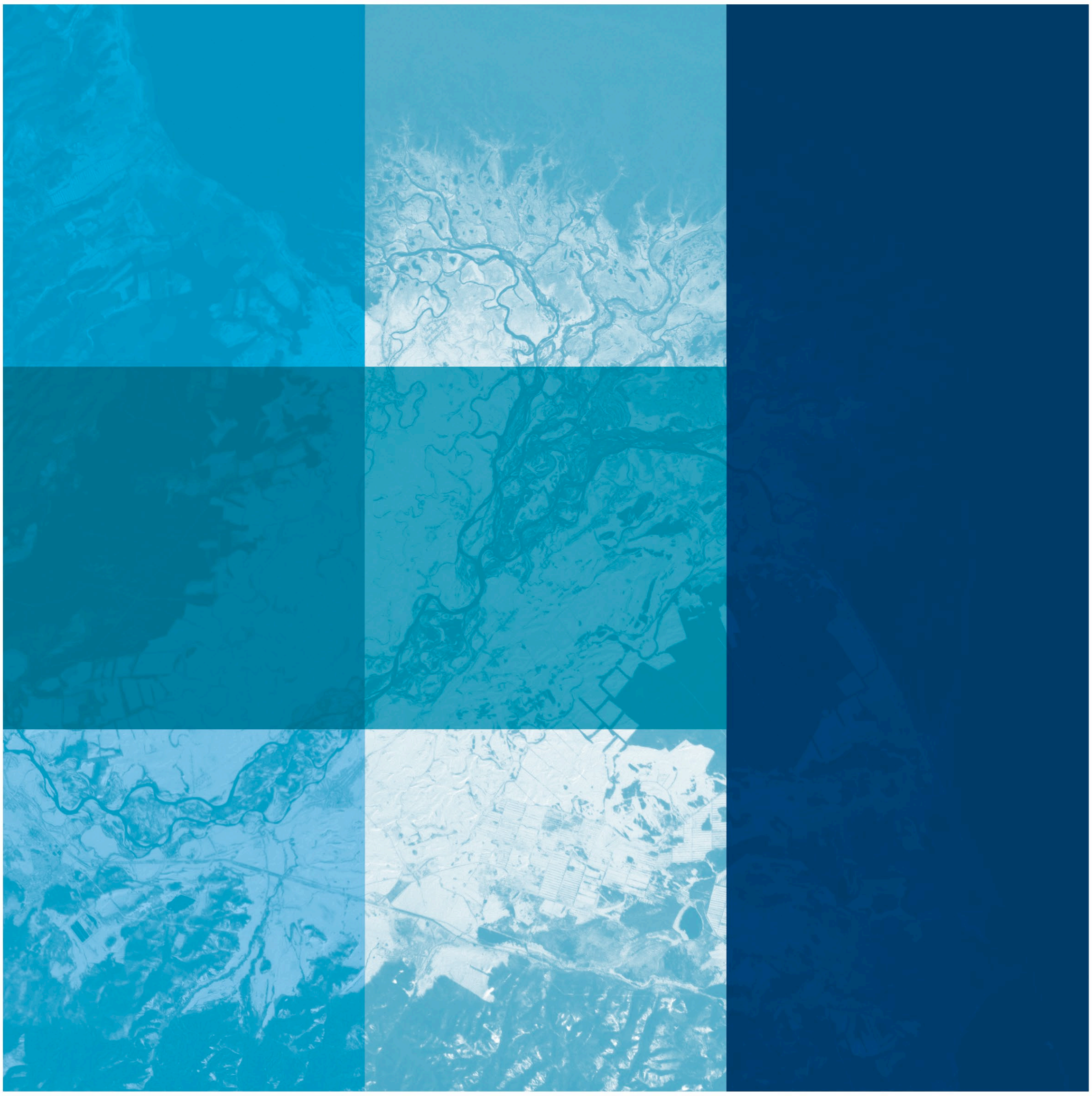

Report: British Hill Surface Hydrology Baseline

Client: IMD Gold Mines Limited

Job number: 0100081

Date: 26 Feb 2020

Executive Summary

Introduction

IMD Gold Mines Limited are developing the British Hill gold mining project, located approximately 73 km south east of Southern Cross at the old British Hill mine. The project involves development of a gold deposit by open pit mining with offsite processing.

This report presents a description of the baseline surface hydrology for the project to support the mining proposal. A concept for management of external stormwater for the site during operation and after closure is given.

Baseline hydrology

Catchments and hydrology

The mine site lies across a low ridge separating two catchments that drain toward a salt lake system to the north. The site is in the far eastern part of the Avon hydrographic basin

There are no large drainage lines in the vicinity of the site and drainage is via overland flow paths or shallow flow in broad valleys. Defined drainage lines form further to the north close to the salt lake system and in areas with more relief.

Drainage through the site area is either to the west or east as overland flow. Residual disturbance from previous mining affects local drainage and flow paths. A number of constructed ponds exist through the area and some intermittent erosion gullies occur.

The footprint of the project is small relative to the local and regional catchments. The total project area, excluding the access road, is 0.69 km^2, as indicated by the mapped extent of the open pit, waste rock landform and hardstand area. By the access road crossing, the catchment has increased to 96 km^2. The total area draining to the salt lake system is 2,096 km^2.

Potentially affected areas

Areas potentially affected by the project are:

- Overland flow pathways immediately downstream of the site; and
- The Jilbadji Nature Reserve close to the access road.

Potential impacts of the project on the downstream environment are:

- Modified overland flow volumes and rates immediately downstream of the site as a result of a mine infrastructure and site stormwater management;
- Shadowing or diversion of shallow overland flow associated with the access road where it passes through the Jilbadji Nature Reserve;
- Erosion associated with disturbed areas, steep slopes and site infrastructure, leading to scour and increased turbidity of stormwater; and
- Impacts of mine infrastructure and mining activities on stormwater quality.

Environmental values

The main values and beneficiaries of surface water through the project area relate to:

- Maintenance of native vegetation communities; and

- Maintenance of the ecosystem of the eastern and western catchment valleys, Jilbadji Nature Reserve and the salt lake system.

Surface water management areas

The site is located in the Outer Avon surface water management area (DWER 2019). It is not in a proclaimed surface water management area.

It is likely that the quality of stormwater flows sourced from the area of the site will largely be fresh but may be turbid. There are no pools or dams in the area of the mine site. The only surface water is in intermittently flowing drainage lines.

Water quality

The salt lake system is an internally drained, saline system. Salinity of water in the lake varies from near fresh to saline depending on water levels.

Flooding

There is little flood risk for the pit or infrastructure in the vicinity of the pit as the site is located on a ridgeline with little catchment and no defined drainage lines.

Ponding and shallow stormwater flow could affect parts of the access road after heavy rain. Ponding and flow is likely to be shallow and low velocity, so there is little risk to the safety of traffic on the road. However excessive ponding could impact on road trafficability.

Conceptual design of stormwater infrastructure

The objectives for surface water management at the site during the operational stage are to:

- Minimise the risk that erosion at the site and on the access road will impact on the downstream environment in the 10% AEP and smaller rainfall events;
- Minimise discharge of contaminated or saline stormwater from the site; and
- Manage flood risk for the 1% AEP event.

After closure, the site will be rehabilitated to a stable landform with minimal impact on the surrounding environment.

Stormwater management during operation needs to address the following site elements:

- The pit;
- Waste rock landform;
- Hardstand;
- Access road; and
- Any other site infrastructure, including topsoil stockpiles.

Operational

During mine operation, inflows to the pit will be managed using in-pit sumps and pumping to disposal on site. A standard safety berm surrounding the pit and, if required, small drains will be adequate for controlling small local stormwater flows and ponding.

While the waste rock landform is being built, attention should be given to managing stormwater runoff and scour from disturbed areas and steep slopes. The top of the waste rock landform will be constructed to be internally draining and as far as practicable take the shape of the final landform.

Scour and stormwater flow on the hardstand area should be controlled by managing grade and flow paths. If necessary, shallow drains can be used to control flow. Assuming stormwater generated across the hardstand area is low in turbidity and not contaminated with salt or other pollutants, it can be released from the site at a rate that does not cause scour or changed flow paths down slope. Discharge from the site should be toward the northeast, to prevent interaction with the heap leach landform to the east.

