Image Resources
Atlas Project
Surface Water Management Plan

Prepared for

Image Resources Ltd

[redacted]

April 2023

MWES
Hydrological Services

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Version: rev4 – April 2023

Front Cover: Nambung River flow over Munbinea Rd, 3 August 2021

EXECUTIVE SUMMARY

The Atlas mineral sand project includes shallow open pit mining and production of heavy mineral concentrate by gravity separation. This report was developed from the baseline hydrology report and is intended to form the basis for detailed surface water management procedures developed for production planning, safety and environmental purposes. This report will be routinely updated to include useful detail of as-built structures and modifications

The Atlas site is located in the Nambung River catchment, which terminates in karst country within the Nambung National Park. This river system has important conservation value for the diversity of habitats it provides. The downstream river floodplain and the terminal karst habitat are considered the primary environmental receptors for control of potential impacts from the proposed mine.

The mine will not intersect mapped creek-lines which are tributaries to Nambung River. The sub-catchment which contains the project is a small portion (0.7%), flat and low yielding portion of the Nambung River catchment. Provided that the mine workings are isolated from flooding as specified here, then the project presents little risk to the quality or quality of flow in the Nambung River. That isolation will also ensure there can be no impact on the stormwater component of the water balance in localised wetlands outside the mine bunds.

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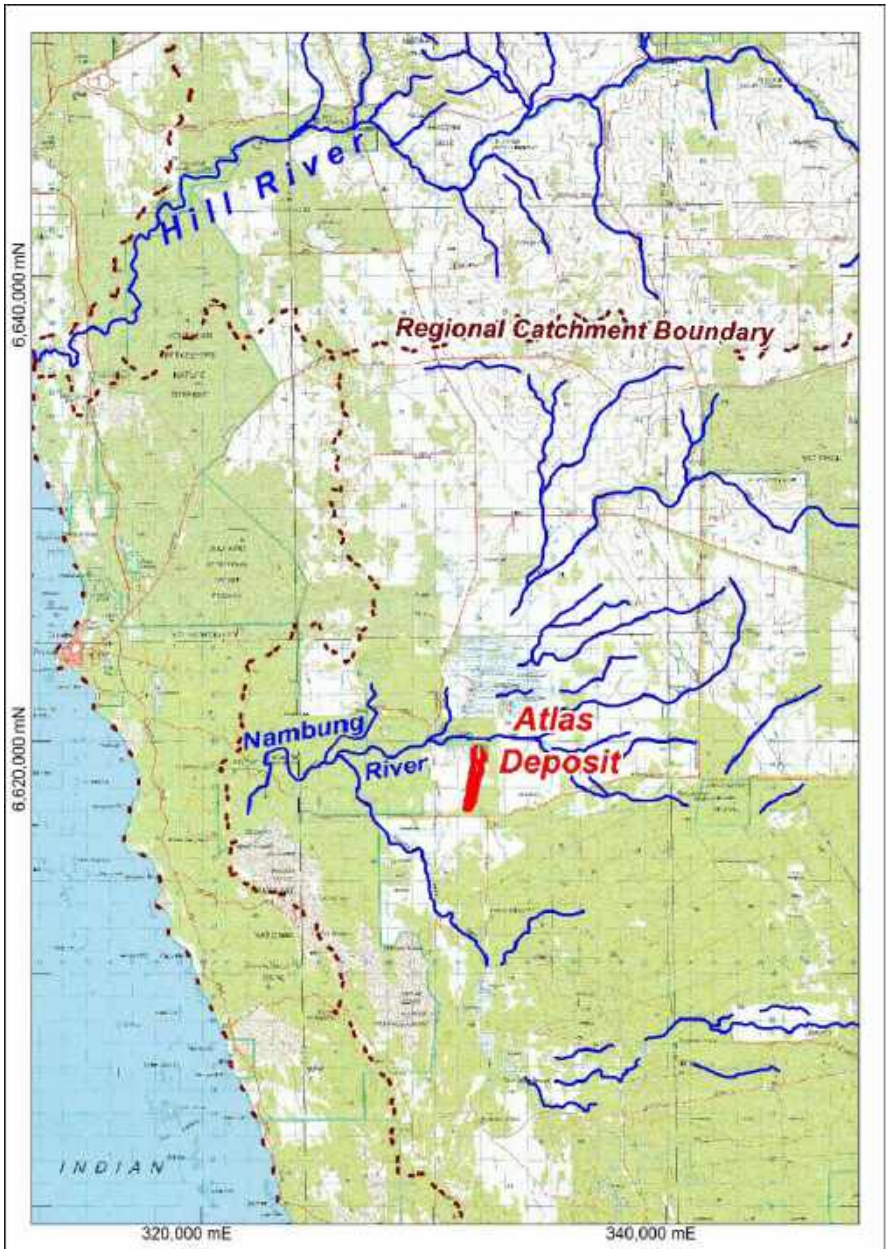
1. INTRODUCTION

Image Resources is seeking approval for development of an open cut mining operation at the Atlas Deposit near Cervantes. Atlas is a shallow beach strand mineral sand deposit located on the Swan coastal plain 170 km north of Perth. The site is located 18 km east of the coastal town of Cervantes. From the Brand Highway the site is 30 km southwest of Badgingarra and 24 km northwest of Cooljarloo mine.

This pre-development report presents preliminary measures for management of surface water. Potential impacts and the hydrological assessment underpinning the surface water control and management measures are presented in the hydrological baseline report (MWES March 2023).

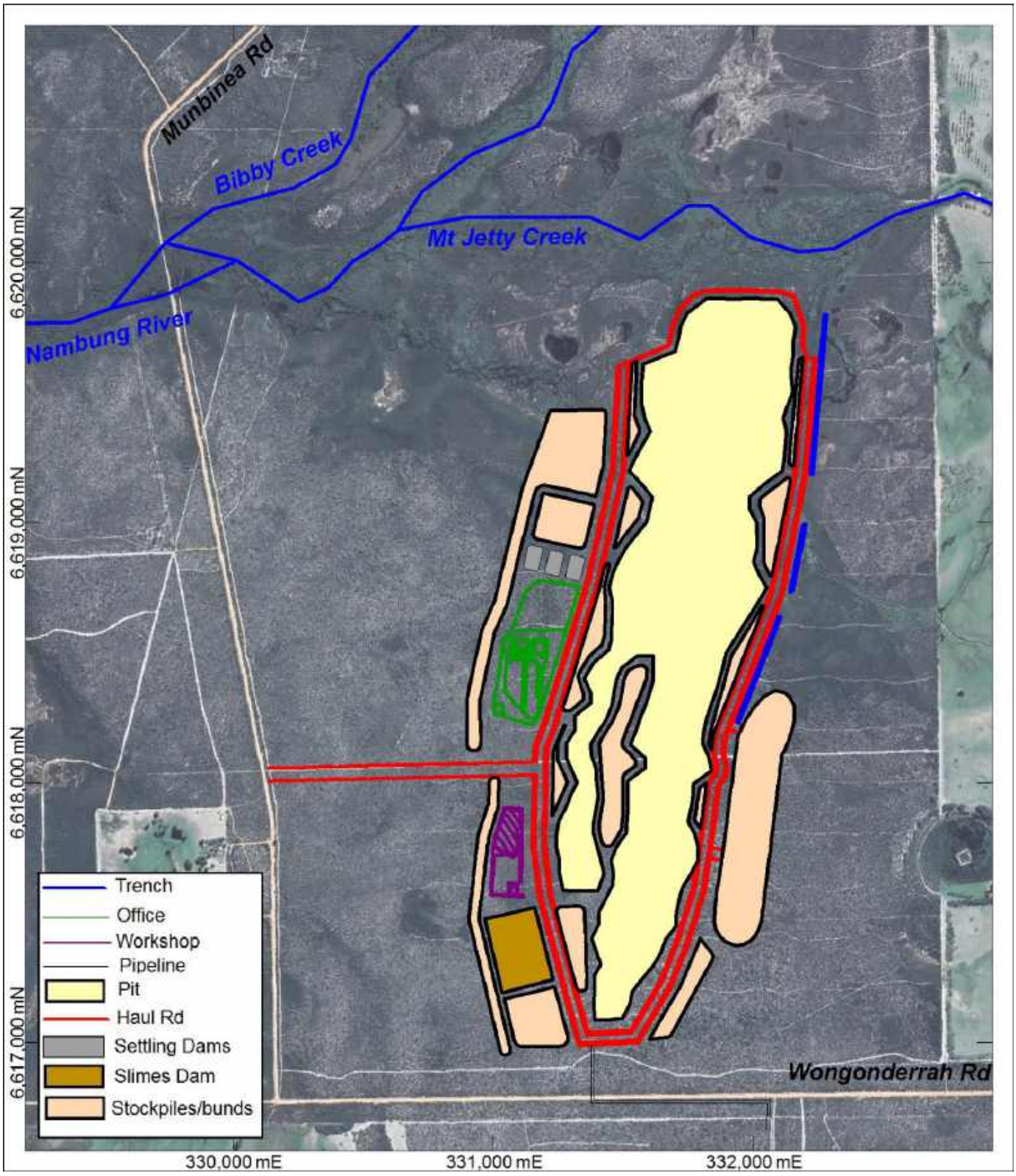
Figure 1 – Atlas Project Regional Location Plan and Regional Catchment Boundaries



2. PROJECT LAYOUT

The indicative layout of project components is shown in Figure 2.

