
Photograph courtesy of Dene Moliere

Notice of Intent

Darwin - consultancy - provision of environment approvals for the construction and operations of a hybrid power station in Jabiru

Surface Water & Erosion

Version 4 - 17 September 2020

SURFACE WATER & EROSION SOLUTIONS

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Frontispiece photograph shows Gulungul Creek during the 2007 extreme rainfall event. Photograph courtesy of Dene Moliere.

Executive Summary

A 9.4ha portion of Lot 2303, subdivision of N.T. Portion 2272 Town of Jabiru is being assessed for construction of a hybrid power station. This reports the assess of surface hydrology and erosion risk as part of a Notice of Intent for the NTEPA.

Surface Hydrology

The site is in the 27.8 km^2 Baralil Creek catchment which is a left bank tributary of Gulungul Creek which is 100.9 km^2 and is a left bank tributary of Magela Creek with an area of 614.7 km^2 at its confluence with Gulungul Creek. Lower Magela Creek has wetlands of international significance.

A perennial backflow billabong has developed at the mouth of Gulungul Creek caused by deposition of sand in Magela Creek. At high flows, water from Magela Creek backflows in to Gulungul Creek effectively damming Gulungul Creek.

Conservative estimates using regional flood frequency estimation methods indicated a probable maximum flood level of ≈17.5m AHD in Baralil Creek at Lot 2303. This is ≈9.5m below the average site level of ≈27 m AHD and based on these estimations, it is unlikely flood will affect the proposed power station. Conversely it is unlikely that flows, even though increased due to the impervious nature of the power station infrastructure, from the site will adversely affect the flow regimes in Baralil, Gulungul and Magela Creeks.

Erosion Risk

The site lies on the Koolpinyah Surface, an extensive sandy plain with open woodland vegetation. Surface slopes on the site range from effectively 0% to 2%. The majority of the HSPS site has surface slopes of 0.75% to 5% and is classified as Class C3 erosion risk which makes the land marginally suitable for development. The remainder of the area is Class S2 making it moderately suitable for development. Soil loss rates determined using the RUSLE had a mode of approximately 16 T ha^{-1} y^{-1} and range from 0.05 T ha^{-1} y^{-1} to 100 T ha^{-1} y^{-1}.

Recommendations

1. Detailed hydrologic and 2-dimentional hydraulic modelling is required to confirm the impacts of the development, particularly if there will be infrastructure changes in Jabiru.
2. A storm water management plan is required to control excess water runoff from the site resulting from increased impervious areas due to the solar panels and infrastructure. This, in general, is required for local government approvals.

3. Development of the site will require erosion and sediment control practices involving engineered works and on-going land management. The area exceeds 2500 m^2 and will require a soil and water management plan possibly incorporating diversion bunds and sediment retention basins.
4. The access road has the steepest slope and the highest risk of erosion and gully formation. This should be managed in accordance with Northern Territory Government requirements.
5. Machinery movement must be restricted to the smallest disturbance footprint possible to reduce excessive erosion rates.

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1. Introduction

1.1 Purpose of this report

The Northern Territory's Department of the Chief Minister (DCM) is planning the construction of a hybrid solar power station (HSPS) at Jabiru, NT. DCM has commissioned CDM Smith to undertake initial investigation as part of a potential Environmental Impact Assessment (EIA).

This report describes the surface hydrology and erosion risk sections of these preliminary investigations prepared by sub-consultants Soil Water and Erosion Solutions.

1.2 Location

The proposed HSPS site is on Lot 2303, subdivision of N.T. Portion 2272 Town of Jabiru (Figure 1).

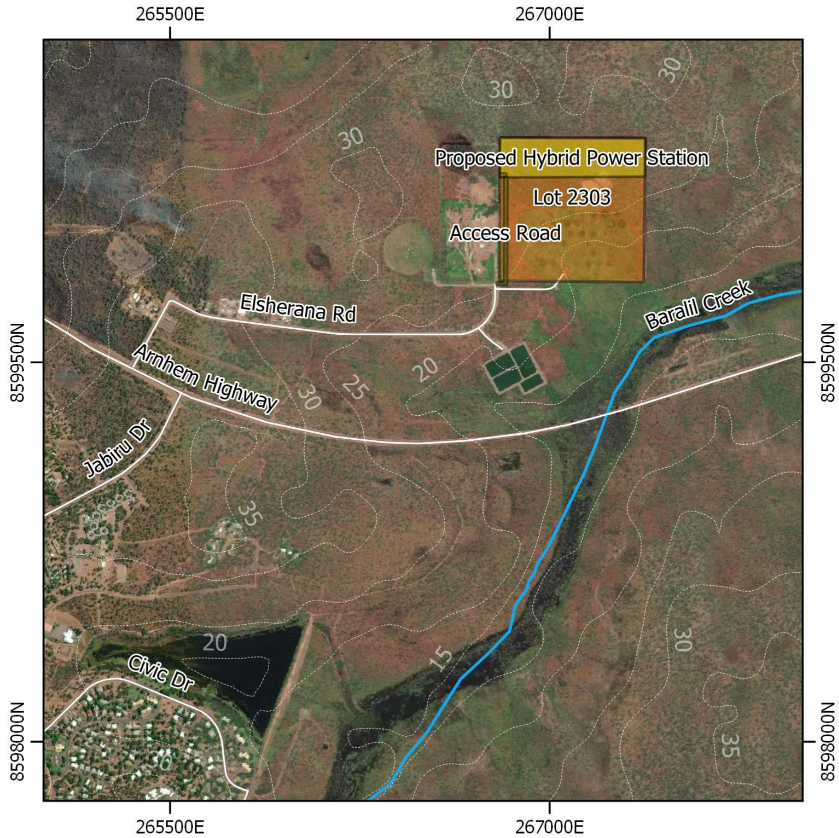

Figure 1 Location of the proposed hybrid solar power station at Jabiru. Map grid of Australia zone 53.

1.3 Rainfall and evaporation

The open source Bureau of Meteorology (BOM) daily rainfall records are available for station 14198 at the Jabiru Airport where data have been collected since 1971. This region has a distinct wet season and dry season with an average annual rainfall of 1553.7 mm. Cyclones and monsoons can occur during the wet season from October to April and very little rain falls during the dry season from May to September. Mean monthly rainfalls and evaporation rates are shown in Figure 2.

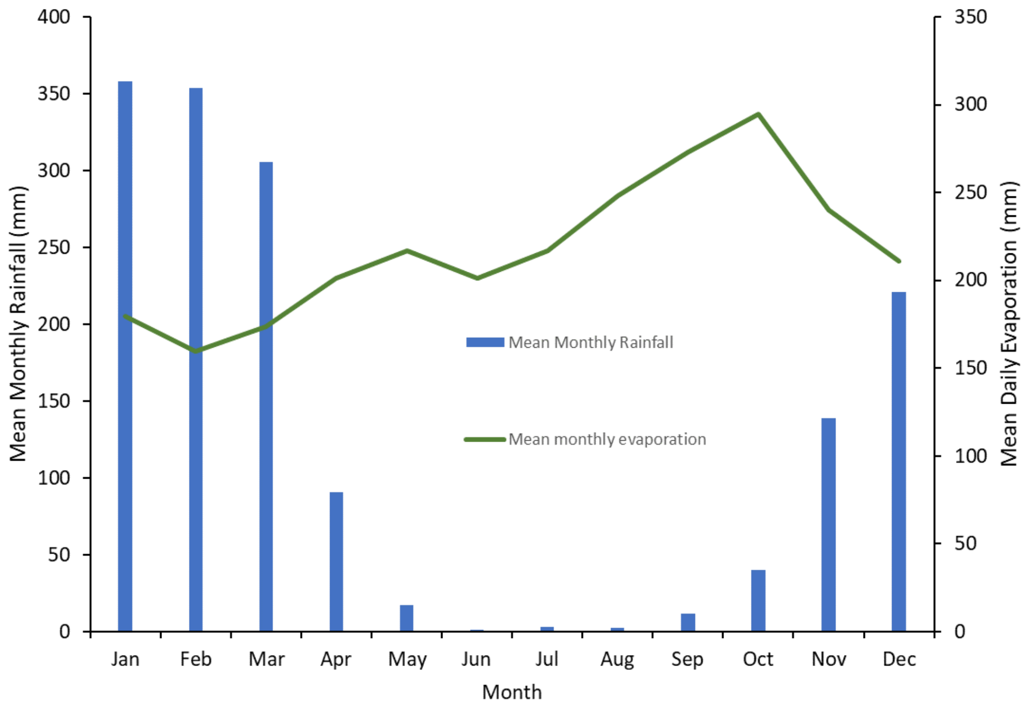

Figure 2 Mean monthly rainfall and mean daily evaporation for BOM station 14198, Jabiru Airport.

