and decline of peak flow by 1.3 m^3s^{-1} (6.6%) under the climate change scenario in the post-mining landform. These losses are mainly due to refilling the pit over several decades post mining. While the TSF increases the post-mining catchment area, the modelled elevations have shown that the water level will not reach a spillway level that may contribute to downstream flows.

Rustlers Roost west (Marrakai Creek)

The simulated post-mining flow for the Marrakai Creek catchment has shown a decline of mean annual flow by 0.5 ML (38%) and decline of peak flow by 1.81 m^3s^{-1} (34%). As the modelled Marrakai Creek catchment domain is small and in the headwaters of the very large Adelaide River catchment, it is unlikely that these reductions will have an adverse impact on environmental flows further downstream.

Quest 29 north (Mount Bundey Creek)

The model has shown little difference for the mean annual flow and peak flow with a decline by 0.02 ML (1%) and decline by 0.08 m^3s^{-1} (1%), respectively. The small reduction has been attributed to the change of catchment size post-mine closure where the rehabilitated heap leach pad potentially drains into the Quest 29 south catchment.

Quest 29 South (McKinlay River)

The simulation for Quest 29 south showed a small decline of mean annual flow by 0.06 ML (1%) and rise in peak flow by 0.6 m^3s^{-1} (11%), potentially associated with the projected climate change.

Based on the hydrological analysis, the Rustlers Roost and Quest 29 sites are not likely to significantly impact surface water flows downstream in Mount Bundey Creek, Marrakai Creek or McKinlay River. This is because the Project area is located in the headwaters of upper catchment areas, where surface water inputs from the minor ephemeral drainage lines (stream one order) contribute a very small portion of the overall catchment flows. At Rustlers Roost, the proposed TSF footprint intersects a minor drainage line within the upper Mount Bundey Creek catchment and Annie's Dam intersects a minor drainage line within the upper Marrakai Creek catchment. At Quest 29, the most southern pits are sited over two minor drainage lines in the McKinlay River catchment.

Localised alteration of flows to the ephemeral drainage lines will occur associated with developing new mine infrastructure, dewatering of existing pit lakes and expansion of existing pits. Some of the direct rainfall into the Project area that under natural conditions would either seep into the ground or runoff into drainage lines, will be retained in pits or other structures on site, whilst 'clean' stormwater will be captured in sediment basins and discharged. This will result in reduced runoff occurring within the immediate sub-catchment and is not expected to have an impact on surface flows in the creeks and rivers downstream to the extent of impacting ecological functioning.

The water balance model has shown that excess water produced at Rustlers Roost Project area requires disposal during operation at a maximum dewatering rate of 950 l/s or a total of 30,000 ML and 420 l/s or a total of 6,000 ML for Quest 29 by the end of mining. Nearly 80% of the water required to be discharged will come from groundwater seepage, with the remaining 20% from direct rainfall into the pit and runoff from the pit faces. However, the water balance model had a high level of uncertainty regarding the actual dewatering volume, due to data paucity that would allow to infer hydraulic conductivity of the aquifers in the vicinity of the Project area. Previous field testing (aquifer slug tests) undertaken at the site resulted in a large range of values representing a few orders of magnitudes and there was also lack of data to support calibrating the model to constrain these values (Appendix H).

Discharge of excess water to Mount Bundey Creek from pit dewatering is not likely to be consequential due to the downstream Mary River Floodplain receiving large volumes of water during the wet season. The surface hydrological model for the Quest 29 catchment has shown a mean baseline environmental flow of 1,640 l/s for Mount Bundey Creek and 5,000 l/s for the McKinlay River tributary (Table 7-21). In contrast, the water balance model (Appendix H) has shown a maximum discharge rate from all pits at a maximum of 410 l/s, with a projected discharge rate well below 100 l/s for most of the time.

In summary, the analysis indicated that mining and the planned water management during dewatering will have little impact on downstream environmental flows. Information on discharge volumes from pit-dewatering is provided in the WMP (Appendix I). The water released will be a combination of intercepted surface flows, rainfall and groundwater dewatered from the open pits to allow for mining in accordance with the WDL.

7.3.3.2 Flooding

Positioned in the upper headwaters, the sites are unlikely to be impacted by flooding. Surface water flow is expected to peak and subside rapidly after rainfall events.

Flooding analysis by CDM Smith (2019a) found that (with the existing infrastructure) the Rustlers Roost site is unlikely to be affected by flooding, with the undisturbed sections largely free draining, and the disturbed sections draining mostly to the pit.

Flooding modelling developed by GHD (2019) for existing site infrastructure at Quest 29 concluded:

- The BHS pit, South Koolpin and North Koolpin pits are likely to be unaffected by flood inflow from the adjacent creeks for events up to and including the probable maximum flood (PMF) event;
- The heap leach pad and leach ponds are also unaffected by external flooding for events up to the 0.1% Annual Exceedance Probability (AEP) flood event;
- The Taipan pit and Zamu pit are flooded from external sources for all the events analysed, having been constructed on a drainage line; and
- Flow velocities are generally low around the pits, except at those locations where the pits are overtopped.

An additional hydrology and flood modelling assessment was completed to inform this Draft EIS (Appendix N). The modelling indicates that from a flood risk assessment standpoint, for a 1% AEP event there are flood risks, but these are not widespread (refer to Figure 7-23 and Figure 7-24). For a PMF scenario, there is a high risk in nearly every channel and around the Taipan pit, however appropriate post-mine safety bunding to 2 m is expected to ameliorate this. For the Rustlers Roost portion of the Project area there is little risk to humans due to direct rainfall and runoff from the mine site as access to the site is restricted and not open to the public. The broader area of the mine site is entered from the Arnhem Highway through fenced private property and through the quarry at Mount Bundey. All remaining water bodies will be bunded.

