4.2 LAND

4.2.1 Description of Environmental Values

4.2.1.1 Topography/Geomorphology

The topography of the site is undulating with a dominant ridgeline, the Knapdale Range, running through the central portion of the Project site in a north-south direction (Figure 4.6). The Knapdale Range extends as a 14 km long x 3 km wide elongate lensoid feature and rises to approximately 300 m above sea level and 100 m above the surrounding area. Immediately to the east of the Knapdale Range the topography forms gently sloping terrain which grades into the floodplain of the Dugald River. The Knapdale Range, which rises in steep, deeply dissected escarpments, forms the drainage divide between the Dugald River and Cabbage Tree Creek within the Project site.

Mount Rose Bee is the other major topographic feature in the vicinity of the Project site, approximately 2 km to the north-east of the Project boundary which rises to 285 m above sea level (Figure 4.6).

There are no major watercourses on the Project site however there are several minor, ephemeral tributaries which run through the Project site. Ephemeral watercourses on the eastern side of the Project drain in an easterly direction emptying into the Dugald River. On the western side of the Project, ephemeral creeks drain into Cabbage Tree Creek, which is a tributary of the Leichhardt River.

Waterways within the boundaries of the Project area are small creeks which exist as tributaries of the two fore mentioned larger waterways. The creeks are primarily small, narrow first order streams. The first order streams within the Project site are meandering single thread streams with one main channel. These streams within the Project site appear to have experienced a low level of disturbance as a result of grazing and exhibit good vegetation growth along the banks.

Overall, the condition of the streams within the Project site appears to be good with little evidence of mass sediment movement or erosion. In most cases, where erosion has occurred it appears to have been part of the natural erosion and deposition cycle of the system.

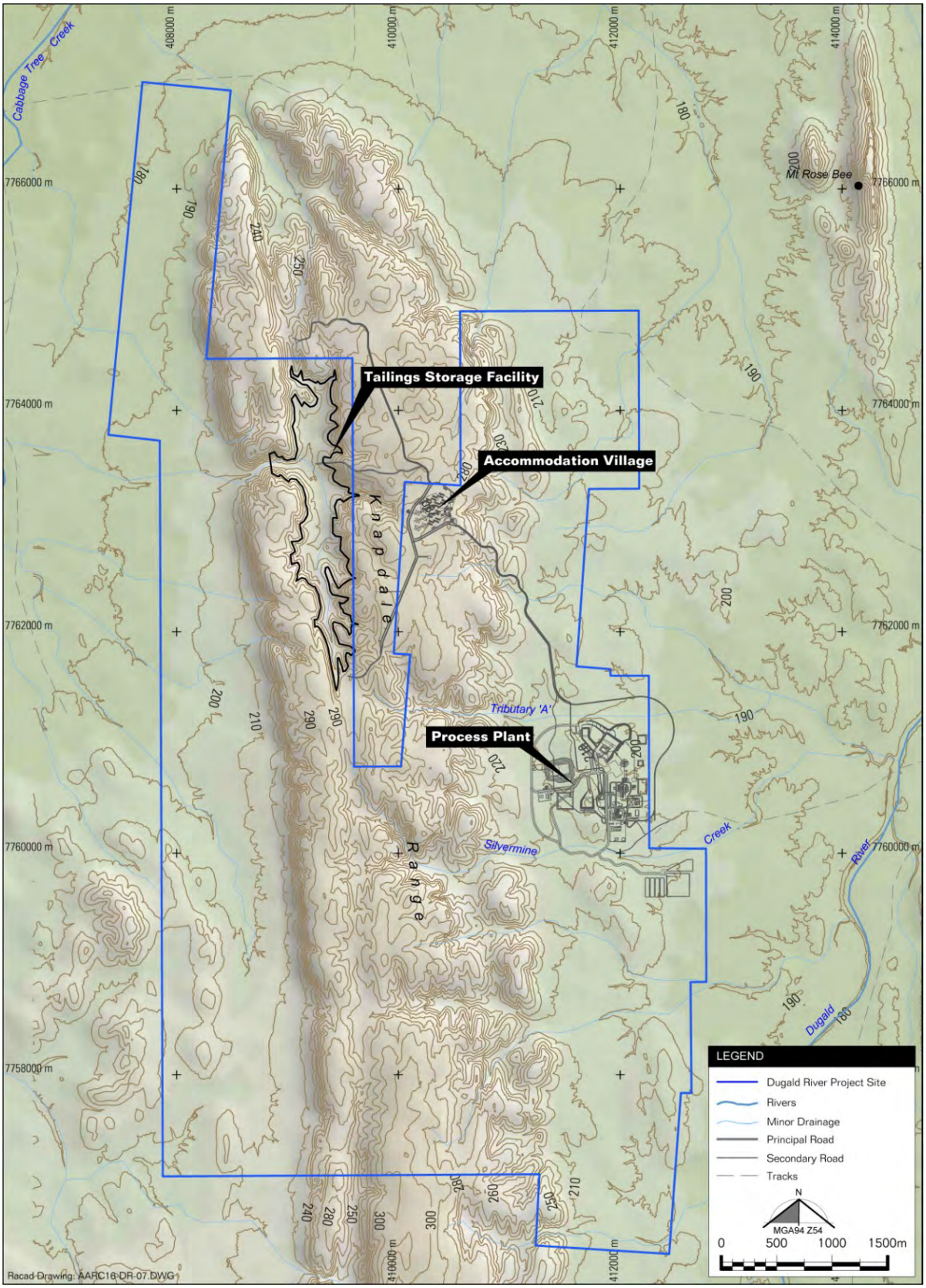


Figure 4.6 Project Site Topography

4.2.1.2 Geology

The Dugald River deposit was discovered before 1881 and is an example of a stra-bound base-metal deposit in a black shale environment. It forms part of a sedimentary basin within the Carpentarian Corella Formation (calc-silicate rocks).

The geology of the Dugald River area is complex due to multiple deformation events and extensive faulting which has resulted in considerable truncation of the rock units. The rock consist of dolomite, quartzite, granofels, amphibolite, siltstone and shale. Tertiary and Quaternary sediments of the Dugald River are described as sand, gravel, silt and clay.

Geological Overview

The Dugald River deposit is located within a 3-4 km wide north-south trending high strain domain named the Mt Roseby Corridor. The Mt Roseby Corridor is bordered to the west by the Knapdale Quartzite and the east by the Mt Rose Bee Fault. The Knapdale Quartzite forms a prominent range of hills within the local area.

The Mt Roseby corridor is comprised of the Mt Roseby Schist Formation that includes the local Hangingwall Calc-silicates, Dugald River Slate (DRS) and the Footwall Limestone shown in Figure 4.7 and 4.8.

The Mt Roseby Corridor was originally mapped as Corella Formation. Whithnal and Carson (2008) have recently revised this based on age and stratigraphic interpretation proposing the Mt Roseby Schist formation (1686±7 Ma). It is placed within the Mt Albert Group between the older Knapdale Quartzite (1728±5 Ma) and the younger Coocerina Formation that outcrop west of the Knapdale Range.

The Knapdale Quartzite dips steeply to the west and contains relict sedimentary structures that indicate overall younging to the west. The contact between the Knapdale Quartzite and the Mt Roseby Schist is interpreted as a low-angle thrust fault characterised by mylonitised quartzite. Younging indicators within the west dipping Mt Roseby Schist are rare, however it is interpreted that the Dugald River Slate and Footwall Limestone package form the overturned limb of the isoclinal Dugald River synform.

The Knapdale-Coocerina-Lady Clare Dolomite sequence located on the western edge of the Knapdale Range shows structurally reactivated but conformable contacts. The sequence youngs to the west and becomes finer-grained and more calcareous from the Knapdale Quartzite to Coocerina to Lady Clayre Dolomite.

The DRS hosts the Dugald Lode. The DRS are metasomatised calcareous to carbonaceous slates similar to the Footwall Limestone and interpreted as part of the Lady Clayre Dolomite package. The Dugald Lode and alteration halo are sub-parallel to the DRS. Figure 4.8 shows the location of the Project infrastructure in relation to the local outcrop geology.

Lithological codes used to subdivide the Dugald River sequence are based on the primary mineralogy and/or distinguishing features, which are most often a product of alteration. These are described in Figure 4.9. Figure 4.10 is a typical cross section of the Dugald River sequence.

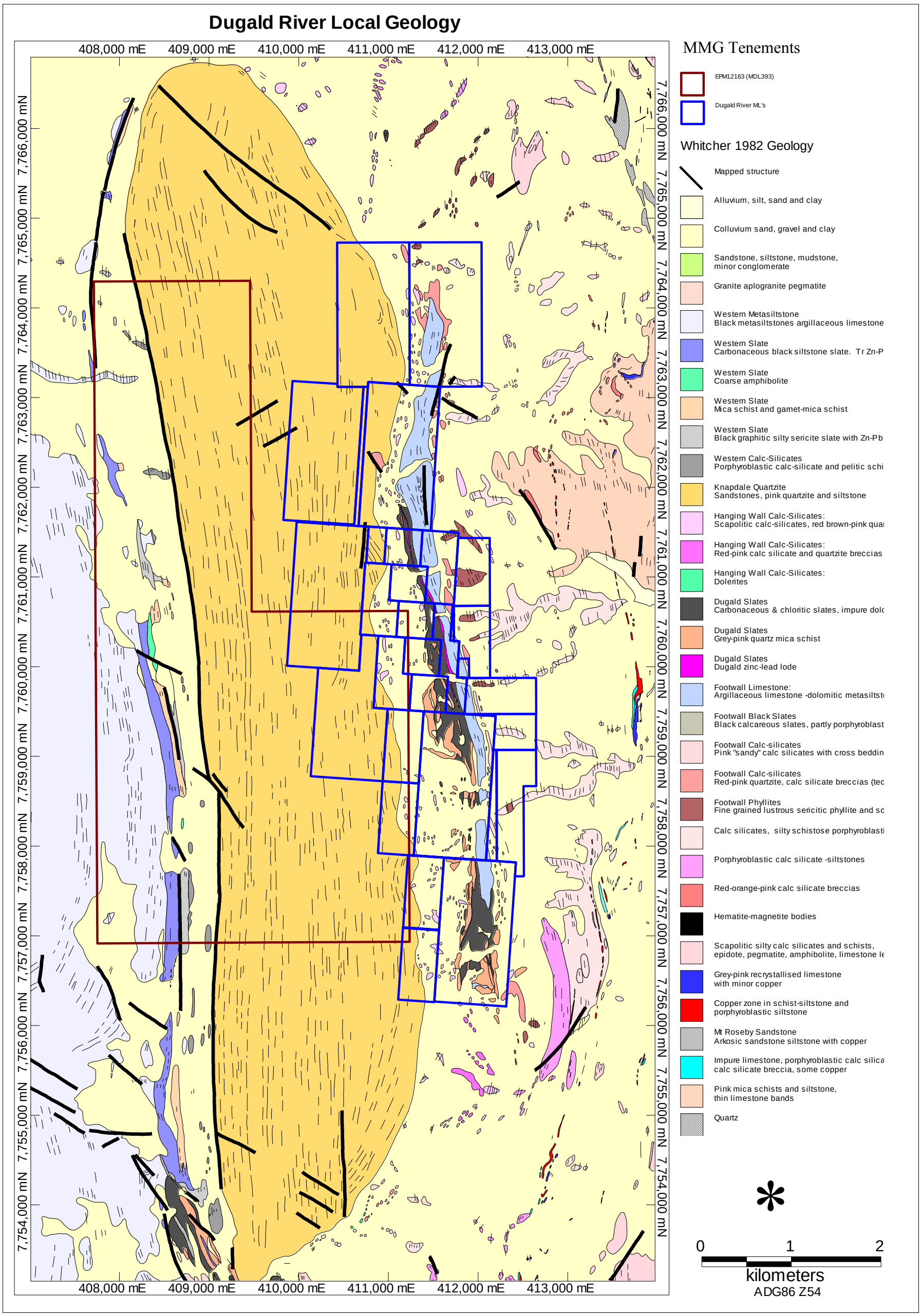


Figure 4.7 Local Outcrop Geology and MMG Lease Boundaries (Whitcher 1982)