1.4 Regional Landforms

There are four main landforms in the region (Appendix A).

1. Alluvial plains developing as over-bank deposits of mainly ephemeral stream dissecting the Koolpinyah Surface (Williams 1969),
2. The Koolpinyah Surface is a Tertiary peneplain, comprising a sandy erosional surface dissected by lowland streams. The peneplain is being exhumed by retreat of the Arnhem land Plateau.
3. The Arnhem Land Plateau escarpment, rising from about 30m AHD to 300m AHD (Erskine and Saynor 2000) comprising cliff faces, colluvial fans, large sandstone block collapses and scree slopes, and
4. The Arnhem Land Plateau, comprising quartz sandstone, that is deeply dissected along fault and joint lines through which water and sediments debouch through deep ravines or waterfalls to the Koolpinyah surface.

2. Surface hydrology assessment

This assessment was based on aerial photograph interpretation and GIS analysis. Such interpretation is usually ground-truthed through fields studies. However, field studies could not be conducted because of the risk of the current Coronavirus pandemic to vulnerable communities.

This aerial photographic interpretation was conducted using Quantum GIS (QGIS.org 2020), ESRI imagery, BOM Geofabric data and GeoScience Australia's 1' SRTM digital elevation data. The 1' SRTM data are provided as a 30 x 30m digital elevation model (DEM). To improve interpolation of streamlines and catchment boundaries the 30m DEM was hydrologically corrected and resampled to a 5 x 5m DEM.

2.1 Stream catchments

There are three stream catchments which may influence the site: Magela Creek, Gulungul Creek and Baralil Creek (Appendix B). The proposed site is in the northern portion of Lot 2303 which is located on the left bank of Baralil Creek at a level of approximately 30m AHD. The town of Jabiru is upstream and to the south west of Lot 2303 on the left bank of Baralil Creek. Catchment details are given in Table 1.

Extensive geomorphic, erosion and hydrologic research has been conducted on Gulungul Creek and Magela Creek by the Environmental Research Institute of the Supervising Scientist (eriss) as part of its research into the management of potential impacts of uranium mining and exploration in the region. The eriss list of relative publications can be found here https://www.environment.gov.au/science/supervising-scientist/publications.

Baralil Creek is an ephemeral stream that is a left bank tributary of Gulungul Creek. Its catchment lies totally on the Koolpinyah Surface and most of the town of Jabiru lies on the western bank of the stream. About 1/10th of the catchment is disturbed. An elongated backflow/channel billabong has developed in Baralil Creek upstream of its confluence with Gulungul Creek due to longitudinal sand deposition in Gulungul Creek (Appendix C). The stream has a long narrow alluvial plain extending to the south of Jabiru where the stream splits in to two distinct channels. (Appendix C)

Flow accumulation analysis was conducted on the small sub-catchment containing Lot 2303 (Insert Appendix B). This analysis clearly shows where water accumulates on the site. The Baralil Catchment comprises mainly sandy soils with black soils present on it flood plains and adjacent to the stream channel.

Gulungul Creek is an ephemeral stream and is a left bank tributary of Magela Creek. It has its headwaters in the Arnhem Land Plateau. Upstream of its confluence with Magela Creek, a perennial backflow billabong of about 11 ha area has developed caused by sand depositing in Magela Creek. Gulungul Creek is a sand-bed stream where in some locations it is a single channel and other places a braided channel.

Magela Creek is a left bank tributary of the East Alligator River and in its lower reaches, Magela Creek has wetlands of international significance. Magela Creek is an ephemeral stream flowing only during the wet season. Water often flows from Magela Creek into Gulungul Creek (backflow) during the wet season (Erskine and Saynor 2000) causing flow in Gulungul Creek to decelerate and drop its sediment load. A sandy plug has been deposited by Magela Creek in the Gulungul Creek mouth effectively damming Gulungul Creek causing the backflow billabong to develop (Nanson, East and Roberts 1993).

Table 1. Study region stream catchment properties.

Catchment	Unit	Gulungul Creek including Baralil Creek	Magela Creek at the confluence with Gulungul Creek
Area	km^2	100.9	614.7
Stream slope	m/m	0.004	0.001
Catchment Outlet	Easting (m)	270262	270035
	Northing (m)	8602830	8603465
Catchment Centroid	Easting (m)	269508	269512
	Northing (m)	8594136	8594128
RFFE Peak Q 1% AEP	m^3s^{-1}	802	2220
PMF Peak Q	m^3s^{-1}	5618	15720

2.2 Flood level estimations

Flood levels in Baralil Creek may affect the proposed power station site or, conversely, the proposed HSPS may affect flow regimes in Baralil Creek due to increased runoff from impervious infrastructure of the power station. To assess the likelihood of negative impacts, regional flood frequency estimates were used to determine possible flood levels.

Flood peak discharges in Gulungul Creek, combined with Baralil Creek, and Magela Creek at its confluence with Gulungul Creek were estimated using Regional Flood Frequency Estimation (RFFE) methods (Rahman, et al. 2015) for a 1% Annual Exceedance Probability (AEP) event (Table 1).

The probable maximum flood (PMF) peak discharge was derived through extrapolation of the RFFE curves to a 5000-year event peak discharge (Ball, et al. 2019) using the best-fit equation for the expected quantiles of the RFFE (Table 1).

Flood inundation levels were derived by iteratively fitting velocity and hydraulic radius in Manning's equation (Manning 1891) and cross sectional area to obtain the peak discharges similar to the RFFE-derived peak discharges. The fitted levels where plotted as static flood levels and are shown in Figures D.1 and D.2 in Appendix D.

Based on the peak discharges for the 1% AEP and PMF, flood levels were derived for the channel profiles of Magela Creek (Figure D.3, Appendix D). The Magela Creek flood levels were used as a static base level in Gulungul Creek. It was assumed that during the flood peak in Magela Creek, at its confluence with Gulungul Creek, backflow entered from Magela Creek into Gulungul Creek with the effect of "damming" Gulungul Creek. This is conservative as the time of concentration calculations indicate that the flood peak in Magela Creek lags the flood peak in Gulungul Creek by approximately 3 hours. Flood levels in Gulungul Creek were superimposed on Magela Creek backflow levels. Flood levels on sections in Baralil Creek (Figure D.5), Gulungul Creek (Figure D.4) and Magela Creek (Figure D.3) are shown in Appendix D.

However, these estimations are not a substitute for probabilistic determination of flood hydrographs using Monte Carlo simulation methods and detailed 2-dimensional hydraulic modelling.

See Appendix D for notes describing the flood estimate results. It is significant to note that the Baralil Creek section (Figure D.5 Appendix D) shows the PMF level reaching the south eastern corner of Lot 2303.

2.3 Surface hydrology assessment conclusions

Conservative estimates indicate that the PMF level (≈17.5m AHD) in Baralil Creek at the Lot 2303 section (Appendix D) is ≈9.5m below the average site level of ≈27m AHD of the proposed power station site and it is unlikely the power station will be affected by flood as shown by these estimates.

The possible impacts, based on the conservative application of RFFE methods, of the power station on existing flow regimes in the receiving stream are negligible. There will be increased surface runoff caused by impervious solar panels and infrastructure. The site and access road have a combined area of ≈9.4ha which is 0.33% of the Baralil Creek catchment and 0.09% of the Gulungul and Baralil Creek catchment combined. The increased runoff from the solar panels and infrastructure will be managed by sediment retention basin/s (see 3. Erosion).

These flood level estimates should not be considered a substitute for detailed probabilistic hydrologic modelling using methods such as Monte Carlo simulations and 2-dimensional hydraulic modelling with a high-resolution DEM in accordance with the Australian Rainfall and Runoff Guidelines 2019 (Ball, et al. 2019).