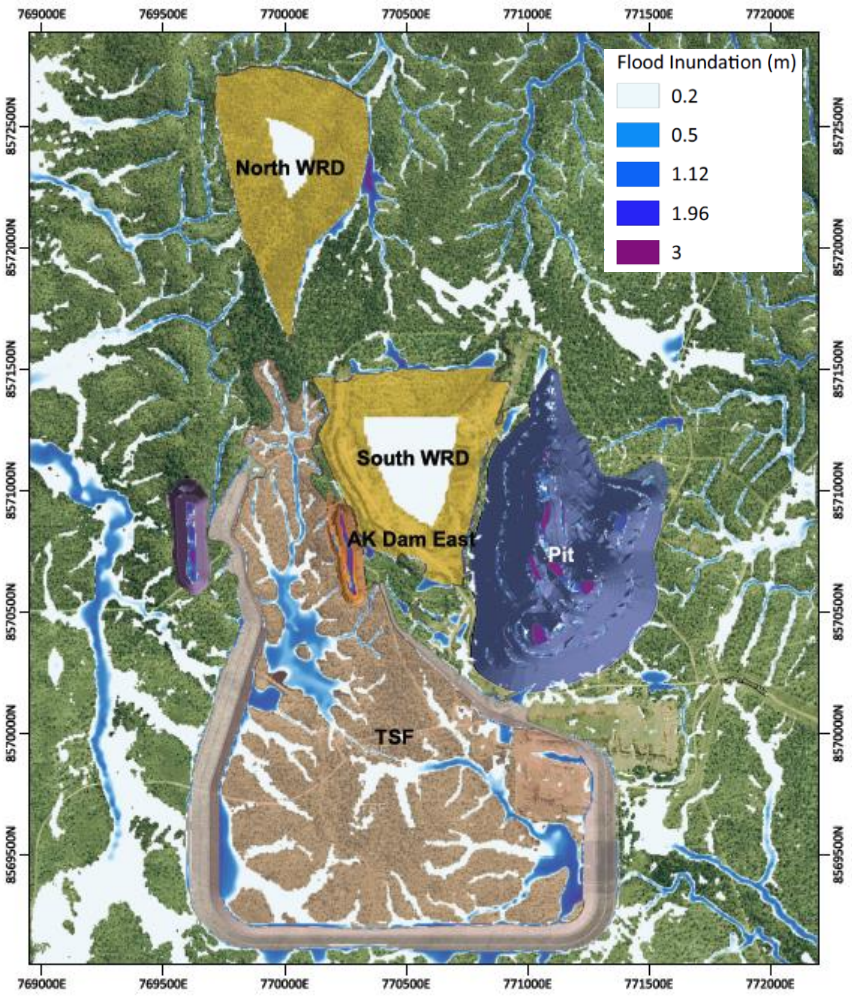


Figure 7-23 **Rustlers Roost 1% AEP Flood Inundation**

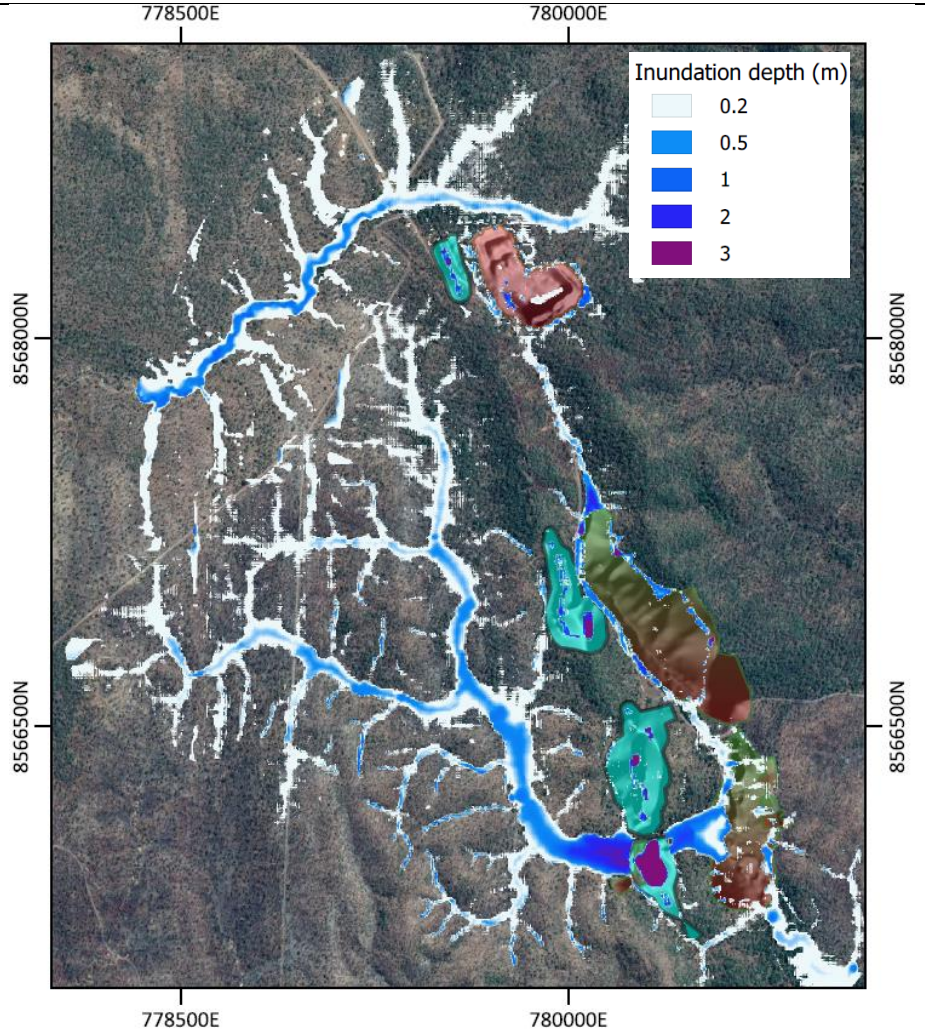


Figure 7-24 **Rustlers Roost 1% AEP Flood Inundation**

7.3.3.3 Drawdown of Groundwater Aquifers

A numerical groundwater model was developed to estimate the potential maximum drawdown induced by mining the pits at Rustlers Roost and Quest 29, and the potential groundwater inflows to the proposed mining pits. The model boundary in the regional setting is presented in Figure 7-25 and the model grid is shown in Figure 7-26. Refer to Appendix H for details of the model setup.

Dewatering of the mine pits during operations and extraction of groundwater as a water supply, has potential to drawdown the water levels in the groundwater aquifer. Typically, these types of activities can create a drawdown cone of depression that alters groundwater flows and lowers groundwater levels for some distance around the open pits and bores. Groundwater modelling has shown that the calculated 1 m drawdown from the pit dewatering may extends extend 5 km to the north and 3 km to the south of the Rustlers Roost pits, and 2 km to the south-west of the Quest 29 pits (Figure 7-27). The modelling also suggests that the probability of Marrakai Creek, Mary River and McKinlay River being impacted by drawdown from the mining is minimal (Appendix H).

Groundwater drawdown associated with the mining activities is unlikely to impact any other groundwater users as the closest user is over 5 km from the Project area, and therefore outside the modelled 1 m drawdown area. Desktop studies have not identified any GDE's in proximity to the site that would be affected by groundwater drawdown. As the level of connection between groundwater and surface water flows in the area is not yet determined, the extent to which any drawdown would impact surface water flows in ephemeral drainage lines is uncertain.

