HASTINGS
Technology Metals Limited

APPENDIX 9

YANGIBANA PROJECT

PRELIMINARY SURFACE WATER

MANAGEMENT PLAN

Prepared for

Hastings Technology Metals Ltd

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Report Distribution

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EXECUTIVE SUMMARY

Hastings Technology Metals Pty Ltd (Hastings) is developing the Yangibana rare earths project. The mine will produce a mixed rare earth carbonate (MREC), which contains up to 16 rare earth elements. The project is located approximately 270 km east-northeast of Carnarvon on Gifford Creek Station in the Gascoyne region of Western Australia.

This report presents a preliminary surface water management plan (SWMP) for the project that will contribute to the mine planning, design and approval process.

The site is located in an arid, low rainfall area. Average annual rainfall for the region is between 210 and 278 mm. Rainfall is unreliable from year to year and extremely variable and successive years with below average rainfall occur frequently. Pan evaporation exceeds mean monthly rainfall in all months of the year, with the total annual evaporation of some 3,500 mm being well over an order of magnitude higher than the annual rainfall.

There are two periods of higher rainfall during the year. Northern monsoon influences tend to produce rain over the summer and early autumn period. Southern frontal influences produce rain in late autumn and winter.

The soils of the local catchment areas are predominantly shallow sandy loams overlying weathered granite or clayey loams. This limits the capacity for rainfall infiltration into the soil. Vegetation in the Gascoyne River catchment is generally in poor condition. Low cover levels combined with low infiltration mean that soils are prone to erosion.

The site is located within the Gascoyne River catchment. The Lyons and Edmund Rivers lie close to the site. Several tributaries of the Lyons and Edmund Rivers traverse the study area. The rivers and creeks are ephemeral and only flow following rainfall although semi-permanent pools occur along their lengths. Two semi-permanent pools occur within 5-10 km of the Proposal.

It is likely that the quality of stormwater flows and ponded water will be variable across the mine site. In the upper areas, stormwater flows will largely be fresh but may be turbid. In the larger creeks and the Lyons River, flows after rainfall events are also likely to be fresh and with variable turbidity. Residual pools may become more saline as they dry. Turbidity in pools is also likely to be variable over time and may depend on external influences, such as disturbance by animals or livestock.

Key surface water management issues are:

- Potential environmental impacts;
- Flood risk; and
- Operational surface water management.

These issues are relevant across the three main phases of the project – development, operation and closure, each of which has distinctly different characteristics.

Environmental impact issues include erosion and sedimentation impacts off-site and release of contaminated stormwater. Flood risk involves considering the consequences of larger flood events, typically the 1% Annual Exceedance Probability (AEP). Key risks relate to floodwater ingress to the Yangibana North and West pits and damage to road crossings. Operational surface water management relates to management of stormwater during smaller, more frequent events. This is important for site operation.

EXECUTIVE SUMMARY

Details of the surface water management plan are given in Section 4. Objectives for the plan are set and guidelines for works, processes and monitoring to meet these objectives are given. Surface water management is discussed under the project phases – development, operational and closure, and across operational areas of the site. A monitoring framework is given.

GLOSSARY OF HYDROLOGICAL TERMS

Annual Exceedance Probability (AEP)

The probability of an event being equalled or exceeded within a year. For rainfall, an event is a total accumulated over a given duration. For floods, an event is typically the annual maximum flow rate. The relationships in terminology between AEP and ARI for specific event probabilities are (Ball *et al.* 2016):

Frequency descriptor	AEP %)	ARI (1 in *x*)
Frequent	63.21	1
Frequent	50	1.44
Frequent	20	4.48
Frequent	18.13	5
Rare	10	9.49
Rare	5	20
Rare	2	50
Rare	1	100

Antecedent Soil Moisture

Water present in the soil prior to a rainfall event.

Average Recurrence Interval (ARI)

The average time period between occurrences of an event equalling or exceeding a given value.

Australian Rainfall and Runoff (ARR)

National guideline document, data and software suite that can be used for the estimation of design flood characteristics in Australia. Currently in its 4th edition it is commonly referred to as ARR2016.

Australian Hydrological Geospatial Fabric (AHGF)

The Australian Hydrological Geospatial Fabric (Geofabric) is a specialised Geographic Information System (GIS). It identifies and registers the spatial relationships between important hydrological features such as watercourses, water bodies, canals, aquifers, monitoring points and catchments.

Backwater

Water backed-up or retarded in its course as compared with its normal or natural condition of flow.

Baseflow

The component of streamflow supplied by groundwater discharge.

Basin

A tract of country, generally larger catchment areas, drained by a river and its tributaries.

Catchment

The land area draining to a point of interest, such as a water storage or monitoring site on a watercourse.

Channel

An artificial or constructed waterway designed to convey water. Often described as open channels to distinguish them from pipes.

Control

Physical properties of a cross-section or a reach of an open channel, either natural or artificial, which govern the relation between stage and discharge at a location in the open channel.

Dead Storage

In a water storage, the volume of water stored below the level of the lowest outlet (the minimum supply level). This water cannot be accessed under normal operating conditions.

Discharge

Volume of liquid flowing through a cross-section in a unit time.

Drainage Division

Representation of the catchments of the 12-major surface water drainage systems across Australia, generally comprising a number of river basins.

Endorheic Basin

A closed surface water drainage basin that retains water and has no outflow to the sea.

Environmental Flow

The streamflow required to maintain appropriate environmental conditions in a waterway or water body.

GLOSSARY OF HYDROLOGICAL TERMS

Ephemeral	Something which only lasts for a short time. Typically used to describe rivers, lakes and wetlands that are intermittently dry.
Evapotranspiration (ET)	The sum of evaporation and plant transpiration from the earth's land surface to the atmosphere.
Evaporation	A process that occurs at a liquid surface, resulting in a change of state from liquid to vapour.
Floodplain	Flat or nearly flat land adjacent to a stream or river that experiences occasional or periodic flooding.
Flood Risk	The combination of the probability (likelihood or chance) of a flood event happening and the consequences (impact) if it occurred. Flood risk is dependent on there being a source of flooding, such as a sufficiently large upstream catchment, and something that is affected by the flood, such as a mine pit.
Full Supply Level (FSL)	The normal maximum operating water level of a water storage when not affected by floods. This water level corresponds to 100% capacity.
Generalised Short-Duration Method (GSDM)	Appropriate for estimating probable maximum precipitation for durations up to six hours and for an area of less than 1000 square kilometres.
Generalised Tropical Storm Method – Revised (GTSMR)	Appropriate for estimating probable maximum precipitation in regions of Australia affected by tropical storms.
Intensity-Frequency-Duration (IFD)	Design rainfall intensities (mm/h) or design rainfall depths (mm) corresponding to selected standard probabilities, based on the statistical analysis of historical rainfall.
Minimum Supply Level (MSL)	The lowest water level to which a water storage can be drawn down (0% full) with existing outlet infrastructure; typically, equal to the level of the lowest outlet, the lower limit of accessible storage capacity.
Precipitation	All forms in which water falls on the land surface and open water bodies as rain, sleet, snow, hail, or drizzle.
Probable Maximum Flood (PMF)	The PMF is the largest flood that could conceivably occur at a particular location, usually estimated from probable maximum precipitation (PMP, and coupled with the worst flood producing catchment conditions.
Probable Maximum Precipitation (PMP)	The theoretically greatest depth of precipitation for a given duration under modern meteorological conditions for a given size storm area at a particular location at a particular time of the year, with no allowance made for long-term climatic trends.
Rainfall	The total liquid product of precipitation or condensation from the atmosphere, as received and measured in a rain gauge.
Riparian	An area or zone within or along the banks of a stream or adjacent to a watercourse or wetland; relating to a riverbank and its environment, particularly to the vegetation.
Stage	Water level relative to a datum, typically measured at a water monitoring site.
Storage	A pond, lake or basin, whether natural or artificial, for the storage, regulation and control of water.
Surface Runoff	Water from precipitation or other sources that flows over the land surface. Surface runoff is the fraction of precipitation that does not infiltrate at the land surface and may be retained at the surface or result in overland flow toward depressions, streams and other surface water bodies.
Sustainable Yield	The level of water extraction from a particular system that would compromise key environmental assets, or ecosystem functions and the productive base of the resource, if it were exceeded.