3. Erosion Risk

This section of the report describes the existing conditions and the risk of potential erosion at the HSPS site.

For these initial investigations, this report does not present detailed calculations and design of an erosion and sediment control plan (ESCP) but, shows the possible locations of diversion bunds and sediment retention basins.

3.1 Existing conditions

The existing conditions were assessed using Google Earth imagery dated 23 April 2020 at an eye altitude of 414m.

The proposed HSPS site sits on the Koolpinyah Surface described above (Sub-Section 1.4 Regional Landforms). A profile slope is provided in Figure D.5, Appendix D. Slopes across the HSPS site are generally between 0.75% and 2% but on the southern areas of Lot 2303 to the south of the HSPS site, slopes are as much as 5%.

The lowlands of the nearby Gulungul Creek catchment, containing Baralil Creek, are part of the Koolpinyah Surface which in this area is vegetated with open woodland and comprises a sandy plain covered by skeletal soil (Needham 1988). The soils have been described as arenic rudisols and are uniformly coarse textured sandy soils (Saynor, et al. 2004). The denudation rate in the area is 0.04 mmy^{-1} (Cull, et al. 1992) which equates to about 1 T ha^{-1} y^{-1} and a gross erosion rate for the area of 0.6 T ha^{-1} y^{-1} has been derived (Evans 2000) which is similar to the Kakadu regional erosion rate (Duggan 1994). The aerial photographic interpretation indicated that these conditions exist for the HSPS site.

While undisturbed, i.e. no excavation and with vegetation in place, the Koolpinyah Surface is a relatively stable erosion surface. However if vegetation is removed and the fragile, skeletal soils are disturbed, large gullies with high sediment yields of up to 937.50 T ha^{-1} y^{-1}can develop (Saynor, et al. 2004). Such disturbance can develop from, *inter alia,* vehicle tracks and wild pig disturbance.

There are existing conditions on and near the HSPS site that may have negative impacts on the surrounding environment. These are (Figure E.1, Appendix E):

A. Bare earth on the adjacent rubbish tip which may lead to increased sediment discharge to Baralil Creek,
B. What appears to be a sprinkler land application area possibly for treated sewage effluent from the nearby sewerage ponds, and
C. Bare earth possibly dumped from rubbish tip excavations. The batter slopes appear to be at angle of repose and there are numerous erosion gullies on the batter slopes. The total surface area of the material is ≈1.1ha, of which ≈0.13ha is on the HSPS site.

3.2 Erosion Risk Assessment

Because Covid 19 restrictions, no field inspection was conducted to assess site conditions.

Analysis of surface slope (%) using QGIS found that there were two erosion risk slope classes (Table 2). These classes are <0.75% and 0.75% to 5% and their distribution is shown in Figure E.2. Appendix E. The erosion risk categories of the classes are giving in Table 2 which is an extract from the NT Land Suitability Guidelines (Northern Territory Government 2013).

The Revised Universal Soil Loss Equation (RUSLE) (Renard, et al. 1997) was used to determine annual erosion rate distribution on the HSPS site.

3.2.1 RUSLE

Geotechnical study results, Appendix E Construction Sciences (2020), were used to derive parameter values for the RUSLE. Sampling locations are shown in Appendix E, Figure E.3. The equation used in this study with the inclusion of an erosion rate ratio is represented by:

$A = R\ K\ LS\ P\ C\ e^{-0.049r}$

where,

A = computed soil loss ($T\ ha^{-1}\ y^{-1}$),

R = rainfall erosivity factor,

K = soil erodibility factor,

LS = slope length/gradient factor

P = erosion control practice factor,

C = ground cover and management factor,

$e^{-0.049r}$ = erosion rate ratio

Parameter values were derived using the methods of Evans et al (2004). A soil erodibility (K-factor) ranging from 0.009 to 0.015 Mg ha h (ha MJ mm)$^{-1}$ was derived from sieve and hydrometer soil particle size distributions and organic matter % (Construction Sciences 2020) and a rainfall erosivity value of 8606 MJ mm (ha h year)$^{-1}$ was derived. The distribution of k-factor values between sampling sites was determined using Voroni polygons in QGIS (Appendix E, Figure E.3). Slope length factor (LS) distributions, based on the 5 m DEM, for the site was derived using QGIS. An average erosion rate ratio of 1.3 was applied to reflect the presence of particles >5mm diameter in the samples. Sediment loss (T ha^{-1} y^{-1}) distribution (Figure E.3. in Appendix E), assuming disturbance and no vegetation, was determined as the product of the LS distribution, k-factor distribution, R, and erosion rate ratio. Soil loss has a range of 0.05 – 100 T ha^{-1} y^{-1} with a mode of 16 T ha^{-1} y^{-1}.

The access road has a slope of ≈2% up to a spur (Figure E.3, Appendix E) and then down to the HSPS site. The upward slope is one of the steepest on site and traffic could result in development of large gullies (Saynor, et al. 2004) if not managed correctly as part of the SWMP.

Table 2 *Proposed hybrid solar power station site at Jabiru erosion risk, based on surface slope %.This table is an extract from Table 1 in (Northern Territory Government 2013)*

Suitability Classes	Description	Drainage	Erosion Risk	Riverine Flooding
Class S2 Moderately Suitable	Land having limitations which in aggregate are moderately severe for sustained application of a given land use. Appreciably inferior to S1 land. Potential negative economic, environmental, health and/or social outcomes if not adequately managed.	Moderately-Well	<0.75% slope	<1% AEP risk of river floodplain flooding for entire land parcel – No Risk
Class S3 Marginally Suitable	Land having limitations which in aggregate are severe for sustained application of a given use. Moderate to high risk of negative economic, environmental, health and/or social outcomes if not adequately managed.	Imperfectly	0.75-5% slope, Development will require practice erosion and sediment control involving engineered works. On-going land management required	≥1% AEP risk of river floodplain flooding on part of the land parcel other than floodway – Low risk and mitigated.

3.3 Preliminary ESCP

This section uses flow analysis and surface slope distribution to determine preliminary locations of sediment control measures in the ESCP.

Site constraints are:

- The area of the site is >2500m^2,
- Run off from the site may reach wet land areas of Gulungul Creek and Magela Creek, and
- the site's location is in a region with high intensity rainfalls

The ESCP may identify the requirements for Type 1 sediment control measures (i.e. sediment basins) depending on the results of the soil loss assessment as determined by the (RUSLE) (Renard, et al. 1997).

The final ESCP should be in accordance with the Northern Territory Government's (NTG) technical notes and fact sheets for erosion and sediment control.

This assessment is based on estimates only, as site slope % and LS factor distribution were based on the 1' SRTM DEM which has a resolution of 30 m x 30m. The error in this DEM is up to 9.8 m.

The HSPS site has 71% of surface slopes of 0.75% to 5% which are classified as Class C3 which makes them marginally suitable for development (Figure E.2, Appendix E). The remainder, 29%, has slopes <0.75% surface slopes which classifies that area as Class C2 (Table 2) making that area moderately suitable for development. Development of the site will require erosion and sediment control practices involving engineered works such as sediment retention basins and diversion bunds and on-going land management (Northern Territory Government 2013). Preliminary locations of sediment retention basins and diversion bunds are shown in Figures E.2 and E.3, Appendix E.

Confirmation of these results and preparation of a final ESCP will require a higher resolution DEM obtained from Lidar and/or photogrammetry techniques, detailed design of sediment retention basins and diversion bunds.

4. Conclusions

1. It is likely that the only impact of the HSPS on the local surface hydrology will be increased runoff resulting from the impervious solar panels and infrastructure. This should be assessed, once the design is finalised, as part of the stormwater management plan.
2. The soils in the area are mostly sandy. Sandy soils generally have low erosion rates if left undisturbed. However, once the surface of these skeletal soils are disturbed erosion rates can increase exponentially. It is important that, where possible, soil disturbance works are conducted during the dry season. Erosion and sediment control plans must be implemented to manage wet season runoff.

5. References

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6. Appendices

Appendix A

Study area regional landforms

Appendix B

Stream catchments relative to the proposed hybrid poser station in Lot 2303, Town of Jabiru.