The access road crosses a number of areas that will have shallow flow or ponding for a short period after heavy rainfall. The roadway in these areas should be constructed as floodways. Culverts are preferred where the road crosses the proposed drain on the eastern edge of the site.

Other infrastructure on site, such as any site buildings or storage areas, should generally be located in free draining areas and avoid any concentrated stormwater flow paths. Tracks should avoid concentrating stormwater flow. Scour on stockpiles should be controlled by encouraging vegetation growth and by limiting the length of slope.

If roads and trafficked areas are to be watered with saline water, consideration should be given to prevention of excessive salt wash off to surrounding shrubland or pasture areas. Stormwater flow should be prevented from concentrating and flowing along the roads and external flow should be allowed to cross the road without being concentrated.

Stormwater management on closure

Elements of the mine site that need to be addressed for closure are:

- The residual pit;
- Waste rock landform dump; and
- The rehabilitated site landform.

It is expected that the residual pit void will remain after closure and will be isolated with levees and a safety bund and will have an equilibrium water level below the ground surface.

The final waste rock landform should be stabilised to prevent scour. Stormwater generated on the outer batters of the landform should be either retained and disposed of on the structure or released in a safe fashion. Stormwater generated on top of the structure should be retained and dissipated to evaporation *in situ*.

On closure, it is expected that general site infrastructure will be removed, topsoil stockpiles will be used in site rehabilitation and the landform returned to natural contours and revegetated.

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Figures

Tables

1. Introduction

1.1 Background

IMD Gold Mines Limited are developing the British Hill gold mining project. The site is located approximately 73 km south east of Southern Cross at the old British Hill mine. Residual disturbance from previous mining activity and an access road to the Marvel Loch-Forrestania Road remains. The project involves development of a gold deposit by open pit mining with offsite processing.

The site location and major regional catchments are shown in Figure 1. Site details are given in Figure 2.

The site will have a waste rock landform and hardstand area. Mining will be via an open pit with ore processed off site. A four km access road connects the site to the Marvel Loch-Forrestania Road. The expected mine life is still being developed. On closure, a residual pit void and rehabilitated waste rock landform will remain.

This report presents a description of baseline surface hydrology for the project to support the mining proposal. A concept for management of external stormwater for the site during operation and after closure is given.

1.2 Scope of work

The scope of work was to:

- Describe the baseline hydrology of the British Hill project to support the mining proposal; and
- Develop a concept for management of stormwater at site during operations and for remaining infrastructure after closure.

The deliverable is this report.

1.3 Summary of methods

The work was undertaken in the following stages:

- Source data;
- Baseline hydrology assessment;
- Concept for stormwater management; and
- Reporting.

Source data

The following data were used in the assessment:

- Site infrastructure layout, from Cadre Enviro;
- Detailed topographic survey data and aerial imagery for the site, supplied by Cadre Enviro;
- Regional topographic data (SRTM DEM-H), supplied by Geoscience Australia;
- Weather data, supplied by the Bureau of Meteorology; and
- Other data and reports, as referenced through this report.

The site infrastructure layout was supplied as an outline of the extent of the proposed pit, waste rock landform and hardstand. Details of the location nor size of these features were not available at this time. The access road alignment was assumed to follow the existing access road.

Regional topographic data available for the area of the site and surrounding catchments were a one second SRTM digital elevation model, supplied by Geoscience Australia (GA 2011). This is a nation-wide ground surface model with a spatial resolution of approximately 30 m and a vertical accuracy of up to 7.6 m. These data were used to define drainage lines and catchments for the baseline assessment and to characterise catchment hydrology.

Detailed topographic survey was collected for an area covering the site and access road by Arvista Pty Ltd, supplied on 24 January 2020. Aerial photographic and LiDAR data were used to produce digital terrain models in GeoTIFF format at 0.05 and 0.1 m spacing. An orthophoto with a 0.05 m pixel resolution was also suppled. These data were used to describe site hydrology and for the concept design of stormwater infrastructure.

The extent of the topographic data sources is given in Appendix A.

For characterisation of climate, a daily record generated for the site using SILO Data Drill (Queensland Government 2019) and Bureau of Meteorology observed weather data for Mulgara Station 012298 (BoM 2019a) were used. 2016 design rainfall intensity data were used (BoM 2019b).

Baseline assessment

The baseline assessment was developed to meet the WA guideline for mining proposals Government of WA (2016).

Stormwater management

Concepts for stormwater management were developed using the available data and considering the terrain, viable options for stormwater infrastructure (mainly drains, levees and road crossings) and potential impact on discharge downstream of the site.

The surface water management plan defines management of stormwater at the site to minimise impact on the downstream environment. As no details of the location of infrastructure through the area of the open cut pit; hardstand area or waste rock landform was known, the existing land surface and free drainage across the site was assumed. Runoff rates from the site area were increased relative to current conditions, to represent likely disturbance during the mine life.

The concept stormwater plan was developed, as far as possible, to accommodate the future infrastructure plans. It was assumed that stormwater collected in the pit and on the waste rock landform would be retention and disposed of in situ or on-site. However the extent of this infrastructure is not know at this time so sizing of stormwater infrastructure and volumes and rates of stormwater to be disposed off-site are indicative.

Two scenarios were evaluated:

- Operational; and
- After mine closure.

Concepts for stormwater conveyance structures during the operation stage of the project were developed to the following criteria:

- Contain flows and minimise scour for the 10% AEP design rainfall event;

- Minimise offsite impacts for the 10% AEP design event; and
- Prevent flooding of key infrastructure (the pit) in the 1% AEP design rainfall event.

The concept addresses key infrastructure; including:

- Location and indicative size of flood protection levees;
- Location of major diversion or stormwater management drains; and
- Location and nature of major road crossings.

General design guidance for smaller or less important structures is provided. Comment on maintenance, as part of the design, is also given.

Closure concepts were developed to the following criteria:

- Reinstate landform and drainage to as close to pre-mining conditions as possible; and
- To minimise impacts on the downstream environment.

Modelling

Detailed hydrologic models were setup for the area of the site and used to model both existing flow conditions and help define stormwater management concepts.

Hydrology was modelled using the Mike SHE model (DHI 2019). Mike SHE is a detailed catchment water balance model. It was applied here as a catchment hydrology model. A rain-on-grid approach was used to represent overland flow. Channel flow was represented using the one-dimensional model component, Mike Hydro.

The following models were applied:

- Regional model of the site and surrounding catchments, existing conditions, using SRTM topographic data, 10 and 1% AEP design rainfall events; and
- Detailed site model, existing and proposed conditions, using detailed site topographic data, 10 and 1% AEP design rainfall events.

The Mike SHE model was parameterised and calibrated using the available data. The Australian Rainfall and Runoff (ARR) regional flood frequency estimation tool (ARR 2019; RFFE 2016; Ball *et al.* 2016) was not available for the site. The Mike SHE model was used to indicatively size proposed stormwater infrastructure.

Details of the model parameters are given in Appendix A. More detail on the Mike SHE software are given at DHI (2019).

1.4 Limitations

This report has been prepared by Hydrologia Pty Ltd for IMD Gold Mines Limited and may only be used and relied on by IMD Gold Mines Limited for the purpose agreed between Hydrologia Pty Ltd and the IMD Gold Mines Limited as set out in Section 1.2 of this report.

Hydrologia Pty Ltd otherwise disclaims responsibility to any person other than IMD Gold Mines Limited arising in connection with this report. Hydrologia Pty Ltd also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by Hydrologia Pty Ltd in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. Hydrologia Pty Ltd has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by Hydrologia Pty Ltd described in this report (refer Section 1.3 of this report). Hydrologia Pty Ltd disclaims liability arising from any of the assumptions being incorrect.

Hydrologia Pty Ltd has prepared this report on the basis of information provided by IMD Gold Mines Limited and others who provided information to Hydrologia Pty Ltd (including Government authorities), which Hydrologia Pty Ltd has not independently verified or checked beyond the agreed scope of work. Hydrologia Pty Ltd does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

Model Results

Flood magnitude predictions have a probability of occurrence. For example, a predicted 1% (or 1 in 100) AEP flood extent has a 1% probability of occurring or being exceeded in any given year. A flood of this magnitude could occur more than once in a year.