Figure 2 – Project Layout



Dry mining will be used to remove and temporarily store or direct return topsoil, subsoil and overburden. Ore will then be processed, with plant tailings and overburden returned to the mine void to reconstruct the baseline landform prior to return of subsoil and topsoil. The whole mining phase will take approximately three years.

3. BASELINE CONDITIONS

3.1. CLIMATE

The climate type is Mediterranean with hot dry summers and cool wet winters, similar to Perth but notably drier and sunnier. Bureau of Meteorology (BoM) Stations located at Jurien Bay and Badgingarra Research Station have continuous records of more than 50 years and straddle the Atlas location. A general description of the average of those two sites is as follows:

Mean monthly temperature maxima range from 18 to 32 degrees and minima from 10 to 21 degrees. Annual rainfall averaged about 540 mm over 50 years, with monthly totals averaging in the range 10 mm (January) to 110 mm (July). Annual pan evaporation is 2128 mm on the BoM continent-wide grid, with monthly averages ranging from 70 to 300 mm.

Rainfall in recent decades has been below longer term (130 year) averages with the period 2000-2019 was mostly well below average. 2021 and 2022 saw drought-breaking winter rains with totals at about the 60 percentile of the long term record.

Rainfall intensity for durations up to 7 days is described by the intensity-frequency-duration (IFD) statistics downloaded from the Bureau of Meteorology (BoM) Design Rainfall Data System and summarised in Table 1.

Table 1 – Rainfall IFD Statistics (mm)

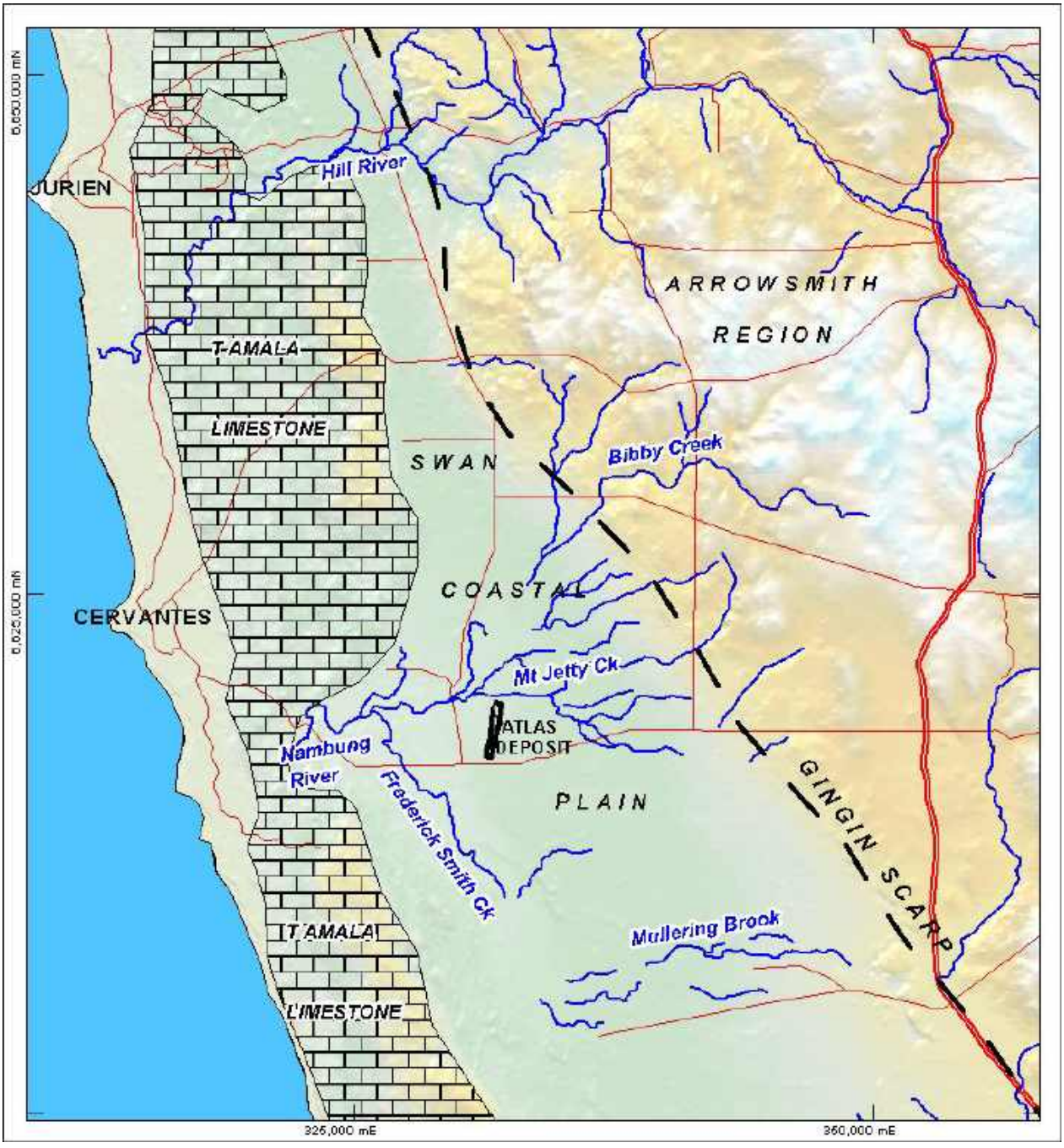
Duration	Units	Annual Exceedance Probability (AEP)				Return Period (ARI years)	
		50%	10%	5%	1% = 100	500	1000
5	min	5.52	8.87	10.4	14.2	19.3	21.9
10	min	8.37	13.6	15.9	21.7	29.4	33.3
15	min	10.2	16.6	19.4	26.5	35.9	40.7
20	min	11.6	18.8	22	30	40.7	46.2
30	min	13.7	22	25.7	35.1	47.7	54.1
45	min	15.8	25.3	29.5	40.5	55	62.4
1	hour	17.5	27.8	32.4	44.7	60.7	68.8
1.5	hour	20.1	31.7	37	51.2	69.5	78.9
2	hour	22.1	34.9	40.7	56.5	76.7	87
3	hour	25.4	40	46.8	65.3	88.4	100
4.5	hour	29.2	46.1	54	75.7	102	116
6	hour	32.2	51	59.9	84.3	114	129
9	hour	37	58.8	69.1	97.8	132	150
12	hour	40.5	64.8	76.2	108	146	166
18	hour	45.8	73.5	86.4	123	166	189
24	hour	49.6	79.6	93.4	133	181	205
30	hour	52.6	84.2	98.5	141	195	223
36	hour	55	87.7	102	146	204	234
2	day	58.8	93	108	153	214	244
3	day	64.5	99.9	115	161	220	250
4	day	69.2	105	120	164	222	251
5	day	73.9	110	124	167	224	253
7	day	83.8	120	134	172	230	260

3.2. REGIONAL PHYSIOGRAPHY

The site is located near the centre of the Swan Coastal Plain which extends 15-20 km further east to where the Gingin scarp is formed by a low ridge of Mesozoic sedimentary rocks (Figure 3). The local Quaternary Bassendean Dune System forms a deflated landscape of sparse low fixed dunes with interdunal swamps. Toward the coast, the more recent Tamala Limestone and Safety Bay Sands form a more rugged and elevated topography.

Local drainage rises on the Gingin scarp 15-20 km to the east at a ridge line elevation of 200-300 metres. The Mount Jetty and Bibby Creeks flood-out and coalesce near the site in an area of very low surface gradients, including the "Nambung Flats". The creek-lines reform and coalesce to the west as the Nambung River which discharges into Tamala Limestone 6km east of the coast. This river system has important conservation value for the diversity of habitats it provides.

Figure 3 – Regional Physiography



The site ground elevation is mostly in the range 39-45 m AHD with a very slight overall gradient of about 0.2% west toward the coast. The local surface is bisected by a widely spaced array of low fixed dunes. Many of the dunes are oriented parallel to the coast, some are perpendicular and other orientations are present.