Appendix C

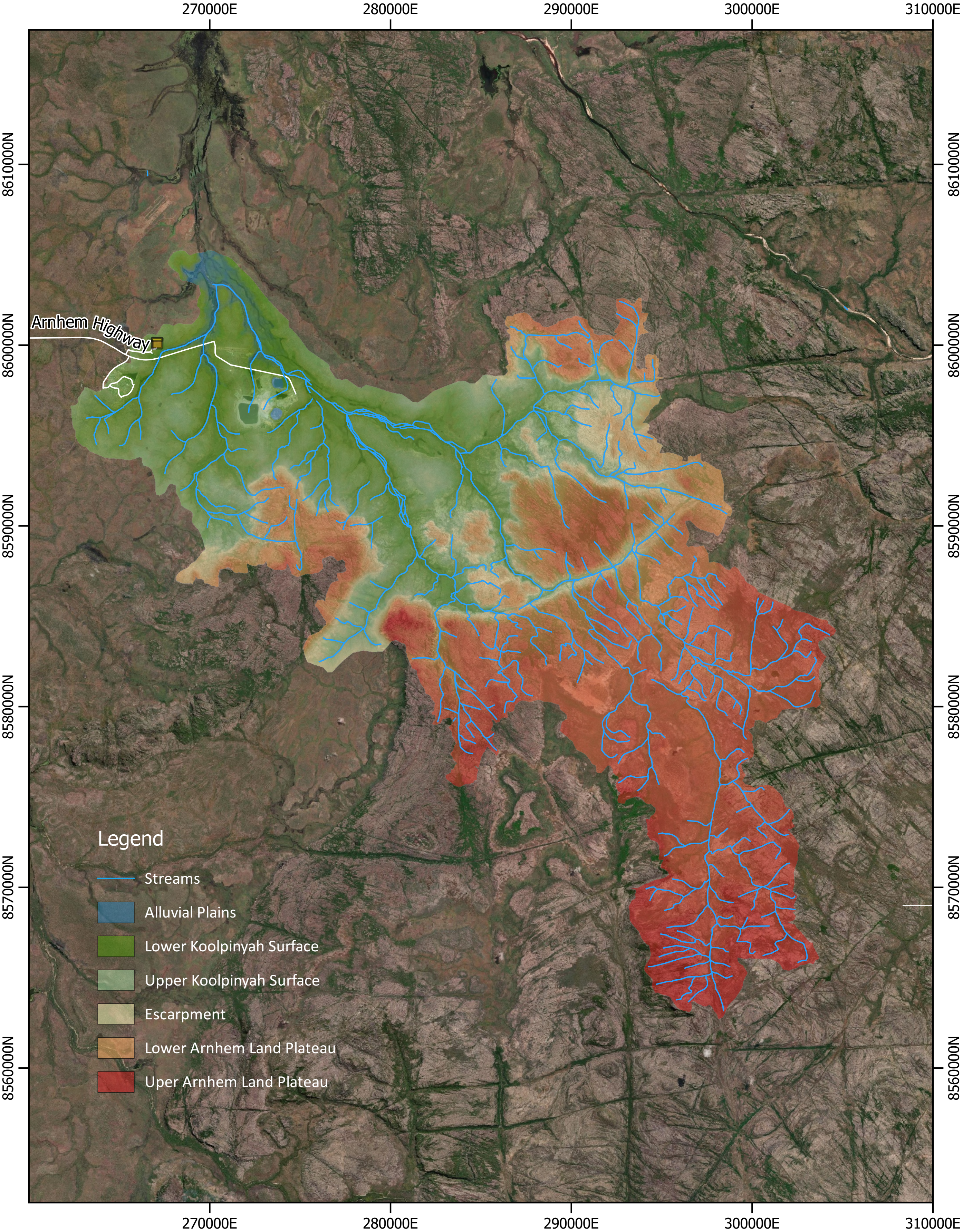
Baralil Creek and Gulungul Creek floodplains and backflow billabongs.

Appendix D

Regional flood frequency Estimations and flood levels.

Appendix E

Hybrid solar power station existing conditions and erosion risk analysis.



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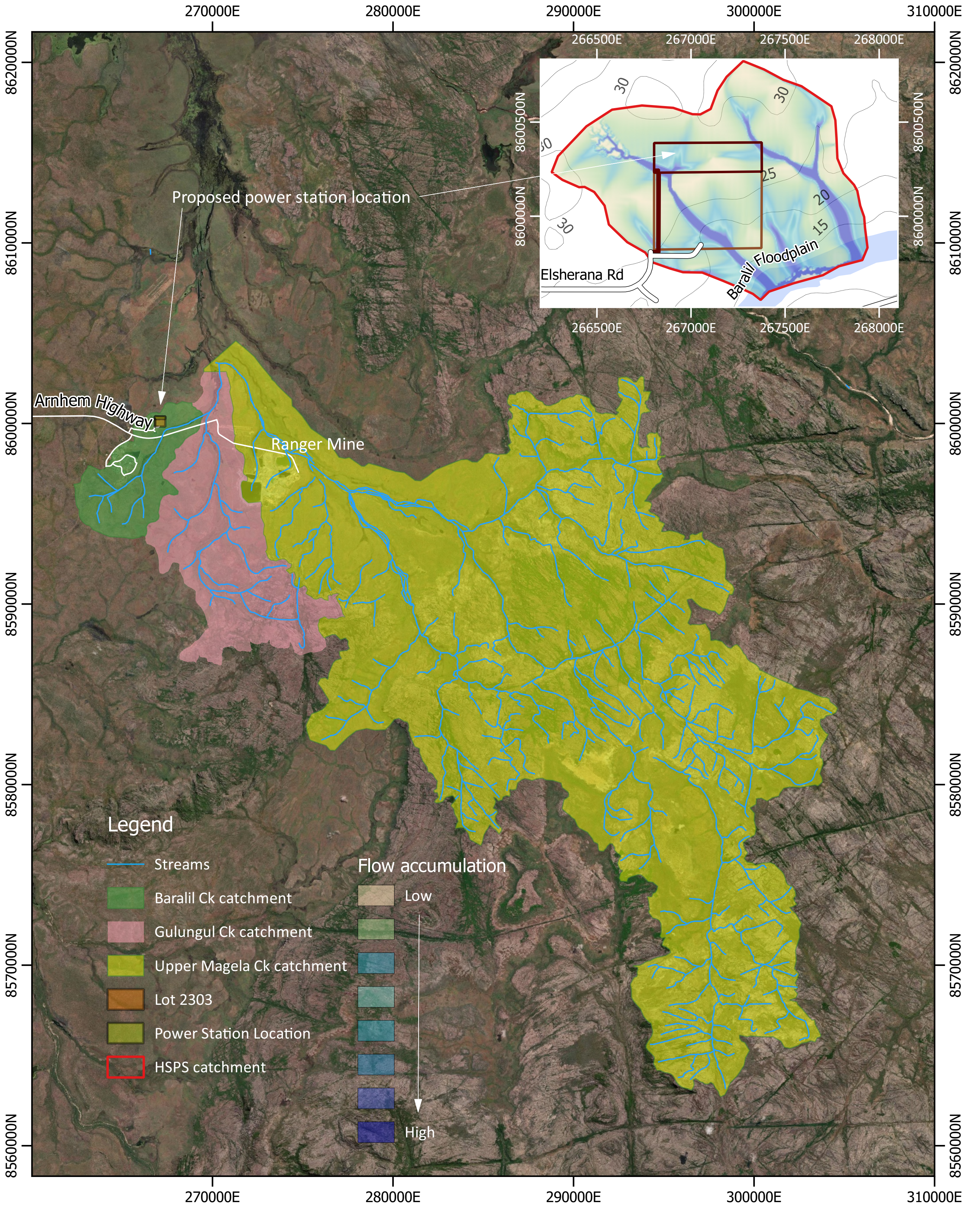
Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Grid: Map Grid of Australia (MGA) zone 53

5 0 5 10 15 km

SURFACE WATER & EROSION SOLUTIONS

Appendix A: Study region landforms



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Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Grid: Map Grid of Australia (MGA) zone 53

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SURFACE WATER & EROSION SOLUTIONS

Appendix B. Stream catchments influencing the proposed hybrid power station site. Insert shows flow accumulation analysis to dertermine flow paths across the HSPS site.