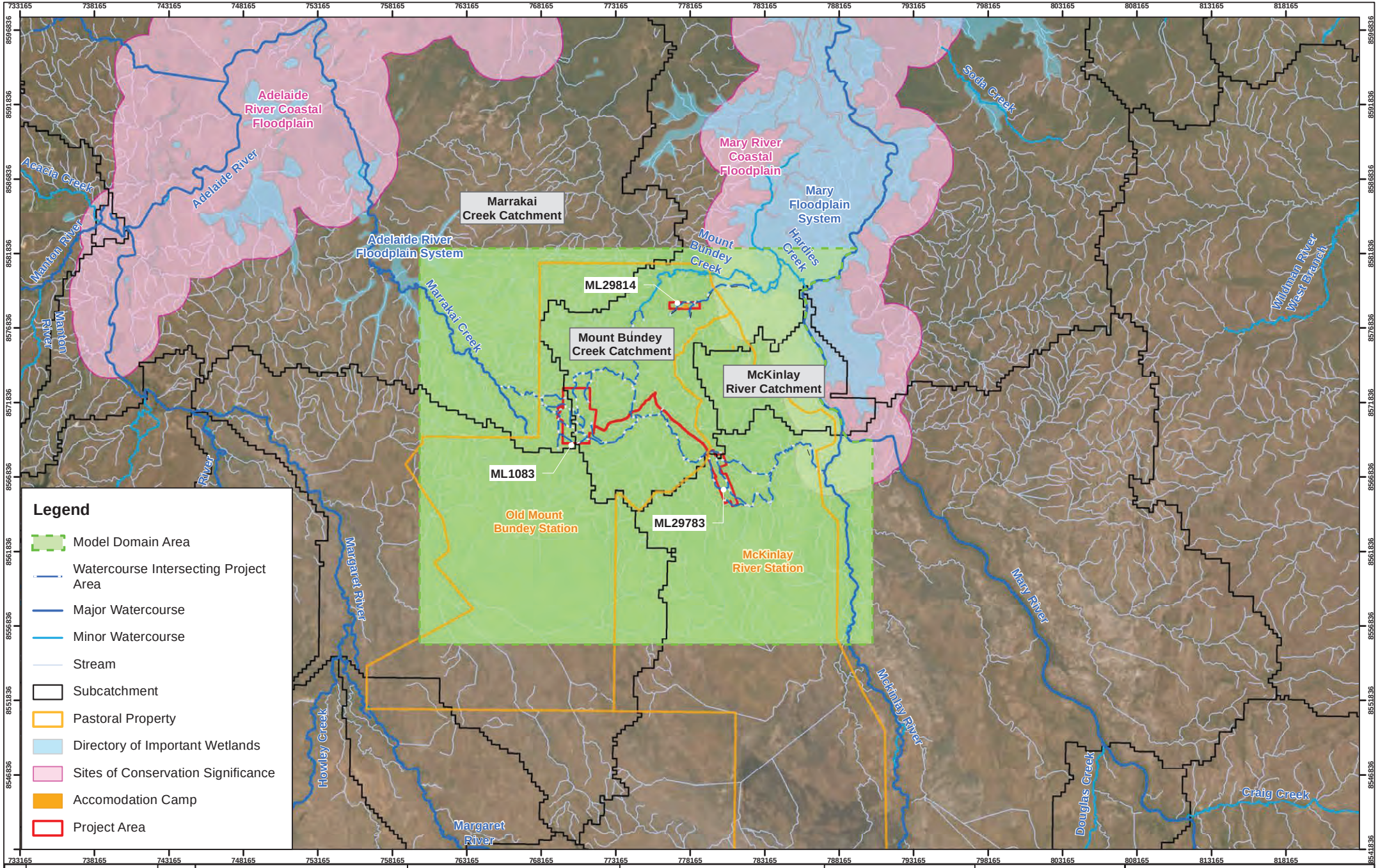
Groundwater recovery post-mining will be verified by groundwater modelling. Historic survey data of the pit shell was derived at the cessation of mining in 1997 and survey level data (mRL) sourced from a computer-aided design (CAD) file, and climate (rainfall and evaporation) data sourced from SILO data was used to develop a pit lake storage curve and pit surface area curve. The data shows, from an empty pit shell in 1997, a steep increase in water level (15 m over the initial 3-4 years), contributed to limited surface area for evaporation. A more gradual increase in water volume occurred with a larger pit lake surface area, reaching a dynamic equilibrium between 56 m AHD (3 GL) and 62 m AHD (4.5 GL). In addition, CDM Smith (2019b) determined that the pit lake acts as a hydraulic sink for a large portion of the disturbed catchment, meaning that the pit lake water evaporates faster than the influx of water (rainfall, runoff and groundwater ingress).

The plan to install investigative and monitoring bores, as well as utilising existing bores on the site will allow for continued refinement of the groundwater model. Continued refinement of the model will improve confidence in the extent and depth of drawdown, sustainable levels of extraction from bores, expected rates of groundwater recovery and surface-groundwater connections.

A site water balance model was developed to estimate the viability of the proposed WMP in its ability to prevent uncontrolled spills to the environment and to keep a dry working environment during mining phases and to evaluate the likelihood of overflowing of the pit lakes (Appendix H).

The output of the water balance model indicates that groundwater seepage is the biggest contributor to the water balance amounting to ~83% of all inflows. While there is a notable amount of uncertainty regarding the degree of groundwater inflow to be managed (i.e. 100 L/s to 600 L/s), monitoring of pit seepage during the initial phase of operation will significantly reduce this uncertainty. Water is planned to be released from the mine site and directed to Mounty Bundey or Marrakai Creeks at times when it cannot be stored or utilised onsite. Over the LOM, it is estimated that around 65 GL of water may be released between 2022 and 2031, which is well within the limits of environmental water flows for these water bodies.

Potential impacts from surface and groundwater contamination have been addressed in Section 7.4– Inland Water Environmental Quality.



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APPROVED	TK	DATE	25/08/21

Notes:

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DATA SOURCE
NT Government Open Source Data

DESIGNER CDM Smith

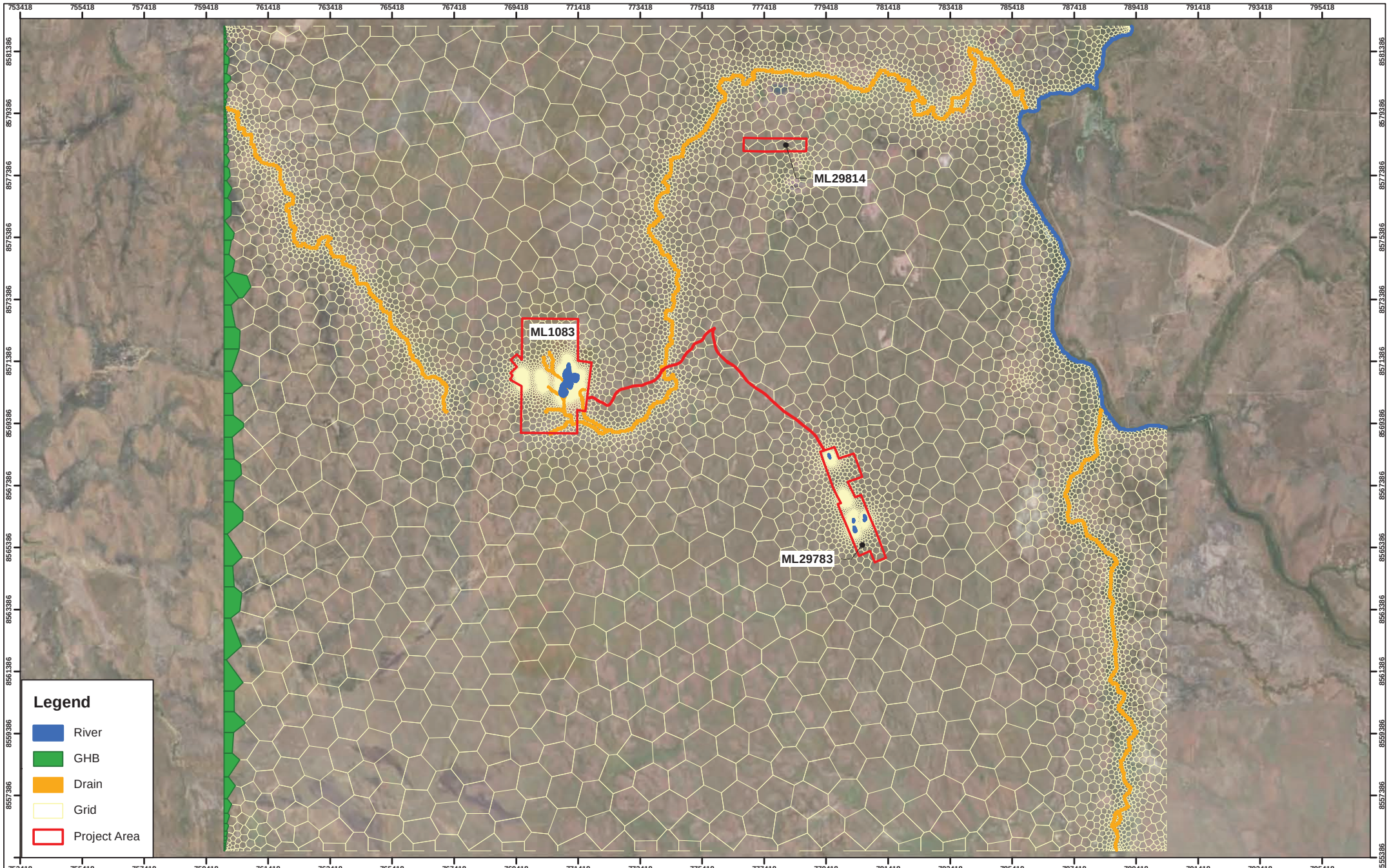
CLIENT PRIMARY GOLD

FIGURE 7-25

Regional Site Map and Groundwater Model Domain

DRG Ref: 1001087-WATERBAL-1.5

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Additional Section\Figure 1-5.mxd