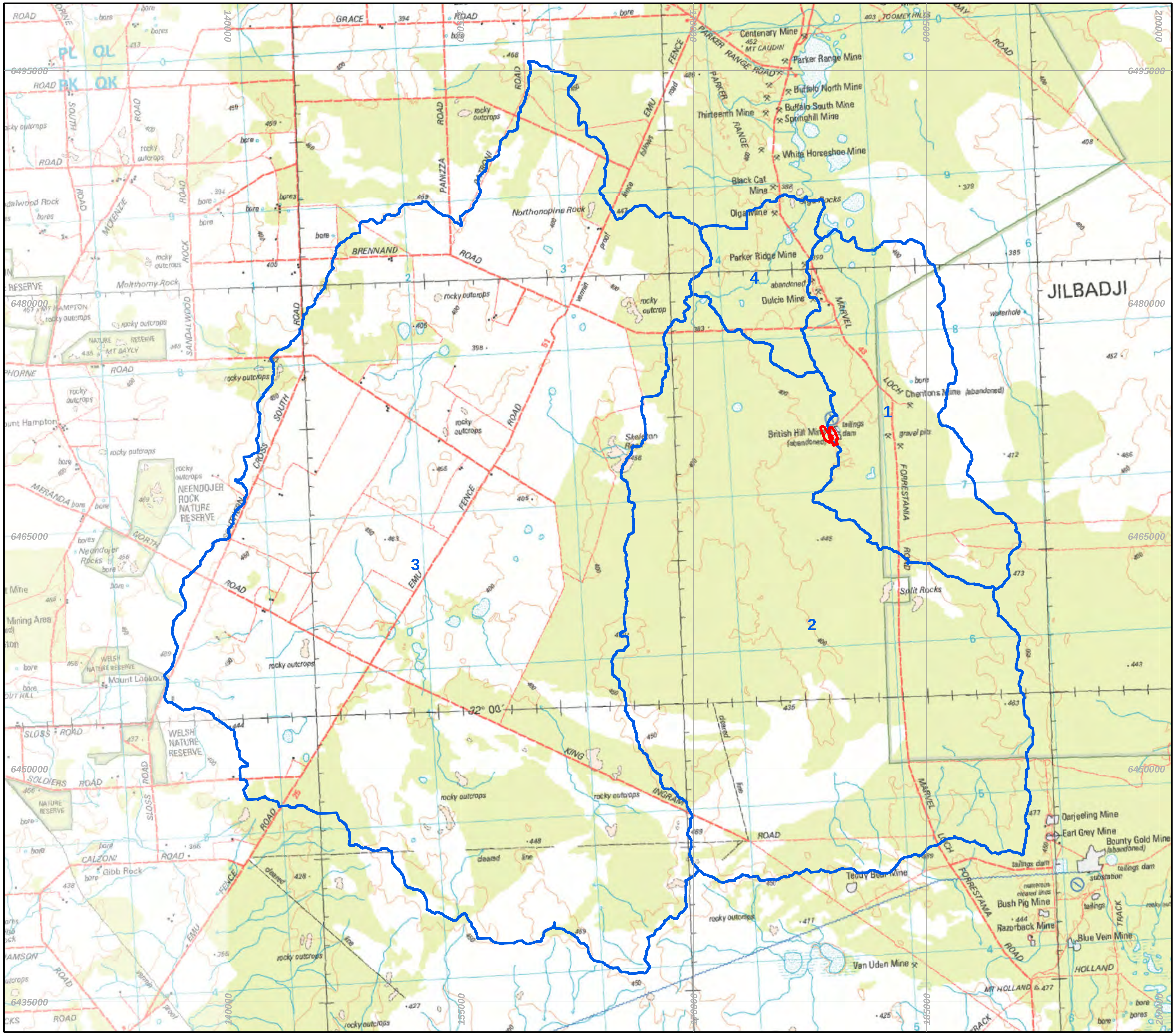
Floods greater than 1% AEP can occur. During such floods, impacts from flooding could be greater than indicated in this study. Conversely properties within the study area can be affected by floods of a lesser magnitude.

Predicted flood level, depth and velocity is predicted based on the available data and on assumptions and limitations described in our report. These results should be read in conjunction with this report.

The Mike SHE model was applied using a 5-25 m square grid derived from 1 second SRTM data provided by Geoscience Australia. Topographic and drainage features, such as swales, gutters, levees, roads, changes in land use or hydraulic roughness are not necessarily accurately represented in the model. Buildings or elevated flood levels at or in buildings are not represented in the original topographic data nor in the model. Underground pipework, culverts or other structures are not represented in the model.

Local increases in flood levels, depths and/or velocities from those predicted in this study can occur as a result of local factors. Using more accurate topography will also affect the predicted flood extent.

No account of the impact of climate change on the magnitude or frequency of occurrence of flood events has been considered. It is widely accepted in the scientific community that changing climate could affect rainfall and runoff in Australia, including in the project area. Accordingly the probability of occurrence for predictions given in this study could change in the future.



Legend

Open Pit, WRD and hardstand

Catchments

Data Sources:
250K Topography - Geoscience Australia
Catchments - Hydrologia
Open Pit, WRD and hardstand - CADRE Enviro

Location

1:100 000 Map Sheet Location

Muntadgin 2634	Holleton 2734	Cheritons Find 2834	
Hyden 2633	O'Connor 2733	Holland 2833	Roundtop 2933

N

SCALE 1:250,000

0 3 6 9 Km

GDA 1994 MGA Zone 51

Hydrologia

Project: British Hill Surface Hydrology Baseline
Job no: J0100081

Figure 1
Site Location and Catchments

Additional Information

COMPILED: Gaia Resources	DATE: 11/02/2020	LOCN: PERTH	A3	SCALE 1:250,000
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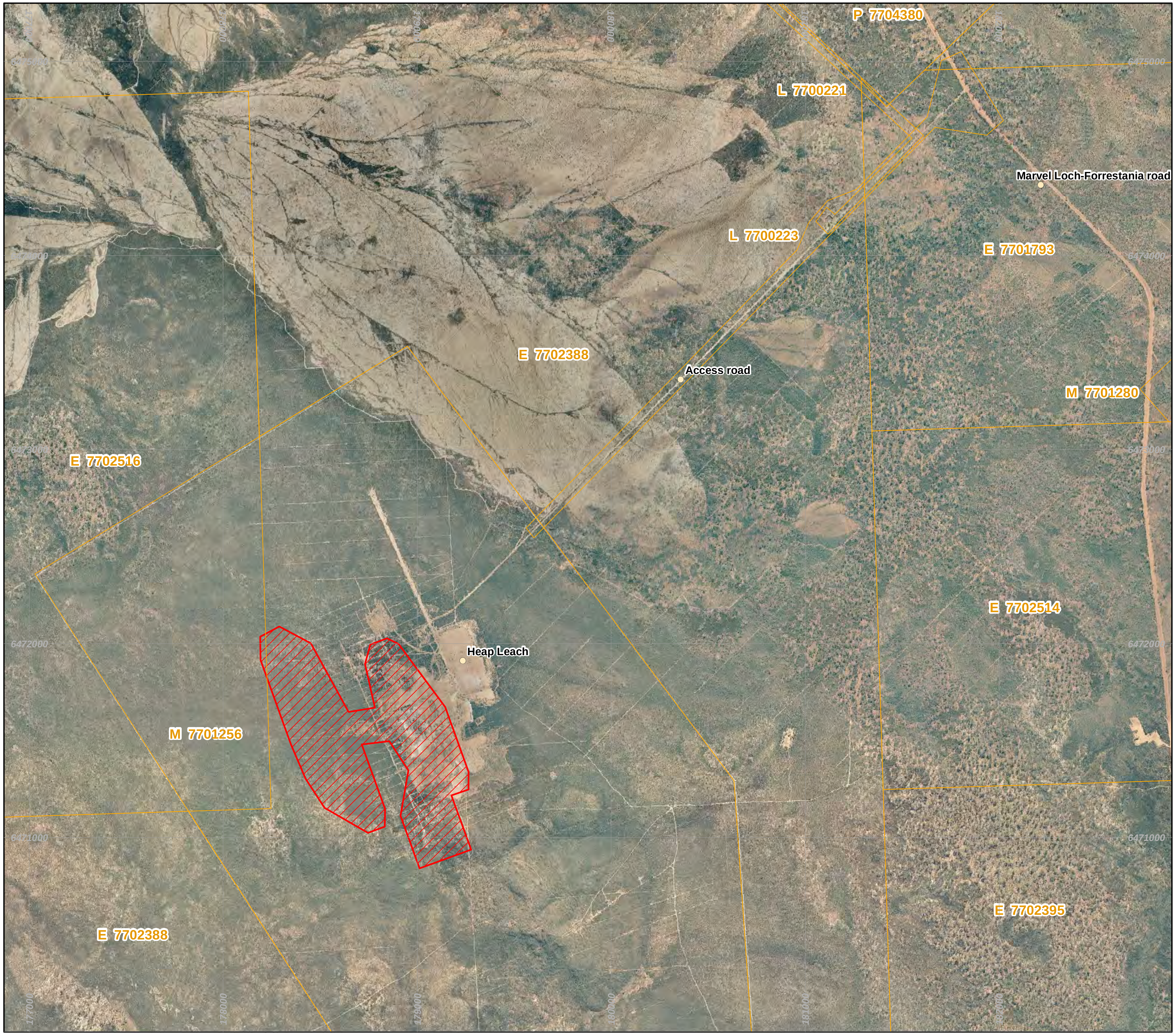
DOCUMENT NAME: GR604-13_BritishHill_Fig1.mxd				