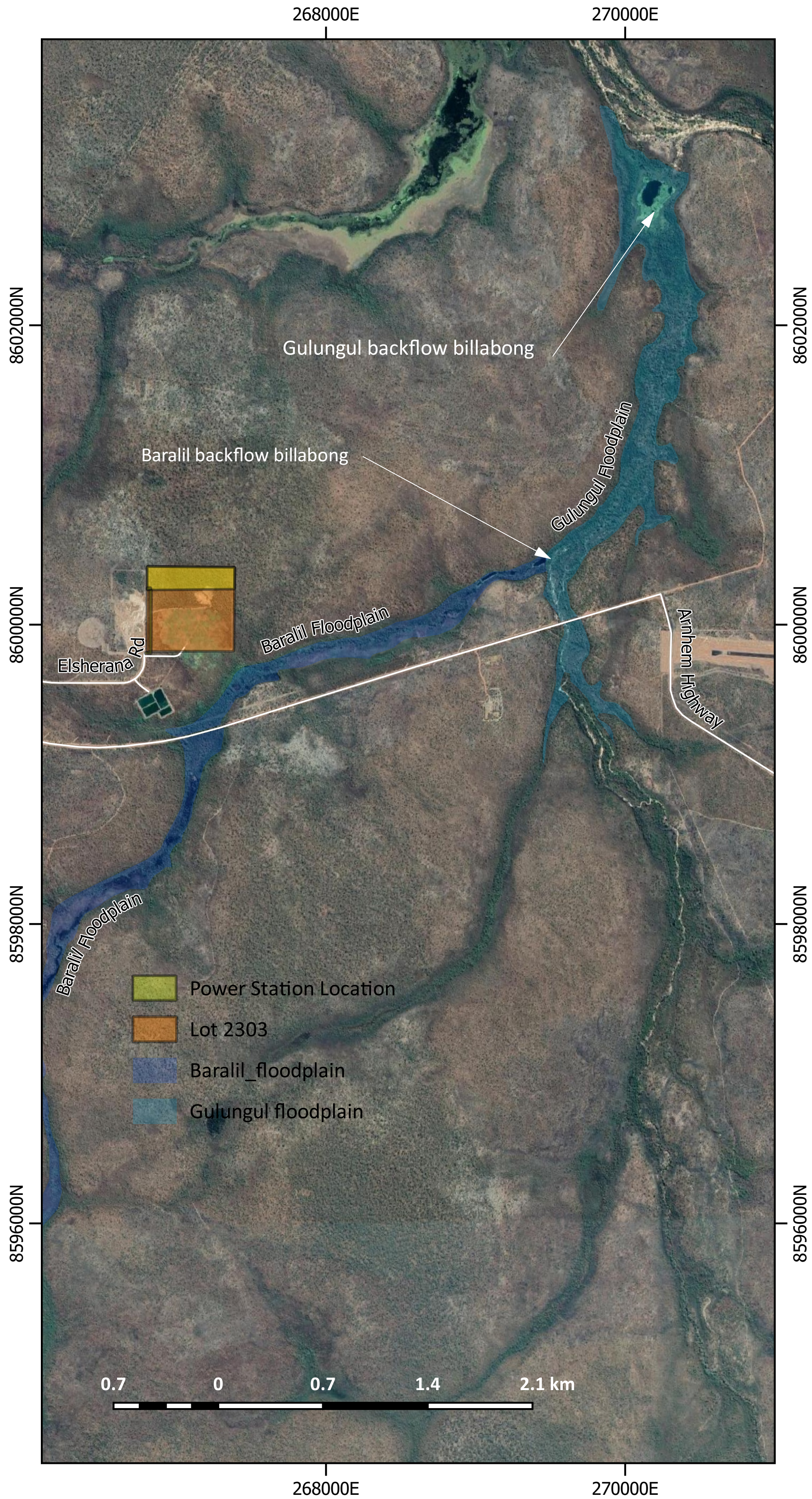

Figure C.1. Floodplains and billabongs in Baralil Creek and Gulungul Creek

Figure C.2. Backflow/Channel billabong in Baralil Creek and sand deposition in Gulungul Creek..

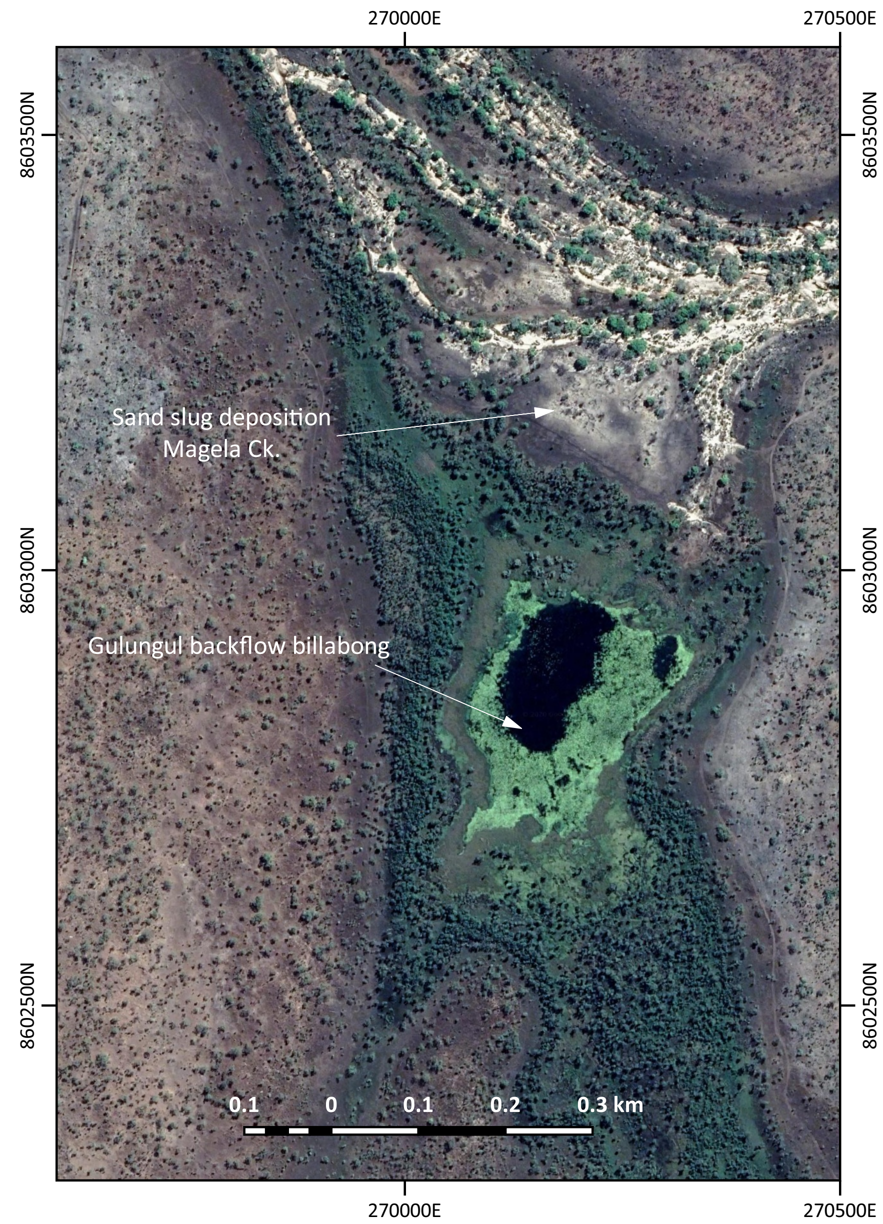

Figure C.3. Backflow billabong and sand "slug" deposition in Gulungul Creek.