Flat and low lying country of the local area and of the Swan Coastal Plain generally are subject to seasonal inundation. Mapped wetlands comprise a large portion of the project area. These include a variety of vegetation zones and geomorphic features. Much of the local mapped wetland area is part of the Nambung Flats, a seasonal swamp formed by the combination of surface runoff accumulation and seasonal groundwater level rise.

3.3. REGIONAL CATCHMENTS AND HYDROLOGY

The Nambung River catchment (2959 sq km) rises on the Dandaragan Plateau where flat sandy uplands generate little runoff to the few small creeks draining west across the Gingin Scarp to the Swan Coastal Plain. Watercourses mostly terminate in swamps, lakes and interdunal depressions. In high rainfall years, seasonal overflows from the Plain combine to generate flow in the downstream Nambung River. The scant flow records from the Nambung River confirm that the lower catchment river hydrograph is highly attenuated with broad flow/level peaks occurring in response to rainfall over several preceding months.

Four sub-catchments of the Nambung River discharge west through or near the project area. The catchment boundaries are shown in Figure 4 overlying the colour-fill DEM grid. The catchment geometrical parameters are summarised in Table 2.

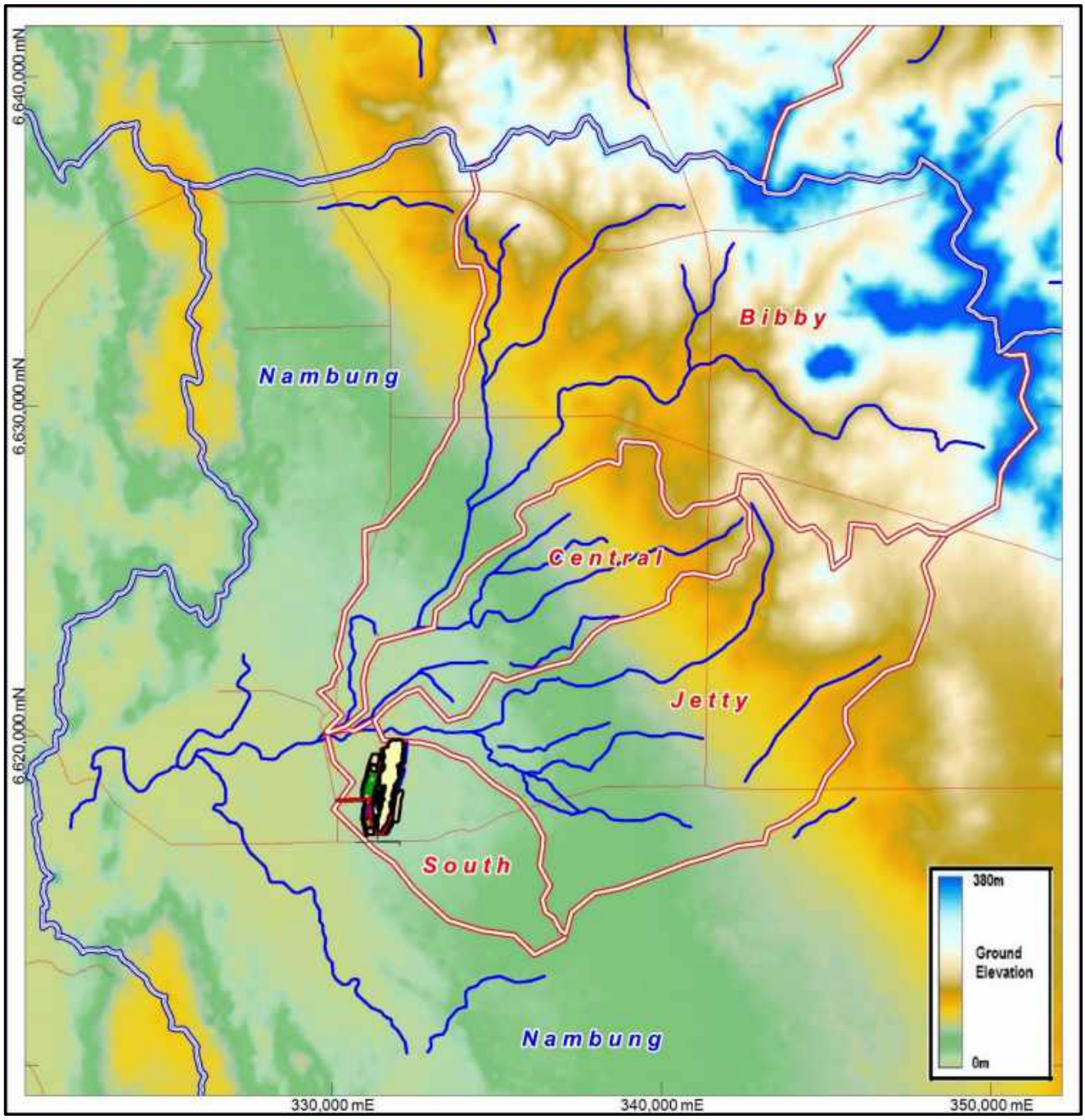
Table 2 – Catchment Parameters

Name	Downstream	Area (sq km)	Mainstream Length (km)	Mainstream Slope (%)
Bibby	Munbinea Rd	185.2	31.5	0.47
Central	Munbinea Rd	42.3	15.5	0.62
Jetty	Munbinea Rd	99.4	18.3	0.56
South	Munbinea Rd	26.7	9.7	0.22

The Nambung River which is formed at the confluence of the four sub-catchments immediately downstream of Munbinea Rd. The Bibby and Jetty sub-catchments are a small portion (10%) but important part of the Nambung Catchment, forming the steepest and most direct surface flow paths, these sub-catchments will typically provide an out-size volumetric contribution to smaller and early wet season flow events. These are unaffected by the Project .

The South sub-catchment which contains the project, is small (0.7 % of the Nambung catchment) and relatively flat with no continuous and well defined mainstream and several large seasonal lakes upstream of the project site. Discharge from the sub-catchment through the project area evidently occurs rarely - only after large and long duration rain events. During such events the sub-catchment provides a trivial contribution to the Nambung River flow.

Figure 4 – Regional Catchments



3.4. RAINFALL – RUNOFF, PEAK FLOW RATE AND LEVEL ESTIMATES

A RORB (Monash et al., 2010) runoff routing model was developed for the local catchments. Catchment delineation was undertaken using a DEM generated from Image Resources 1-metre contour data set. Catchment boundaries are shown in Figure 4.

The model simulates rainfall losses and drainage line storage impacts on the peak flow rate through 15 sub-catchments to the confluence near Munbinea Rd which is the upstream limit of the Nambung River.

Design rainfall is based on the 1% AEP (1: 100 year) totals from the IFD table (Table 1). A front-loaded temporal pattern was created which includes 1% AEP totals for durations in the range 1.5 to 36 hours. Maximum rainfall intensity is 52.2 mm over the fourth 1.5-hour time-step.

Rainfall losses were based on the Hill River record analysis due the similarities in terms of catchment geometry, soils and land use. A constant runoff coefficient of 20% was adopted and is considered conservatively high. Such a runoff rate would require an already fully saturated catchment, which typically only occurs for a few months and not in every year. The combined probability of two conditions means that the peak flow estimates have an indicative recurrence interval of 200-500 years.

The catchment storage parameter (Kc), was set at 15 (with m=0.8). The Hill River gauging data shows the catchments to be relatively “non-peaky” (high storage). The high stage ratio between peak flow and average daily flow at Hill River (typical factor = 2) also provided guidance to trial and error RORB simulations. The selected value is considered conservatively low considering the observed Hill River responses and RORB estimation formulae (in turn based on Australian Rainfall and Runoff 1987).

Further model details and outputs are summarised in Appendix A.

Outputs from the RORB model are the peak flow rates for the catchments as summarised in Table 3.

Table 3 - Peak Flow Rate Estimates

Catchment	Area	1% AEP Peak Flow Rate (cumecs)	Lag Time (hours)
Jetty	North of mine	63	7.8
Bibby	Southwest from Nambung Flats	98	8.5
Central	Southwest from Nambung Flats	33	6.6
Nambung	Munbinea Rd crossing	183	9.3

No estimate is presented for the South catchment which contains the whole of the disturbance area for the proposed mine (Figure 4). The South catchment is small and flat lying and apparently generates little runoff since there is no clear mainstream drainage line. Stormwater is apparently contained locally in minor lakes and interdunal swales southeast of the project area.

The Mt Jetty Creek bed elevation is 40 m AHD to the north of the project area. The flood level for the 1:100 year flow rate (63 cumecs) for the cross section north of the mine was calculated using the Manning Equation for open channel flow as follows:

Q (cumecs)=V (m/sec). A (sq m) = 1/n . R^0.67 . S^0.5 . (w . d)

n = 0.03 (Manning coefficient for flood plain)
R = hydraulic radius = depth = 0.4 m
S = downstream gradient = 0.002
V = 0.8 m/sec
w= flow path width = >200m
d = flow depth = 0.4 m (Q = 65 cumecs)

The peak flood level for the 1:100 year AEP flow rate (Q100=63 cumecs) is estimated at 40.4 m.