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Notes:

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Meters

1 cm = 1,112 meters

GCS GDA 1994 MGA Zone 52

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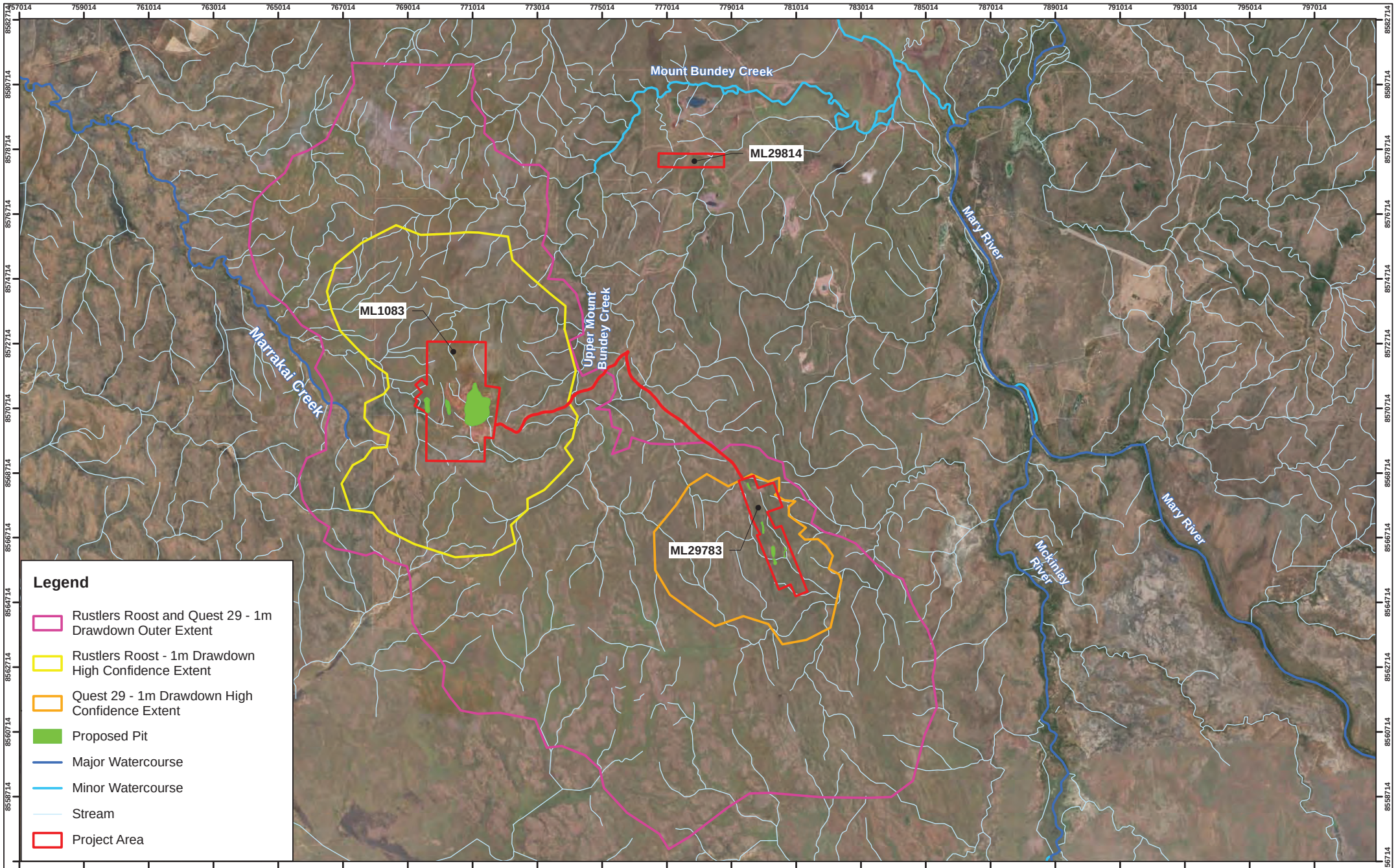
FIGURE 7-26

Groundwater Model Grid and Boundary Conditions

DRG Ref: 1001087-WATERBAL-1.7

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Additional Section\Figure 1-7.mxd



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APPROVED	TK	DATE	07/09/21

Notes:

N

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Meters

1 cm = 1,070 meters

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FIGURE 7-27

Groundwater Model Predicted Extents

DRG Ref: 1001087-EIS-07-7.27

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Chapter 7\Figure 7-38.mxd

7.3.3.4 Cumulative Impact

There are four active extractive industry operations and one approved, but not yet active, mining operation in proximity to the Project area. The construction and operation of the Project has the potential to incrementally alter environmental flows in a cumulative context with adjacent hydrologically connected projects.

To address the ToR requirement for this Draft EIS, an assessment of the cumulative impacts of the Project across four spatial scales has been conducted. The spatial scales of consideration are:

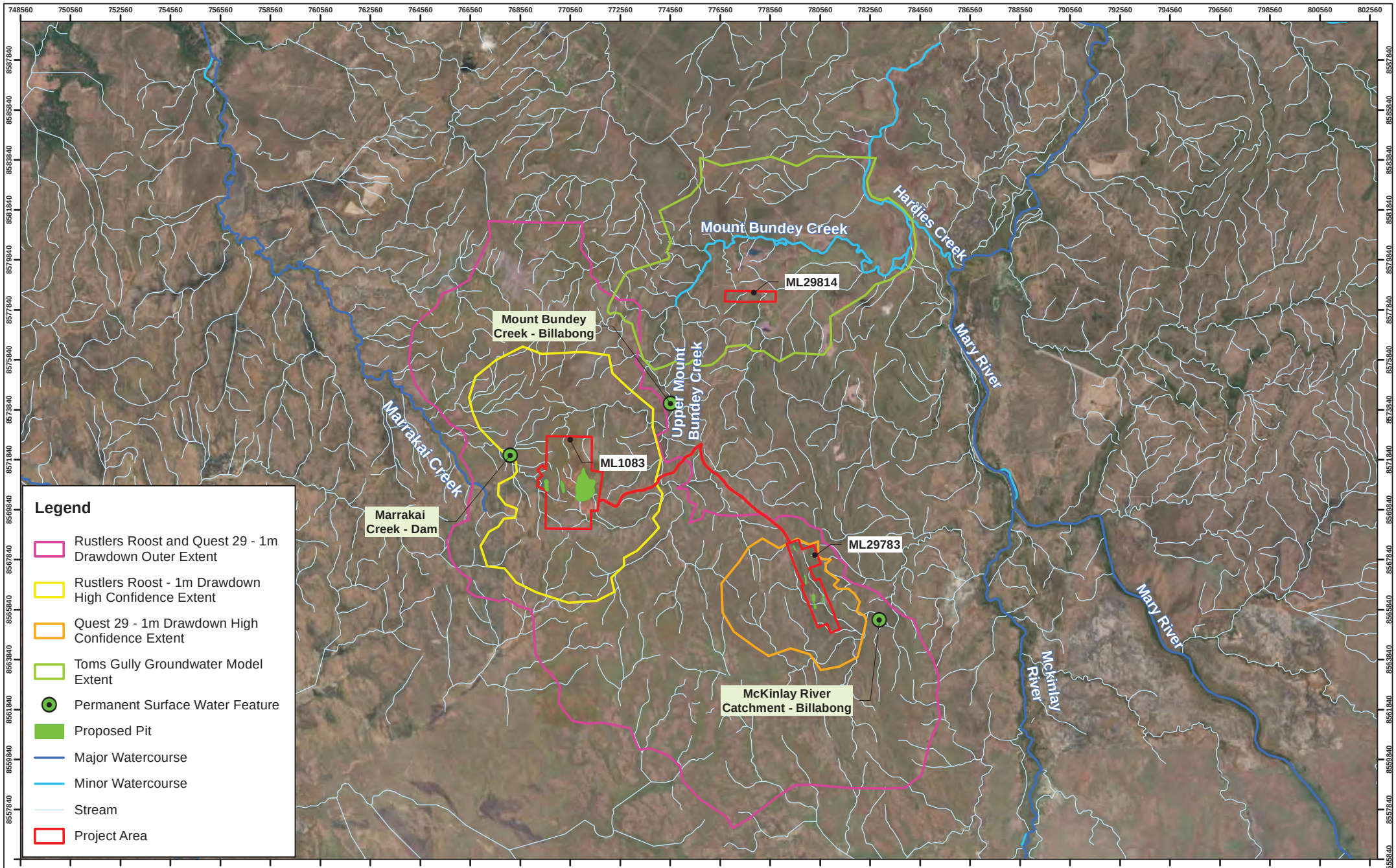
- Property – defined as Mount Bundey Station and McKinlay River Station;
- Catchment – defined as the Mount Bundey Creek catchment, Marrakai Creek catchment and McKinlay River catchment;
- Region – defined as the Marrakai-Douglas Daly unincorporated area; and
- Bioregion – defined as the Pine Creek bioregion.