Legend

- Features
- Tenements
- Open Pit, WRD and hardstand

Data Sources:
Features - Hydrologia
Open Pit, WRD and hardstand,
Tenements - CADRE Enviro

Location

1:100 000 Map Sheet Location

Holleton 2734	Cheritons Find 2834	Lake Percy 2934
O'Connor 2733	Holland 2833	Roundtop 2933

N
SCALE 1:20,000
0 0.5 1 1.5 Km
GDA 1994 MGA Zone 51

Hydrologia

Project: British Hill Surface Hydrology Baseline
Job no: J0100081

Figure 2
Proposed Site Layout

Additional Information

COMPILED: Gaia Resources	DATE: 11/02/2020	LOCN: PERTH	A3	SCALE 1:20,000
GDA 1994 MGA Zone 51	PLAN No: GR604-13_BritishHill_Fig2.pdf			
DOCUMENT NAME: GR604-13_BritishHill_Fig2.mxd				

2. Baseline hydrology

2.1 Introduction

This section presents a description of baseline hydrology for the mine site and for local and regional catchments.

The description is presented in a format recommended in the WA Government's guidelines for mining proposals (Government of WA 2016). This description of baseline hydrology also informs the concept for stormwater infrastructure (Section 3).

2.2 Catchments

The mine site lies across a low ridge separating two catchments that drain toward a salt lake system to the north. These regional catchments are shown in Figure 1. Local catchments are shown in Figure 3 and catchment characteristics are summarised in Table 1. The site is in the far eastern part of the Avon hydrographic basin

There are no large drainage lines in the vicinity of the site and drainage is via overland flow paths or shallow flow in broad valleys. Defined drainage lines form further to the north close to the salt lake system and in areas with more relief.

The salt lake system is formed of a series of disconnected lakes extending north toward Yellowdine. These lakes are internally drained and saline, filling to a shallow depth intermittently after heavy rain. Water ponded in the lakes is then lost mainly to evaporation over a period of up to six to nine months. Water in the lakes would be relatively fresh after filling then becomes saline as the water level drops.

In the area of the site, a low ridge runs in a north-south direction through the site. Drainage through the site area is mainly either to the west or east as overland flow. There are no defined natural drainage lines in the area. There is, however, substantial residual disturbance from previous mining that affects local drainage. An old heap leach pad lies just to the east of the mine site. This is a rectangular structure, oriented north-south and built to some 6 m above the ground surface. It intercepts overland flow and small erosion channels from the small catchment to the west. This flow ponds against the western edge of the pad and drains around the northern edge of the pad as shallow, distributed flow, rejoining the natural, diffuse overland flow pathway to the east. There appears to be no constructed drainage channel around the pad though areas of both constructed and apparently unplanned ponds are evident.

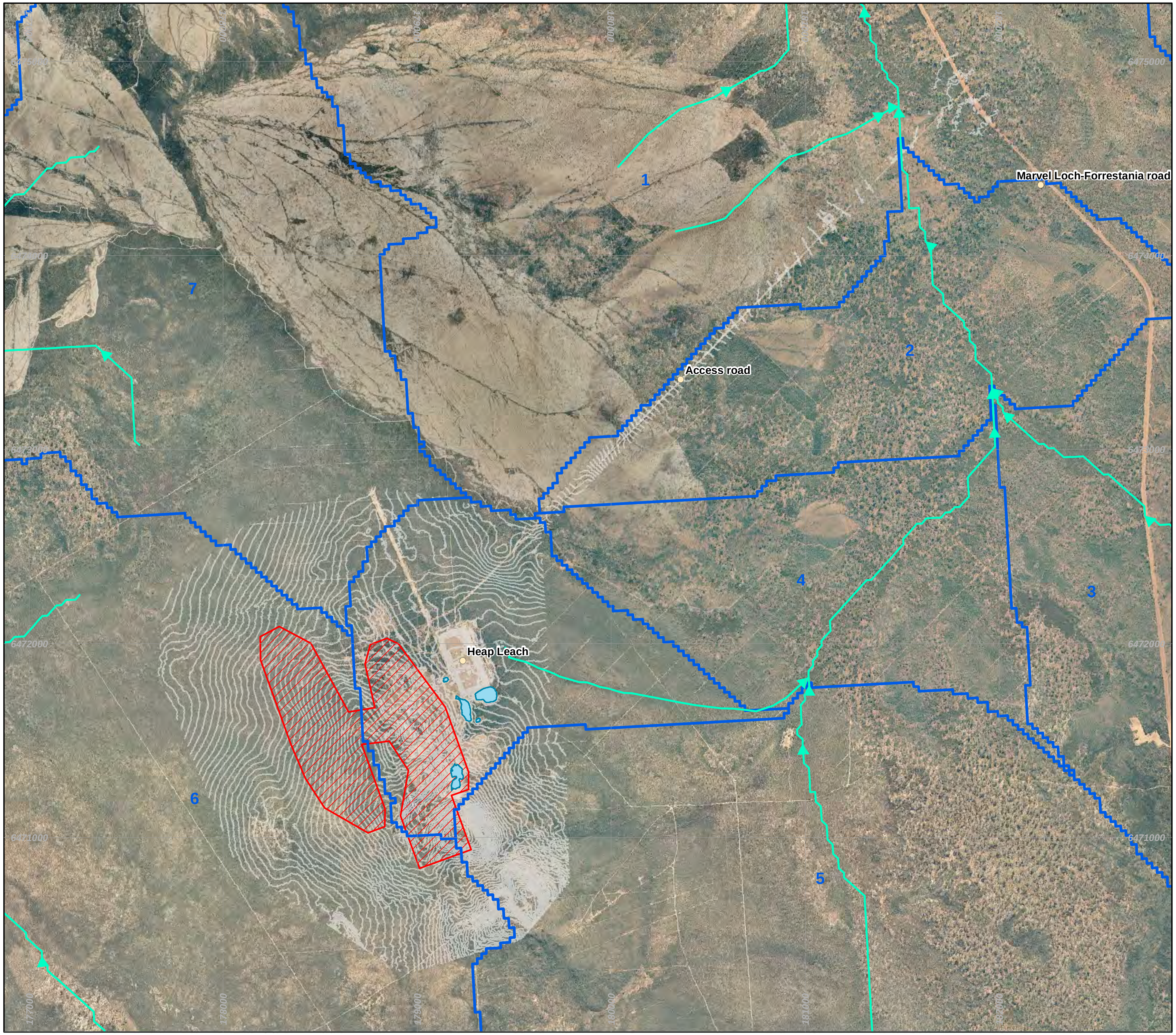
The eastern draining part of the proposed project area has been extensively modified by previous mining activities. Bare, disturbed areas and roads and exploration tracks are common. Other areas appear to have been rehabilitated. A number of constructed ponds exist through the area. These contain varying amounts of stormwater after rainfall. There are no constructed channels but some intermittent erosion gullies occur. Stormwater generally flows in small, shallow valleys.