3.5. PROJECT CATCHMENT

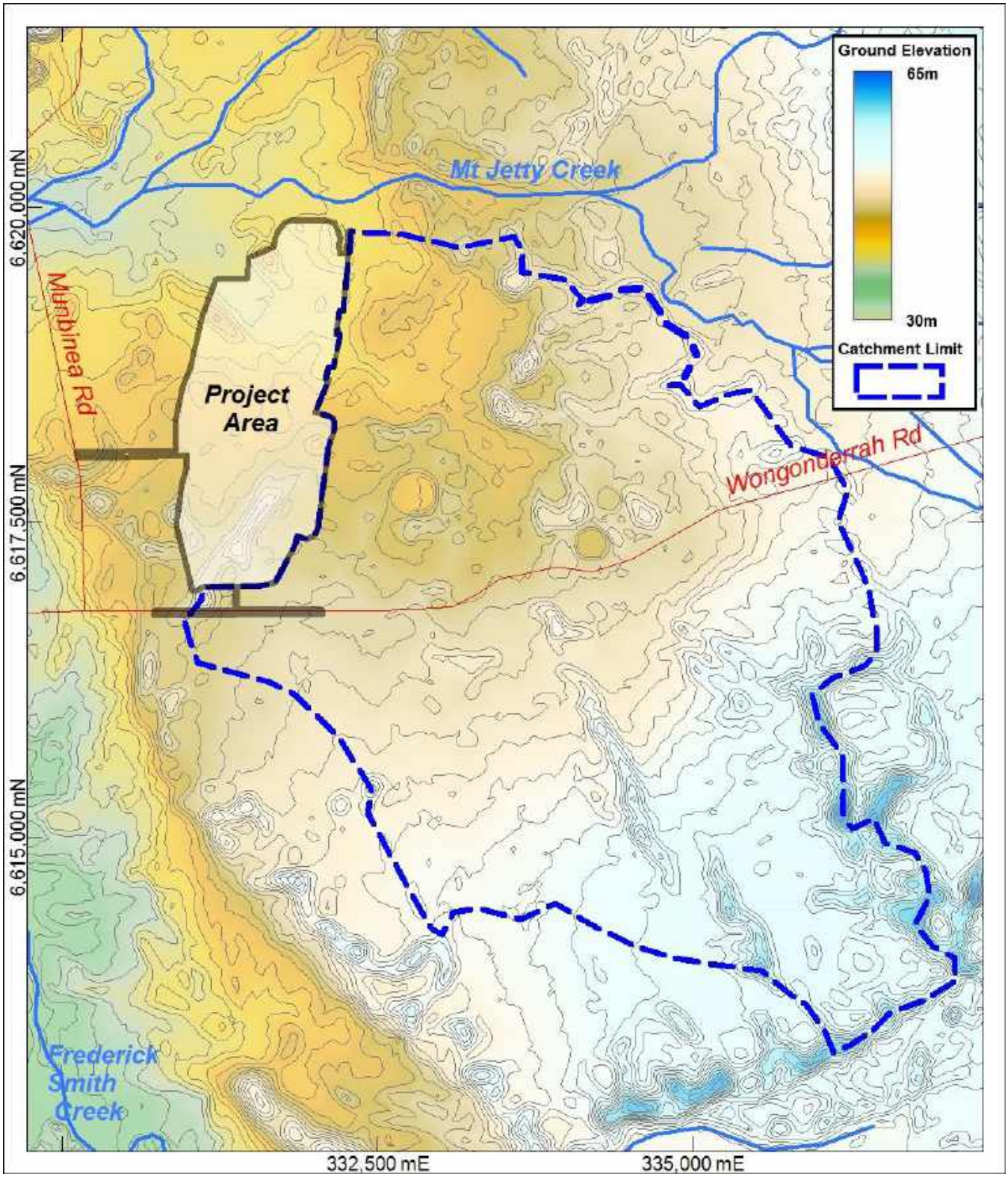
The catchment to the project development footprint is located within the South Catchment as described in Section 3.3. The catchment area is 22 sq km with geometrical parameters listed in Table 2. Catchment boundaries are shown in Figure 5 along with 1 metre interval contours and a colour-fill DEM underlay.

The catchment limits are mostly dune crests at elevations at up to 65 m in the south. The land surface slopes gently north toward Mt Jetty Creek. Natural ground level on the eastern (upslope) side of the project area grades from about 44 m in the south to 41 m in the north.

Wongonderrah Rd bisects the catchment east-west at an elevation of about 45 m. Of the total catchment area (22 sq km) 65% is in naturally vegetated sand plain shrubland south of the road, where there are no discernible natural surface drainage lines.

The lower, northern portion of the catchment is nearly flat, apart from the irregular network of low dunes. Cleared farmland there includes a network of vegetated natural swale sumps . These have been interconnected by a constructed drainage network which feeds northwest across the property and discharges into a natural swale on the east side of the mine lease at 6,618,630 mN. This swale would convey any minor flow from the South sub-catchment under extreme or prolonged rainfall.

Figure 5 – Project Catchment Topography and 1 m Surface Contours



4. ENVIRONMENTAL RISKS AND IMPACTS ASSESSMENT

The project is located in the Nambung River catchment. The downstream river floodplain and the terminal karst habitat (Nambung Caves) are considered the primary potential environmental receptors for any potential surface water impacts. The lower reaches of the River were impacted by a long and sustained period of low flow until February 2021. Since then, drought-breaking flows in, should have substantially relieved water-related habitat stresses. The observed cycle demonstrates the overwhelming sensitivity to climate related variability.

The proposed mine is located in a minor sub-catchment of the Nambung River. The project catchment is small and relatively flat and there are no substantial natural drainage lines across the project footprint. Evidently, much of the project sub-catchment does not generate runoff from normal moderate intensity rain events. Some surface water discharge from the project catchment may occur in response to extreme and sustained rainfall.

The project catchment area (22 sq km) comprises 0.7% of the total Nambung River catchment area (2989 sq km). Runoff from much of the project catchment is commonly near zero and in the remainder is low even compared to the very low regional averages. This means that the project catchment generates much less than 0.7% of the Nambung flows, in practice an immeasurably small portion. Hence there is no potential for measurable water quantity impacts on the Nambung River due to the infinitesimal contribution from the project catchment.

The northern quarter of the project area is subject to partial inundation in late winter of high rainfall years. Very high water levels occurred in 1999 and were about 40 m AHD at the project site. Perimeter bunds will be required to isolate the project site from the regional catchment.

Project catchment runoff will need to be routed north around the operation. This drainage line will provide an ideal location to monitor upstream and downstream water quality.

Isolation bunding will provide primary control on external surface water quality impacts. Potential water quality impacts are further mitigated by the circumstance that mine catchment runoff has a higher rainfall threshold than the broader catchment – ie local runoff will only occur during substantial flows in the receiving creeks, ensuring substantial dilution during such major flow events.

Sand mining and heavy mineral separation is a physical rather than chemical process, so that risks of local stormwater contamination are moderate. Mobilisation of excessive natural fine sediment is the main water quality risk. Runoff from hardstands within the disturbance area should be retained locally. The risk of impacts on the Nambung River water quality is mitigated by the absence of any substantial tributary creek lines across the development footprint.

The proposal should have no impact on the stormwater component of the water balance in wetlands outside the mine bunds. It is noted that the water balance of some of these wetlands may have a substantial groundwater component (seasonal water level rise) which could be impacted if groundwater abstraction causes drawdown in the underlying aquifer.