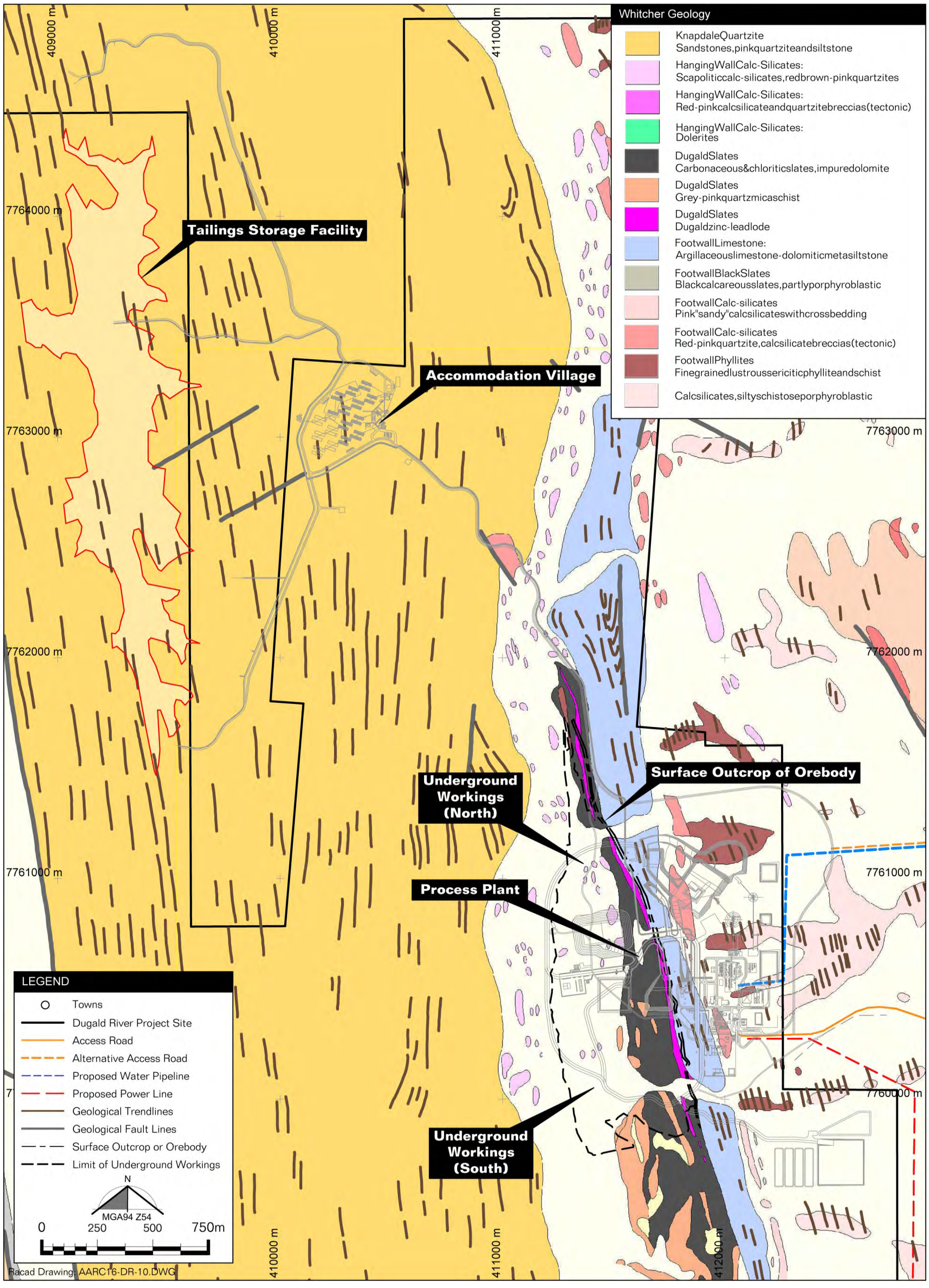


Figure 4.8 Local Outcrop Geology and Project Infrastructure Layout (Whitcher 1982)

GROUP	WESTERN SEQUENCE	DUGALD RIVER SEQUENCE	CODE	LITHOLOGY	MINERALOGY	TEXTURE	ALTERATION MINERALS	PRE-CURSOR LITHOTYPE	CODE
MT ALBERT GROUP	LADY CLAYRE DOLOMITE	FOOTWALL LIMESTONE	LMST	Limestone	Quartz, muscovite, dolomite, pyrite, pyrrhotite, calcite, biotite, phlogophite	Well bedded, spotted, occasional sedimentary structures, minor shears	Pyrite, pyrrhotite, carbonate, silica	Interbedded carbonaceous/ dolomitic calcite argillite, fine sandstone/ siltstone	ALTN or BXZN
		DUGALD LODE	BSCB	Carbonate banded spotted slate	Quartz, biotite, muscovite, K-feldspar, scapolite, garnet, calcite	Spotted carbonate bands, calcite healed with a high strain fabric	Silica, sericite, carbonate, pyrite, chlorite, garnet	Calcareous dolomitic siltstone	
		HANGING WALL SHEAR ZONE	BSMS	Massive black slate	Quartz, feldspar, muscovite, scapolite, calcite, pyrite, biotite	Finely laminated to massive, localized shearing	Silica, carbonate, pyrite, chlorite, de-calcification, epidote-talc-sericite	Carbonaceous dolomitic siltstone	
		DUGALD RIVER SLATES	BSGB	Grey and black banded slate	Quartz, biotite, muscovite, feldspar, calcite, carbonate	Strongly banded and laminated, bands of scapolite / biotite porphyryblasts	Scapolite, biotite, chlorite, sericite, silica, de-calcification, sodic	Carbonaceous dolomitic siltstone	
		QFPD: Quartz feldspar porphyry: massive quartz-feldspar groundmass, feldspar phenocrysts, epidote-sericite alteration, Cp-Py-Po	BSPH	Phyllitic siltstone	Quartz, muscovite, biotite, calcite	Thinly bedded to laminated, minor shears	Sericite, silica	Carbonaceous dolomitic siltstone	
		MFPD: Mafic porphyry: biotite quartz, plagioclase, amphibole, chlorite, albite phenocrysts, Cp, Bn, chalcocite, schistose and porphyritic, biotitic shears, hematite-silica-carbonate alteration	MCSH	Porphyro-blastic muscovite schist	Muscovite, sericite, quartz, biotite, garnet, kyanite, staurolite, sillaminate	Schistose, relict bedding, lamination, crenulations, porphyroblastic	Sericite, silica, weak hematite	Fine sandstone/ siltstone	
		BSUN - Undifferentiated black slate							
	COOCERINA FORMATION	HANGINGWALL CALC-SILICATES	MBSH	Biotite Epidote schist	Biotite, epidote, quartz, scapolite, feldspar, calcite, tourmaline, hematite	Strongly schistose, banded, sheared, strongly veined	Weak hematite, carbonate, epidote	Calc-argillite, fine sandstone	
			CSBD	Biotite Scapolite schist	Biotite, quartz, scapoltite, muscovite, calcite, plagioclase, epidote, clay	Schistose, banded, shear mélange leuco zones, disharmonic folding	Weak silica, hematite, carbonate, scapolite, chlorite, epidote	Calc-argillite, fine sandstone	
			CSBI	Biotite schist and un-differentiated schist	Biotite, quartz, muscovite, calcite, plagioclase, epidote, scapolite, clay	Schistose, banded,	Silica, hematite, carbonate, chlorite, epidote	Calc-argillite, fine sandstone	
			CSSL	Silicified hematitic calc-silicate	Quartz, biotite, actinolite, epidote, hematite, calcite	Relict schistose, granular, micro-crystalline	Silica, hematite	Calc-argillite, fine sandstone	
			CSMS	Brecciated calc-silicate	Quartz, muscovite, calcite, plagioclase, scapolite,, hematite, garnet	Massive, dense stockwork veining, breccia pervasive iron oxide staining	Silica, hematite, actinolite, carbonate	Calc-argillite, fine sandstone	
		CSUN - Undifferentiated calc-silicate							
	KNAPDALE QUARTZITE		QTZT	Quartzite: arenitic to arkosic quartzite, and schist	Quartz, muscovite, calcite, plagioclase, scapolite, magnetite	Well to poorly bedded, ripple cross-laminated, desiccation cracks, graded beds, no cleavage	Silica, hematite	Orthoquartzite to arkosic sandstone, interbedded siltstone,	

PROPOSED MT ROSEBY SCHIST ((I. WITHNELL ET AL, 2008) (FORMERLY CORELLA FM)

Figure 4.9 Dugald River Host Rock Represented in Stratigraphic Order

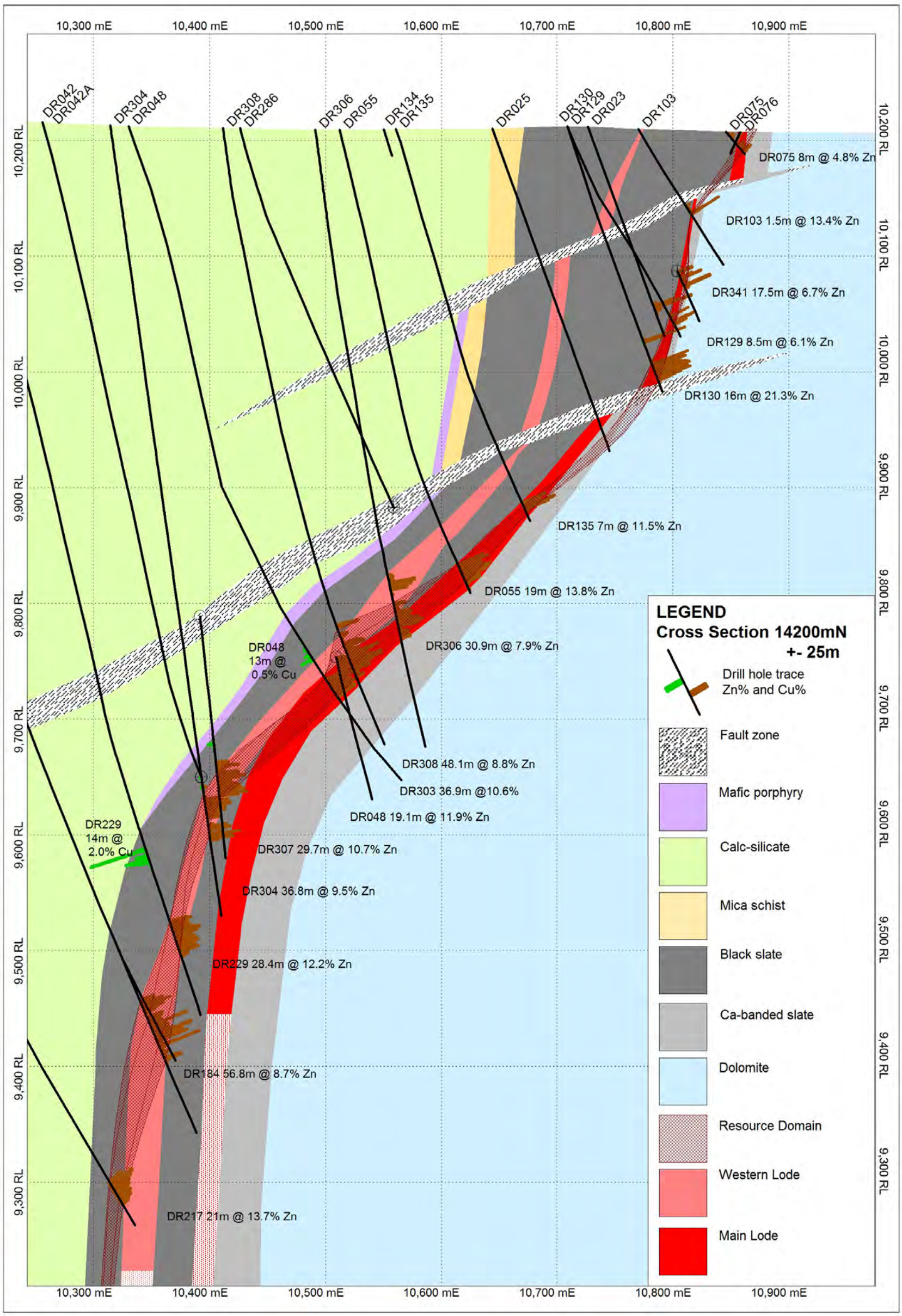


Figure 4.10 Cross Section through the Dugald River Sequence at 14200mN

Seismicity and Stability

A seismic analysis was carried out to review the stability of the main embankment of the TSF. For the purposes of the seismic analysis of the TSF Main Embankment, a deterministic, prescribed approach to design was adopted, which is the method recognised as the most widely used to date.