The western draining part of the project area appears to be relatively undisturbed and is vegetated. There are no defined natural drainage lines nor constructed structures. Stormwater moves via shallow overland flow.

The footprint of the project is small relative to the local and regional catchments. The total project area, excluding the access road, is 0.69 km^2, as indicated by the mapped extent of the open pit, waste rock landform and hardstand area. By the access road crossing, the catchment has increased to 96 km^2. The total area draining to the salt lake system is 2,096 km^2.

Table 1 Catchment characteristics

Catchment	Area (km^2)	Description
Project area	0.69	Total project area, excluding the access road.
Eastern side of project	0.52	Eastern slopes of the project area.
Western side of project	0.87	Western slopes of the project area.
Access road crossing	96	Catchment to the access road, near the Marvel Loch-Forrestania Road. Crossing 3 on Figure 6.
Eastern regional catchment	183	Eastern catchment and wider drainage valley. Drains in a south to north direction toward the salt lake system.
Western regional catchment	646	Western catchment, draining south to north.
Total catchment to the salt lake system	2,096	Total catchment to the salt lake system, including the wheat belt area to the west.



Legend

- Features
- Flowpaths
- Contours (1m)
- Ponds
- Catchments
- Open Pit, WRD and hardstand

Data Sources:
Features, Catchments, Ponds, Flowpaths - Hydrologia
Open Pit, WRD and hardstand - CADRE Enviro

Location

1:100 000 Map Sheet Location

Holleton 2734	Cheritons Find 2834	Lake Percy 2934
O'Connor 2733	Holland 2833	Roundtop 2933

N

SCALE 1:20,000

0 0.5 1 1.5 Km

GDA 1994 MGA Zone 51

Hydrologia

Project: British Hill Surface Hydrology Baseline
Job no: J0100081

Figure 3
Site catchments and drainage

Additional Information

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GDA 1994 MGA Zone 51	PLAN No: GR604-13_BritishHill_Fig3.pdf			
DOCUMENT NAME: GR604-13_BritishHill_Fig3.mxd				

2.3 Surface hydrology

Climate

Climate of the area is classified by the modified Köppen system (BoM 2019c) as Grassland warm (summer drought). The site is located on the edge of the north eastern part of the wheat belt and western goldfields, falling between a temperate and desert climate.

Average annual rainfall (as observed at Mulgara, BoM Station 012298, 22 km northwest of the project area, record from 1984-2019) is 328 mm. Several long term rainfall statistics for the site (derived from SILO and BoM IFD data) are plotted in Figure 4. Rain can fall all year round, but most tends to fall from May to September. Larger events tend to occur between February and March but can occur in winter. Annual rainfall can vary by between 70 and 130% of the average (between the 10 and 90 percentiles).

By comparison, the 1% AEP 24 h design rainfall total is 118 mm (BoM 2019b). The largest local event (from SILO data), associated with Cyclone Ingrid, generated a total of 117 mm over two days.

Rainfall at the site often occurs as a result of decaying tropical cyclones in summer and cold fronts in winter. Rainfall is unreliable and highly variable. Spatial rainfall patterns tend to be highly variable, with individual rainfall event totals varying substantially across even short distances.

Average annual evaporation is 2,068 mm, much higher than average rainfall. Evaporation exceeds rainfall in all months of the year.

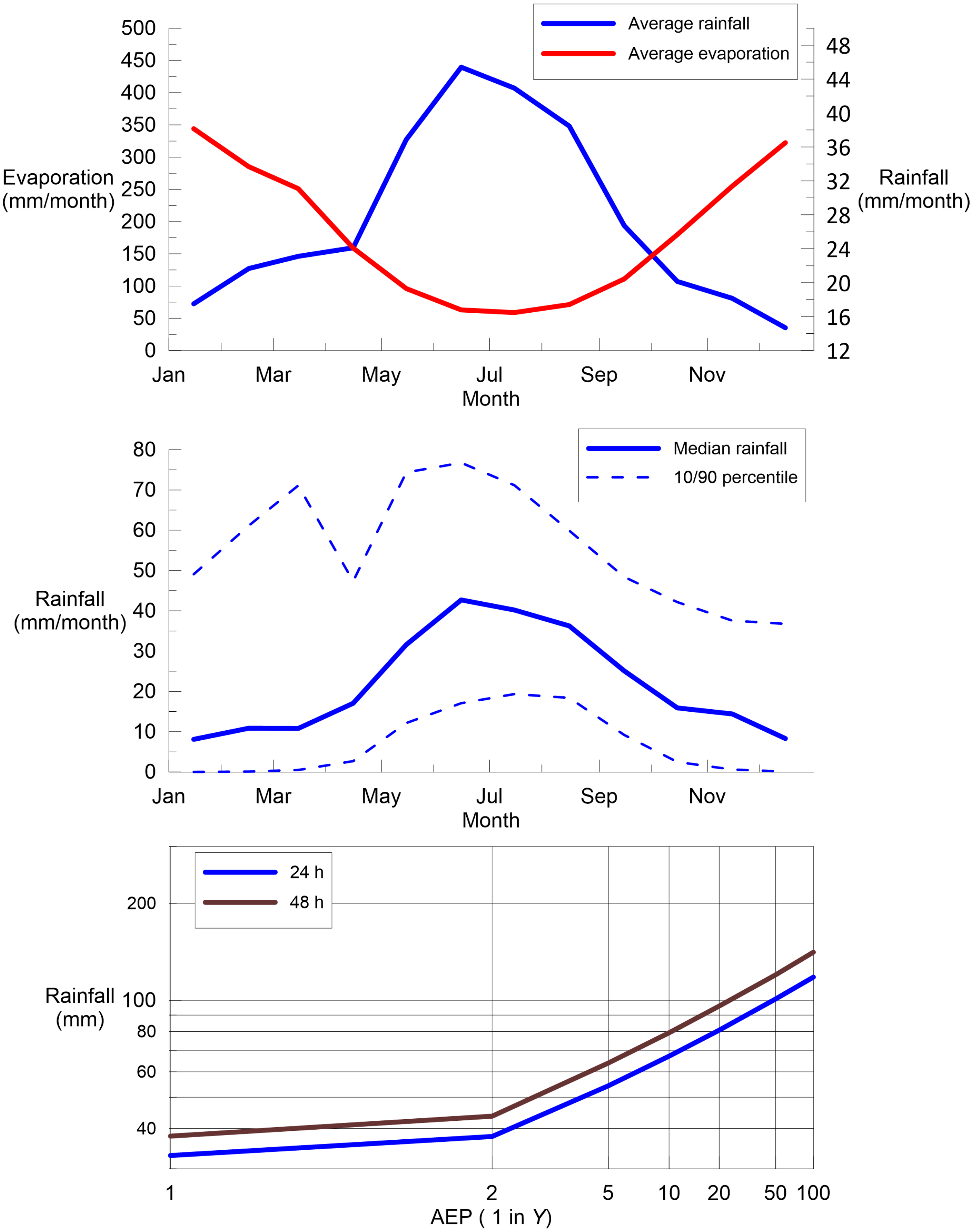


Figure 4 Rainfall and evaporation at the site

Land systems and soils

Land system and soil mapping data are available at a large scale for the site (CSIRO 1991). Surface geology is mapped by Geoscience Australia (GA 2012). Mapping in these documents is at a much larger scale than that of the site so only indicative conditions can be inferred.

The landscape through the site is described in CSIRO (1991) as gently sloping to gently undulating plateau areas, or uplands, on granites, gneisses, and allied rocks, with long gentle slopes and, in places, abrupt erosional scarps, some granitic bosses, and tors; and irregularly traversed by narrow shallow valleys and flats. Soils are yellow earths and ironstone gravels. The valleys to the west and east of the site are associated with sandy plains with some clay pans and small salt lakes, dunes, and lunettes.

Surface geology through the project area is mapped similarly, with sedimentary rock at the site and sandplain to the east and west (GA 2012).

Vegetation and land use

The site is located in a gold mining and pastoral area. There are a number of active and residual mines in the area through the site has not been commercially mined. Agricultural activity in the area is low intensity pastoral grazing with sheep. The Marvel Loch-Forrestania Road passes to the east of the site.