GLOSSARY OF HYDROLOGICAL TERMS

Total Suspended Solids (TSS)	The sum of all particulate material suspended (i.e. not dissolved) in water. Usually expressed in terms of milligrams per litre (mg/L). It can be measured by filtering and comparing the filter weight before and after filtration.
Transpiration	Evaporative loss of water from the leaves of plants through the stomata; the flow of water through plants from soil to atmosphere.
Watercourse	A river, creek or other natural watercourse (whether modified or not) in which water is contained or flows (whether permanently or from time to time).
Wind Run	The product of the average wind speed and the period over which that average speed was measured.

Reference: BoM (2017).

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1.0 INTRODUCTION

1.1 BACKGROUND

Hastings Technology Metals Pty Ltd (Hastings) is developing the Yangibana Rare Earths Project (the Project). The mine will produce a mixed rare earth carbonate (MREC), which contains up to 16 rare earth elements. Of these the highest value elements are Neodymium and Praseodymium, materials that are used in the production of permanent magnets. These types of magnets are used in many new technology products, including electric vehicles, wind turbines and electrical consumer products.

The Project is located approximately 270 km east-northeast of Carnarvon on Gifford Creek Station in the Gascoyne region of Western Australia. The Project location is shown on Figure 1. Details of the mine site are given in Figure 2.

Mining will be undertaken using open cut methods, initially from four pits – Yangibana North and West, Bald Hill and Fraser's. Infrastructure on site includes the pits, process plant (incorporating beneficiation and hydrometallurgy) and supporting roads and infrastructure. The MREC produced on site will be transported off-site by road for export from the Port of Carnarvon. The initial mining life is expected to be ten years.

This report presents a preliminary surface water management plan that will contribute to the mine planning, design and approval process. The plan draws on studies that have been completed and the mine approval and planning documentation. Design of site flood protection and drainage works is currently underway. This plan will incorporate design principals that can be used to inform the design process. This plan may need to be revised as more design details become available and/or the mine plan changes.

1.2 SCOPE OF WORK

The scope of work is to prepare a preliminary surface water management plan for the Yangibana mine site. The plan covers the existing mine footprint – the Yangibana North and West, Bald Hill and Fraser's pits, site infrastructure and roads to the existing State road network.

The plan is intended to:

- Demonstrate that flood protection and drainage measures used at the site will be suitable to protect important site infrastructure and to minimise impacts on the environment; and
- Inform the engineering design of flood protection and drainage infrastructure.

1.3 METHODOLOGY

The work was undertaken in the following stages:

- Receive and review data; and
- Develop the surface water management plan.

The work was undertaken using the existing available information. No modelling or design work was undertaken as part of this study.

Receive and review data

The following data were supplied by Hastings and used in the assessment:

- Site GIS and mine information data;
- Previous study reports and mine planning and approval documentation; and
- Design information.

Development of the SWMP

The surface water management plan (SWMP) layout was developed in consultation with Hastings and incorporating input from regulators and stakeholders. Key components of the plan include:

- Description of the existing physical environment, as it relates to management of site stormwater and flood risk;
- Identification of potential flood risks and environment impacts;
- Surface water management principals, including advice for the design process; and
- Monitoring.

The plan covers the following mine phases:

- Development;
- Operation; and
- Closure.

1.4 LIMITATIONS

This report has been prepared by Groundwater Resource Management Pty Ltd (GRM) for Hastings and may only be used and relied on by Hastings for the purpose agreed between GRM and Hastings as set out in Section 1.2 of this report.

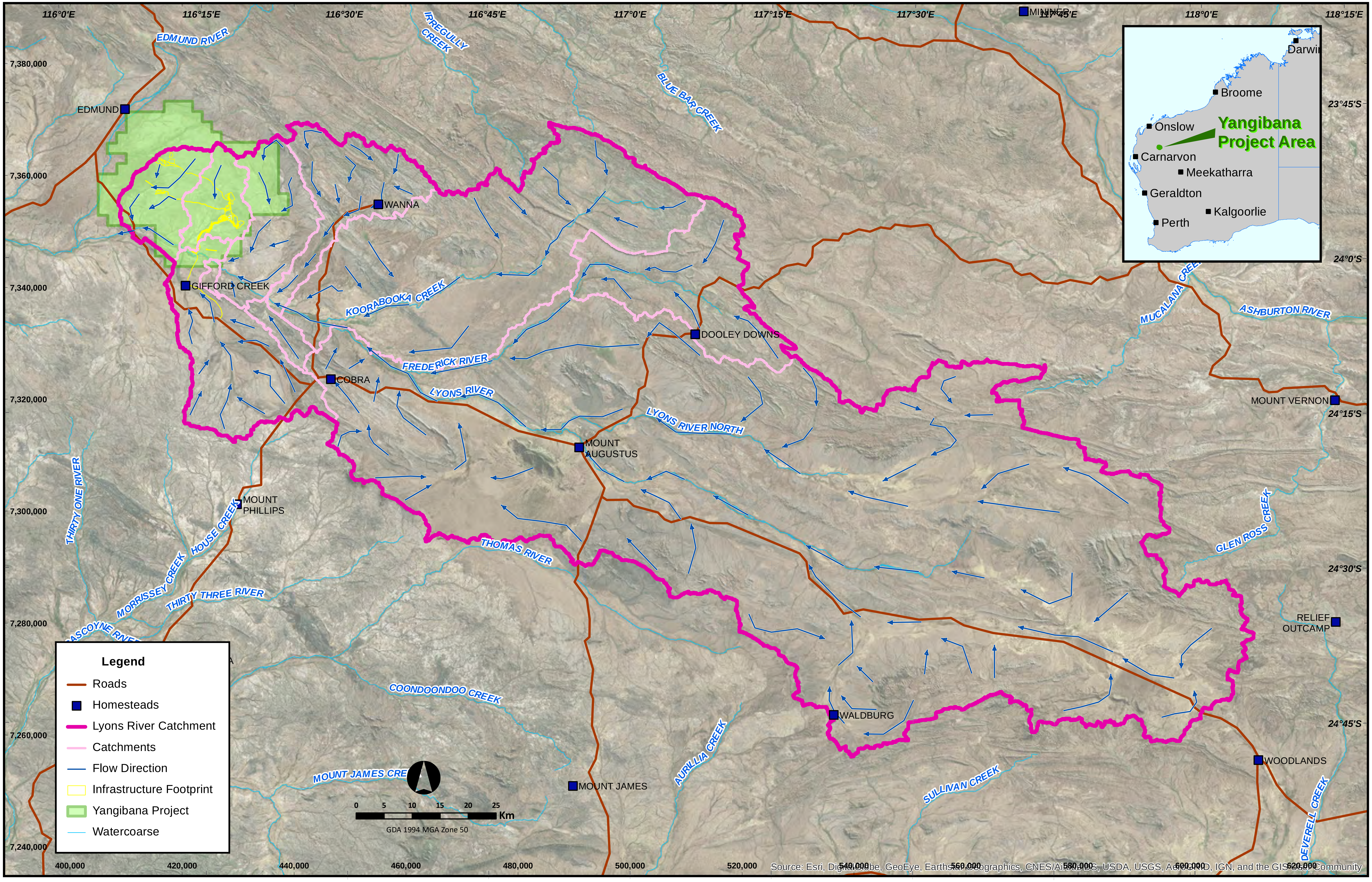
GRM otherwise disclaims responsibility to any person other than Hastings arising in connection with this report. GRM also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GRM 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. GRM 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 GRM described in this report (refer Section 1.3 of this report). GRM disclaims liability arising from any of the assumptions being incorrect.