As part of this work, a probabilistic seismic hazard assessment of the region was conducted by the Seismology Research Centre (SRC) in Australia. The assessment identified faults and added them to the seismotectonic model. The SRC review presented an AEP versus ground motion relationship determined for the seismotechnic province in which Dugald River is located.

The SRC review presented an AEP versus ground motion relationship determined for the seismotechnic province in which Dugald River is located.

The ground motion relationship is described by two levels of earthquake motion, as defined in the Australian National Committee on Large Dams (ANCOLD) dam design guidelines.

- Operating Basis Earthquake (OBE): the OBE is for the purposes of evaluating the serviceability of a dam, rather than its safety. It is an earthquake which could reasonably be expected to occur during the life of the dam, and should only result in minor, easily repairable damage.

  The ANCOLD guidelines description of the OBE reports deterministically derived earthquakes with a typical AEP range of 1 in 200 to 1 in 1,000 years. For Dugald River, the OBE acceleration coefficient is based upon a 10 percent chance of exceedance in 50 years, which is roughly equivalent to an AEP of 1 in 500 years.

- Maximum Design Earthquake (MDE): the MDE will produce the maximum level of ground motion for which a dam should be designed or analysed. It is a minimum requirement that the impounding capacity of the dam be maintained when subjected to that seismic load.

  The ANCOLD guidelines summarise MDE deterministic, prescribed design methods used by various international dam authorities. From this summary, accepted practice for High Hazard dams is typically to adopt a probabilistic AEP of 1 in 10,000 years.

From the SRC review, the horizontal peak ground acceleration (PGA) for both the OBE and MDE events are as presented in Table 4.1, where ‘g’ refers to the acceleration due to gravity.

Table 4.1 Summary of Design Criteria

Design Event	OBE	MDE
Average Recurrence Interval	1 in 500 yrs	1 in 10,000 yrs
Peak Ground Acceleration	0.042 g	0.24 g

These results indicate that the Project is located in an area of low seismic risk.

The shallow depth of weathering, relatively flat topography and low occurrence of clays in the near-surface materials indicate that stability issues associated with construction or landslides should not be expected.

Geology and Health

The health implications created by the geology of the Project area particularly relate to high metal content, both naturally occurring and through the concentration of the minerals during the Project's operation.

The most significant metal is lead which can cause serious health issues for the Project workforce, environment and the community in general. A number of strategies will be put in place to manage lead bearing ores and mineral concentrates, particularly dust. The potential impacts of lead on human health are further discussed in Section 4.10.2.1.

Archaeological Significance

Whilst the original geological history of the area is sedimentary, the nature of the geology and the high levels of metamorphism which have occurred over time mean that the likelihood of the area containing fossils of archaeological significance is very low.

4.2.1.3 Mineral Resources

The zinc/lead/silver resource estimate defined for the Project totals 53.0 Mt (as of July 2009) at a cut off grade of 6 % zinc. The average zinc grade of the ore is 12.5%, lead is 1.9 % and silver is 36 ppm. The copper resource defined for the Project totals 3.4 Mt (as of June 2010) at a cut off grade of 1 % copper. The average copper grade is 1.8%, gold is 0.3 ppm, cobalt is 105 ppm and molybdenum is 60 ppm. Installation of the copper processing circuit will be subject to the successful proving up of sufficient resources from currently identified areas of copper mineralisation. Additional feed may also be sourced by toll treatment of third party ores.

Figure 4.11 is a plan of the Project showing the surface extent of the known resource (red), planned underground workings (blue) and surface facilities.

From the surface expression indicated, the orebody dips down to the west (to the right of the plan) at 60-65 degrees. The underground workings shown indicate where known economic mineralisation exists, which is entirely contained within the MLs already granted to MMG.

The mine design incorporates the use of paste fill which will allow as close to full recovery of the resource as practicable.

None of the known zinc and lead resources will be sterilised by any planned infrastructure. A sterilisation drilling programme has been conducted beneath the main process plant site.

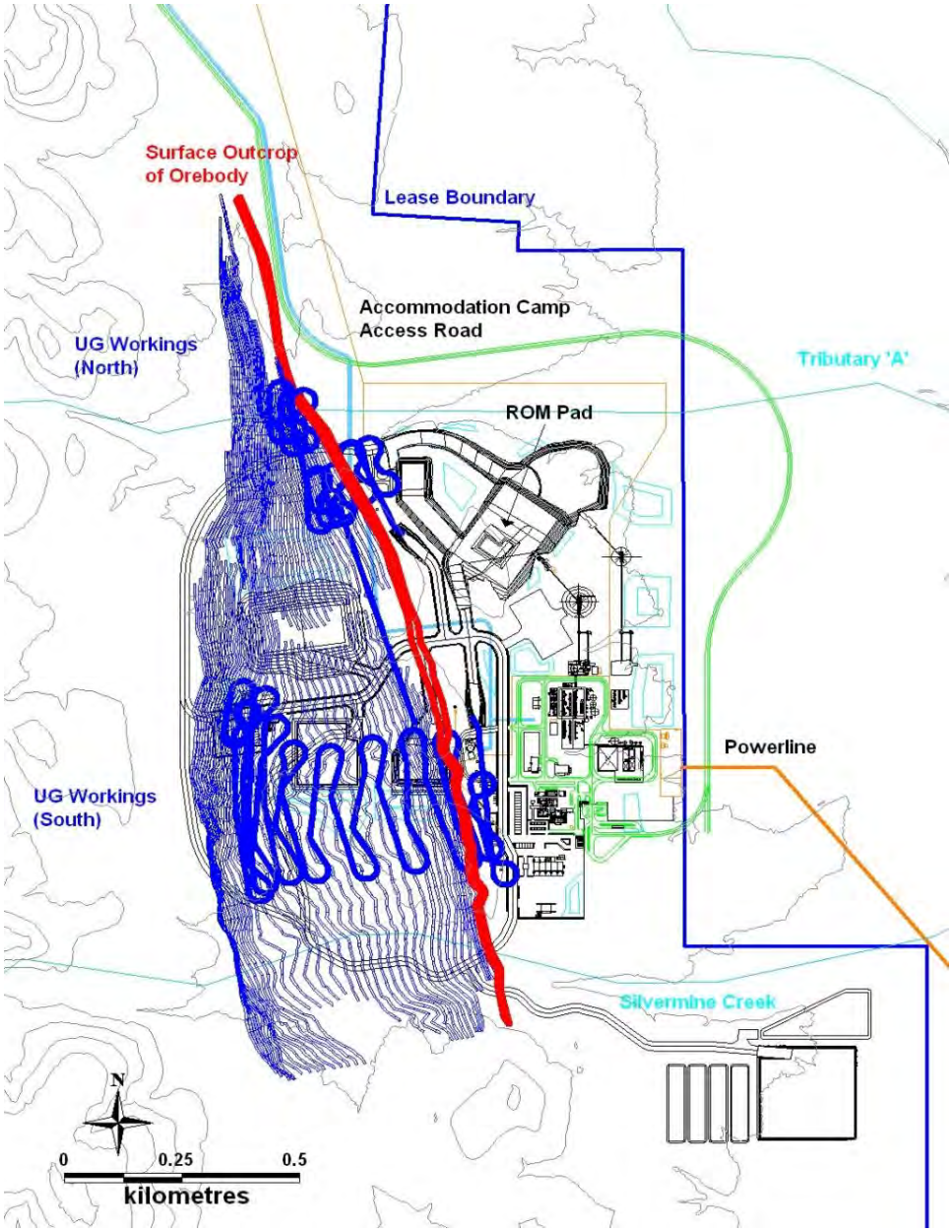


Figure 4.11 Plan of Surface and Underground Facilities and Surface Outcrop of Ore Body

Two dominant and six minor ore types have been recognised. Oxidation is reported to be complete to 12 m. The primary sulphides are pyrhotite, pyrite, sphalerite, and galena, while at least four offshoots are thought to stem from the main lode. Sulphides are often seen as recrystallised bands and veins.

Sporadic copper mineralisation is observed and occurs as chalcopyrite mineralisation at the schist/calc-silicate - slate contact in the hanging wall of the Dugald zinc/lead/silver lode. Copper is also observed with mafic-intermediate porphyry dykes.

4.2.1.4 Resource Utilisation

The mine design incorporates the use of paste fill which will allow as close to full recovery of the known zinc-lead resource as practicable. None of these resources will be sterilised by any planned infrastructure the use of paste fill will minimise the amount of ore sterilised in mining pillars.

Since the region is highly prospective for additional mineralisation which is yet to be identified, a sterilisation drilling programme was conducted beneath the main process plant site. The results of this drilling did not return any results indicating economic near the surface that would be not be able to be extracted after construction.

The Project also possesses a number of points which will promote the development of potential mineral resources which may be identified in the future. These are:

- In addition to the zinc and lead processing circuit, the Project plans to construct a copper circuit once sufficient resources are identified.

- Underground mining will produce less waste, resulting in a smaller area covered by waste rock dumps which often sterilise unidentified mineralization, or increase the future cost of extracting those minerals.

- Selection of 220 kV as the powerline distribution voltage means that, with only Dugald River using the line, there is additional capacity to economically transmit power to other potential users in the area.

4.2.1.5 Soils

AARC has undertaken a Soil and Land Suitability Assessment of the Project site which is contained in Appendix M. The following information summarises the main finding in regards to the soils on the Project site from that report.

The soil sampling methodology used for the assessment was taken from the *Australian Soil and Land Survey Field Handbook* (McDonald *et al* 1990) and modified as appropriate to the Project site. Soils were assessed at a total of 72 locations within the Project boundary. Sampling locations were selected to provide a broad coverage of the Project site, in addition to targeting those areas where mining infrastructure is proposed. The expanse of the Knapdale Ranges running north-south through the middle section of the Project site was a significant obstacle to field sampling. However, several representative samples were taken from the Knapdale Ranges, and together with topography and an aerial photograph used to extrapolate soils across the rest of the range.

At each sampling site, a mechanical hand auger or a pelican pick was used to excavate a hole through the topsoil. A 500 g sample of soil was taken at three depths (where possible) throughout the profile, these being:

- 0 - 10 centimetres (cm);

- 10 - 20 cm; and

- 40 - 50 cm.