The vegetation in the proposed project area consists of *Eucalyptus* woodland and Mallee and *Melaleuca* shrubland and rehabilitation vegetation (Botanica 2012). Vegetation at much of the eastern part of the project area has been disturbed from previous mining activity at the site and has been rehabilitated.

The eastern end of the access road in the project area falls within the Jilbadji Nature Reserve (Rapallo). The Jilbadji Nature Reserve has conservation significance for both flora and fauna in terms of maintaining existing regional scale processes (Botanica 2012).

Potentially affected downstream areas

The Jilbadji Nature Reserve lies 3 km to the east of the site and part of the access road passes through the reserve. The salt lake system is 18 km north of the site. The main site has a small footprint, so it is unlikely that The Jilbadji Nature Reserve or salt lake system would be impacted by the project. However, the access road passing through the Jilbadji Nature Reserve could have some local impact.

Areas potentially affected by the project are:

- Overland flow pathways immediately downstream of the site; and
- The Jilbadji Nature Reserve close to the access road.

Potential impacts of the project on the downstream environment are:

- Modified overland flow volumes and rates immediately downstream of the site as a result of a mine infrastructure and site stormwater management;
- Shadowing or diversion of shallow overland flow associated with the access road where it passes through the Jilbadji Nature Reserve;
- Erosion associated with disturbed areas, steep slopes and site infrastructure, leading to scour and increased turbidity of stormwater; and
- Impacts of mine infrastructure and mining activities on stormwater quality.

Modified overland flow

During operation of the mine, site infrastructure (the pit, waste rock landform and hardstand area) could influence overland flow in areas just downstream of the site. Internal drainage and on-site disposal of stormwater in the pit and on the waste rock landform could reduce the local catchment area compared with the existing condition. Stormwater generated from hardstand and other disturbed areas could increase stormwater generation.

Impacts of increased stormwater generated on the site can be managed with appropriate onsite drainage infrastructure and release at rates that does not increase flows downstream.

On closure, these hard areas will be rehabilitated, bringing the stormwater generated back in line with pre-existing conditions.

Spoil banks alongside the access road or the road formation itself could interrupt local, shallow overland flow patterns. This is particularly important where the road traverses the Jilbadji Nature Reserve. This effect can be mitigated be constructing the road to allow overland flow to cross without diversion.

Catchment reduction associated with the pit and waste rock landform will remain on mine closure. However the area of catchment reduction is small in the context of the wider catchment. Reduced stormwater flows will only be evident close to the mine, probably just in the area around the heap leach pad, which is already disturbed. Further downstream flow contributions from other parts of the catchment will reduce any impacts to negligible.

Erosion

Erosion of topsoil from disturbed areas and steep slopes could occur. This can be managed with appropriate design and construction of stormwater and facility infrastructure and with rapid rehabilitation. If the timeline for the project is short, o this reduces the chances of a large event occurring during the time of mining. There is also considerable buffer between the site and the main downstream receiving riverine environment (the eastern and western catchment valleys, The Jilbadji Nature Reserve and the salt lake system). The site is located approximately 3 km from the edge of Jilbadji Nature Reserve and 18 km from the edge of the salt lake system. Accordingly, erosion at the site is unlikely to affect the wider environment.

Erosion associated with the access road could impact local undisturbed areas, including the Jilbadji Nature Reserve. This can be managed by preventing stormwater flowing along or lateral to the road at an erosive velocity and by protecting the road surface.

Water quality

The potential for contamination of stormwater is low. There are no workshop or processing infrastructure to be located on site, so contamination sources are limited. Any watering of roads and disturbed areas with saline water is unlikely to lead to significant salt build if the mining timeframe is short. However, if salt does accumulate near vegetated areas, particularly near the access road in the Jilbadji Nature Reserve, appropriate action should be taken to prevent the salt entering the wider landscape at concentrations that could cause impact.

Stormwater generated on the pit and waste rock landform will be managed internally within the structure and will not be released to the environment.

2.4 Environmental values and beneficial uses

The main values and beneficiaries of surface water through the project area relate to:

- Maintenance of native vegetation communities; and
- Maintenance of the ecosystem of the eastern and western catchment valleys, Jilbadji Nature Reserve and the salt lake system.

Local vegetation communities through the mine site are generally dependent on in situ rainfall. There are no nearby drainage lines. Vegetation along overland flow paths and drainage valleys is possibly affected by the intermittent flows they receive after storm events and by local soil characteristics.

The western edge of the Jilbadji Nature Reserve cuts through the drainage valley east of the site. The valley may have intermittent, fresh storm flows after heavy rainfall. There are no pools or ponded water in the valley near the site and the area would dry out rapidly after flow events.

The salt lake system receives fresh stormwater inflows from a wide network of drainage lines and from direct rainfall. After heavy rainfall the lakes fill with fresh water which is then lost to evaporation over time. The area is an internally drained, salt lake system. As such the quality of water ponded in the lake system would vary from highly saline when water levels are low to fresh or moderately saline when flooded.

2.5 Surface water management areas

The site is located in the Outer Avon surface water management area (DWER 2019). It is not in a proclaimed surface water management area.

2.6 Water quality

No publically available water quality data for surface water or stormwater for the local catchment is available. The quality of surface water is inferred here from observations of land systems and weather patterns.

It is likely that the quality of stormwater flows sourced from the area of the site will largely be fresh but may be turbid. There are no pools or dams in the area of the mine site. The only surface water will be in intermittently flowing drainage lines.

The salt lake system is an internally drained, saline system. Salinity of water in the lake will vary from near fresh to saline depending on water levels.