Key elements of surface water control for environmental management include

1. Drainage to route Project Catchment runoff around the north end of project area
2. Bunding to isolate the northern operation area from external inundation
3. Monitoring to determine any project-induced changes in contaminant loads and concentrations

5. PERIMETER FLOOD AND STORMWATER CONTROLS

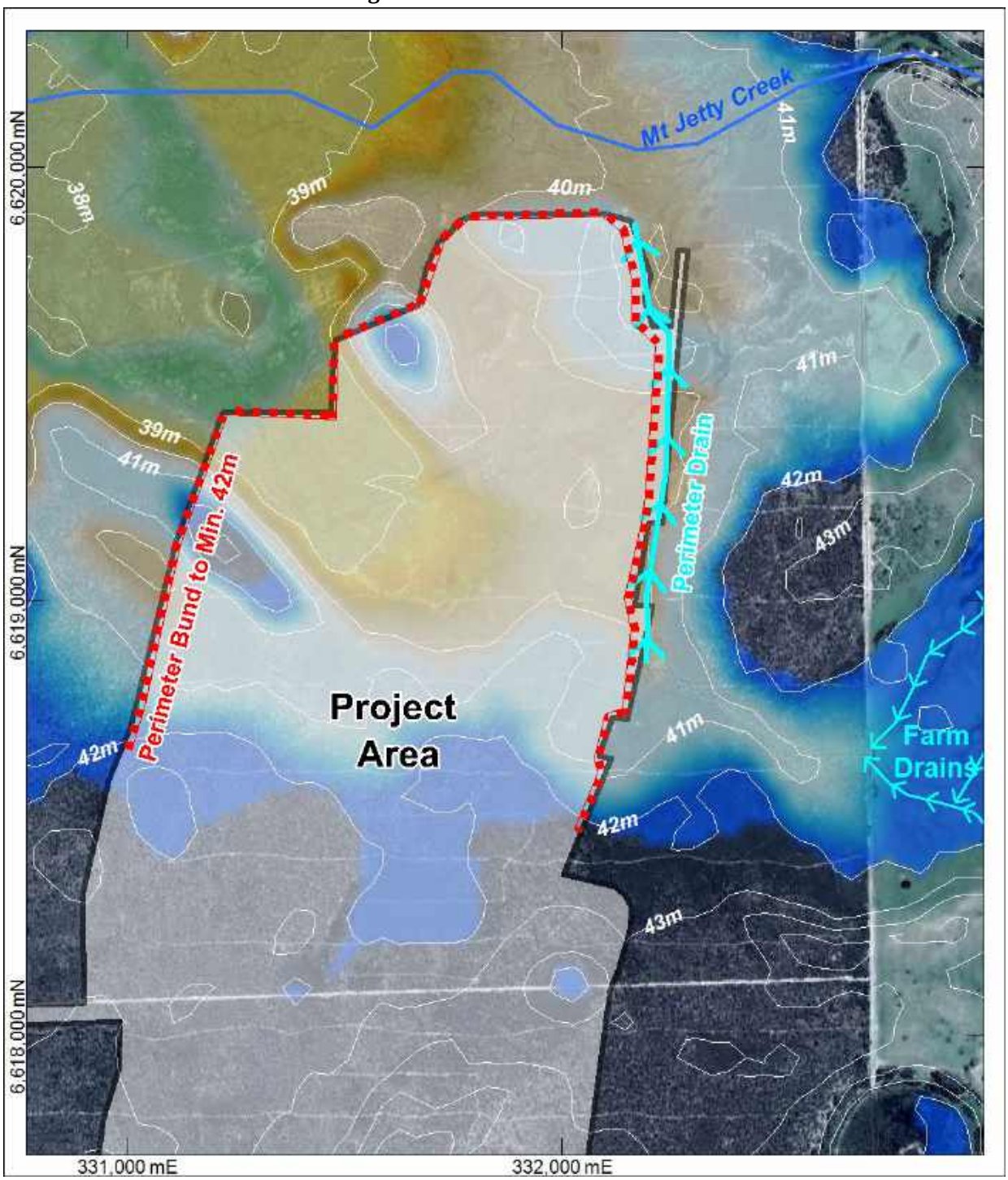
The project area must be isolated from stormwater inflows/ rising water levels associated with general inundation and with major flood events. The mainstream drainage lines of the Jetty catchment (Mt Jetty Creek) pass north of the proposed mine and from there the channel disaggregates westward from a single minor and slightly incised channel into an area of minor swales/channels.

The Jetty Creek 100 year estimated peak flow depth is 0.4 m above the surface elevation of 40 m equates to a peak flood level of 40.4 m AHD. High water levels in late winter 1999 show areas of inundation around the northern quarter of the project area, with ponding to about 40 m AHD.

The northern pit bund crest elevation specification is 42.0 m AHD, providing more than 1 metre of freeboard above the extreme flood level. Bunding to this elevation will extend 3.5 km around the northern perimeter of the project area (Figure 6). The perimeter bund should be constructed using select coarse sandy materials, avoiding dark clayey materials.

Minor flows from the farmed portion of the project catchment are routed toward mine lease near 6,618,660 m N from farm drains (Figure 6). To minimise ponding in the swale adjacent to the eastern bund a drain should be cut at the outer toe of the bund, providing a continuous fall to the north.

Figure 6 – Perimeter Bunds and Drains



6. MINE AND PLANT AREA STORMWATER CONTROLS

Primary potential sources of emissions via stormwater include:

- Waste dumps
- Unvegetated topsoil stockpiles
- Cleared/built up areas: haul roads, concentrate pads, concentrator and workshop

The flat terrain and sandy substrate of the Project Area means runoff rates are low. There are no active natural drainage lines within or across the project area such that throughflow and erosion potential are minimal.

The project component detail design will further minimise stormwater flows by including drainage and containment for areas of potential contamination.

The northern half of the project area is isolated from the surrounding catchment by perimeter bunding. The southern half of the project area is underlain by deep structureless sands to depths of >1.5 m. The mine open area at all stages is minimised, with backfilling and revegetation concurrent with mining.

Potential sources of stormwater contamination include runoff from the mining area. Stormwater from the active mining area will be collected in the pit and directed to the process water dam.

Other potential contamination sources include the concentrator area, workshop washdown and fuel areas. Runoff from these areas will be directed to the process water dam. Hydrocarbon management controls will be in place on site in areas of hydrocarbon storage and use. Stormwater containment for areas of potential contamination will depend on the finalised site levelling, layout and utilisation. Sumps should be designed for a minimum first flush capacity of 25 mm across the micro-catchment. A freeboard of at least 1 metre will be maintained in the settling and process water ponds.

Rainfall and runoff is included in the site process water balance does not require off-site water discharge.

7. SURFACE WATER MONITORING PROGAMME

7.1. OBJECTIVES

While there is limited direct baseline information, it is clear that baseline flow rate and quality are extremely variable. In the natural drainage system, many water quality parameters are expected to range across several orders of magnitude. Each flow event will have different ranges depending on antecedent conditions in the catchment and the magnitude of the event. Typically, higher and most variable concentrations occur in the rising stage and lower concentrations occur later and during larger events.

Surface water monitoring has the following objectives:

- Ensure maintenance and integrity of stormwater control structures and systems
- Provide basis for estimation of any increment in load (mass) to the downstream surface water environment if required
- Determine any significant increase in concentrations caused by the Operation
- Identify opportunities for improved water management.
- Improve baseline hydrological knowledge

7.2. OPERATIONAL FUNCTIONS

Maintain short term (hours-days) awareness (shift log) of weather, hydrological and site conditions including:

- Weather forecasts
- Recent daily site rainfall totals
- Pond Levels

Prior to and during periods of high rainfall:

- Daily reading of staff gauge at Munbinea Rd
- Bund integrity and crest elevation
- Drain and sump siltation and water levels
- Catchment Flows – “River Conditions” map at BoM website (Mid West Rainfall and River Conditions
- Catchment Rainfall - “24 hour Rainfalls” map at BoM website (Mid West Rainfall and River Conditions
- BoM Rainfall Radar – Watheroo