GRM has prepared this report on the basis of information provided by Hastings and others who provided information to GRM (including Government authorities), which GRM has not independently verified or checked beyond the agreed scope of work. GRM 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.



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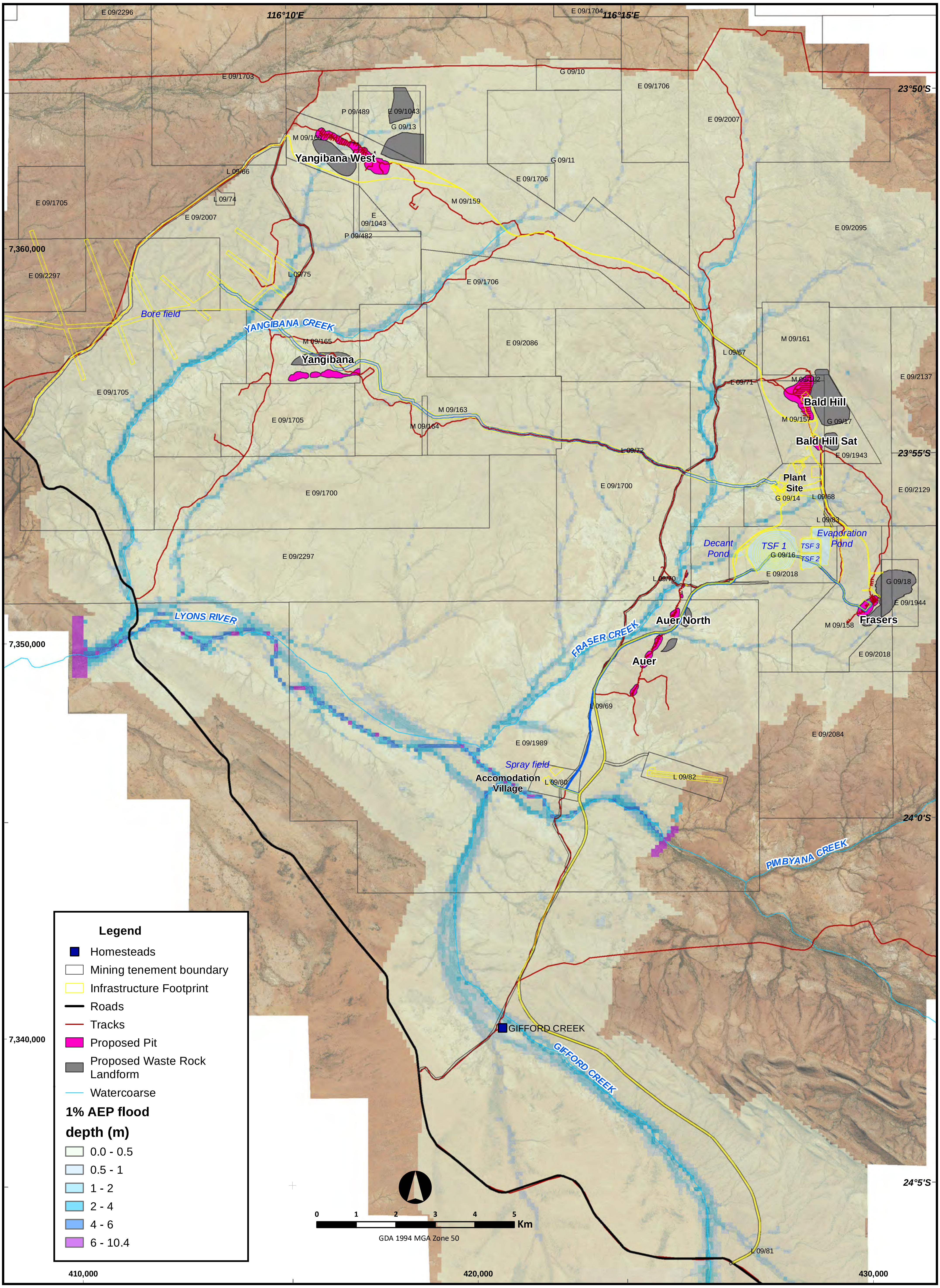
YANGIBANA RARE EARTHS PROJECT

Site location and catchments

Hydro_Figure1.mxd
27 November 2018

Figure 1



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YANGIBANA RARE EARTHS PROJECT

Site Details

Hydro_Figure2.mxd
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Figure 2

2.0 THE EXISTING ENVIRONMENT

2.1 INTRODUCTION

This section presents a summary of existing environmental conditions for the mine site and local catchment. The site location and catchment are shown in Figure 1. The description is focused on variables that influence surface water management at the mine site.

This section informs the assessment of potential impacts of the mine development on surface water hydrology (see Section 3) and management actions (Section 4).

Information presented here is drawn from existing planning documentation.

2.2 CLIMATE

Climate of the area is classified by the Bureau of Meteorology as Arid, low rainfall (Hastings 2018). The site is subject to northern monsoon influences over the summer and early autumn period, and southern frontal influences in late autumn and winter. There are two periods of higher rainfall during the year - from January to April and June to July, and a drier period from August to December.

Rainfall tends to occur as a result of two types of meteorological events:

- Rare and high intensity rainfall resulting from tropical cyclonic activity; and
- Frequent, lower intensity rainfall resulting from low pressure systems, localised thunderstorms or tropical upper air disturbances.

The annual rainfall for the region ranges between 210 and 278 mm. Rainfall is unreliable from year to year and extremely variable, and successive years with below average rainfall occur frequently.

Pan evaporation exceeds mean monthly rainfall in all months of the year, with the total annual evaporation of some 3,500 mm being well over an order of magnitude higher than the annual rainfall.

2.3 LAND SYSTEMS AND SOILS

The soils of the local catchment areas are predominantly shallow sandy loams overlying weathered granite or clayey loams (Landloch 2016). This limits the capacity for rainfall infiltration into the soil and with a lack of vegetation cover is prone to erosion.

2.4 VEGETATION AND LAND USE

The Gascoyne River catchment is generally in poor condition, as characterised by a loss of plant cover, few perennial plants and ongoing soil loss. The poor condition rating has been in effect at least since the 1960s and possibly the 1930s due to historical overgrazing by pastoral activities (Waddell et al. 2012).

2.5 Drainage and Topography

The site is located within the Gascoyne River catchment. This catchment covers an area of about 80,400 km^2, discharging to the Indian Ocean at Carnarvon. Two tributaries of the Gascoyne River – the Lyons and Edmund Rivers, lie within or close to the Project area.