The desired depth of 50 cm was reached at very few sampling sites, with the soils generally being rocky and skeletal and difficult to get deeper than 20 cm. At the completion of the field survey, the soil samples were sent to SGS Laboratory in Toowoomba, which is a National Association of Testing Authorities registered laboratory for chemical and physical analysis.

Soil classification was undertaken using the methodology specified in the *The Australian Soil Classification* (Isbell, 1996). Based on field and laboratory assessment, six soil types were observed

to occur. These have been described and mapped as six soil mapping units which are described in Table 4.2 and Figure 4.12.

Table 4.2 Soil Management Unit Descriptions

Soil Type	Brief Description
Soil Type 1: Red Plain Soil Management Unit	Red Sandy Loam to Sandy Clay Loam (red/yellowish red/brownish red) with neutral to slightly acid pH. Structure is typically weak to moderate with mostly no definition between the A and B horizons. This soil type is non-saline and non-sodic. This soil type was found up to a depth of 50 cm. This soil type covers approximately 1,327 ha of the Project Site. The current land use over this soil type is very low intensity cattle grazing. The dominant vegetation community growing on this soil type is Cloncurry Box and Snappy Gum Open Woodland. This soil type is found on the flatter plain areas of the Project site and has slightly higher grazing pressure on it than the rest of the site. This soil is defined as a Rudosol within the *Australian Soil Classification* system (Isbell et al, 1996).
Soil Type 2: Knapdale Soil Management Unit	Brown Skeletal Sandy Clay Loam (strong brown/dark brown) neutral to slightly acid pH. Structure is typically weak with no clear definition between A and B Horizons. This soil type is neutral to slightly acidic and increases in clay content the lesser the slope. This soil type has low salinity and is non-sodic. The soil is very skeletal and rocky and was not found deeper than 20 cm in depth. This soil type covers approximately 1,623 ha of the Project site. This soil type is mostly found on the eastern and western slopes of the Knapdale Range (at slopes of 30- 40°) and is dominated by Snappy Gum Open Woodland and Spinifex grass. The current land use over this soil type is native habitat, as the slopes are not suitable for cattle grazing. This soil is defined as a Rudosol within the *Australian Soil Classification* system (Isbell et al, 1996).
Soil Type 3: Dale Soil Management Unit	Brown Sandy Loam (reddish brown/yellowish brown) slightly acid pH increasing in pH with depth. Weak to moderate structure. This soil type was found up to a depth of 50 – 70 cm. This soil type is non-saline and not sodic. This soil type covers approximately 38 ha of the Project site. This soil type is found within the Knapdale Ranges typically located in depressions such as valley floors or plateaus. The dominant vegetation community on this soil type is Snappy Gum Open Woodland. This soil type is classified as a Rudosol.
Soil Type 4: Miners Soil Management Unit	Lode Outcrop Sandy Clay Loam (dark yellowish brown) slightly alkaline with weak structure. This soil type was not found anywhere at a depth of more than 20 cm. This soil type is alkaline and has high levels of lead and zinc. This soil is non-saline and is non-sodic. This soil type covers approximately 166 ha of the Project site. This soil type is found on and immediately surrounding the outcropping black slates associated with the Dugald River deposit lode on the eastern side of the Knapdale Range. The current land use over this area is native habitat and in some flatter areas low intensity cattle grazing. The dominant plant species growing on this soil type is Cloncurry Box Open Woodland. The topography over this area is generally moderate relief of 10-20°. This soil type is classified as a Rudosol.
Soil Type 5: Prospectors Soil	Western Knapdale Clay Loam (dark yellowish brown) slightly acid with weak structure. This soil type is very similar in appearance to the Miners Soil Management Unit, however it is slightly acidic. This soil is non-saline and non-

Soil Type	Brief Description
Management Unit	sodic The soil is skeletal and was not found at any greater depth than 20 cm. This soil type covers approximately 165 ha of the Dugald River Project site. The current land use over the area is native habitat and low intensity cattle grazing. This soil type is found on the toe slope of the western side of the Knapdale Range. The dominant vegetation community on this soil type is Snappy Gum Open Woodland. The topography is typically sloped and rocky. This soil type is classified as a Rudosol.
Soil Type 6: Pocket Soil Management Unit	Grey Clay Loam (pale brown/light brownish grey/yellowish grey) alkaline, weak structure with no definition between A and B profiles. This soil type is high in calcium carbonate and non-saline and non-sodic. The soil is skeletal and was not found at any greater depth than 20 cm. This soil type covers approximately 48 ha of the Project Site. The current land use over the area is low intensity cattle grazing. This soil type occurs in small pockets on the eastern and northern side of the Knapdale Range. The dominant vegetation communities are a mixture of Snappy Gum Open Woodland and Cloncurry Box Open Woodland. This soil type typically occurs in areas of low relief with slopes tending to be less than 5°. This soil type is classified as a Calcarosol.

A discussion of the background levels of metals in each soil type is provided in Section 4.2.2.3. The erosion potential of the soils on the Project site and management of soil erosion are discussed in Section 4.2.2.4.

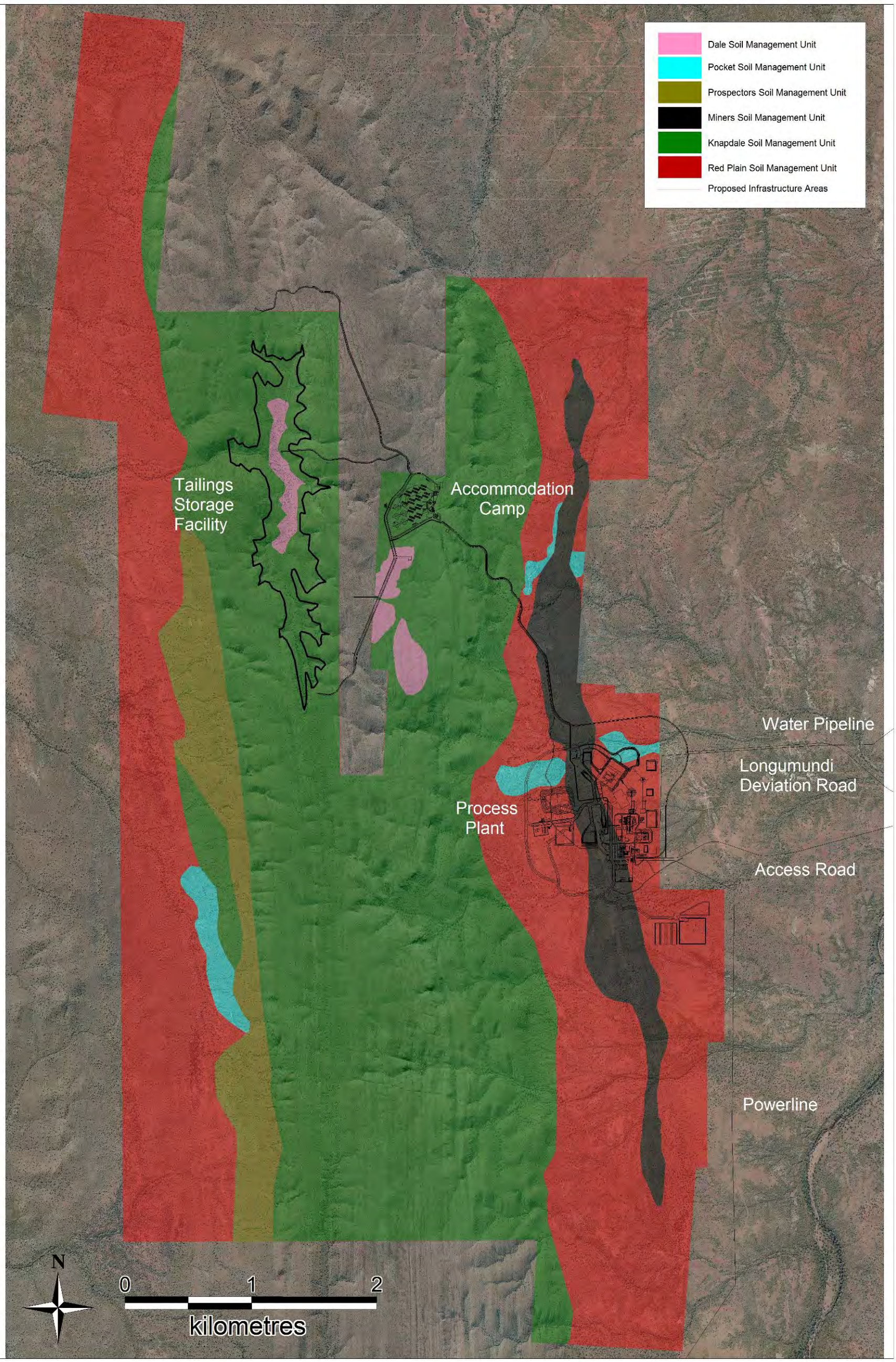


Figure 4.12 Locations of Soil Types Across Project Site

4.2.1.6 Land Use and Suitability

The current land use of the Project site is low intensity cattle grazing, mineral exploration and native habitat. Current land tenures and Native Title is discussed in Section 4.2.1.7.

As mentioned in Section 4.2.1.5, AARC has undertaken a Soil and Land Suitability Assessment of the Project site and this report is contained in Appendix M. The following information summarises the main finding in regards to land use and land suitability on the Project site from that report.

The Land Suitability Assessment aimed to evaluate the land suitability of the Project site for a variety of uses prior to mining. This was evaluated using the *Planning Guideline - The Identification of Good Quality Agricultural Land* (Department of Infrastructure and Planning (DIP), 1993) and the DME's *Land Suitability Assessment Techniques Guideline* (DME, 1995).

The soil management units were classified into land classes according to *Planning Guideline -The Identification of Good Quality Agricultural Land* published by DIP 1993. Agricultural land classes are described in Table 4.3 below.

Table 4.3 Agricultural Land Class Descriptions (DIP 1993)

Class	Description
Class A	**Crop Land –** Land that is suitable for current and potential crops with limitations to production which range from non to moderate levels.
Class B	**Limited Crop Land –** Land that is marginal for current and potential crops due to severe limitations and suitable for pastures. Engineering and/or agronomic improvements may be required before the land is considered for cropping.
Class C	**Pasture Land –** Land that is suitable only for improved or native pastures due to limitations which preclude continuous cultivation for crop production; but some areas may tolerate short period of ground disturbance for pasture establishment.
Class D	**Non-Agricultural Land –** Land not suitable for agricultural uses due to extreme limitations. This may be undisturbed land with significant habitat, conservation and/or catchment values or land that may be unsuitable because of very steep slopes, shallow soils, rock outcrops and poor drainage.

Table 4.4 details the agricultural land class of each soil management unit based on the descriptions provided in Table 4.3. No soil management unit on the site was found to be good quality agricultural land due to limiting factors, such as no available water, low nutrient levels, shallow soils, steep slopes and rocky outcrops. Review of the Soil and Land Suitability Assessment for the adjacent Roseby Copper Project found that no good quality agricultural land exists adjoining the Roseby Copper Project either. Therefore *State Planning Policy 1/92: Development and the Conservation of Agricultural Land* does not apply to the Dugald River Project Site.