The cumulative impact assessment has considered the effects of multiple actions or impacts on hydrological process (surface water and groundwater) (refer Table 7-18)

Cumulative discharges from the Project area and the downstream Toms Gully Mine are unlikely to impact the hydrological processes as discharges will be proportional to flows occurring in the Mount Bundey Creek Catchment. Mount Bundey Creek is a higher stream order, has intact riparian vegetation and is able to withstand high flows throughout the wet season, and it is anticipated very little erosion beyond natural occurrence will occur (Aquatic Ecology Services 2019).

As part of the Toms Gully Mine EIS, potential groundwater inflow into that project decline access was modelled. The modelling found that the cone of depression is mainly contained in the Toms Gully Mine tenements and it is therefore unlikely that mine dewatering would affect bores outside the mining tenements or have a cumulative drawdown interaction with the Project. The Old Mount Bundey homestead bore RN027956 is the bore most at risk of being affected by dewatering from the Toms Gully Mine and that bore is outside the area of influence for the drawdown related to this Project (refer to Figure 7-28).

Furthermore, the groundwater model for this Project predicts the cone of depression induced by the proposed groundwater extraction may extend up to 5 km to the north and 3 km to the south of the Rustlers Roost pits and 2 km to the south-west of the Quest 29 pits. There is only a minor potential area of overlap in the modelled maximum extents of influence between the Project and Toms Gully Mine (refer to Figure 7-28). Therefore, the likelihood of cumulative groundwater interactions with Toms Gully Mine is considered low.



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Notes:

N

0 1,500 3,000 6,000

Meters

1 cm = 1,386 meters

GCS GDA 1994 MGA Zone 52

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CLIENT

PRIMARY GOLD

FIGURE 7-28

Cumulative Groundwater Drawdown Extents

DRG Ref: 1001087-EIS-07-7.28

C:\Users\shilpass\Desktop\Hanking Gold Mine EIS\1001087 - Rustlers Roost EIS\1001087 - Rustlers Roost EIS\02 MXD\Chapter 7\Figure 7-39.mxd

Table 7-25 Assessment of Cumulative Impacts to Hydrological Processes

Project	Spatial Extent				Approx. Distance from Project	Impact Details	Reference
	Property	Catchment	Region	Bioregion			
Toms Gully Mine	✓	✓	✓	✓	0 km	Approximately 76 ha of disturbance. Altered surface and water flow regimes. Groundwater drawdown from pit dewatering activities interaction is limited minor extent shown in Figure 7-28.	NT EPA 2020a
Boral Quarry	✓	✓	✓	✓	700 m	Approximately 35 ha of disturbance (including access road of 2.5 ha) Altered surface and water flow regimes. Groundwater drawdown from pit dewatering activities.	NR Maps spatial mapping (DEPWS 2021)
HB Quarry	✓	✓	✓	✓	2 km	Approximately 47.5 ha of disturbance. Altered surface and water flow regimes. Groundwater drawdown from pit dewatering activities.	NR Maps spatial mapping tool (DEPWS 2021)
McKinlay Quarry	✓	✓	✓	✓	3.5 km	Approximately 17.5 ha of disturbance (including access road of 3 km) Altered surface and water flow regimes. Groundwater drawdown from pit dewatering activities.	NR Maps spatial mapping tool (DEPWS 2021)
Ostojic Quarry	✓	✓	✓	✓	4.4 km	Approximately 47.5 ha of disturbance. Altered surface and water flow regimes. Groundwater drawdown from pit dewatering activities.	NR Maps spatial mapping tool (DEPWS 2021)
Mount Bundey Military Training Area			✓	✓	9 km	The Mount Bundey Training Area is a 117,300 ha. No publicly available data No more than 10 ha of disturbance.	NR Maps spatial mapping tool (DEPWS 2021)
Woolwonga Mine				✓	47 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021)
Hayes Creek Mine				✓	58 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) LES 2017
Union Reefs Gold Mine				✓	60 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) NT EPA 2020b

Project	Spatial Extent				Approx. Distance from Project	Impact Details	Reference
	Property	Catchment	Region	Bioregion			
Frances Creek Iron Ore Mine				✓	75 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) MBS Environmental 2006
Finnis Lithium Mine					80 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) EcOz 2020
Fountain Head Gold Mine				✓	90 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) ERIAS 2021
Jabiru Hybrid Power Station				✓	140 km	Unlikely cumulative impacts on hydrological processes, due to distance and different sub-catchment.	NR Maps spatial mapping tool (DEPWS 2021) CDM Smith 2021

7.3.4 Avoidance, Mitigation and Management

Avoidance, mitigation and management measures for hydrological processes are presented in Table 7-26.

Table 7-26 Avoidance, Mitigation and Management Measures for Hydrological Processes

Potential Consequences	Measures
Alteration of drainage lines, disruption of natural alignment of creeks and streams	**Avoid** ▪ Only clearing the practical minimum footprint necessary for the portion of the Project to be implemented ▪ Clearly mark limits of clearing ▪ Make use of already disturbed areas where possible ▪ Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines ▪ Avoid land clearing during the December to March portion of the wet season. **Mitigation and Management** ▪ Adherence to Ground Disturbance Procedures ▪ Implement erosion and sediment controls in accordance with an ESCP ▪ Implementation of Biodiversity Management Plan ▪ TSF to be planned, designed, constructed and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016a) ▪ Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria ▪ An operational emergency spillway to be constructed as part of each embankment raise ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure ▪ Manage the site water balance to reduce any build-up of water ▪ Implementation of AMDMP and WMP ▪ Geotechnical studies and assessment to ensure structural stability Engineering design to ANCOLD standard ▪ Tracking of the waste rock and dumping locations ▪ WRD plan ▪ Maximisation of placement within pit ▪ Ongoing and regular (weekly) inspections of Project areas and after rainfall events ▪ Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc.) ▪ Construction of Project infrastructure with suitable materials ▪ Daily monitoring of waste rock handling and tailings disposal. ▪ Use of a perimeter spigot with regular movement to evenly distribute tailings ▪ Regular surveys to measure the tailings and waste rock deposition and water depths ▪ Infrastructure design to withstand extreme events ▪ Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc.) ▪ Improve site drainage controls ▪ Ongoing management of levels in water infrastructure