The Lyons River is one of the Gascoyne River's largest tributaries, joining the Gascoyne River just east of the Kennedy Range. The mine site is situated at the base of the Lyons River catchment. The site access road crosses the Lyons River, about 10 km south of the mining areas. The catchment area at the site access road is approximately 11,000 km^2 (JDA 2016).

The Edmund River, a tributary of the Lyons River, traverses the western edge of the mine site and flows in a southerly direction, discharging into the Lyons River west of the mine site. The Edmund River comprises several smaller catchments, including Dingo Creek Catchment (344.4 km^2), Rock Hole Creek Catchment (85.6 km^2) and the Upper Edmund Creek Catchment (830.3 km^2).

Several tributaries of the Lyons and Edmund Rivers traverse the study area: The proposed Fraser's and Bald Hill pits are located within the Fraser Creek Catchment, which covers an area of just over 150 km^2. The proposed Yangibana North and Yangibana West pits are located within the Yangibana Creek Catchment (to the west of the Fraser Creek Catchment), which is slightly larger, covering an area of almost 200 km^2 (GRM 2018).

The rivers and creeks are ephemeral and only flow following rainfall although semi-permanent pools occur along their lengths. Two semi-permanent pools occur within 5-10 km of the Proposal.

2.6 Water quality

Water quality analysis has been conducted by Hastings at two ephemeral pools (LC - Pool 800US and FR – Pool) on the Lyons River, located approximately 5-10 km from the proposed processing plant. These samples were collected at the end of the dry season and thus parameters measured will vary depending on time since last rainfall. Hastings has collected samples from Lyons River Pool on several occasions, however Fraser Creek Pool has only been sampled on one occasion. The Fraser Creek Pool is much smaller than the Lyons River Pool and dries out much faster. The samples indicated total suspended solids of less than 5 mg/L to 18 mg/L.

By inference from land systems and weather patterns, it is likely that the quality of stormwater flows and ponded water will be variable across the mine site. In the upper areas, stormwater flows will largely be fresh but may be turbid. In the larger creeks and the Lyons River, flows after rainfall events are also likely to be fresh and with variable turbidity. Residual pools may become more saline as they dry. Turbidity in pools is also likely to be variable over time and may depend on external influences, such as disturbance by animals or livestock.

3.0 POTENTIAL IMPACTS

3.1 INTRODUCTION

This section presents an assessment of potential issues associated with surface water management across the mine site.

Issues can be grouped into the following categories:

- Potential environmental impacts;
- Flood risk; and
- Operational stormwater management.

These issues are also relevant across the three main phases of the project – development, operation and closure. These phases have distinctly different characteristics and are considered separately.

This section discusses surface water management under these issue categories with specific reference to project phases. Operational management of surface water, including flood risk, and potential environmental impacts is central to the outcomes of sound surface water management planning. Accordingly, this section is intended to inform the surface water management plan, given in Section 4.

The assessment is based on the available information, mainly the Hastings definitive feasibility study and environmental review document. The flood risk assessment is summarised from JDA (2016).

3.2 POTENTIAL ENVIRONMENTAL IMPACTS

3.2.1 During Mine Development

The development phase of the mine typically covers construction of infrastructure for the operation of the mine. This often includes development of accommodation, office and workshop areas, the pit and processing area, waste rock landforms, tailings storage facilities, the access and internal roads and other operational infrastructure. The proposed development timeline, to commissioning, is just less than two years (Hastings 2017).

Development of the mine site typically involves rapid and extensive disturbance to the ground surface. Construction of appropriate surface water management systems may, however, take some time. Areas of bare and or/steep soil may persist for longer periods than during operation because of the amount, timing and nature of activity during construction.

A key characteristic of the development phase is that areas will be disturbed temporarily or move through several phases before the operational condition is reached. Full site facilities may also not be available until operations commence and even then, capacity to manage scour and other issues related to stormwater damage and impacts will be limited.

The full site footprint may also steadily increase over time, particularly for waste rock landforms (WRLs) and the tailing storage facility. Accordingly, expansion areas will effectively be in a development phase until expansion has stabilised.

Key potential impacts on the environment relating to surface water during the development phase of the project are:

- Uncontrolled release of concentrated stormwater flows leading to scour and/or sediment deposition impacting on the downstream environment;
- Erosion of unprotected or unfinished steep slopes leading to deposition of sediment in the downstream environment; and
- Release of potentially contaminated stormwater from workshops, fuel and chemical storage areas until containment facilities have been constructed.

3.2.2 Operational Phase

The operational phase of the mine begins when the site is commissioned and switches to production mode. At this point much of the key infrastructure will have been constructed and the progressive development of WRLs and the tailings storage facilities have been planned. A comprehensive surface water management system will have been designed and constructed as appropriate to suit mine staging.

Environmental impacts relate now to the scale of mine assets and the adequacy of design and construction of surface water management assets. Management focus is more on monitoring the performance of the surface water management system and rectifying damage or failures.

Key potential environmental impacts relating to surface water during the operational phase of the project are:

- Concentration of stormwater flows and increased runoff from operational and disturbed areas leading to scour and/or sedimentation impacting on the downstream environment;
- Diversion of stormwater reducing flow to local areas downstream (shadowing);
- Ponding upstream of infrastructure impacting on the local environment; and
- Release of potentially contaminated stormwater off-site.

Most environmental impacts are likely to occur as a result of small rainfall events, due to the nature of impact mechanisms and the short mine life. The operational life of the mine is expected to be ten years for the four pits assessed in this study. The chance of receiving a large flood event in this time is relatively low. For example, the chance of receiving a 1% (1 in 100) AEP event in a ten year mine life is about 10%. The chances of receiving a relatively small event are higher – 89% for a 20% AEP event.

Accordingly, impacts arising from gross scour or sedimentation due to failure of drains or levees in a large event are unlikely. Impacts are more likely to occur as a result of failures in design or construction (such as erosionally unstable outlet from a drain to the environment) or management systems (such as failure to maintain sediment traps) and occur in smaller rainfall events.

3.2.3 Closure

Closure activity with respect to surface water relates mainly to rehabilitation and stabilisation of a final landform. Environmental impacts arising after closure often relate to failure of the constructed landform, particularly large diversion channels and structures containing contaminants that are mobile in the environment. Contaminated leachate from tailings storage facilities and WRLs can enter the riverine environment downstream, either via groundwater or surface water pathways. Excessive erosion of cover material on WRLs may expose contaminants and rapid transport in the surface water pathway can occur.

Timelines for closure are much longer than for the development or operational phases of the mine. Accordingly, design of the closure landform that mimics the stable, natural environment as closely as possible is important as per the Landform Evolution Report (Trajectory 2018).

3.3 Flood Risk

Flood risk for mine assets is a combination of the probability of a flood event happening and the consequences of the event. Accordingly, the highest flood risk on mine sites tends to occur when high value assets, such as pits, are placed in or near streams that have a sufficiently large upstream catchment. Assets most at risk tend to include pits, roads and areas where people may be working or living. Human safety is a key factor in flood risk assessment. But interruption to operations, such as if a haul road is cut or pit flooded, are also important for the mine as a business.

An analysis of flood risk for the mine site was undertaken by JDA (2016) and the results of this study are summarised here. Results are presented for each main area at risk. The flood risk assessment is focussed on the operational mine assets but still applies to assets during construction (such as roads).