Projection: Universal
Transverse Mercator
Horizontal Datum: Geocentric
Datum of Australia 1994
(GDA94)
Grid: Map Grid of Australia
(MGA) zone 53

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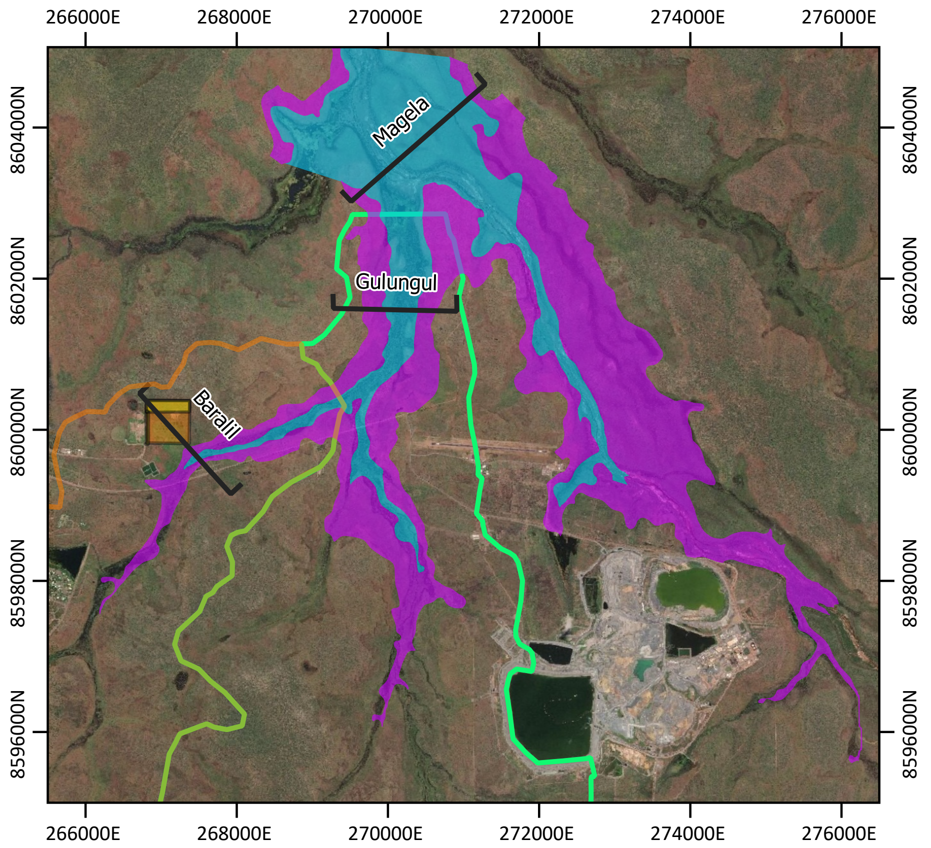

Figure D.1 Estimates of backflow flood levels in Gulungul Creek resulting from 1% AEP event and a PMF in Magela Creek.

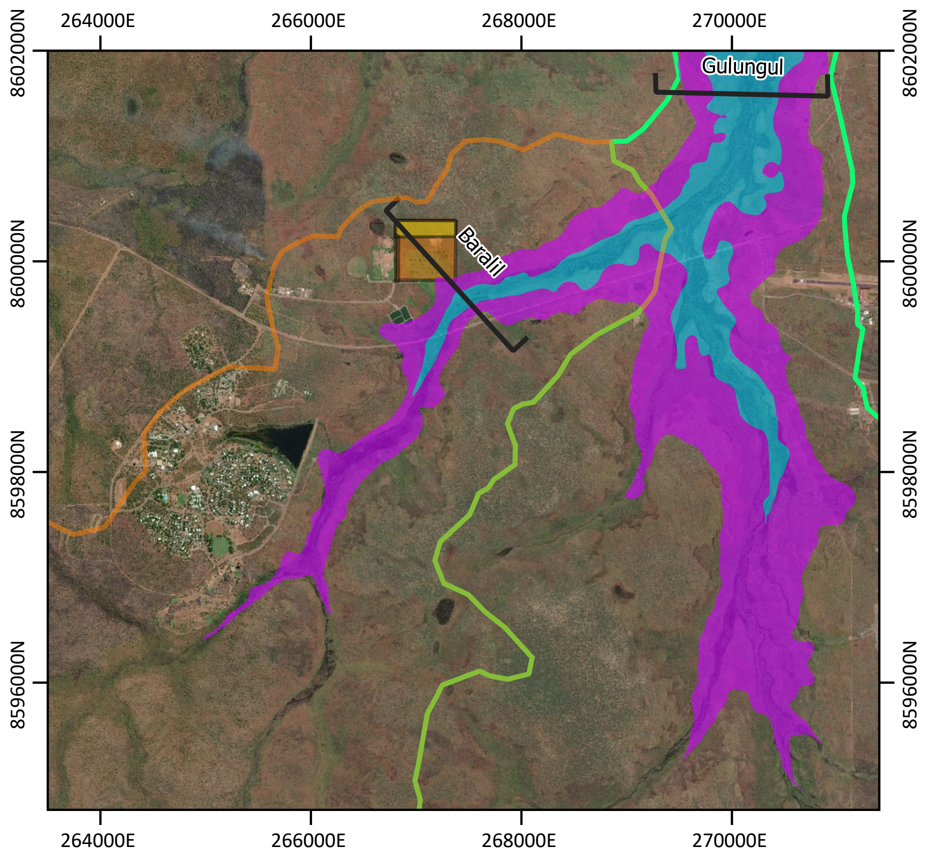

Figure D.2 Estimates of 1% AEP and PMF inundation levels in Gulungul Creek superimposed on a Magela Creek 1% AEP event and a PMF.

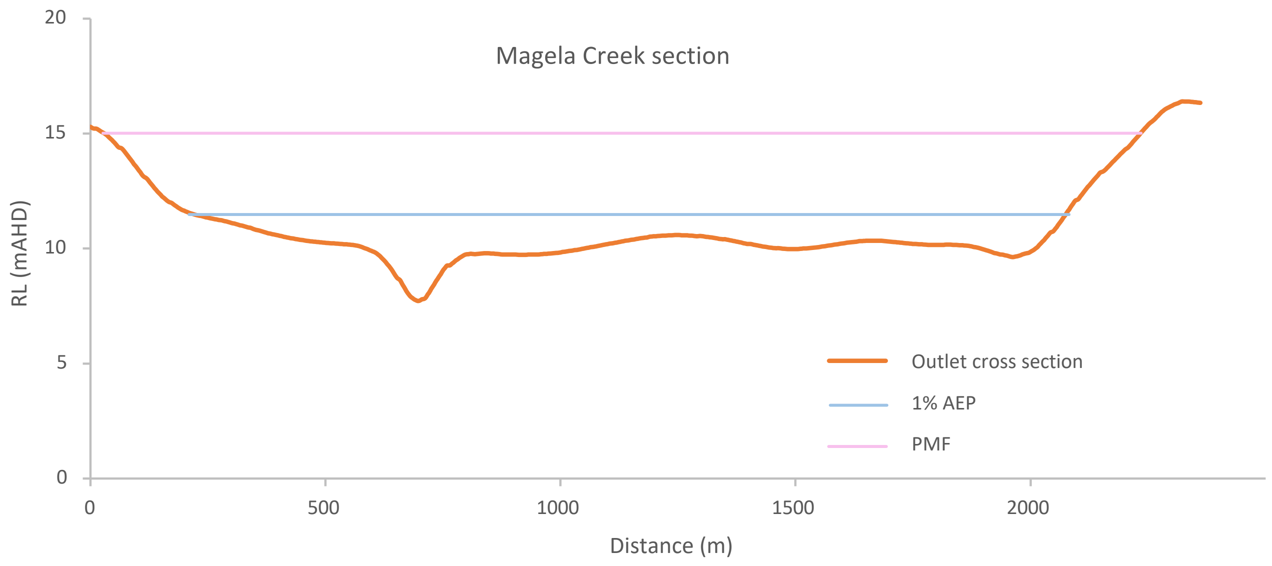

Figure D.3 Magela Creek section showing 1% AEP and PMF levels.