7.3. SAMPLING AND ANALYSIS

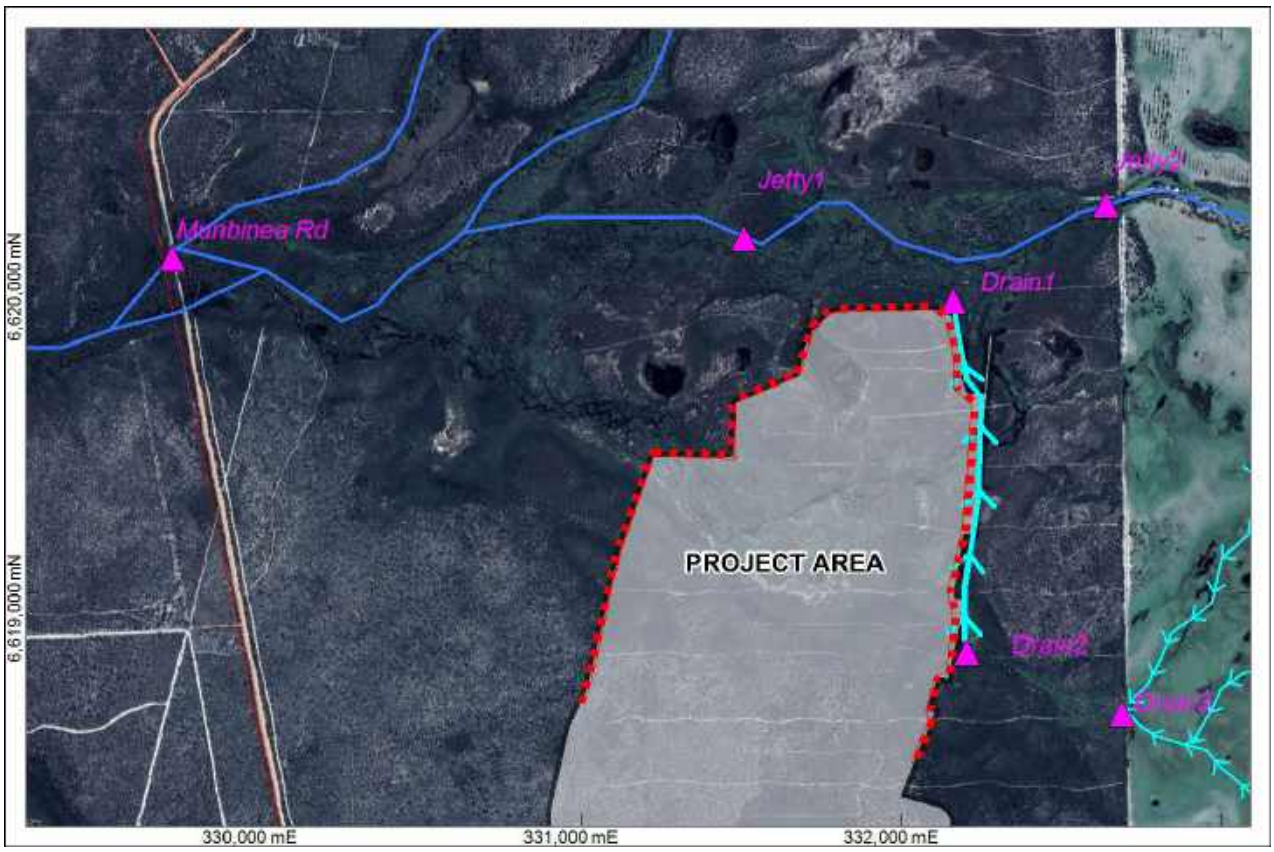
Six external monitoring sites are listed in Table 4 and shown in Figure 7. Surface water sampling is to commence and continue through periods of substantial flow (>25 L/sec) through the culverts at the Munbinea Rd floodway and to include:

- Continuous (hourly) flow depth and flow velocity for Nambung River at Munbinea Rd crossing - (instrumented and data logged)
- Weekly: Field Water Quality (FWQ) analysis at Munbinea Rd site.
- Monthly: sample (when accessible) and analysis at all locations in Table 4

Table 4 – Surface Water Monitoring Locations

Monitor Site	East	North
Munbinea Rd	329,724	6,620,048
Jetty1	331,083	6,620,161
Jetty2	332,636	6,620,214
Drain1	332,162	6,619,913
Drain2	332,205	6,618,820
Drain3	332,685	6,618,630

Figure 7 – Surface Water Monitoring Locations



Sampling analytes are based on the soils, waste and groundwater investigations (Mine Earth 2022, a, b, c. MWES, 2022a, b). The analyte list is provided at Appendix 2 and is identical to that for groundwater samples as per the Groundwater Licence Operating Strategy.

7.4. SURFACE WATER QUALITY TRIGGER ACTION RESPONSE PLAN

Parameters used in the trigger action response plan (TARP) are those with greatest source potential as determined in the baseline geochemical studies. FWQ are favoured due to rapid, robust and repeatable data generated.

Water quality trigger values were based on ANZECC/ARMCANZ (2000) as follows:

EC: South-west WA Aquatic Wetlands – Lakes, reservoirs & wetlands range : 300-1500 (uS/cm)
pH: South-west WA Aquatic Wetlands – Lakes and reservoirs range : 6.5-8.0
Arsenic: 95% protection level (slightly-moderately disturbed aquatic ecosystems): 0.03 mg/L
Selenium: 95% protection level (slightly-moderately disturbed aquatic ecosystems): 0.005 mg/L

The TARP is detailed in Appendix 3. Outcomes from TARP actions are included in routine and specific external reports as appropriate.

8. REFERENCES

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Report Limitations

MWES Consulting (MWES) have prepared this report for the use of Image Resources in accordance with the usual care and thoroughness of the consulting profession. It is based on generally accepted practices and standards at the time it was prepared. No other warranty expresses or implied, is made as to the professional advice included in this report.

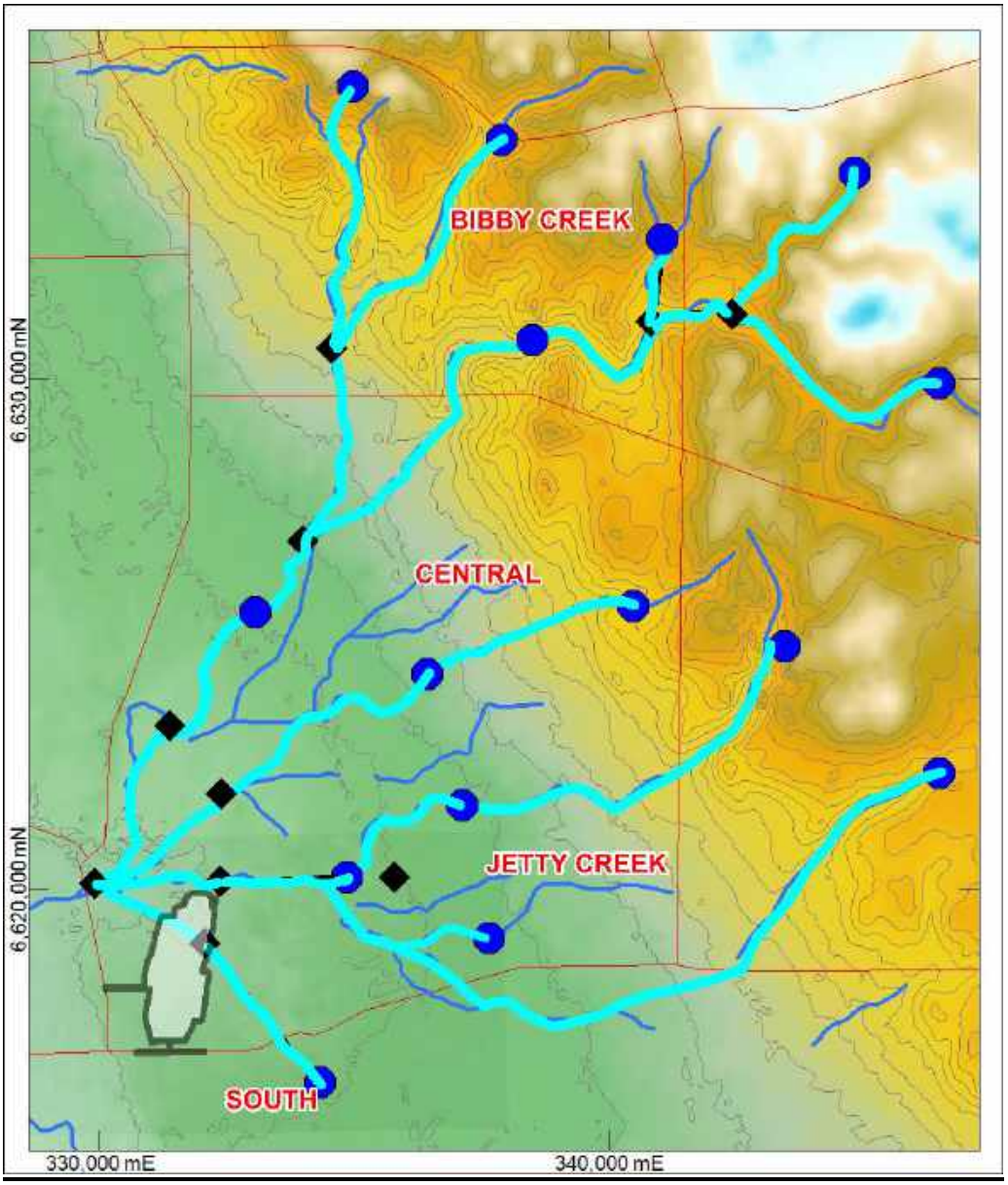
MWES has made no independent verification of this information beyond the agreed scope of works and MWES assumes no responsibility for any inaccuracies or omissions. No indications were found during our investigations that information reviewed at the time of our investigations that information contained in this report as provided to MWES was false.

This report was prepared in 2020-2023 and is based on the conditions encountered and information reviewed at the time of preparation. MWES disclaims responsibility for any changes that may have occurred after this time.