Flood risk is most relevant during the operational phase, when important infrastructure has been developed, the site is fully staffed and interruption to production is possible. However, flood risk still applies during the development phase, relating particularly to site access and construction delays.

Post closure, damage occurring in larger events (1% AEP or greater) is important, due to the long-term nature of the remaining landform.

3.3.1 Bald Hill and Fraser’s Mining Area

The mining area footprint for this area is located within the upper catchment of Fraser Creek. Both the Bald Hill and Fraser’s pits sit almost directly on local catchment divides. As such local drainage is away from the site. No notable drainage paths are located within the processing plant and there is only minor risk from tributaries to the north and south of the processing plant. The haul road corridor to the south of Bald Hill traverses the alignment of a small drainage system and also crosses a more significant drainage path, which has a 1% AEP discharge of 129 m^3/s.

There is no direct flood risk to the Bald Hill and Fraser’s mining area. Flows are generally maintained within the flow channels, with little breakout of flows. Large sections of the mining area are unaffected by flood flows, other than shallow, localised overland runoff.

3.3.2 Yangibana North

The Yangibana North and West pits are located in the upper reaches of Yangibana Creek and cross a number of minor tributaries. Diversion of these drainage networks is required to protect the integrity of proposed WRLs and to prevent flooding of the open pits. A concept for this diversion drain is given in JDA (2016).

3.3.3 Road Crossings

Flood waters from Yangibana Creek, Fraser Creek, Lyons River and Gifford Creek traverse either the main access road or the haul road. It is proposed that at all crossings except for the crossing of the

Lyons River would be floodways, constructed flush with the natural creek invert. The Lyons River will require a more substantial structure. Floodways without culverts mean that water will flow across the roadway in all runoff events. Once flow depth and/or velocity exceeds what vehicles can safely traverse, the road will be unserviceable. Analysis of road serviceability by JDA (2016) indicates that smaller crossings will be closed for less than one day for all size events. The Lyons River crossing could be closed for up to 2.5 days for the 18% AEP (5-year ARI) event.

The southern access road is a 7.5 km stretch of proposed access road running in a north-west direction from Cobra/Gifford Creek Road towards the mining area (parallel with Gifford Creek). The current alignment has the road crossing a number of minor ephemeral drainage courses which ultimately feed Gifford Creek. To prevent obstruction of surface water flows and sheet flow to Gifford Creek it is proposed to use culverts distributed in a relatively uniform fashion along the road (JDA 2016).

3.4 Operational surface water management

Management of stormwater during smaller, more frequent events is important for site operation. Smaller events are more likely to occur during the life of the project and can lead to disruption of site operations. Minor flooding, scour and sediment deposition and off-site transport of pollutants can occur in even a small event (such as 50% AEP).

During the development phase, this can lead to offsite environmental impacts, delays in construction and possibly increased construction cost. During operation, production delays as well as environmental impacts can occur.

After closure, though damage to landform can still occur in smaller events and can accumulate, most focus is on effects of larger events.

3.5 Legislation and Regulatory Framework

The project occurs in a proclaimed surface water catchment area under the *Rights in Water and Irrigation Act 1914* (WA). As such, all river, creek and drainage channel crossings require a Bed and Banks Permit to ensure surface water flow is maintained.

Surface water management is also documented in the:

- Mining Proposal (in development) and Preliminary Mine Closure Plan; and
- State and Federal environmental approvals process.

A Bed and Banks Permit (PMB2011993) has been obtained for the construction of the access road to the accommodation village, a component of the Minor or Preliminary Works program. The conditions of the Permit are:

1. The permit holder is to comply with designs and specifications submitted to the department with the application dated 23/02/2018 and any amendments made by or with the approval of the Department.
2. The permit holder shall ensure that the river crossing does not act as an artificial barrier or levee, causing water to pond upstream.
3. The permit holder must undertake the works authorised by this permit with minimal disturbance to the bed and banks of the river.

4. The permit holder must stabilise all sites affected by construction or removal activities using methods described in the designs and specifications submitted to the Department of Water and Environmental Regulation, as provided with the application dated 23/02/2018.
5. The permit holder must only undertake works in the area defined as Lyons River Crossing or Floodway on the aerial photograph/diagram titled Surface Water Mitigation Areas submitted with the application dated 23/2/2018 (Figure 3).

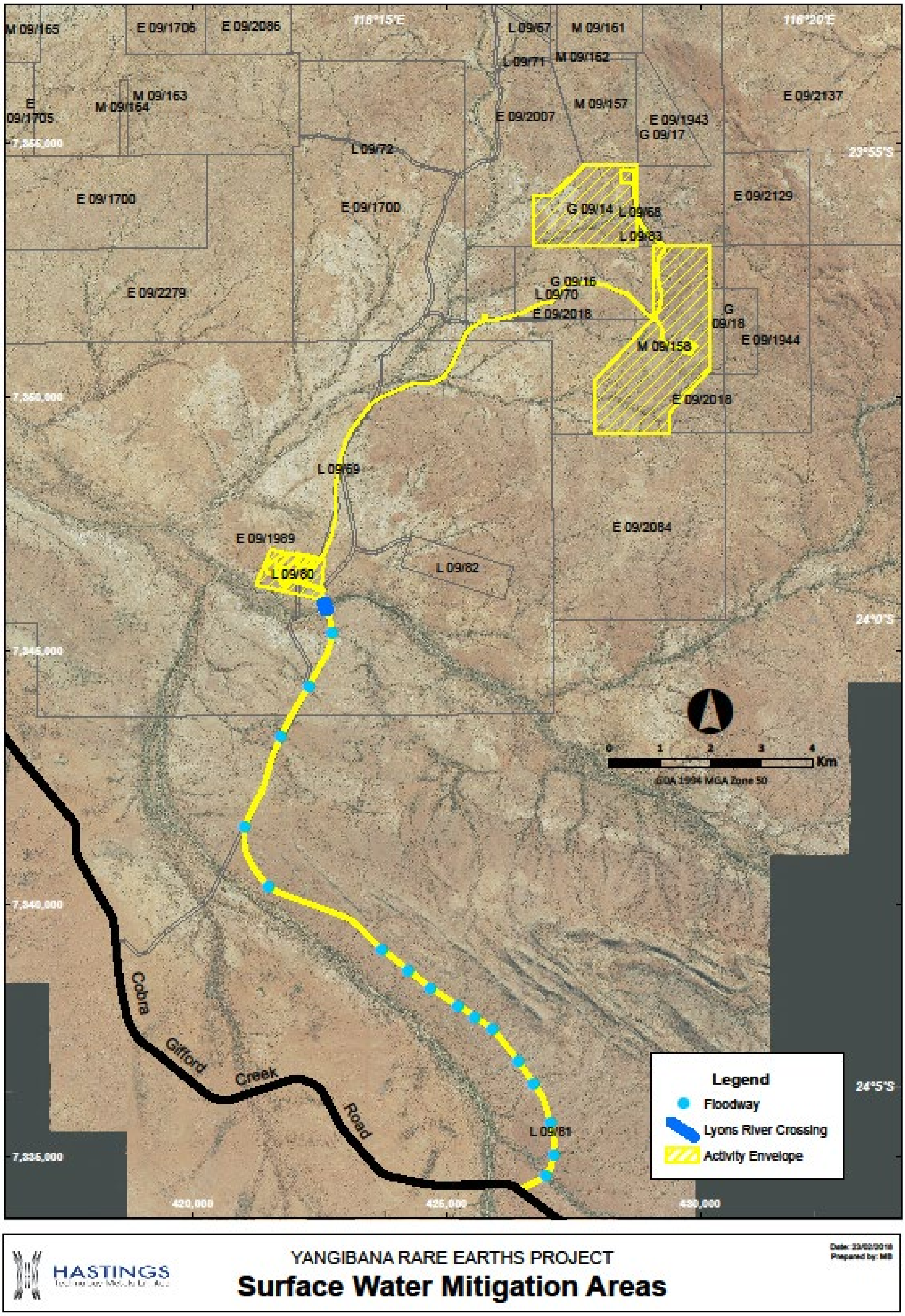


Figure 3 Minor or Preliminary Works Program: Access Road Surface Water Mitigation Areas

4.0 MANAGEMENT ACTIONS

4.1 INTRODUCTION

This section establishes objectives for the management of surface water across the site and presents guidelines for works, processes and monitoring to meet these objectives. Surface water management is discussed under the project phases – development, operational and closure, and across operational areas of the site. A monitoring framework is given.