	▪ Environmental Management System and various management plans (EMP, WMP, MMP etc.). ▪ All personnel will be inducted into the area and informed of the hazards and relevant management protocols of the areas ▪ All personnel will be trained in the appropriate management practices as is relevant to their position **Rehabilitation** ▪ Monitoring and active rehabilitation of disturbed soils and landscapes ▪ Progressive clearing and rehabilitation ▪ Revegetation of exposed areas where not proposed to be utilised ▪ Stable design of landforms ▪ Implementation of detailed mine closure plan ▪ Early planning and financial provision for closure work ▪ Review options for WRD Rehabilitation ▪ Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning ▪ Financial provisioning for closure implementation ▪ Implement fencing and access restriction to prevent vehicle and livestock accessing rehabilitation areas
Groundwater drawdown from pit dewatering activities	**Mitigation and Management** ▪ Groundwater monitoring ▪ WMP **Rehabilitation** ▪ Implementation of detailed mine closure plan ▪ Early planning and financial provision for closure work ▪ Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning ▪ Financial provisioning for closure implementation
Groundwater interaction with site infrastructure seepage	**Avoid** ▪ Design TSF to be planned, designed, constructed and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry (Australian Government 2016a). ▪ Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria ▪ An operational emergency spillway to be constructed as part of each embankment raise ▪ Install seepage control and underground drainage including a cut-off trench, compact soil liner, basin underdrainage collection system, underdrain collection sump and embankment tow drain ▪ Sump below pit decline to reclaim contaminated water **Mitigation and Management** ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure ▪ Tailings performance monitoring (e.g. TSF water volume, collection efficiency of underground system). ▪ Groundwater monitoring to check quality and any seepage ▪ Implementation of WMP ▪ Manage the site water balance to reduce any build-up of water ▪ Capping of the WRDs to reduce ongoing water infiltration and seepage

	▪ Geotechnical studies and assessment to ensure structural stability, engineering design to ANCOLD standard. ▪ Implementation of AMDMP including ore and waste rock controls and tailings controls. ▪ Treatment of pit and underground water to within SSTV criteria ▪ Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc ▪ Daily monitoring of waste rock handling and tailings disposal. ▪ Tailings and Waste Rock will be managed in accordance with the Tailings Management Plan and Operational Manual (including inspections); ▪ Use of a perimeter spigot with regular movement to evenly distribute tailings ▪ Regular surveys to measure the tailings and waste rock deposition and water depths ▪ Ongoing management of levels in water infrastructure **Rehabilitation** ▪ Implementation of detailed Mine Closure Plan ▪ Monitoring and active rehabilitation of disturbed soils and landscapes ▪ Progressive clearing and rehabilitation ▪ Revegetation of exposed areas where not proposed to be utilised ▪ Stable design of landforms ▪ Implementation of detailed mine closure plan ▪ Early planning and financial provision for closure work ▪ Review options for WRD Rehabilitation ▪ Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning ▪ Financial provisioning for closure implementation
Change in volume, spatial and temporal distribution of surface water flows	**Avoid** ▪ Improve and maintain site drainage infrastructure Adherence to Ground Disturbance Procedures ▪ Implement erosion and sediment controls in accordance with an ESCP ▪ Only clearing what is absolutely necessary for the portion of the Project to be implemented ▪ Clearly mark limits of clearing ▪ Make use of already disturbed areas where possible ▪ Avoid land clearing during the December to March portion of the wet season. ▪ Discharge of dewatering effluent into drainage lines only during wet-season. **Mitigation and Management** ▪ Implement erosion and sediment controls in accordance with an ESCP ▪ Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria. ▪ An operational emergency spillway to be constructed as part of each embankment raise ▪ Install TSF seepage control and underground drainage including a cut-off trench, compact soil liner, basin underdrainage collection system, underdrain collection sump and embankment tow drain. ▪ Tailings performance monitoring (e.g. TSF water volume, collection efficiency of underground system) ▪ Use of a perimeter spigot with regular movement to evenly distribute tailings ▪ Groundwater monitoring to check quality and any seepage ▪ Implementation of AMDMP and WMP ▪ Manage the site water balance to reduce any build-up of water

	▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams. ▪ Capping of the WRDs to reduce ongoing water infiltration and seepage ▪ Regular surveys to measure the tailings and waste rock deposition and water depths ▪ Implementation of AMD Management Plan including ore and waste rock controls and tailings controls ▪ Treatment of pit and underground water to within SSTV criteria ▪ Ongoing and regular (weekly) inspections of Project areas and after rainfall events ▪ Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc.) **Rehabilitation** ▪ Implementation of detailed Mine Closure Plan ▪ Monitoring and active rehabilitation of disturbed soils and landscapes ▪ Progressive clearing and rehabilitation ▪ Revegetation of exposed areas where not proposed to be utilised ▪ Stable design of landforms ▪ Implementation of detailed mine closure plan ▪ Early planning and financial provision for closure work ▪ Review options for WRD Rehabilitation ▪ Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning ▪ Financial provisioning for closure implementation
Flooding	**Avoid** ▪ Only clearing the practical minimum footprint necessary for the portion of the Project to be implemented ▪ Clearly mark limits of clearing ▪ Make use of already disturbed areas where possible ▪ Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines ▪ Avoid land clearing during the December to March portion of the wet season. **Mitigation and Management** ▪ Adherence to Ground Disturbance Procedures ▪ Design TSF to contain a range of design storm and rainfall sequence events up to and greater than the required design criteria ▪ Manage the site water balance to reduce any build-up of water. ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams. ▪ Development of Monitoring Plan / Operational Manual which includes weekly inspections of the pits ▪ Implementation of AMDMP and WMP ▪ Implement drainage diversions as per the ESCP ▪ Ongoing and regular (weekly) inspections of Project areas and after rainfall events ▪ Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc.) ▪ Stable design of landforms **Rehabilitation** ▪ Progressive clearing and rehabilitation of disused areas ▪ Implementation of detailed Mine Closure Plan ▪ Monitoring and active rehabilitation of disturbed soils and landscapes

	▪ Progressive clearing and rehabilitation ▪ Revegetation of exposed areas where not proposed to be utilised ▪ Stable design of landforms ▪ Implementation of detailed mine closure plan ▪ Early planning and financial provision for closure work ▪ Review options for WRD Rehabilitation ▪ Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning ▪ Financial provisioning for closure implementation.

Due to the location of the ore bodies and constraints of the ML area available for development, it is not possible to avoid all of the minor drainage lines present in the Project area. To minimise potential impacts, the mine site design will incorporate internal stormwater drainage and water storages that will allow for capture and controlled release of excess water during the wet season. The water management arrangements (Appendix I and Appendix L) have been developed concurrently with the site-specific water balance model (Appendix H) to avoid uncontrolled discharges.

Dewatering of pits during operations will only occur during wet season when stream flows occur naturally. Discharges will be altered with existing creek flow regimes and tapering discharge volumes towards the end of the wet season, reducing potential impacts to natural flow regimes, riparian vegetation and aquatic communities. Wastewater discharges as required for operations will be undertaken in accordance with conditions of an approved WDL. In general, discharges will be controlled and timed to ensure that the volumes released do not significantly alter stream flows to a point that causes scouring or overtopping of the banks. For example, discharge from dewatering of the mining pits will occur progressively and intermittently with changing volumes. The planned dewatering activities for each individual pit are outlined in Table 7-27. Note that dewatering of the pits will be required until at least to the start date of phase 3 – post-mining. After this date the pits that have not been backfilled will be progressively flooded over time.