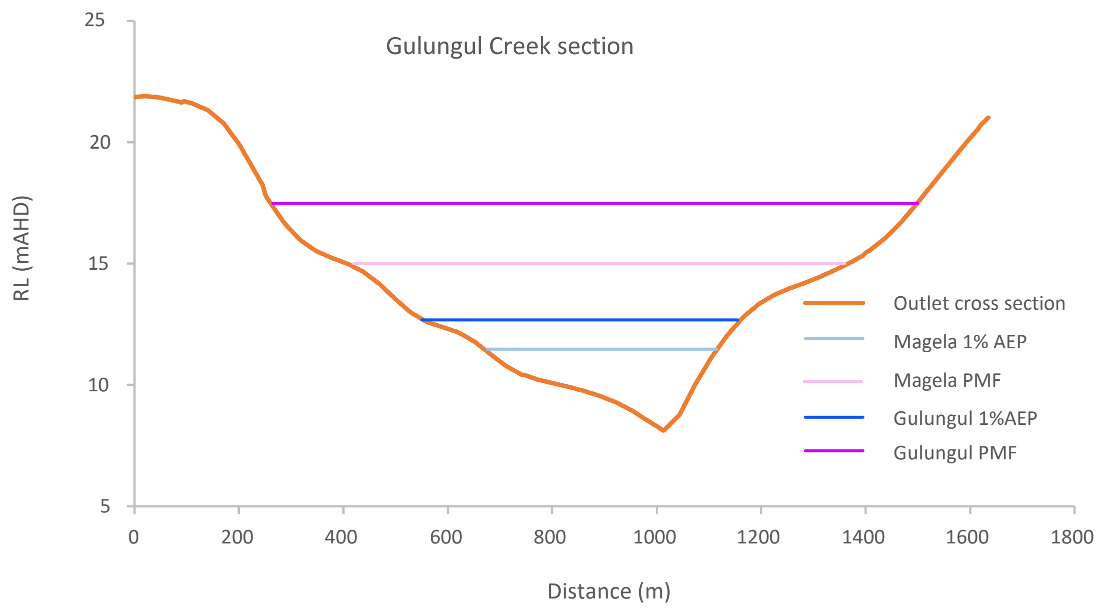

Figure D.4 Gulungul Creek section showing 1% AEP and PMF levels.

Notes

1. Flood inundation levels presented here are estimates derived using empirical methods.
2. The 1% AEP levels were derived using regional flood frequency estimation (RFFE) of peak discharges.
3. The probable maximum flood (PMF) levels were derived by extrapolation of the RFFE relationship to a 5000 y interval.
4. The levels represent the Magela Creek peak discharge and the Gulungul Creek peak discharge occurring at the confluence of their channels at the same time. However, the Magela Creek peak lags the Gulungul Creek peak by >3h.
5. The Magela Creek peak discharge is an order of magnitude greater than the Gulungul Creek peak discharge.
6. The Magela flows prevent Gulungul flows exiting to Magela Creek and a backflow billabong has formed.
7. The Magela flood inundates the lower reaches of Gulungul Creek and the Gulungul flood discharge is superimposed on the Magela levels.
8. The Baralil Creek section shows the PMF levels reaching the southeastern corner of Lot 2303. The PMF level in Baralil Creek is approximately 10m below the proposed power station site.
9. These estimates should not be considered a substitute for detailed probabalistic hydrologic modelling using methods such as Monte Carlo simulations and 2-dimensional hydraulic modelling in accordance with the Australin Rainfall and Runoff Guidelines 2019.

Legend

- Power Station and Access Road Location
- Lot 2303
- 1% AEP flood Level
- PMF flood level
- Baralil Ck catchment
- Gulungul Catchment
- Stream section

Data source:
Name
Esri Imagery
Source
crs=EPSG:3857&format&type=xyz&url=http://server.arcgisonline.com/arcgis/rest/services/World_Imagery/MapServer/tile/%7Bz%7D/%7By%7D/%7Bx%7D&zmax=22&zmin=0
Source
CRS
EPSG:3857 - WGS 84 / Pseudo-Mercator - Projected

Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Grid: Map Grid of Australia (MGA) zone 53

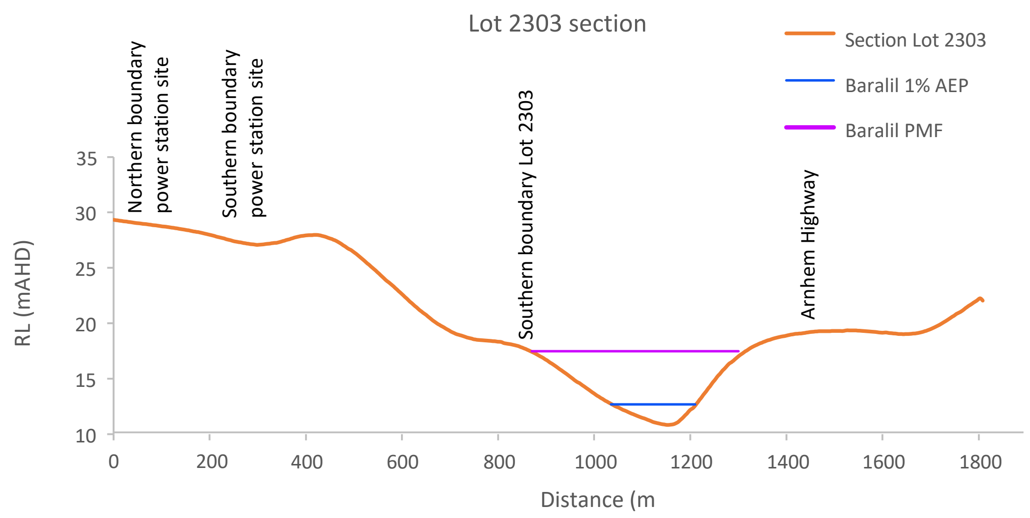

Figure D.5 Baralil Creek section showing 1% AEP and PMF levels.