The assessment is based on the information available at this time. This available information shows the likely extent of the pits and associated waste rock landforms, location of major roads and site infrastructure. Detailed design information is not yet available. Concepts for permanent diversion of Yangibana Creek around the Yangibana pits and for road crossings have been proposed in JDA (2016).

4.2 SURFACE WATER MANAGEMENT OBJECTIVES

The following three goals define the objectives for surface water management for the Yangibana project:

1. Reduce potential risk of loss of life, health hazards or property damage:
    - Provide protection for life, livelihood, and property;
    - Control the incidence of nuisance or damage related to flooding, poor drainage and sedimentation to an acceptable level; and
    - Protect project infrastructure.
2. Preserve the environment:
    - Minimise potential project impacts such as changes in stream-flow regime, alteration of habitat, pollution or increased erosion and sedimentation;
    - Where feasible, maintain the shape and composition (geomorphology) of the natural watercourse geometry, natural biological indicator conditions and flow conditions;
    - Employ protection measures to prevent adverse hydrological and water quality impacts for all recognised watercourses within the site limits;
    - Promote sound development that respects the natural environment; and
    - Rehabilitate watercourses that are impacted as soon as practicable.
3. Conserve social and financial resources:
    - Treat water as a resource, ensuring that water management facilities are functional and integrate multi-use objectives where possible;
    - Provide a system of infrastructure that enhances site personnel convenience and safety, and allows development to proceed according to the mine plan;
    - Sustain future mine development, support orderly and managed development of resources and integration of land uses within the site limits;
    - Use best management water and sediment practices where feasible; and
    - Encourage economic design of drainage systems.

These objectives are intended to ensure a consistent approach to:

- Planning and analyses required for surface water management;

- Constructing new operational phase surface water management works; and
- Installing future closure stage surface water management works.

4.3 Surface Water Management During Mine Development

Due to the temporary and rapid nature of construction, issues to be addressed during the development phase tend to involve mainly management of disturbed areas prior to construction of infrastructure and implementation of a final surface water management system.

A number of actions to mitigate these issues are given here. Consideration to the implementation of these actions should be made as far as is practicable.

Actions to mitigate potential impacts include:

- Limiting the extent of clearing and disturbance to vegetation to that required for immediate construction in accordance with the *Land Clearing and Topsoil Management Procedure*;
- Timing of clearing of vegetation to just prior to construction;
- Scheduling ground disturbing activity away from likely wet periods;
- Stabilising steep slopes to protect against erosion as soon as practicable; and
- Employing temporary drainage works until operational structures are in place.

Consideration should be given to the timing and extent of activities. Good erosion prevention measures should generally be employed.

Excessive ponding of stormwater upstream of infrastructure should be avoided. Persistent waterlogging or development of large ponded areas could lead to impacts on local vegetation, affect the behaviour of fauna and impact on site infrastructure.

4.4 Operational Surface Water Management

The focus for surface water management during the operational stage of the mine life changes to implementing, managing and maintaining the operational surface water management system and rectifying damage or failures.

It is important that infrastructure to manage surface water for the operational phase of the mine is appropriately designed and constructed. This will involve defining flow pathways and developing appropriate conveyance and disposal structures. Management of potential pollution from point sources (such as fuel tanks) and diffuse areas (such as workshop areas, areas watered with saline water) sources will need to be considered in infrastructure design and confirmed in site operating practices.

A well designed and implemented surface water management system will allow the operational phase to focus on management of the infrastructure and reduces the chance of adverse impacts of failure of surface water infrastructure on mine operations. This is particularly important for minimising impacts on the receiving environment, where large impacts can occur due to gross failure of structures or management processes.

4.4.1 General Operational Management

Key aspects of surface water management during the operational phase of the mine could include:

- Ensuring appropriate construction of infrastructure to a comprehensive design;
- Establishment of appropriate operational management of potentially pollution-causing activities; and
- Monitoring of the performance of infrastructure and rectification of issues.

Currently, there are no plans to release dewater from the pits to the environment. If dewater from the pit is to be released to local streamlines, consideration will need to be given to the quality of this water, the release location and rate and potential impacts on downstream flora and fauna.

Groundwater quality data to date indicates that groundwater supply sources are fresh to brackish. If saline water is used for dust suppression around the site, consideration needs to be given to the amount of salt likely to be washed off into the surrounding terrestrial environment and potential impacts on local flora.

Contaminants stored and used on site (such as fuel, grease and oils, processing materials) need to be stored in appropriately bunded locations. Potential diffuse contaminant sources, such as workshops, need to maintain suitable oily water and contaminant interception systems.

Other water quality management systems, such as collection of wash down water from machinery to prevent dispersal of seeds or pests to the environment may be required.

4.4.2 Pit Flood Risk

Analysis undertaken by JDA (2016) indicates that the greatest flood risk to pits is from the streamflow in Yangibana Creek through the area of the Yangibana North and West pits. In this area streamflow should be diverted around the pits and returned to the natural drainage line downstream. A diversion concept is presented in JDA (2016).

In areas away from the Yangibana Creek and for the Bald Hill and Fraser's pits, the pits only need to be protected from local stormwater runoff and overland flow. Stormwater in these areas can be managed using small levees, including the pit safety berm, ponding and small drains.

4.4.3 Stormwater and Sediment Management

In addition to protecting key infrastructure from large floods, it will also be necessary to manage runoff from more common rainfall events. Although such events give rise to much lower runoff rates and volumes they should be managed appropriately in order to protect project infrastructure, minimise erosion and reduce the potential loss of sediment laden or other contaminated runoff from the site.

For the management of storm water the various project facilities can be segregated as:

- Plant area;
- Mine services areas;
- Hazardous material storage areas;
- Disturbed mine areas; and
- Undisturbed mine areas.

Plant Area

Rain falling within wet processing areas will be collected within bunded areas and returned to the process water pond. Provision will be made for the return of such flows to the process by means of drains, launders, sumps, pumps, etc. Alternatively, such water may be used for dust suppression within the process area if of acceptable quality.

Mine Services Areas

The mine services area (including mine yard and workshops) will include surface water runoff and wash down water drainage and recovery systems. Runoff from the mine yard/workshops area, including roads, building roofs, laydown yards, etc. will be captured in open drains. The drains will report to a water management/sedimentation pond where water will be temporarily stored prior to reuse.