Table 4.4 Assessment of Project Site Against Agricultural Land Classes (DIP, 1993)

Soil Management Unit	Limiting features	Agricultural Land Class
Soil Type 1 – Red Plain	No available water, relatively shallow soil, low nutrient levels.	D
Soil Type 2 – Knapdale	No available water, shallow rocky soil, low nutrient levels and steep slopes.	D
Soil Type 3 – Dale	This soil type may be suitable as pasture land as it is found up to 50-70 cm however it still has low nutrient levels and it is very inaccessible as it is surrounded by steep slopes.	D
Soil Type 4 - Miners	Shallow and rocky, high levels of lead, rocky outcrops, no available water and low nutrients	D
Soil Type 5 - Prospectors	No available water, shallow soil, low nutrient levels.	D
Soil Type 6 - Pocket	No available water, relatively shallow soil, low nutrient levels, slightly alkaline.	D

An interpretation of the data collected on the physical, chemical and nutritional characteristics of the soil was made to rank the land according to a five-class system in the DME Guideline *Land Suitability Assessment Techniques* (1995) that applies to grazing, rainfed cropping and conservation.

The classes are described as:

Class 1 Suitable land with negligible limitations which is highly productive requiring only simple management practises to maintain economic production.

Class 2 Suitable land with minor limitations which either reduce production or require more than the simple management practices of Class 1 land to maintain economic production.

Class 3 Suitable land with moderate limitations which either further lower production or require more than those management practices of Class 2 land to maintain economic production.

Class 4 Marginal land with severe limitations which make it doubtful whether the inputs required to achieve and maintain production outweigh the benefits in the long term (presently considered unsuitable due to the uncertainty of the land to achieve sustained economic production).

Class 5 Unsuitable land with extreme limitations that preclude its use for the proposed purpose.

The following conclusions were made based on the results of the land suitability assessment against the *Land Suitability Assessment Techniques Guideline* (DME 1995):

- Three soil units Red Plain, Dale and Pocket, were found to have severe limitations for use as beef cattle grazing areas (Class 4). The main limitations were the PAWC and low nutrient levels. These soil types would require significant inputs to be productive and support pasture growth for cattle grazing. The input required would probably outweigh the benefit. It is noted that some of the Red Plain Soil Management Unit is currently used for very low intensity grazing, however the stocking rate of cattle decreases the closer the proximity to the Knapdale Ranges;

- The remaining three soil units Knapdale, Miners and Prospectors, were found to have extreme limitations (Class 5) which preclude cattle grazing as a suitable land use on these soil management units. Again the main limitation of the soil is the PAWC, however more practically, these areas could not be used for cattle grazing as they are extremely rocky and steep and do not support suitable pastures due to a lack of nutrients;

- All soil management units have been found to have extreme limitations precluding rainfed broadacre cropping as a suitable land use for the Project site (Class 5). The obvious limitations are slopes, rockiness, topography and the limited PAWC; and

- The suitability class for conservation on the Project site is Class 4. The lands contain some conservations values pre-mining, however nothing of significance that is not common in the wider area. Some areas on the Project site are disturbed from cattle grazing and exploration works that have already taken place, significant restoration of these areas would be required which is not feasible. The site is neither rare nor unique and would not warrant conservation as a primary land use.

The pre-mining land use suitability for six soil types is summarised in Table 4.5 and Figure 4.13, Figure 4.14 and Figure 4.15.

Table 4.5 Pre-Mining Land Use Suitability

Soil Type	Beef Cattle Grazing	Broadacre Cropping	Conservation	Limitations	Area
1: Red Plain	4	5	4	Severe to Extreme Limitations in PAWC. Extreme Limitation in Slope, Topography, Rockiness.	1,327ha
2: Knapdale	5	5	4	Extreme Limitation in Slope, Rockiness, PAWC and Topography.	1,623ha
3: Dale	4	5	4	Severe to Extreme Limitation in PAWC and access.	38ha
4: Miners	5	5	4	Extreme Limitation in Rockiness, and PAWC.	166ha
5: Prospectors	5	5	4	Extreme Limitation in Rockiness, and PAWC.	165ha
6: Pocket	4	5	4	Extreme Limitation in Rockiness, and PAWC.	48ha