Table 7-27 Overview of Pit Dewatering and Mining Phases

	Phase 1: Pre-mining Dewatering			Phase 2: Mining	Phase 3: Post-mining	
	Start Date	**End Date**	**Note**	**Start Date**	**Start Date**	**Note**
Rustlers Roost pit	1/12/2021	30/04/2023	With a pause between 30/04/2022 and 1/12/2022)	1/03/2023	31/10/2031	
Annie Oakley pit	N/A	N/A	Not Applicable	1/02/2024	31/05/2024	Backfilled pit
Annie Dam pit	N/A	N/A	Not Applicable	1/03/2023	31/01/2024	Backfilled pit
Zamu pit	15/12/2024	30/04/2025	Maintain empty pit until start of operation	1/07/2025	30/06/2030	Backfilled pit
South Koolpin pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/06/2031	
North Koolpin pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/06/2031	
Taipan pit	15/02/2029	30/04/2030	Maintain empty pit until start of operation	1/07/2030	30/11/2031	
BHS pit	15/03/2030	30/04/2031	Maintain empty pit until start of operation	1/08/2031	30/11/2031	Backfilled pit

Sustainable levels of groundwater extraction will be determined through continued refinement of the groundwater model as further data becomes available and any measures required to protect surface and groundwater flows, will be addressed in the MMP. The proposed activities are not located within a WCD established under the *Water Act 1992*. As a result, the proposed surface water extraction from Annie's Dam and groundwater bores to supply the mine sites, does not require a licence.

7.3.5 Monitoring and Reporting

PGO commits to a comprehensive surface and groundwater monitoring program to improve knowledge of surface and groundwater flows and environmental water quality parameters. The monitoring program aims to detect changes in groundwater levels and monitor impacts to riparian vegetation and aquatic communities. The monitoring program will allow for adaptive management and/or rehabilitation of damage.

In summary, the following detailed monitoring and reporting measures will be included for further environmental approvals and the subsequent MMP and WMP:

- Site-specific groundwater modelling reporting including groundwater drawdown contours and assessment of potential impacts to watercourses; and
- Water Management Plan (WMP) detailing a groundwater, surface water and aquatic monitoring program and reporting, including a Trigger Action Response Plan (TARP).

The program will also include the potential area of influence to inform the requirement to assess potential cumulative impacts. Proposed monitoring sites are outlined in the WMP (Appendix I) and the WDL. In addition, water levels will be reported in accordance with any relevant legislative requirements. The appropriate monitoring and reporting framework is further outlined in more detail in Section 10.

7.3.6 Residual Impact

All potential residual impacts were assessed as below moderate, with the exception of impacts related to groundwater drawdown from pit dewatering activities, which are certain to occur despite the expected environmental impacts to be insignificant. Groundwater drawdown is the only source of impact that had a residual risk classified as high after the application of mitigation and management measures. Source of risk to hydrological processes associated with vegetation clearing, overtopping, embankment failure or seepage from the TSF, WRDs, process water storage, pit dewatering, erosion of site infrastructure are sources that retained a residual risk rating of moderate following application of controls.

It is acknowledged that despite the efforts to reduce the likelihood of uncontrolled discharges (i.e. from embankment failure and poor quality stormwater) the consequential impacts to surface and groundwater could still remain at a moderate level as per the definition for hydrological process impacts in the risk assessment. However, as the TSF, Process Water Dam and WRD will be planned, designed, constructed, and operated in accordance with approaches detailed in the "Leading Practice Sustainable Development Program for the Mining Industry" (Australian Government 2016a) and the relevant ANCOLD (2012) guidelines in conjunction with the development of a monitoring plan/ operational manual which includes weekly inspections of the site storage infrastructure, there is high certainty that the infrastructure embankments will remain stable.

Additionally, the potential impacts to groundwater drawdown in the vicinity of the mining pits are unavoidable. The Project will require the localised lowering of the groundwater table to maintain safe operation and mining activities. The extent of the drawdown cone has been determined by groundwater modelling undertaken during mine planning. It is not expected that there will be any impact to other consumptive users of groundwater due to their distance from the Project area. If there is a connection between the groundwater and surface water systems (which may occur in streams), drawdown could reduce

flows in surface water courses; however, the vegetation types present along the drainages do not indicate groundwater dependence and therefore riparian and aquatic habitats are unlikely to be affected.

Localised reduction of surface water flows will occur along short sections of streamlines located within and downstream of the Project area as a result of water being retained within the mine sites and Annie's Dam and/or associated with reduces groundwater expression into surface water courses. The reduction in flow is expected to be minor and localised due to the location in the upper catchment and therefore, relatively small contribution of the ephemeral drainage lines to downstream flows. The availability of water for use by cattle, riparian vegetation and aquatic ecosystems is unlikely to be impacted. Groundwater levels will be lowered around the pits during mining.

Table 7-28 Hydrological Processes Residual Impact Assessment Summary

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
HP-1	Vegetation clearing for the Project	Construction Operation	Extreme	> Adherence to Ground Disturbance Procedures. > Progressive clearing and rehabilitation. > Implement erosion and sediment controls in accordance with an ESCP. >Only clearing what is absolutely necessary for the portion of the Project to be implemented. > Implementation of Biodiversity Management Plan. > Clearly mark limits of clearing. > Make use of already disturbed areas where possible. > Adhere to buffer widths recommended by the Northern Territory Land Clearing Guidelines with regard to riparian vegetation in drainage lines. > Avoid land clearing during the December to March portion of the wet season.	Moderate
HP-2	Overtopping, embankment failure or seepage from the new TSF at Rustlers Roost leading to uncontrolled release of tailings material to surrounding environment.	Construction, Operation, Decommissioning or Closure	High	> TSF to be planned, designed, constructed and operated in accordance with approaches details in the guideline Tailings Management: Leading Practice Sustainable Development Program for the Mining Industry. (Australian Government 2016a). > Design TSF to contain a range of design storm and rainfall sequences events up to and greater than the required design criteria. > An operational emergency spillway to be constructed as part of each embankment raise. > Development of Monitoring Plan / Operational Manual which includes weekly inspections of the TSF, survey pins to monitor the embankment and piezometers to measure pore water pressure. > Tailings performance monitoring (e.g. TSF water volume, collection efficiency of underground system). > Install seepage control and underground drainage including a cut-off trench, compact soil liner, basin underdrainage collection system, underdrain collection sump and embankment tow drain. > Groundwater monitoring to check quality and any seepage. > Implementation of AMDMP and WMP. > Manage the site water balance to reduce any build-up of water.	Moderate
HP-3	Overtopping, embankment failure or seepage from the process water storage at Rustlers Roost leading to uncontrolled	Operation, Decommissioning and Closure	High	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams.	Moderate

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
	release of process water to surrounding environment.			> Groundwater monitoring > Manage the site water balance to reduce any build-up of water.	
HP-4	Embankment failure or seepages from the new WRDs at Rustlers Roost and Quest 29 to surrounding environment.	Operation, Decommissioning and Closure	Extreme	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the process water dams. > Groundwater monitoring > Manage the site water balance to reduce any build-up of water. > Capping of the WRDs to reduce ongoing water infiltration and seepage	Moderate
HP-5	Embankment failure of Annie's Dam water storage or process water ponds and uncontrolled water and sediment release.	Construction, Operation	Moderate	> Geotechnical studies and assessment to ensure structural stability Engineering design to ANCOLD standard. > WMP. > Weekly inspections to check sufficient freeboard and structural integrity.	Low
HP-6	Groundwater drawdown.	Construction, Operation	High	> Hydrogeological assessment indicated that minimal connection of groundwater to Mount Bundey Creek Water MP > No documented drawdown impacts from previous operations > Groundwater monitoring	High
HP-7	Indiscriminate use of existing waste rock for construction. Storage of waste rock outside of pit footprint for too long.	Construction Operation Decommissioning Closure	Moderate	> Tracking of the waste rock and dumping locations > WRD plan > ESCP to prevent mobilisation > Maximisation of placement within pits > On-going and regular inspections of Project areas	Low
HP-8	Pit and groundwater dewatering exposing PAF and causing AMD.	Construction Operation Decommissioning Closure	High	> Sump below pit base to reclaim contaminated water > Implementation of AMD Management Plan including ore and waste rock controls and tailings controls. > Treatment of pit and underground water to within SSTV criteria. > > Visual inspection of pit walls to identify locations and volumes of acid producing material.	Moderate
HP-9	Planned pit over topping or release to surface water features during extreme rainfall and flooding events.	Construction Operation	Low	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the pits. > Implementation of AMDMP and WMP > Manage the site water balance to reduce any build-up of water.	Low