To aid management of runoff from areas likely to be impacted by hydrocarbons, e.g. fuel storage and dispensing areas, truck wash and workshops, it is proposed to capture runoff from these areas using open drains that report to an oily water separator (OWS) provided upstream of the water management/sedimentation pond.

Hazardous Materials Storage Areas

All fuel, chemical, oil and other hazardous material storage areas will be enclosed within bunded areas in accordance with the relevant codes and standards. Water collected within the bunded areas will be assessed and, if suitable, will be discharged to the proposed water management/sedimentation pond.

Water collected within the bunded areas that is found to be impacted will be disposed of appropriately.

Disturbed Areas

Source controls will be used to improve the quality of runoff from all disturbed ex-pit areas, including ROM, haul roads, waste rock dumps, stockpiles, laydown areas etc. Runoff from these areas will be directed to a water management/sedimentation pond prior to re-use or discharge.

For runoff within the proposed pits, source controls will comprise practices such as mining from upper benches or processing stockpiled material following significant rainfall events. An in-pit sump will be used to settle out sediment from collected runoff prior to pumping to surface for re-use or discharge.

Undisturbed Areas

Run-off from undisturbed areas within the project boundaries will be diverted around proposed project facilities into existing natural watercourses or drainage lines by providing diversion drains typically sized for the 10% AEP event with a minimum 250 mm freeboard. Flow velocities along all diversion drains will be limited to minimise erosion and the generation of sediment.

Where active mining areas or other sensitive facilities require protection from runoff from undisturbed areas the 1% AEP event will typically be used for the design of flood protection berms and diversion drains.

4.4.4 Drainage Design

Open Drain Construction

Open drains will be designed as far as practicable using the following criteria:

- Sized for the peak of the 10% AEP event as a minimum
- Minimum self-cleansing velocity of 0.7 m/sec for a 50% AEP event;
- Maximum velocity for a 10% AEP event for unlined earth channels to not cause scour;
- Channel erosion control protection in the form of appropriate drop structures, rock check dams, rock-lined channels or concrete lined channels.

Levee and Berm Construction

Flood protection levees, safety berms, roads, waste rock dumps and other structures with the function of preventing stormwater ingress (to pits) should be designed and constructed with this intended function in mind. Details of these structures should be developed as part of detailed design. Consideration needs to be given to:

- Drainage along the levee or berm, with a view to minimising ponding and impinging water velocity;
- Ensuring all potential ingress pathways are blocked, including allowing for the change in nature and location of structures over time;
- Ensuring sufficient freeboard above a flood water level (usually the 1% flood); and
- Maintenance of the structure.

Some guidelines for closure safety berms are given in DOIR (2017). Predicted flow paths and water levels are given in JDA (2016).

Road crossings

Flood waters from Yangibana Creek, Fraser Creek, Lyons River and Gifford Creek traverse either the main access road or the haul road. It is proposed that at all crossings except for the crossing of the Lyons River will be floodways, constructed flush with the natural creek invert (JDA 2016). The Lyons River will require a more substantial structure. Rip rap will be required upslope and downslope of floodways for protection against erosion.

Drainage control along the southern access road should be based on the following concepts JDA (2016):

- A series of corrugated steel pipe or concrete pipe culverts of varying diameters to convey flood waters under the access roads back into the natural watercourse (Gifford Creek);
- Ensuring culverts are adequately sized to convey adopted design flows beneath the access roads while avoiding adverse impacts on local watercourses. MRWA (2006) guidelines suggest regional road networks convey the 10% AEP discharge;
- Minimising erosion of the proposed hydraulic structures up and down slope of the road; and
- A number of minor diversion channels constructed adjacent to the road to intercept runoff from the upslope catchments and direct flow along the road to pass through the culverts at selected locations. All channels should be aligned with a grade sufficient to ensure flow

velocities would prevent pooling of water along the channels. A minimum channel slope of 0.1% is recommended.

Hardstand Overland Flow Drainage

Hardstand area drainage will be designed with a minimum surface grade of 0.5% in open yard areas and a minimum grade of 1% for a distance of 25 m away from structures.

Hardstand areas with finished elevations 1 m or greater above natural surface elevations will have a safety berm constructed along their outside edge. Suitably spaced breaks will be placed along the berm to allow runoff to escape. Rock or geomembrane lined slope drains will be constructed at these breaks to minimise erosion of fill material.

Outfalls to drains will be stabilised as required to prevent scour of the drain bank.

Water Management/Sedimentation Pond Design

For preliminary design purposes water management/sedimentation ponds will be designed to store runoff from the 5 day 85th percentile rainfall event i.e. 23.5mm rainfall, without discharge in accordance with International Erosion Control associations: Best Practise Erosion and Sediment Control.

The detailed design of sedimentation ponds will be based on removing the settleable fraction down to a selected minimum design particle size based on an analysis of the sediment particle size distribution reporting to the pond. The adopted design particle size will correspond to 25% of the sample passing by weight or an absolute minimum particle size of 20 micron (unless chemical coagulant dosing is used). The required pond surface area will be estimated in accordance with International Erosion Control associations: Best Practise Erosion and Sediment Control).

Sedimentation ponds will have a minimum live settling depth of 0.6 m and an aspect ratio (length: width) of not less than 3:1 and preferably 5:1. Sufficient provision for dead (sediment) storage and freeboard will also be made.

4.5 Surface Water Management at Closure

Closure activity relates mainly to rehabilitation and stabilisation of a final landform. This is particularly important in areas that will have steep slopes and/or collect and concentrate stormwater – such as the tailings storage facility and waste dumps.

Phased rehabilitation of areas of the mine site will occur throughout the life of the mine. This will help to bring forward the closure process and may provide opportunities for trialling and/or monitoring revegetation effectiveness.

Built mine infrastructure should be removed and the site generally rehabilitated to a stable, vegetated condition. This will involve re-establishing a landform that was similar to the predevelopment condition, ideally with gentle slopes and minimal concentration of stormwater (in accordance with the Landform Evolution report by Trajectory, 2018).

The rehabilitated landform should generally be designed to be maintenance-free and stable indefinitely. Complex stormwater management structures (such as channels or weirs) should be avoided as these have increased risk of failure in the future. Areas that will require maintenance in the future should be avoided.

Pits will remain as open voids, bunded to prevent ingress of external stormwater. The pits will partially fill with water of increasingly saline water. Consideration of the quality of water in the pit and water level fluctuations into the future have been undertaken as part of hydrogeology studies (GRM 2018). It is expected that the pits will be retained and ultimately become partially filled with saline water.

The diversion channel around the Yangibana North and West pits will remain as a permanent diversion. This channel should be designed as a permanent structure and constructed to mimic characteristics of natural drainage lines as far as practicable.

The waste rock landforms and tailings storage facility, stabilised and rehabilitated, will remain after closure. Details of the design of these structures will be developed as part of detailed design. General design guidance for these structures includes:

- Retention and disposal (by evaporation) in situ of rainfall falling on top of the structure; excessive seepage into the structure below the root zone of vegetation should be avoided; and
- External batters should be stabilised to prevent erosion gulley's destabilising the structure and discharging sediment to the environment.
- Design criteria of WRLs and Tailings Storage Facilities are listed in Trajectory (2018).

4.6 MONITORING

The monitoring plan is developed assuming that if surface water management infrastructure is properly designed, constructed and maintained, there will be little impact on the surrounding environment. Due to limitations on access and the extremely variable nature of streamflow, it is not practical to sample streamflow through the site area or downstream in smaller drainage lines. Pools in the Lyons River can be sampled at regular intervals but access is limited during storm events.