This report should be read in full. No responsibility is accepted for use of any part of this report in any context.
Whilst to the best of our knowledge information contained in this report is accurate at the date of issue, subsurface conditions, including groundwater levels; can change in a limited time. Therefore, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

APPENDIX 1 – RORB MODEL DETAILS

Appendix A - Configuration of Catchment Nodes and Reaches. 10 m Surface Contours



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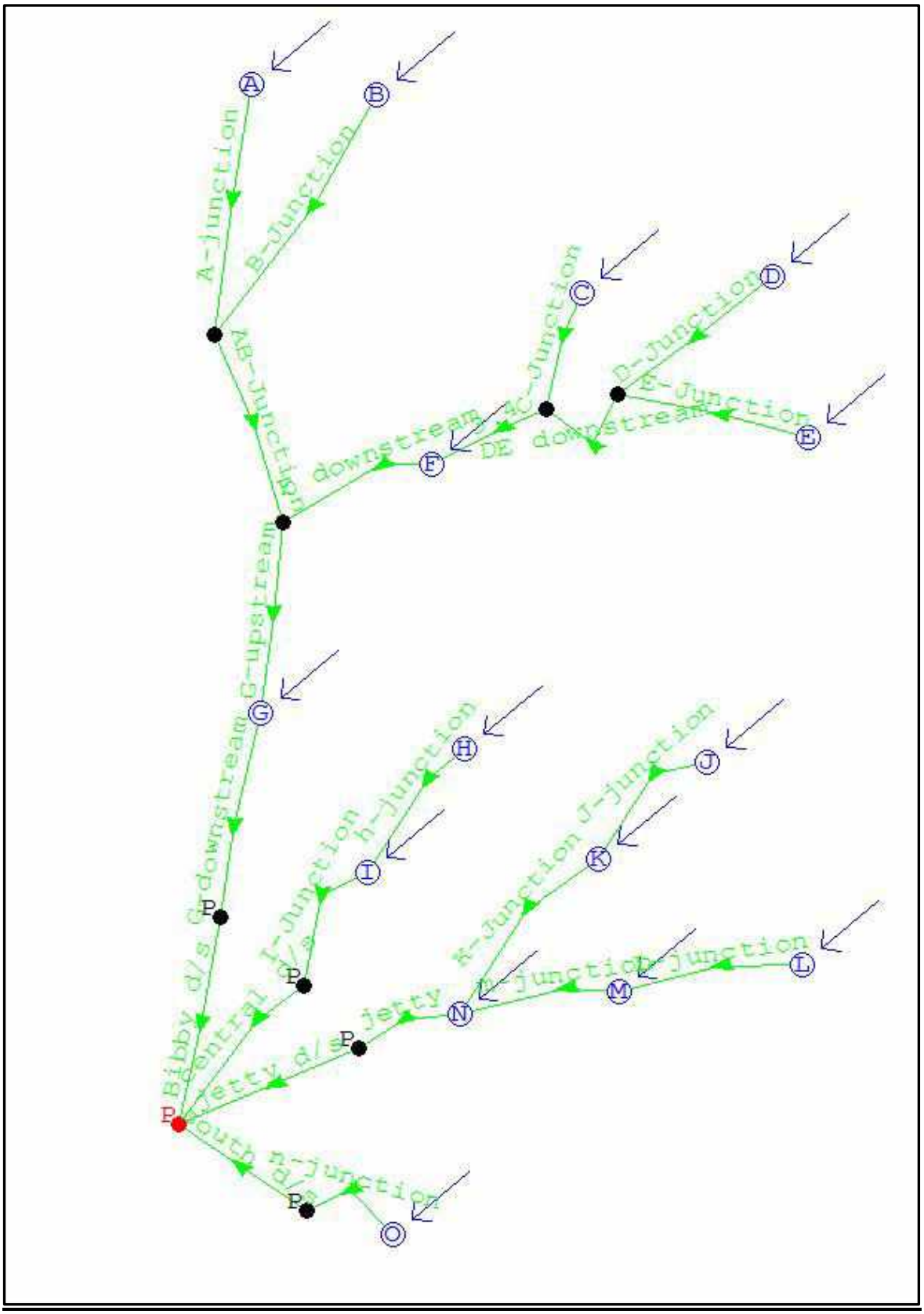
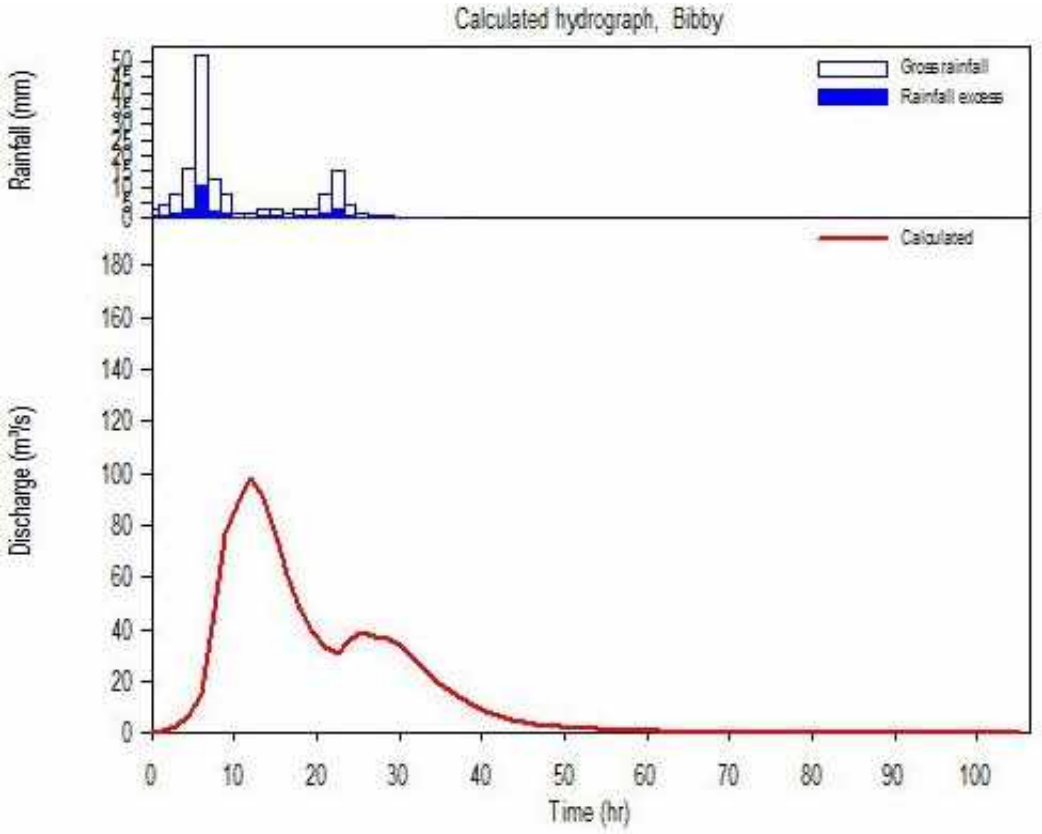
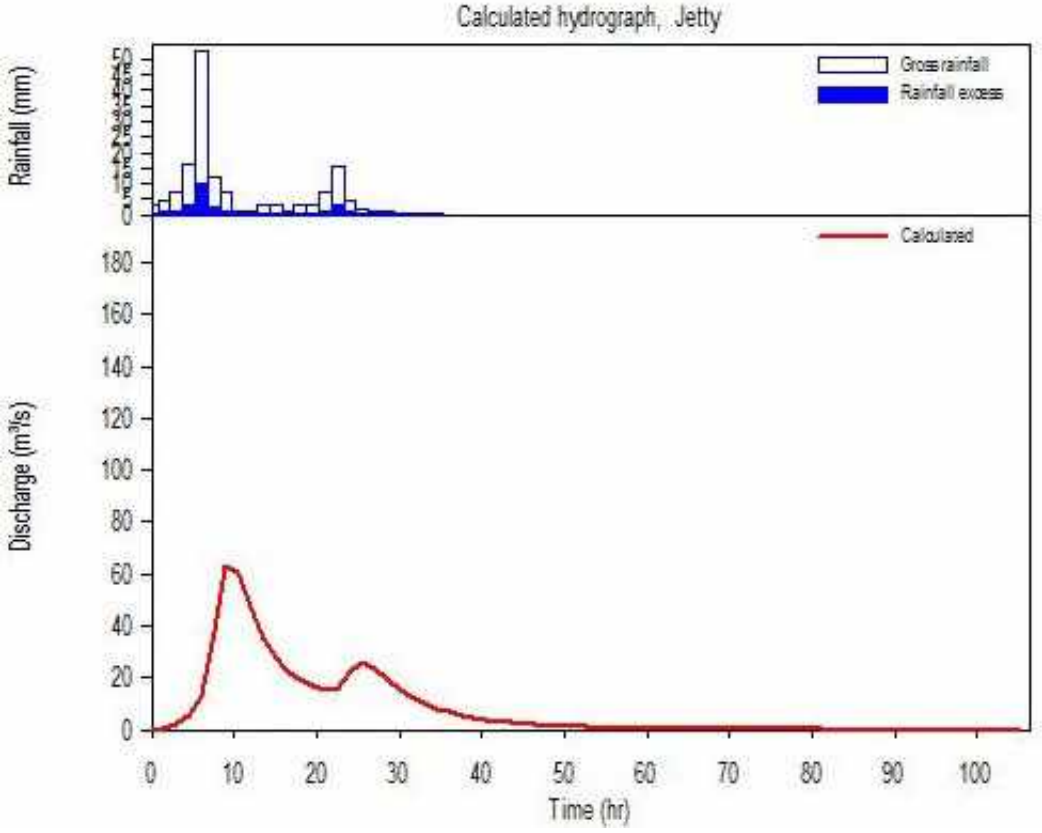
Appendix A – Model Configuration of Catchment Nodes and Reaches