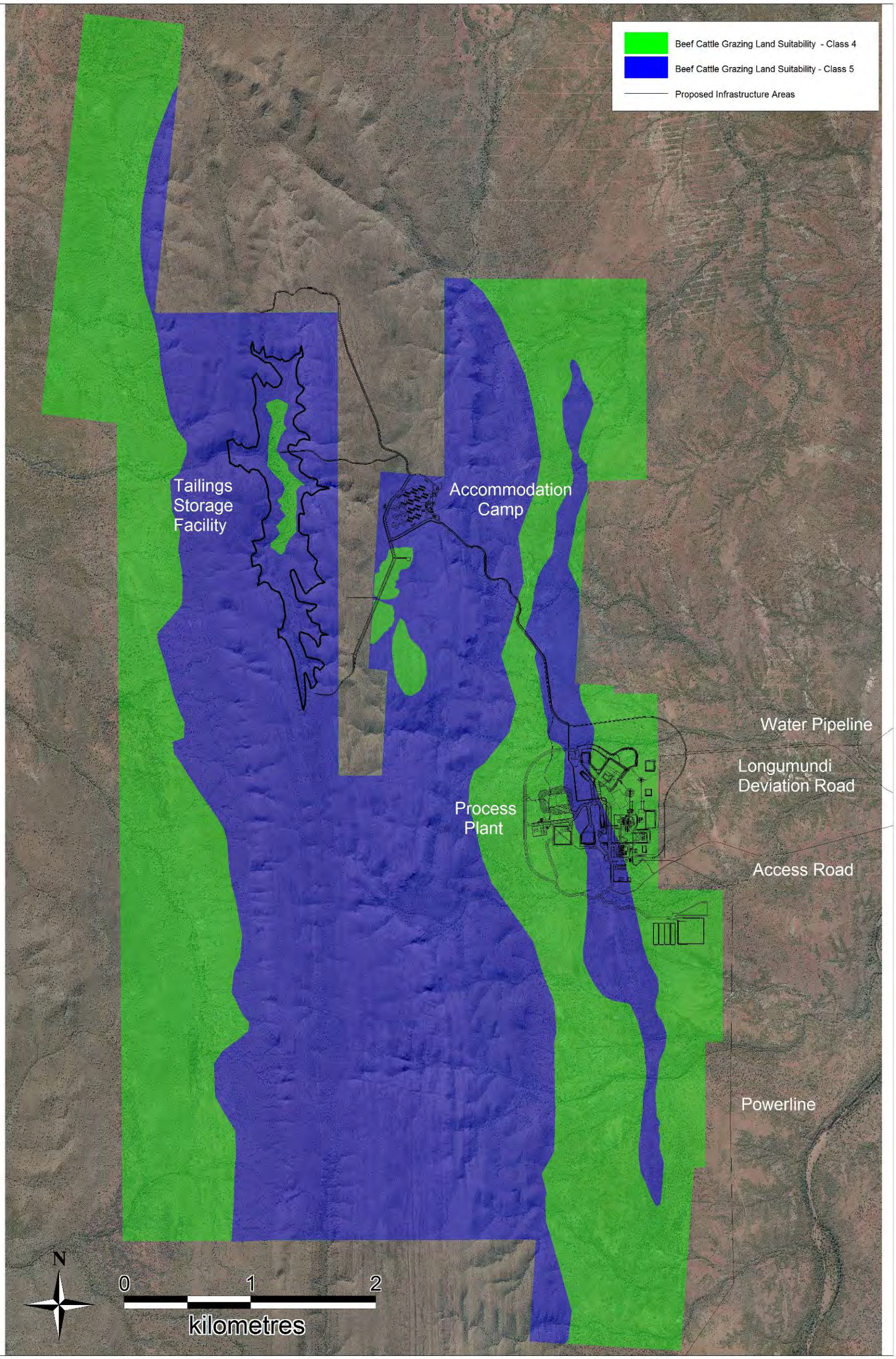


Figure 4.13 Land Suitability Class Map for Beef Cattle Grazing

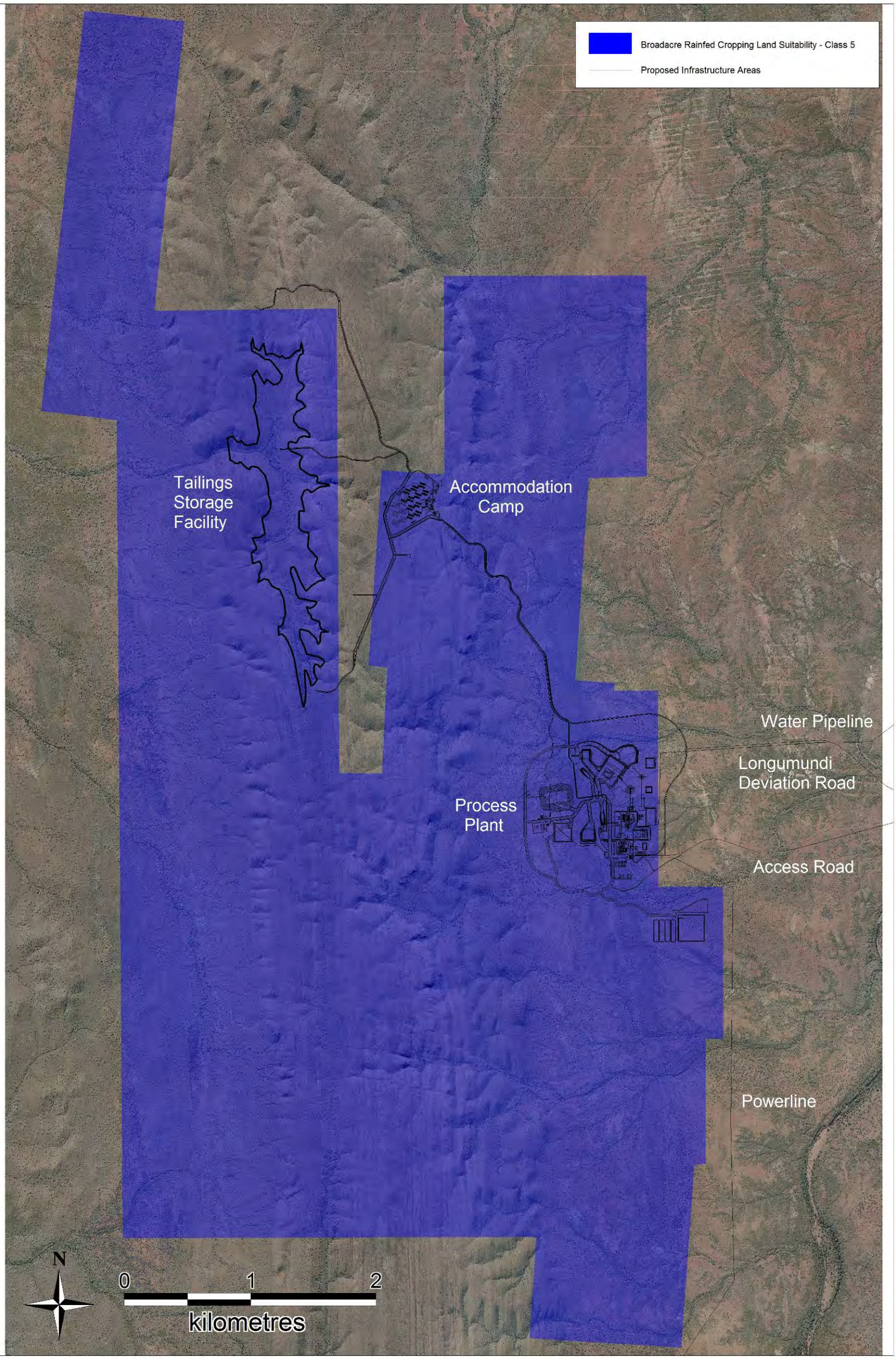


Figure 4.14 Land Suitability Class Map for Rainfed Broadacre Cropping

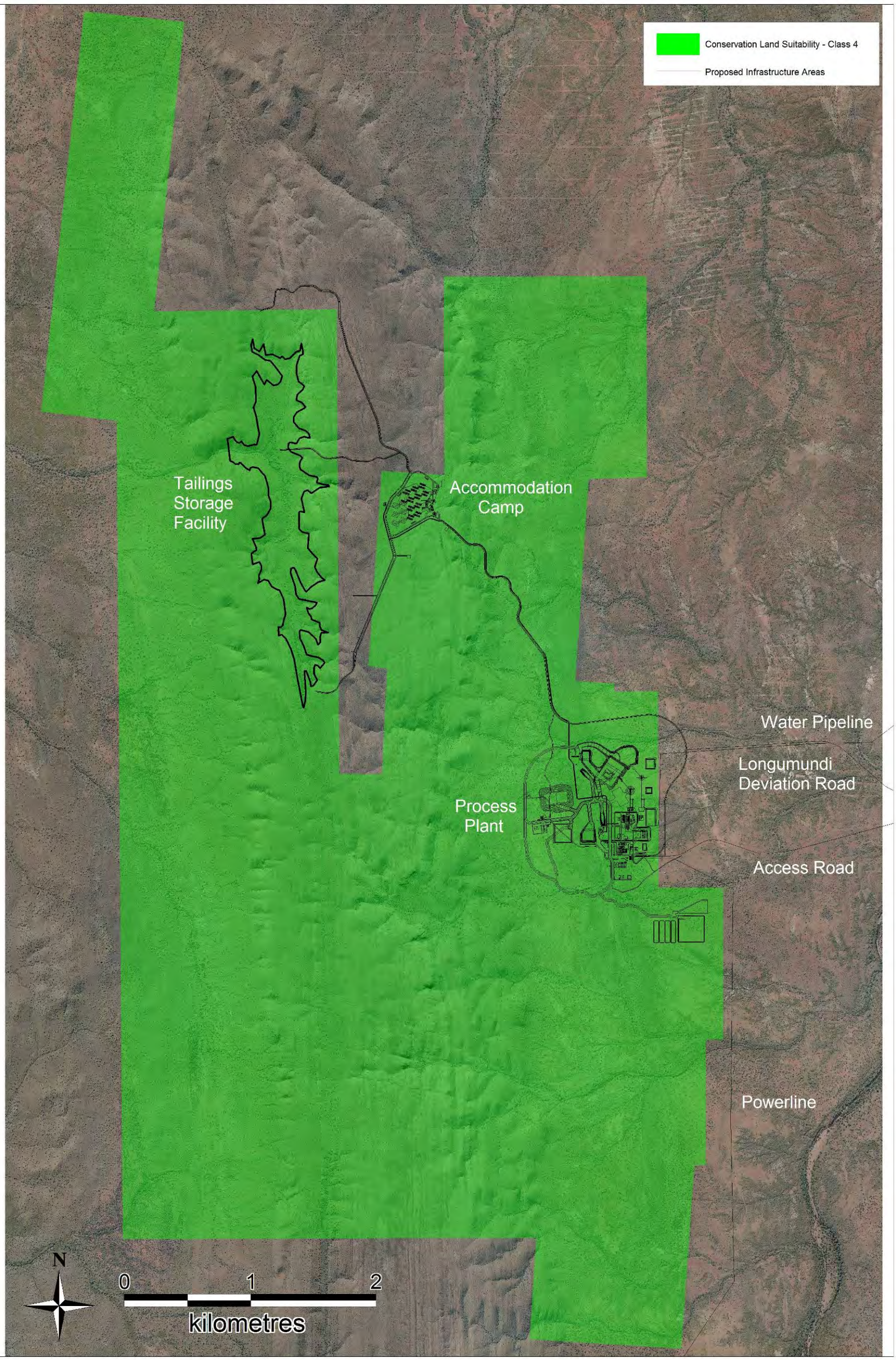


Figure 4.15 Land Suitability Class Map for Conservation

4.2.1.7 and Tenure and Native Title

Cadastral maps of the Project site and infrastructure corridors are shown in Figure 4.16 and Figure 4.17. The majority of the underlying tenures (Lots on Plans) are held for cattle grazing purposes. The Mount Roseby Homestead is the closest homestead to the Project site and is located on the Carsland Holding (held by the McMillan's) approximately 2.5 km to the south east of the Project boundary. The Lot on Plan details for the land under the Project site or infrastructure corridors is described in Table 4.6.

For details of relevant exploration and mining tenements for the Project site see Section 3.3.1 Location and Tenure.

Table 4.6 Lot on Plan Details for the Project Area

Name of Interested Person or Organisation	Lot and Plan Details
Harold Henry McMillan	Holder of land directly under the Project tenements and under the grid connection corridor. L2-4 BD56 : PH 13/3712 Urquhart Holding L6 GR33: (Non-specific) reserve 1 L2577 PH139 : PH 13/2577 Yambani Holding L3692 PH2168: PH 13/3692 Carsland Holding
North Australian Pastoral Co Pty Ltd	Holder of land directly under the Project tenements. L59 TG40: PH 13/64 Coolullah Holding
Altona Mining Limited	Holder of land directly under the Project tenements: L28 B15753
MMG	Holder of land directly under the Project tenements: L27 B15753 L35 B15753 L36 B15753
Queensland Rail	State Land lot 211 on SP136468
Jersey Plains Pastoral Company	Holder of land underlying grid connection corridor. Owner of Lot 521 on CP905413 Holder of Lot 4144 on PH2265
Cameron Creek Pastoral Co PTY LTD	Holder of land underlying grid connection corridor. L3635 PH2175: PH 13/3635 Cameron Creek Holding
Anita Maree and Grant James Telford AS TTE	Holder of land underlying grid connection corridor. Dipvale Property LA AP6651:PO 216513 L4025 PH173:PH 13/4025 Dipvale Holding

The Project site itself is in the Kalkadoon #4 People's Native Title claim area (0). Part of the southern section of the powerline is in the Mitakoodi and Mayi People's Native Title claim area (Figure 4.17). Agreements with both these groups have been made regarding cultural heritage management. Claim details are shown in Table 4.7.

Table 4.7 Native Title Claims over the Project Area

Native Title Group	Claim Number
Kalkadoon People 4	QC05/12
Mitakoodi and Mayi Peoples 4	QC06/9