Most potential impacts on the environment will arise in association with failure of surface water management infrastructure. This is most likely to occur in disturbed areas, around outfalls from diversion drains where they discharge into the environment and at road crossings. Regular visual monitoring of the performance of surface water management infrastructure is a simple and effective means of identifying failure of infrastructure and triggering rectification action.

Water quality sampling from pools in the Lyons River will also be used to indicate if downstream receiving environments are being adversely affected by mining.

Accordingly, the objectives of the monitoring plan are to:

- Confirm that surface water management infrastructure is functioning to design criteria;
- Trigger rectification action if required; and
- Confirm that water quality downstream of the mine site is not adversely affected by mining activities.

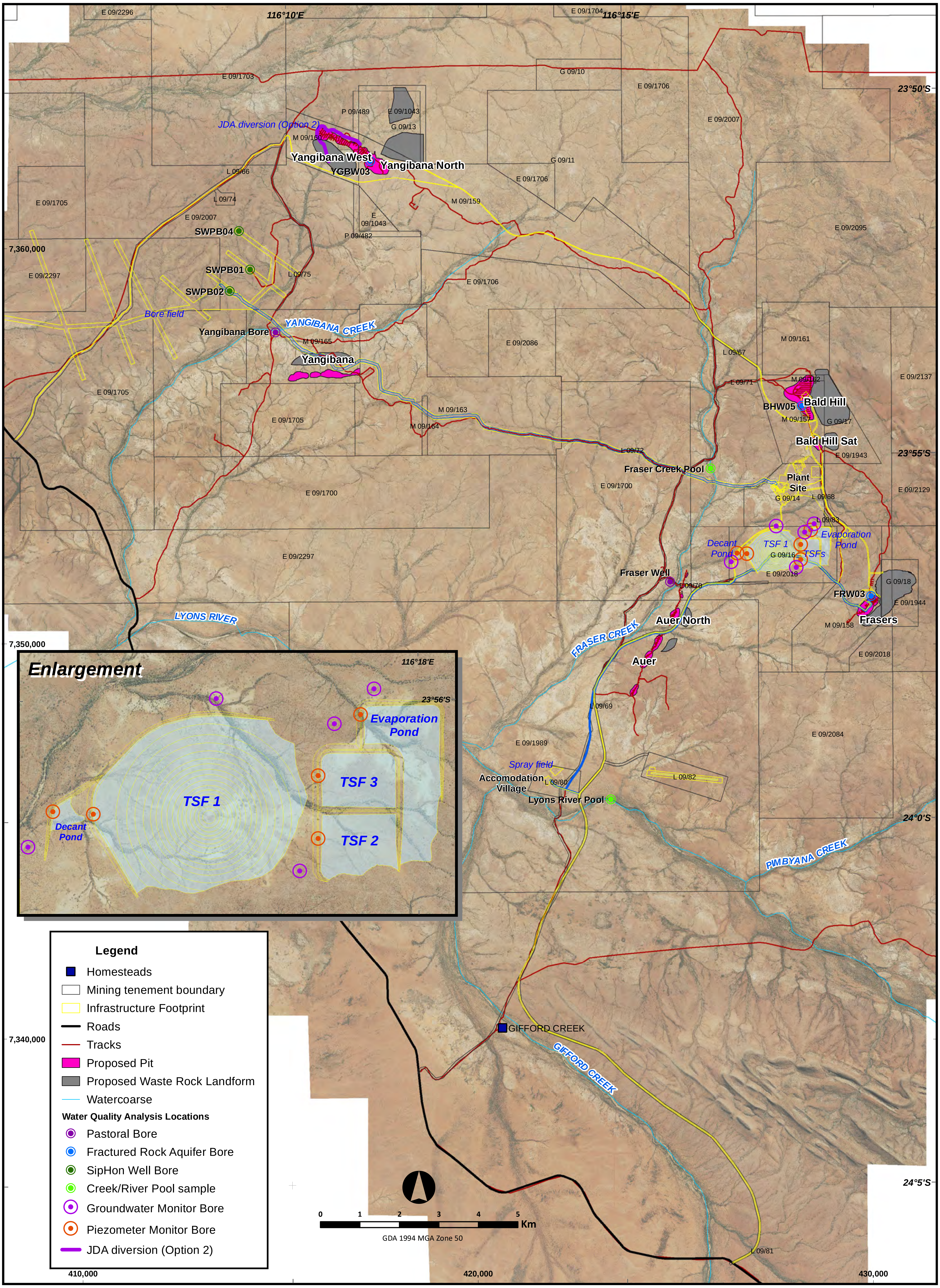
A monitoring plan is summarised in Table 1. Sampling locations are shown in Figure 2.

Monitoring is based mainly around visual observation of operational assets. Water quality sampling of pools in the Lyons River has already commenced and it is proposed that this continues.

Table 1 Summary of the Surface Water Monitoring Program

Area to be monitored	Monitoring type	Analysis suite	Frequency
Lyons River pools	Water quality sample	Water quality suite*	Biannual - winter and summer rainfall peaks.
Yangibana North and West pits diversion drain	Visual	Observation of scour, deposition or failure of drainage infrastructure.	After runoff events.
Mine site drains	Visual	Observation of scour, deposition or failure of drainage infrastructure.	After runoff events.
Road culverts and flood ways	Visual	Observation of scour.	After runoff events.
Water management ponds	Visual	Observation of freeboard.	During large runoff events or periods of low water reuse/discharge.
Sediment ponds	Visual	Observation of sediment build up.	After larger runoff events.

* The standard water quality suite is: pH, total suspended solids, total dissolved solids, total alkalinity, ions, metals and selective radioactive elements.



HASTINGS
Technology Metals Limited

YANGIBANA RARE EARTHS PROJECT

Monitoring Locations

Hydro_Figure3.mxd
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Figure 3

4.7 CONTINGENCY

Contingency planning will form a component of the risk assessment, in case pre-determined mitigation is not effective. The trigger limits and associated contingency actions include:

Trigger limits	Contingency actions
Visible erosion or sedimentation events	• determine the cause; • repair damaged infrastructure; • stabilise area of erosion; • implement controls to prevent on-going or future erosion events (e.g. diffusion of kinetic • energy); and • monitor the performance of the controls.
Water quality exceedances beyond natural variation	• investigate cause; and • implement remedial action (e.g. installation of sediment traps, revise chemical • storage/handling procedures, repair equipment.
Significant change in flow regime impacting vegetation composition and structure upstream or downstream	• identify the cause (e.g. design, maintenance of drainage, damage); • determine management action (engineering design, drainage maintenance, repair); and • implement remedial actions.

The above triggers will be reported as an incident in accordance with the *Incident Reporting and Investigation Procedure*.

5.0 REVIEW

This document will be reviewed as a minimum on an annual basis or updated as required based on:

- Lessons learned;
- Incidents and investigations;
- Licence conditions; and
- New technologies.

6.0 REFERENCES

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7.0 CLOSING REMARKS

A preliminary surface water management plan for the proposed Yangibana Project is described in this report. Note that this is a preliminary document and is based on the mine plan and design information available at this time. It would be expected that this plan would be updated as mine planning and design progresses.

We trust that this report satisfies Hastings Technology Metals Ltd's current requirements and we look forward to discussing the future development of the project with you.

Groundwater Resource Management Pty Ltd

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