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
HP-10	Unplanned pit overtopping or release to surface water features during extreme rainfall and flooding events.	Construction Operation Decommissioning Closure	Extreme	> Development of Monitoring Plan / Operational Manual which includes weekly inspections of the pits > Implementation of AMDMP and WMP > Manage the site water balance to reduce any build-up of water. > Implement drainage diversions as per the ESCP	Low
HP-11	Erosion of site infrastructure leading to sedimentation	Operation, Decommissioning Closure	High	> Implementation of ESCP > Ongoing and regular (weekly) inspections of Project areas and after rainfall events > Avoid land clearing during wet season > Minimise concentrated flow of surface water and ponding (drain lines, sediment bunds, liners etc.) > Revegetation of exposed areas where not proposed to be utilised > Stable design of landforms > Construction of Project infrastructure with suitable materials	Moderate
HP-12	Release of hazardous chemicals or materials during storage and handling onsite.	Construction, Operation, Decommissioning	Moderate	> Design, storage and handling of hazardous materials to Australian Standards and regulations. > Specific adherence of the ANFO storage to *Dangerous Goods Act 1998* and the NT *Work Health and Safety (National Uniform Legislation) Act 2011*. > Regular maintenance of storage facilities. > Bunding of the process plant > Ensure containment bunding is adequate and SDSs are available > Diesel in bunded storage tanks, waste oil in stored bunded tanks > Weekly inspections of storage areas, tanks, containers > Develop Emergency Response Plan and include in inductions > Weekly inspections of storage areas for leaks or damages > Spill kits available around the site and procedures and training for the cleaning up of hazardous spills > Implementation of hazardous materials management plan training for emergency response > Cyanide management and storage will be aligned to the Commonwealth of Australia Leading Practice Handbook for Sustainable Mining - Cyanide Management (Australian Government 2008). > Groundwater monitoring. > Chemical storage will be located a minimum 30m from any drainage line or watercourse.	Low

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
HP-13	Poor handling and management of tailings and waste rock	Operation, Decommissioning	Moderate	> Daily monitoring of waste rock handling and tailings disposal. > Tailings and Waste Rock will be managed in accordance with the Tailings Management Plan and Operational Manual (including inspections). > Use of a perimeter spigot with regular movement to evenly distribute tailings. > Regular surveys to measure the tailings and waste rock deposition and water depths. > Groundwater monitoring	Low
HP-14	Production of domestic waste and storage of the waste onsite	Construction, Operation, Decommissioning.	Moderate	> Secure dustbin lids. > Establish dedicated hardstand at accommodation camp for waste receptacles > Weekly inspections of, waste area, landfill and general tidiness of site. > Burial of waste in dedicated landfill. > Design and construct landfill in accordance with relevant standards > Implement leachate prevention and capture into landfill design > Groundwater monitoring > Segregation of wastes and recycling of wastes where possible.	Low
HP-15	Unfinished/unsuccessful rehabilitation of Project due to inadequate funds or natural disaster (e.g. cyclone).	Construction, Operation, Decommissioning and Closure	Extreme	> Progressive rehabilitation of disused areas > Implementation of detailed mine closure plan > Early planning and financial provision for closure works > Infrastructure design to withstand extreme events > Ongoing management of levels in water infrastructure > Improve site drainage controls	Moderate
HP-16	Long term positive water balance	Construction, Operation, Decommissioning and Closure	High	> Improve and maintain site drainage infrastructure > Review options for WRD Rehabilitation > Implementation of Mine Closure Plan and adherence to commitments > Closure Plan updated and refined throughout mining operations including LOM closure planning and contingency planning > Financial provisioning for closure implementation	Moderate
HP-17	Inappropriate management of the decommissioned site, post closure landform.	Closure	Moderate	> Implement fencing and access restriction to prevent vehicle and livestock accessing rehabilitation areas. > Ongoing monitoring of rehabilitation. > Progressive rehabilitation during mining to enable more established areas upon closure	Low

Risk No.	Source of Impact	Project Phase(s)	Inherent Risk	Summary of Controls	Residual Risk
HP-18	Ineffective operational implementation of site environmental management system, plans and procedures.	Construction, Operation, Decommissioning Closure	High	> Corporate commitment to EMS implementation via policy > Environmental Management System and various management plans (EMP, WMP, MMP etc.). > All events/incidents to be reported and managed through to resolution via event/incident reporting procedures. > All personnel will be inducted into the area and informed of the hazards and relevant management protocols of the areas. > All personnel will be trained in the appropriate management practices as is relevant to their position.	Moderate
HP-19	Inappropriate liquid and solid waste disposal.	Construction, Operation, Decommissioning Closure	High	> Manage disposal of wastes in accordance with the Project EMP (including bunded waste oil bins). > Hazardous materials stored in accordance with Australian standards. > Spill kits available around site and spill clean-up procedures implemented. > Employees and contractors trained in clean up procedures. > Weekly inspections of, waste area, landfill and general tidiness of site. > Burial of waste in dedicated landfill. > Design and construct landfill in accordance with relevant standards > Implement leachate prevention and capture into landfill design > Groundwater monitoring	Low
HP-20	As part of closure and rehabilitation, creeks and drainage alignments are not consistent to the surrounding landforms and catchment area.	Closure	Moderate	> Progressively rehabilitating the mine. > Clearing and Topsoil Procedures Implementation of Mine Closure > Implementation of the ESCP addressing post closure drainage	Low

7.3.7 Predicted Outcome and Conclusions

This section has outlined the risks associated with mining activities, the potential altered surface water flows and impacts to groundwater levels from alterations to creek lines and pit dewatering to the environmental vales defined for Hydrological Processes. While mining can pose risk to surface and groundwater, the risk assessment process has demonstrated that the risks can be managed in accordance with legislative requirements by relevant management plans and relevant licences.

The potential risks from uncontrolled discharge, spills and poor closure will remain throughout the Project. However, with the application of effective controls in accordance with the environmental decision framework, management and mitigation measures the risks will remain sufficiently low.

The environmental objective identified in the ToR (NT EPA 2021) is to protect hydrological processes, to support and maintain environmental values including water quality, aquatic flora and fauna and riparian vegetation. As such the Project is not determined to cause significant decline to relevant environmental, social, cultural, and economic values at the local scale.

Considering the assessment of residual impacts, and the application of mitigation and monitoring committed by PGO, it is concluded that impacts on surface and groundwater are manageable, such that the ToR objective for this factor is able to be met.

7.3.8 Assumptions

The key assumptions made in assessing potential impacts on hydrological processes are:

- The zone of potential impact from groundwater drawdown, while currently uncertain, is assumed to be contained mainly within the mining tenements and will not affect other users. Groundwater modelling has shown that the 1 m drawdown contours may extend 5 km to the north and 3 km to the south of the Rustlers Roost pits, and 2 km to the south-west of the Quest 29 pits;
- Due to the location at the headwaters of the catchment, any reduction in flows from altered drainage lines in ephemeral watercourses and groundwater levels will be localised and not affect the higher order watercourses downstream i.e. Mount Bundey Creek, Marrakai Creek and McKinlay River;
- Water from pit dewatering will be stored onsite in appropriate facilities during dry-season, and will only be discharged during wet-season to accommodate natural surface water flow regimes; and
- Discharge from pit watering activities into drainage and creek lines will not affect significantly natural flow patterns in higher order watercourses downstream i.e. Mount Bundey Creek, Marrakai Creek and McKinlay River.