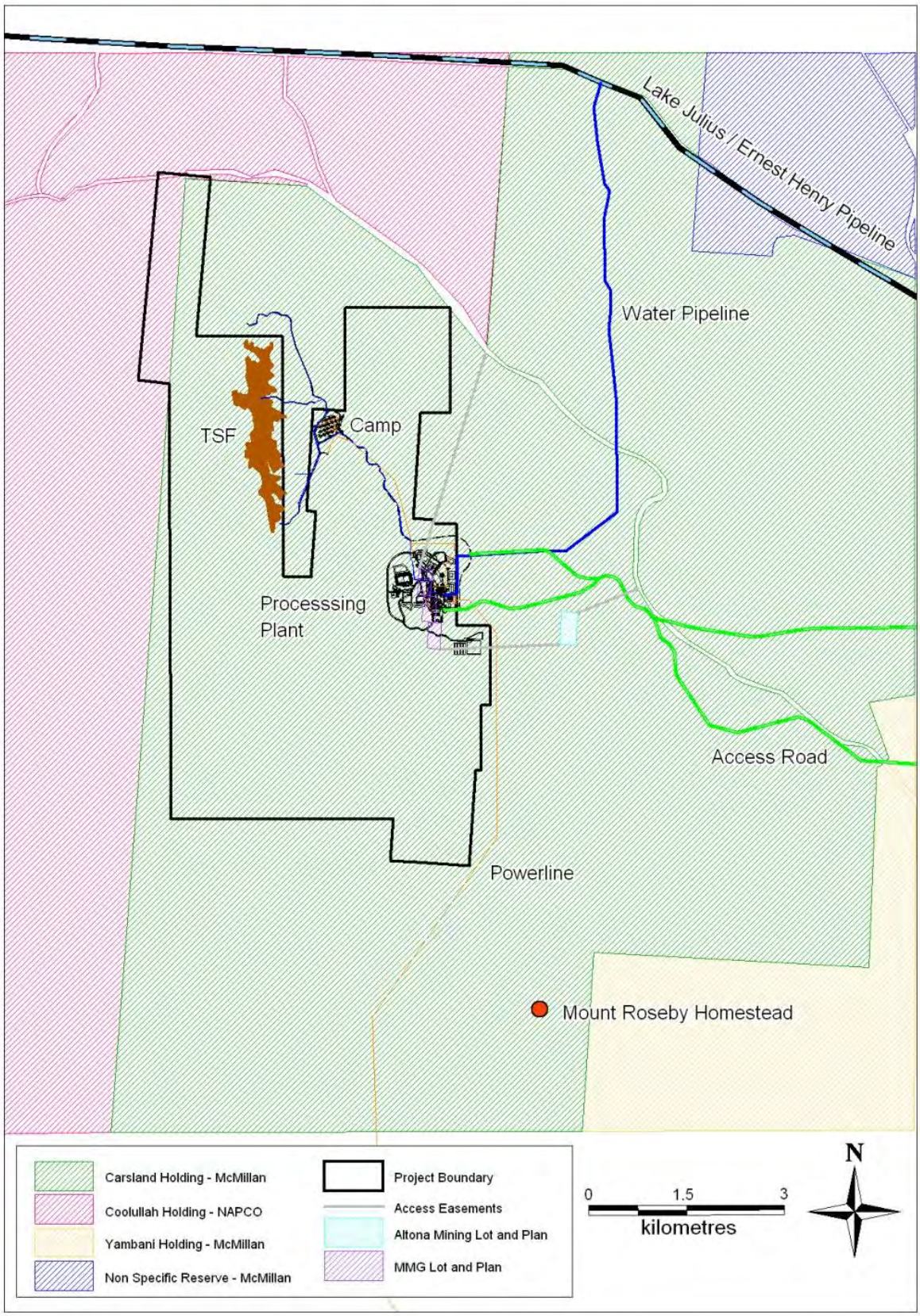


Figure 4.16 Cadastral Map with Project Boundary

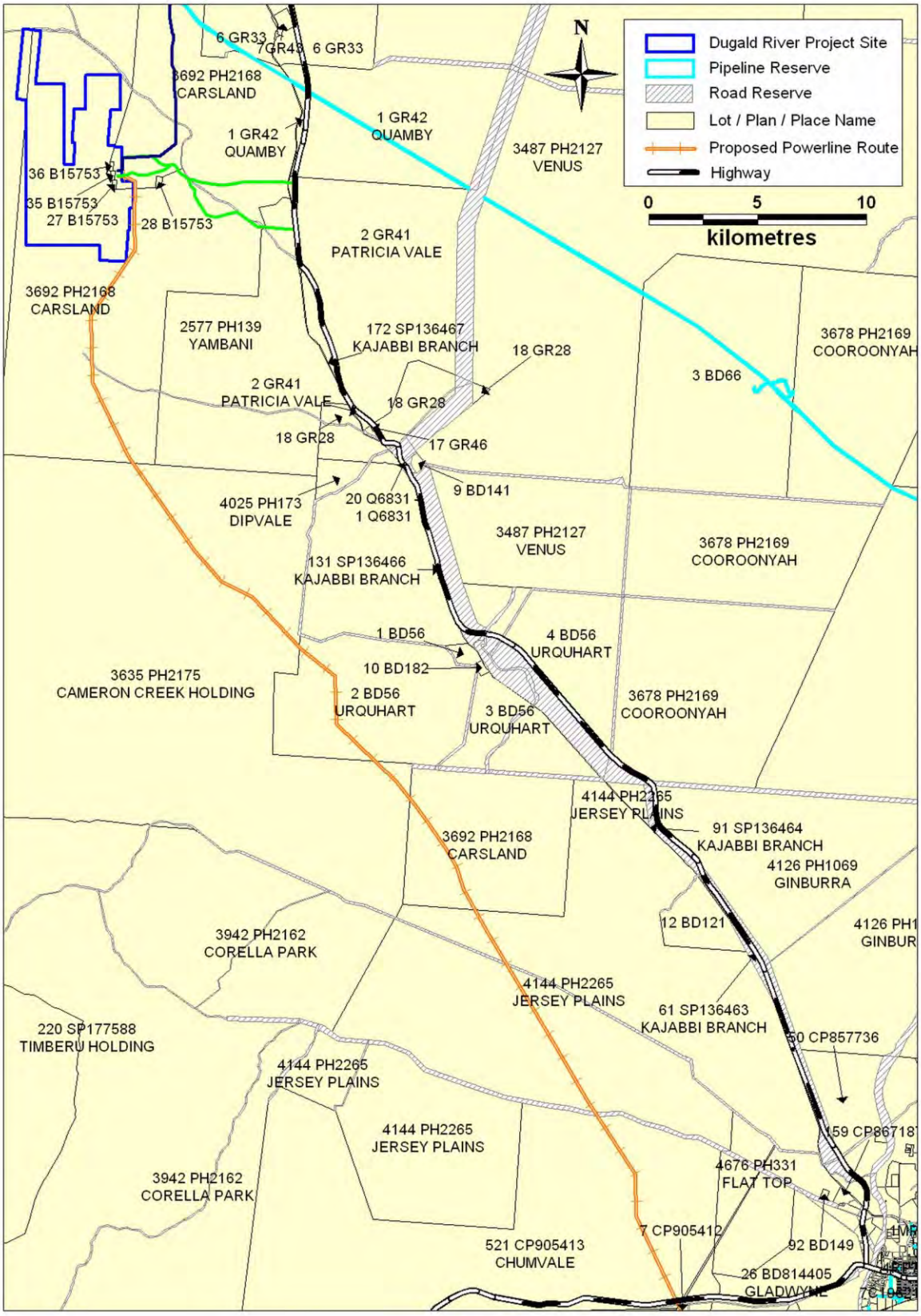


Figure 4.17 Cadastral Map Showing Proposed Power Transmission Line

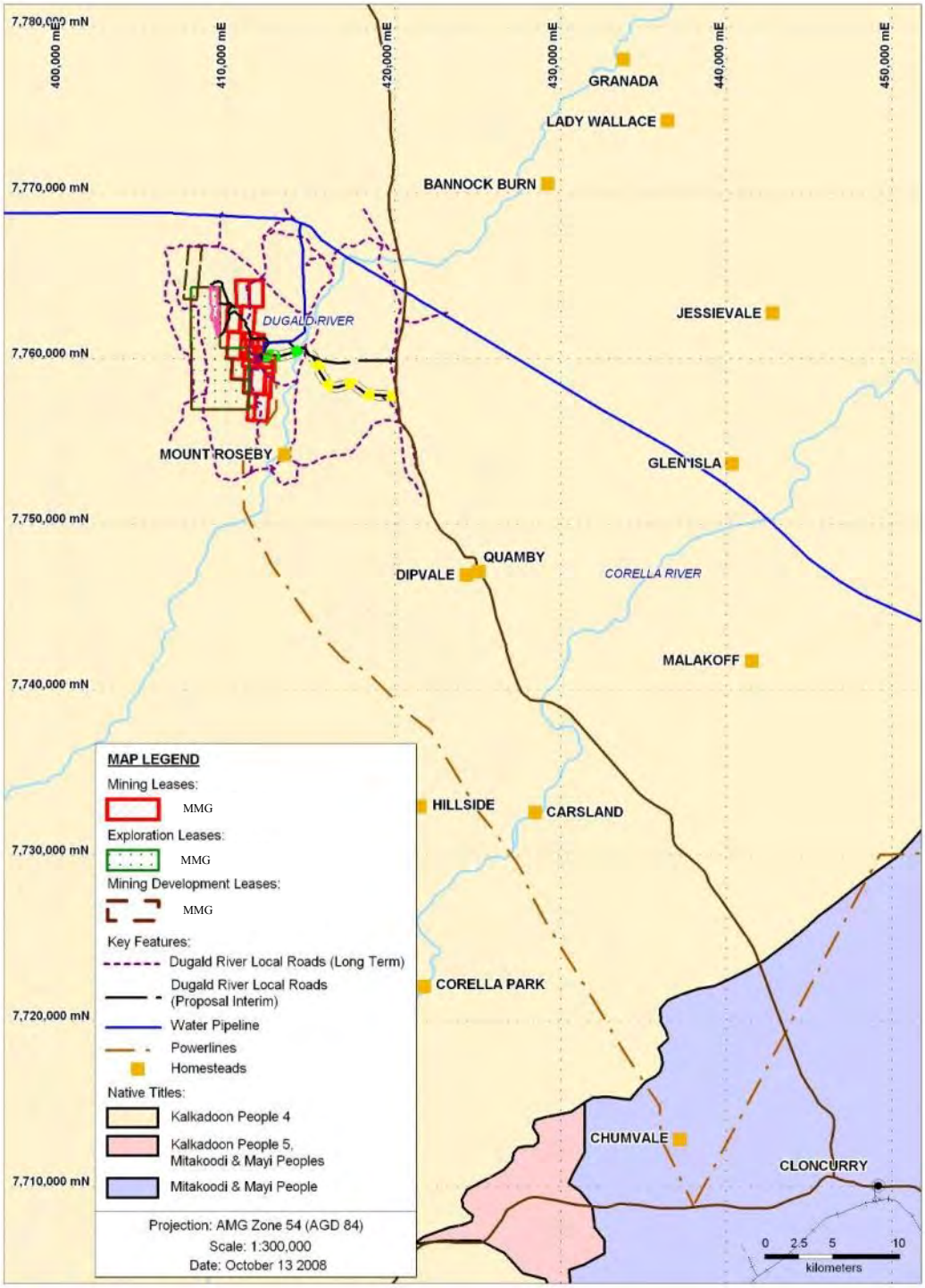


Figure 4.18 Native Title Claim Areas

4.2.1.8 Infrastructure

A water pipeline from Lake Julius to the Ernest Henry Mine passes above the northern portion of the Project Site in an east-west direction. This infrastructure is owned by the North West Queensland Water Pipeline Pty Ltd. The pipe runs underground, with some valve pits and outlet points along the cleared track that marks the course of the pipeline. The location of this pipeline is shown in Figure 4.19.

The Burke Developmental Road from Cloncurry to Normanton passes approximately 8 km to the east of the Project area, and is administered by the DTMR. This road will be accessed to transport concentrate to Yurbi from the Project and supply goods and equipment to the Project.

The current site access route takes the road through several creek crossings, and the road condition is typical of natural formation roads in the area. The road crosses the Dugald River by ford and also crosses Silvermine Creek upstream of its confluence with the Dugald River.

The Project is situated near a corridor through which the now disused (and removed) Kajabbi Branch rail line passed. Initial contact with Queensland Rail indicated that the corridor (which is now classed as a 'Non rail Corridor') will be retained by the State as a future transport corridor and is not available for sale.

There is a drill cores shed, and a small exploration camp housing 25 people currently located on the Project site. Semi-permanent environmental monitoring devices are located throughout the Project site, including Rising Stage Samplers and Falling Stage Samplers (for collecting water samples) and dust deposition gauges.

The environmental values affected by the current infrastructure include:

- Native habitat values;
- Riparian vegetation communities;
- Surface waterways; and
- Pastures for grazing.

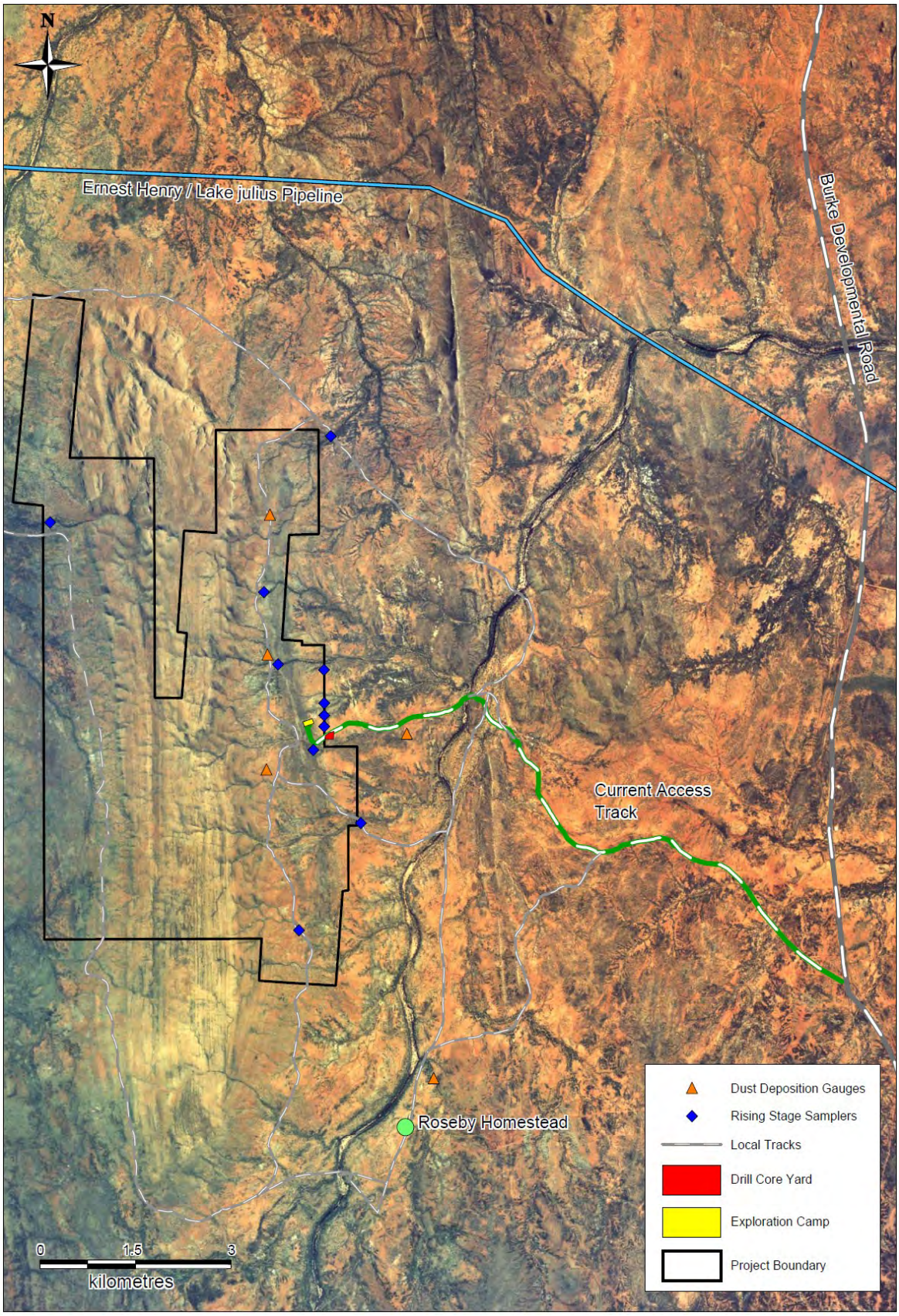


Figure 4.19 Location of Current Infrastructure

4.2.1.9 Sensitive Environmental Areas

The DERM Environmentally Sensitive Areas (ESA) map (Figure 4.20)identified no National parks, Conservation Parks, Forest Reserves, State Forests, Timber Reserves, Heritage Register Places, Fish Habitat Areas, Wilderness or Habitat Corridors, Wild Rivers or Important Wetlands within or adjacent to the Project site. No areas of critical habitat under the *Nature Conservation Act 1992*, areas listed with high nature conservation values or areas particularly vulnerable under the *Vegetation Management Act 1999* have been identified. In addition, no areas proclaimed, or under consideration for proclamation, under the *Nature Conservation Act 1992* or *Marine Parks Act 1982* have been identified as being on or adjacent to the Project Site. One 'Category B' ESA was identified within and adjacent to the Site, an 'Endangered Regional Ecosystem' under the Queensland Biodiversity Status. This Endangered Regional Ecosystem is defined as RE 1.3.7 – Red Gum (Eucalyptus camaldulensis) woodland on channels and levees. Riverine wetlands or fringing riverine wetlands are identified within this RE. This RE was identified within the Project site and associated infrastructure corridors, and is fully described in Section 4.7.1.2.