APPENDIX 1 – RORB MODEL DETAILS

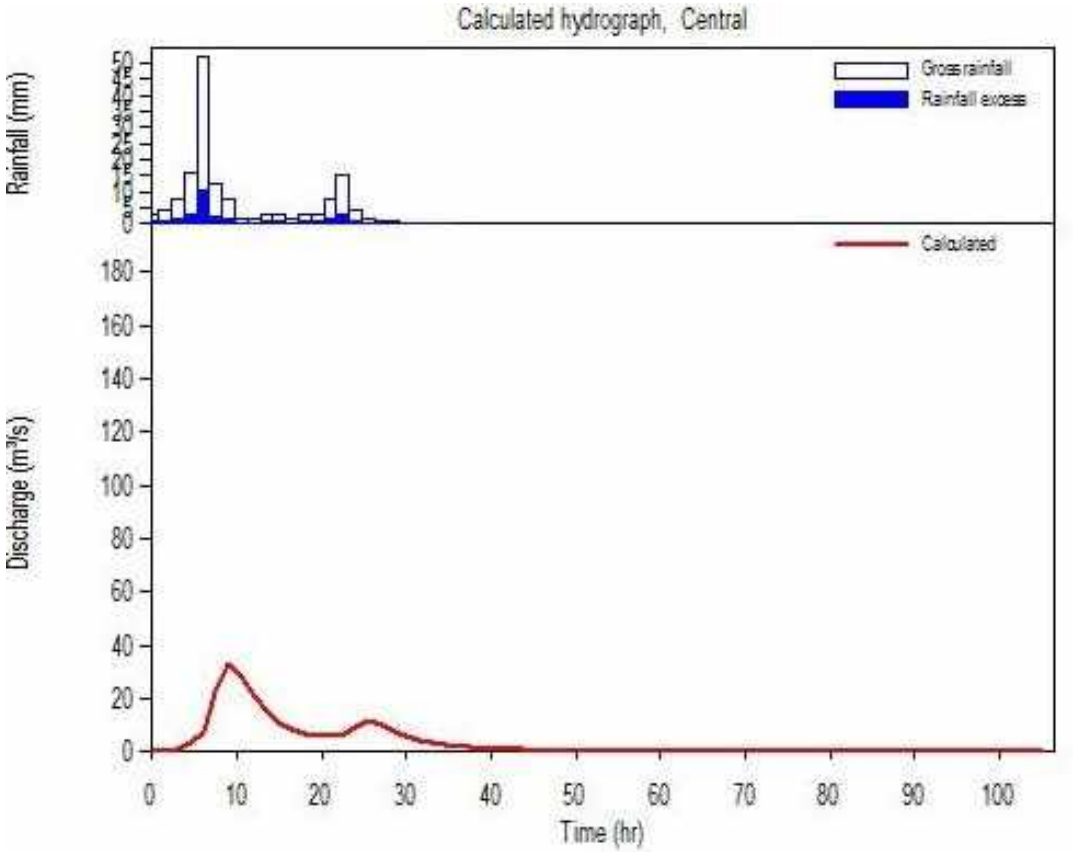
Appendix A – Model Output

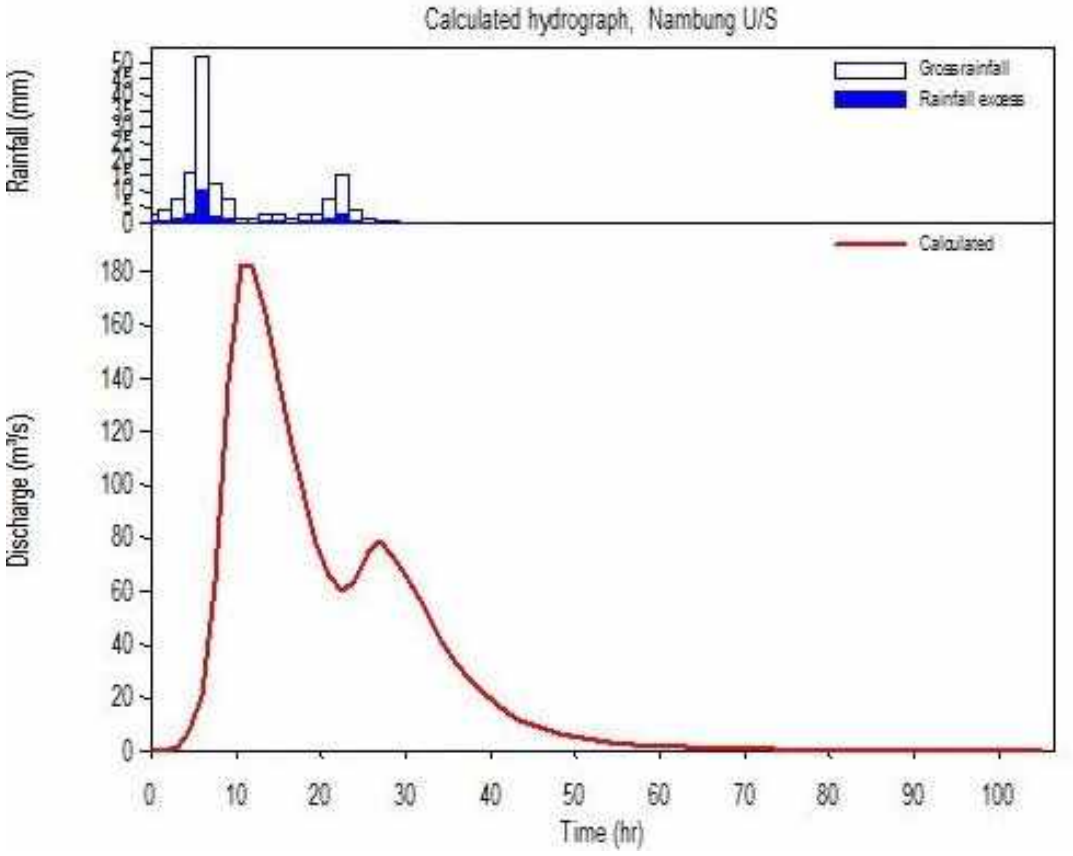




APPENDIX 1 – RORB MODEL DETAILS

Appendix A – Model Output





Appendix 2: List of Comprehensive Analysis Parameters

Field Water Quality (FWQ) Analysis

- Temperature (ºC)
- Field EC (Electrical Conductivity compensated to 25ºC)
- Field pH

Laboratory Analysis

Physico-chemical

- Lab pH
- Lab EC (compensated to 25ºC)
- TDS (Total dissolved solids measured by drying at 180ºC)
- Total hardness (as $CaCO_3$)
- Total alkalinity (as $CaCO_3$)

Ions

- Calcium Ca
- Magnesium Mg
- Sodium Na
- Potassium K
- Ammonium NH_4
- Phosphate PO_4
- Carbonate CO_3
- Bicarbonate HCO_3
- Chloride Cl
- Sulphate SO_4
- Nitrate NO_3
- Nitrite NO_2
- Silica SiO_2

Metal/Metalloids (filter and acidify samples in field to report the dissolved component)

- Aluminium Al
- Arsenic As
- Cadmium Cd
- Chromium Cr
- Iron Fe
- Lead Pb
- Manganese Mn
- Mercury Hg
- Selenium Se
- Zinc Zn

Appendix 3: Trigger Action Response Plan

Site	Parameter	Frequency	Criteria	Trigger	Action	Response	Plan
Munbinea Rd	FWQ and Analysis	Twice Weekly	pH < 6.5 EC >1500 As > 0.03 mg/L Se > 0.005 mg/L	Single Incidence out of range	Follow-up samples from remaining 5 upstream sites	Assess spatial and temporal data patterns	Increase monitoring frequency until resolved
				As above and multiple sequential out of range	1. Additional FWQ survey including transects along major tributaries to Munbinea Rd 2. Perimeter inspections	Determine source and pathway.	Document the incident including maps of FWQ exceedance - ie source and flow paths
				As above and spatial data indicate project source and pathway	Review site stormwater controls	Remediate any indicated site based source/pathway	Assess impacts on downstream environment, including loads and concentrations