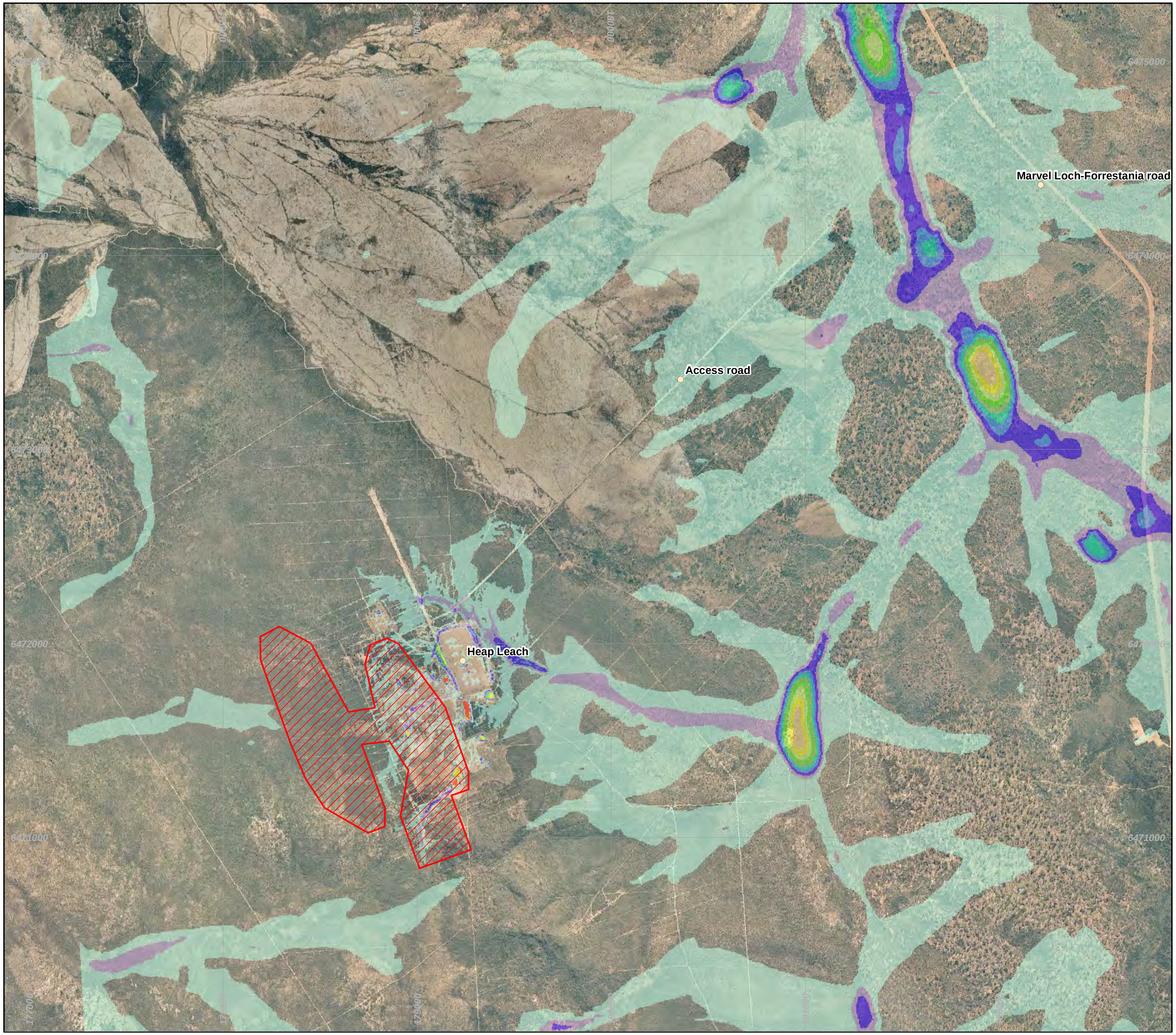
2.7 Flooding characteristics

The site is located across a low ridge forming the divide between two catchments. There are no local defined drainage lines and little contributing catchment to the area of the site.

The access road crosses a broad, shallow valley and the Jilbadji Nature Reserve to the east of the site near the intersection with the Southern Cross-Forrestania Road. This valley will have shallow flow and/or ponding during larger storm events. There is also a considerable amount of overland flow or potentially ponded areas along the access road alignment. Predicted flood extent and depths for the 1% AEP event are mapped in Figure 5. Flow paths and ponding areas in the 10% AEP event are similar to the 1% AEP.

There is little flood risk for the pit or infrastructure in the vicinity of the pit as the site is located on a ridgeline with little catchment and no defined drainage lines. Stormwater here can be managed using normal drainage infrastructure (such as shallow drains and culverts, safety berms for the pit).

Ponding and shallow stormwater flow could affect parts of the access road after heavy rain. Ponding and flow is likely to be shallow and low velocity, so there is little risk to the safety of traffic on the road. However excessive ponding could impact on road trafficability. Stormwater flow across the road and ponding needs to be managed using road crossings to main. Details of proposed crossings are given in Section 3.



Legend

- Features
- Open Pit, WRD and hardstand

Depth 1% AEP (m)

- Above 1.000
- 0.900 - 1.000
- 0.800 - 0.900
- 0.700 - 0.800
- 0.600 - 0.700
- 0.500 - 0.600
- 0.400 - 0.500
- 0.300 - 0.400
- 0.200 - 0.300
- 0.100 - 0.200
- 0.025 - 0.100
- Below 0.025

Data Sources:
Features, Depth 1% AEP - Hydrologia
Open Pit, WRD and hardstand - CADRE Enviro

Location

1:100 000 Map Sheet Location

Holleton 2734	Cheritons Find 2834	Lake Percy 2934
O'Connor 2733	Holland 2833	Roundtop 2933

N

SCALE 1:20,000

0 0.5 1 1.5 Km

GDA 1994 MGA Zone 51

Hydrologia

Project: British Hill Surface Hydrology Baseline
Job no: J0100081

Figure 5
Predicted flooding - existing

Additional Information

COMPILED: Gaia Resources	DATE: 12/02/2020	LOCN: PERTH	A3	SCALE 1:20,000
GDA 1994 MGA Zone 51	PLAN No: GR604-13_BritishHill_Fig5.pdf			
DOCUMENT NAME: GR604-13_BritishHill_Fig5.mxd				

3. Stormwater management

3.1 Introduction

This section presents advice at a concept level on management of surface water across the site for operational and closure phases. Details of flood risk and potential for impact on the environment are given in the baseline hydrology assessment given in Section 2. The stormwater management strategy addresses these risks.

It is not intended at this time to develop a detailed design of surface water management structures but to indicate at a concept level where attention to mitigation of potential impacts may be required as part of the environmental approvals and infrastructure design process.

The assessment is based on information available at this time. This information shows the indicative outline for the pit, waste rock landform and hardstand. As the size and location of these structures is not know at this time, stormwater management guidance given here is indicative, and should be updated when more details become available.

3.2 Objectives

The objectives for surface water management at the site during the operational stage are to:

- Minimise the risk that erosion at the site and on the access road will impact on the downstream environment in the 10% AEP and smaller rainfall events;
- Minimise discharge of contaminated or saline stormwater from the site; and
- Manage flood risk for the 1% AEP event.

After closure, the site will be rehabilitated to a stable landform with minimal impact on the surrounding environment.

3.3 Operational stormwater management

Stormwater management during operation needs to address the following site elements:

- The pit;
- Waste rock landform;
- Hardstand;
- Access road;
- Topsoil stockpiles; and
- Any other site infrastructure, including topsoil stockpiles.

Details of proposed stormwater management infrastructure are shown on Figure 6.

Managing flow velocity and scour risk is integral to the stormwater management plan and the stormwater management concept, as presented, will be relevant for the project moving forward. The main site drain in the stormwater management strategy has a storage capacity with a restricted outflow to control the velocity and rate of flow released to the downstream environment. However, as there are currently no details of the internal site layout, more detailed stormwater management concepts cannot be presented at this time.

Under the stormwater management strategy, existing ponds to the east of the site near the old heap leach won't interact with site drainage. The proposed drain diverts flow from the site around the heap leach. This is a simpler solution than using the ponds and ill-defined drainage around the heap leach as part of the site's stormwater infrastructure. It is also appropriate to keep changed drainage from the site away from legacy areas to minimise any chance of mobilising residual contamination or causing scour.

Pit

The main surface water inflows to the pit void will be from direct rainfall, any runoff from surrounding catchment inside perimeter levees and bunds around the pit, and any inflow from groundwater. It is expected that these inflows will be managed using in-pit sumps and pumping to disposal on site.

A standard safety berm surrounding the pit should be adequate for controlling small local stormwater flows and ponding.

Depending on the location of the pit, it is possible that stormwater from small local catchments could intersect and pond against the pit perimeter levee. The extent of this ponding should be managed using small perimeter drains and levees as required. These drains may be permanent, depending on the amount of flow likely after the site is closed and rehabilitated.

Waste rock landform

The waste rock landform will be built in stages until mining is complete. During construction, attention should be given to managing stormwater runoff and scour from disturbed areas and steep slopes. Temporary perimeter drains or sediment traps may be required to prevent excess sediment entering the surrounding environment. The top of the waste rock landform should be constructed to be internally draining and as far as practicable take the shape of the final landform.

If contaminated stormwater is generated on the waste rock landform, it should be contained and disposed of on the structure.

If the waste rock landform intersects any small upslope catchment, small temporary or permanent diversion drains can be used to protect the toe of the waste rock landform.

Hardstand

The hardstand is likely to take the form of a large graded area, cleared of vegetation. The area would be used for temporary storage of plant and equipment and other supplies.

It is likely that disturbance to the existing vegetation, ground surface and landform across the proposed hardstand area will lead to an increase in stormwater generation, particularly in medium sized events (10% AEP) and larger. Scour and stormwater flow on the hardstand area should be controlled by managing grade and flow paths. If necessary, shallow drains can be used to control flow. Assuming stormwater generated across the hardstand area is low in turbidity and not contaminated with salt or other pollutants, it can be released from the site at a rate that does not cause scour or changed flow paths down slope.

Assuming that the hardstand area occurs on the eastern side of the proposed site outline, a catch drain is suggested on the eastern edge of the site (see Figure 6). This drain discharges toward the northeast of the site, to prevent interaction between the site and the heap leach landform to the east. Preliminary modelling indicates that outflow from this drain would need to be controlled to prevent increased flows downstream. This can be achieved using a drain with adequate capacity and culverts at the site edge.

This concept should be revised when more details of the site layout are known.

Access road

The access road crosses a number of areas that will have shallow flow or ponding for a short period after heavy rainfall. The roadway in these areas should be constructed to accommodate these conditions to allow the road to remain trafficable. The indicative locations of these areas are given in Figure 6.

Floodways are suggested for the crossing in shallow flow or ponded areas (Crossings 1-4). Where the road crosses the proposed drain on the eastern edge of the site (Crossing 5), culverts are preferred.