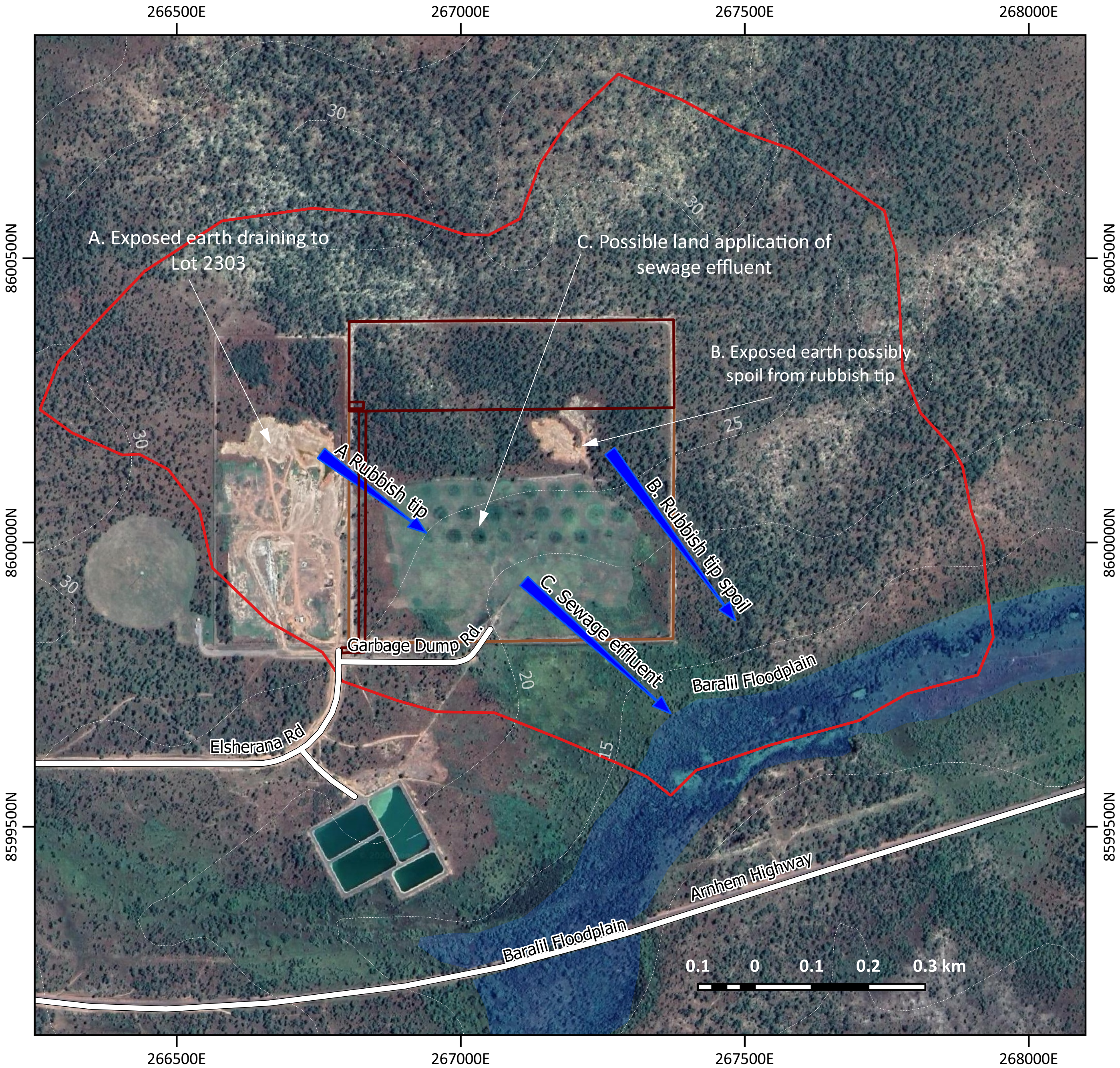

Figure E.1. Existing surface features that may become erosion hazard at the hybrid power station site.

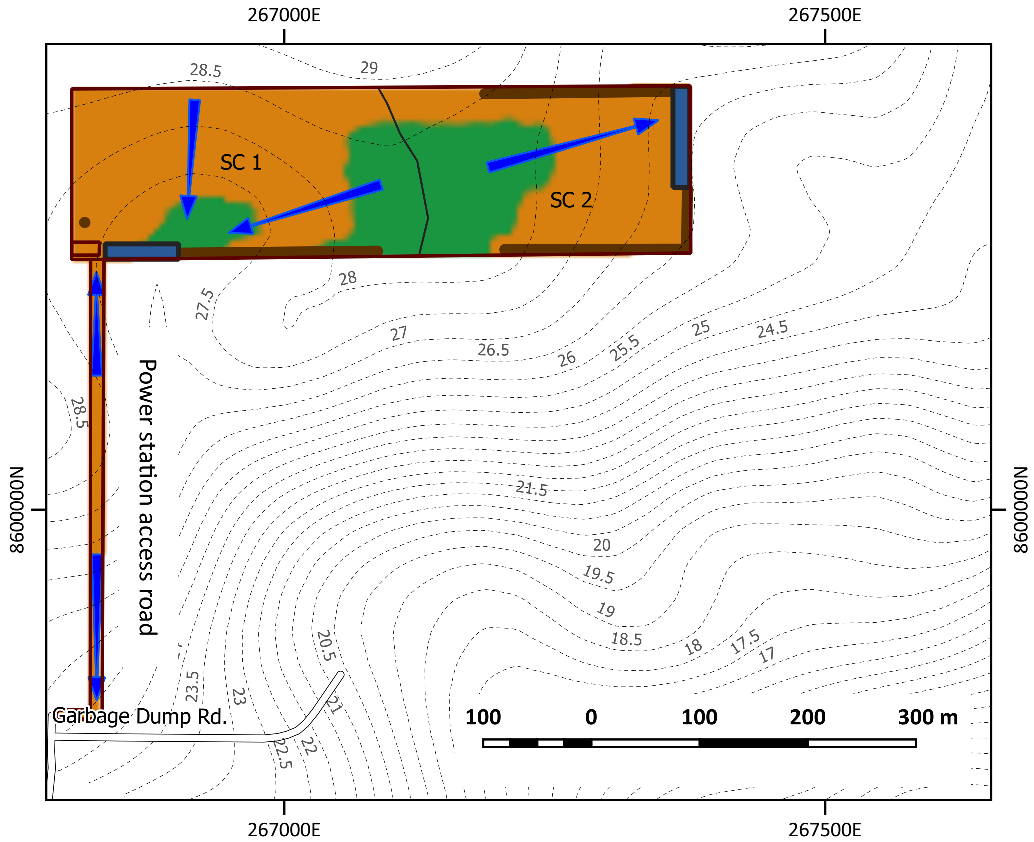

Figure E.2. Erosion risk class based on surface slope % distribution. Preliminary locations for erosion and sediment control plan diversion bunds and sediment retention basins are shown.

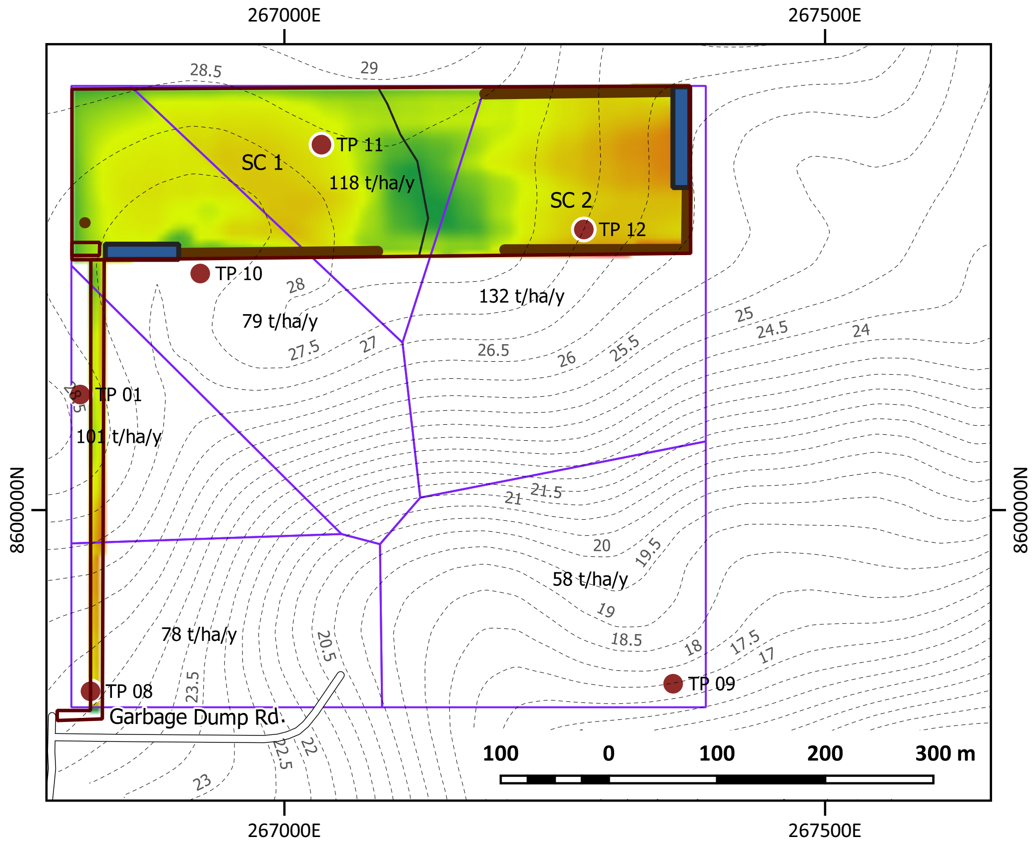

Figure E.3. Annual erosion rate distribution.

Legend

- Baralil_floodplain
- Gulungul floodplain
- Lot 2303 outline
- Power Station Location & access road
- Power station catchment
- Flow paths
- Diversion Bunds
- Sediment retention basin

Erosion risk class

- Class S2
- Class S3
- RUSLE sample locations
- Voroni polygons with Rainfall erosivity (R) x Erodibility (k) (t/ha/yr) derived from geotechnical data
- Site sub-catchments (SC1 & SC2)

RUSLE Soil Loss (t/ha/y)

- 0.06
- 10
- 16 approximate node
- 30
- 60
- 90

Projection: Universal Transverse Mercator
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
Grid: Map Grid of Australia (MGA) zone 53
Google Earth Image 23/04/2020 eye altitude 1.89km

SURFACE WATER & EROSION SOLUTIONS

Appendix E. Hybrid solar power station site existing conditions and erosion risk analysis.