The floodways could take the form of a protected road surface and free drainage to the valley or ponded area upstream and downstream. Roadside berms should be discontinued through the floodway. Floodways should be constructed so as to not unduly concentrate flows. Culverts or an elevated roadway may not be required unless there is persistent ponding or interference to road operation.

Topsoil stockpiles

Topsoil stripped from disturbed areas through the site should be stockpiled and used on closure for site rehabilitation.

Scour on stockpiles should be controlled by encouraging vegetation growth and by limiting the length of slope. Flat tops and any concentration of runoff on the slopes should be avoided. Stormwater flow from other areas of the site or from external catchments should not be allowed to flow against or scour the edges of the stockpiles. Temporary perimeter drains or sediment traps may be required around the base of the stockpiles to prevent excess sediment entering the surrounding environment.

Other site infrastructure

Other infrastructure on site, such as any site buildings or storage areas, should generally be located in free draining areas and avoid any concentrated stormwater flow paths. Tracks should avoid concentrating stormwater flow.

Storage of any potentially contaminated areas or point pollution sources (such as fuel tanks) should be managed using standard containment or treatment structures and spill management procedures.

If roads and trafficked areas are to be watered with saline water, consideration should be given to prevention of excessive salt wash off to surrounding shrubland or pasture areas. Stormwater flow should be prevented from concentrating and flowing along the roads and external flow should be allowed to cross the road without being concentrated.

3.4 Stormwater management on closure

Elements of the mine site that need to be addressed for closure are:

- The residual pit;
- Waste rock landform dump; and
- The rehabilitated site landform.

Pit

It is expected that the residual pit void will remain after closure and will be isolated with levees and a safety bund. No information is available on the pit water balance, but it is assumed that any lake that forms in the bottom of the pit, fed by groundwater inflows and direct rainfall, will have an equilibrium water level below the ground surface.

There should be no surface water inflows to the pit other than from direct rainfall and a limited catchment surrounding the pit inside the perimeter safety berm. These should be kept as close to the pit as possible to minimise this catchment area.

The bund and final landform around the pit should be constructed to minimise ponding against the bund, either internally or externally, and to allow free drainage of stormwater collected inside the bund into the pit lake. Any minor diversion drains required to alleviate ponding against the outside of the perimeter berm can remain. Consideration should be given to ensuring that entry points for stormwater to the pit do not scour and breach the safety bund.

Waste rock landform

The final waste rock landform should be stabilised to prevent scour. Stormwater generated on the outer batters of the landform should be either retained and disposed of on the structure or released in a safe fashion.

Stormwater generated on top of the structure should be retained and dissipated to evaporation *in situ*. This is a simpler and more stable solution to allowing drainage off the structure but reduces the local catchment area. Ponding or accumulation of stormwater on the top should be avoided by levelling of the landform. Evaporation and infiltration should be encouraged with vegetation and an absorbent soil profile.

Stormwater generated on the external slopes of the dump will need to be managed to control flow and minimise scour. The slopes should be stabilised against erosion using a combination of landform shape, vegetation and ground protection (such as rock or timber). Concentration of stormwater flow on the slopes should be avoided. Low ground surface grade, high infiltration or vegetated areas on the downstream edge of slopes might be useful for containing any eroded material and filtering stormwater exiting the slope area to the environment. Stormwater from the slopes can be released to the environment as long as the quality of the water is similar to the surrounding environment and the outfalls are erosionally stable.

The general site

On closure, it is expected that general site infrastructure will be removed, topsoil stockpiles will be used in site rehabilitation and the landform returned to natural contours and revegetated.

The site is located across a catchment divide and has little contributing catchment. Scour as a result of concentrated flows or from erosion of disturbed areas is the main potential impact on the surrounding environment.

Stormwater flows across the site can be managed as shallow overland flow with drainage similar to the natural landform. Concentrating flows should be avoided. Disturbed soil should be revegetated as quickly as possible.

Legend

- Features
- Proposed crossings
- Proposed drain
- Open Pit, WRD and hardstand

Data Sources:
Features, Proposed drain,
Proposed crossings - Hydrologia
Open Pit, WRD and hardstand - CADRE Enviro

Location

1:100 000 Map Sheet Location

Holleton 2734	Cheritons Find 2834	Lake Percy 2934
O'Connor 2733	Holland 2833	Roundtop 2933

Map Area

N
SCALE 1:20,000
0 0.5 1 1.5 Km
GDA 1994 MGA Zone 51

Hydrologia

Project: British Hill Surface Hydrology Baseline
Job no: J0100081

Figure 6
Surface water management strategy

Additional Information

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GDA 1994 MGA Zone 51	PLAN No: GR604-13_BritishHill_Fig6.pdf			
DOCUMENT NAME: GR604-13_BritishHill_Fig6.mxd				

4. References

ARR (2019). ARR Data Hub. https://data.arr-software.org/.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I, (Editors), 2016, Australian Rainfall and Runoff: A Guide to Flood Estimation, Commonwealth of Australia.

BoM (2019a). Western Australia Observations. http://www.bom.gov.au/wa/observations/. Australian Government, Bureau of Meteorology.

BoM (2019b). 2016 Rainfall IFD Data System. http://www.bom.gov.au/water/designRainfalls/revised-ifd/. Australian Government, Bureau of Meteorology.

BoM (2019c). Köppen system. http://www.bom.gov.au/jsp/ncc/climate_averages/climate-classifications/index.jsp. Australian Government, Bureau of Meteorology.

CSIRO (1991). Digital Atlas of Australian Soils. http://www.asris.csiro.au/themes/Atlas.html#Atlas_Digital. Australian government, CSIRO.

DHI (2019). Mike software. https://www.mikepoweredbydhi.com/products. Mike powered by DHI.

DWER (2019). Surface Water Management Areas. https://catalogue.data.wa.gov.au/dataset/surface-water-management-areas. Government of Western Australia, Department of Water and Environmental Regulation.

GA (2011). 1 second SRTM. https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search?node=srv#/metadata/72759. Australian Government: Geoscience Australia.

GA (2012). Surface Geology of Australia 1:1 million scale dataset 2012 edition. Australian Government, Geoscience Australia. https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search?node=srv#/metadata/c8856c41-0d5b-2b1d-e044-00144fdd4fa6.

Government of WA (2016). Guidelines for mining Proposals in Western Australia. Government of Western Australia, Department of Mines and Petroleum. April 2016.

Queensland Government (2019). SILO Data Drill. https://www.longpaddock.qld.gov.au/silo/point-data/.

RFFE (2016). Regional Flood Frequency Estimation Model. Version RFFE Model 2016 v1. http://rffe.arr-software.org/.

Appendices

Appendix A – Model parameter values

Mike SHE hydrology model

Software:

Mike SHE and Mike Hydro release 2019 Update 1.

Simulation specification:

- Two model domains:
  - Regional – covering catchments down to the salt lake system; and
  - Site – covering the immediate site area;
- For the scenarios:
  - Regional – existing, 10% and 1 % AEP design rainfall events;
  - Site – existing and proposed, 10% and 1 % AEP design rainfall events;
- Overland flow represented using Mike SHE and rain-on-grid:
  - Regional - 25 m square grid, topography derived from SRTM data;
  - Site - 5 m square grid, topography derived from detailed site data;
- Channel hydraulics represented in Mike Hydro;
- Mike SHE overland flow resistance: Manning's M of 10 (undisturbed) and 33.3 (disturbed site area), Mike Hydro channel resistance: Manning's n = 0.022 for constructed drains.
- Design rainfall:
  - Total rainfall used in Mike SHE;
  - Design rainfall from 2016 IFD data (BoM 2019b);
  - Temporal pattern:
    - Regional: areally reduced for 830 km^2, 10% AEP: 12 h, Pat20, 1% AEP: 12 h, Pat02;
    - Site: point rainfall, 10% AEP: 2 h, Pat08, 1% AEP: 2 h, Pat10;
- Loss model:
  - 2 Layer UZ and evapotranspiration;
  - Evaporation 9.2 mm/day;
  - Detention storage: 10% and 1% AEP: 10 mm (undisturbed), 2 mm (disturbed site area); and
  - UZ hydraulic conductivity: five soil types with varying properties.

Hydrologia

Topographic data extents