The ESA map over the proposed powerline corridor shows the extent of RE mapping. The powerline will cross several rivers and creeks which have been identified as Endangered Regional Ecosystems as Red Gum woodland on channels and levees (Figure 4.21). This is further discussed Section 4.7.1.

The land affected by the proposal is not, nor is it likely to become, part of the protected area estate, or is subject to any treaty. Consideration has been given to National Parks, conservation parks, declared fish habitat areas, wilderness areas, aquatic reserves, heritage/historic areas or items, national estates, world heritage listings and sites covered by international treaties or agreements (e.g., Ramsar, JAMBA, CAMBA), areas of cultural significance and scientific reserves.

The EPBC Act identifies and provides protection for Matters of National Environmental Significance. Under the EPBC Act an action will require approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance, where a Matter of National Environmental Significance is:

- World Heritage properties;
- National Heritage Places;
- RAMSAR wetlands of international importance;
- Listed Threatened species and communities under the EPBC Act 1999;
- Migratory species protected under international agreements;
- Nuclear Actions; and
- The Commonwealth marine environment.

The Dugald River Project is unlikely to impact on Matters of National Environmental Significance and has not been referred to Department of Environment, Water, Heritage and the Arts (DEWHA). This is further discussed in Section 4.7.1.

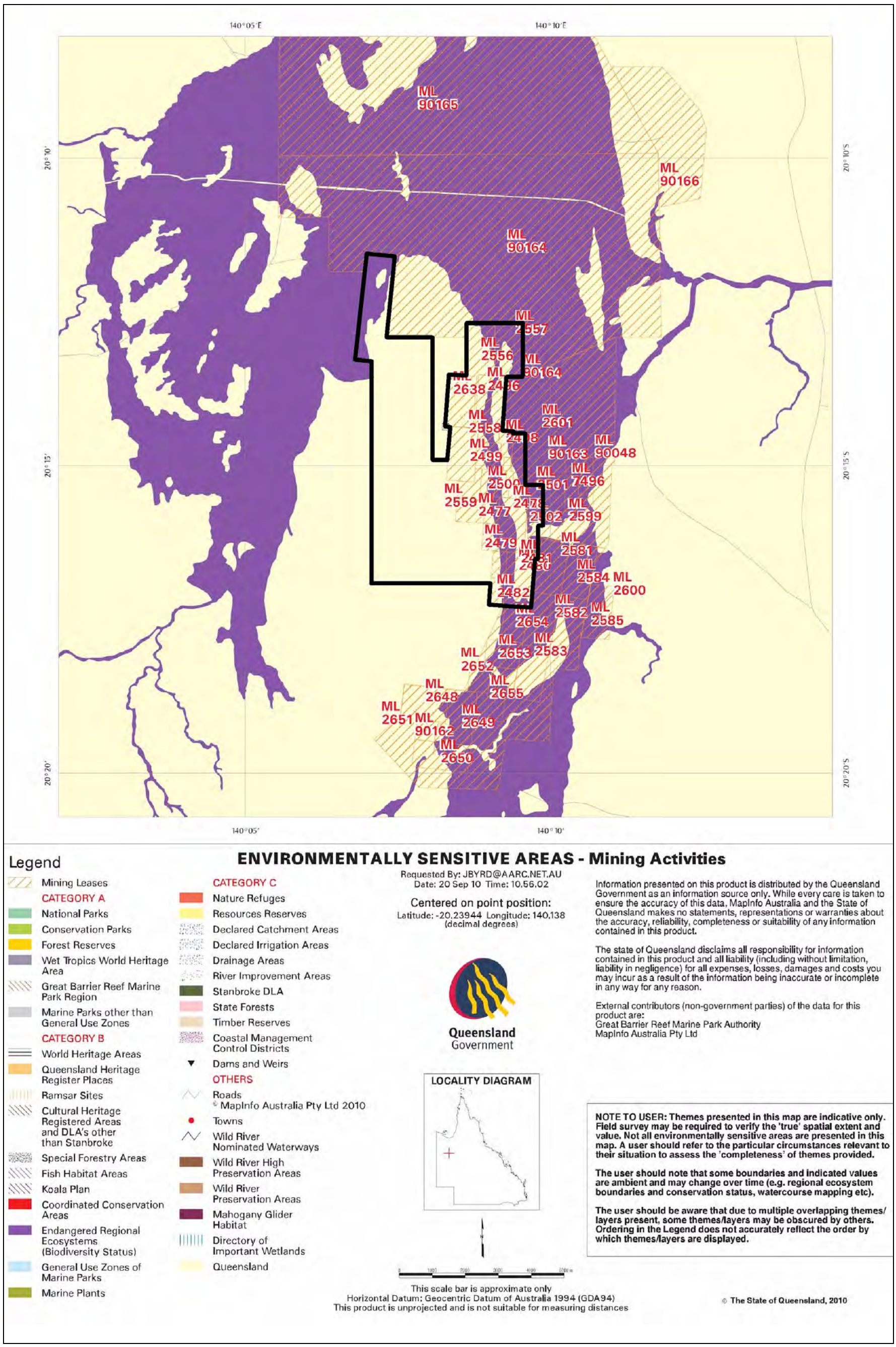


Figure 4.20 Environmentally Sensitive Areas Map Overlaid with Project Boundary

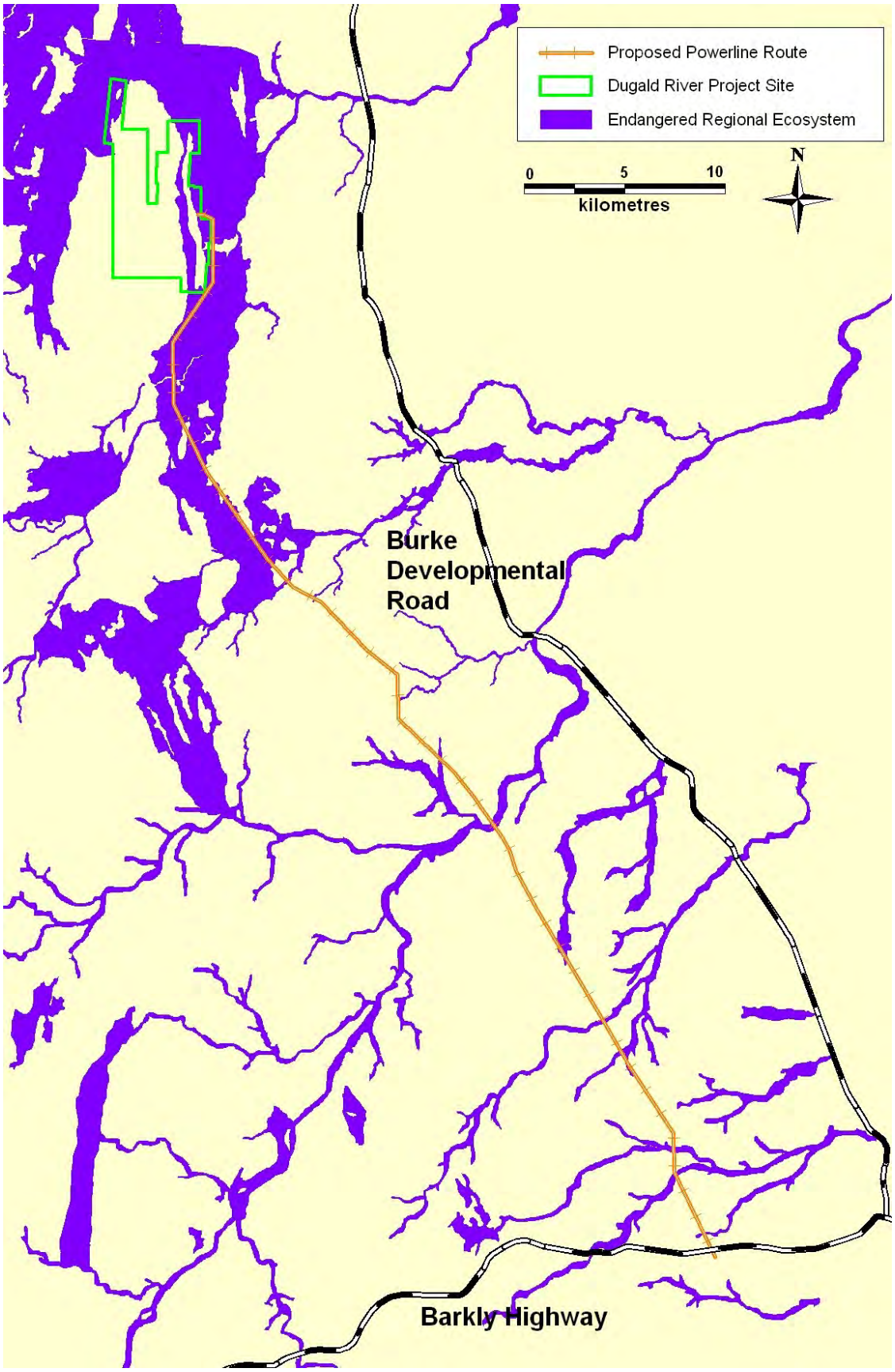


Figure 4.21 Environmentally Sensitive Areas Map – Powerline Area

4.2.1.10 Landscape Character

The Project Site has undergone moderate changes since European settlement. On the eastern side of the Knapdale Ranges the pastoral lease holder has used the land for cattle grazing and much of the flatter grassland areas have been disturbed. The western side of the Knapdale Ranges appears to have had less grazing pressure (it is further from the pastoral station and associated cattle infrastructure). The Knapdale Range itself has had very little grazing pressure, most probably due to the slope and inaccessibility to cattle, hence the ranges being relatively undisturbed.

The Dugald River deposit was discovered over 100 years ago and small scale prospecting, exploration and mining operations have been undertaken. Some areas on the eastern and western side of the Knapdale Ranges have been gouged for mineral deposits and some dilapidated shafts still exist (see Section 4.8.1). The eastern side of the Knapdale Ranges is where current exploration activities are focused. As such there are exploration tracks and drill holes present in addition to a small exploration camp, a core shed, and roads.

Overall the landscape character can be described as flat semi-grassed areas, undulating open woodlands with many rocky outcrops. The slopes of the Knapdale Ranges are dominant in the landscape and include a combination of rocky scree slopes and sheer rock walls. The Knapdales are sparsely vegetated mostly with Spinifex and Snappy Gum open woodland.

4.2.1.11 Visual Amenity

The Knapdale Range includes a considerable ridgeline that provides a vantage point for views over the surrounding area. The Knapdale Ranges are a continuous expanse of rocky outcropping hills that run north-south through the length of the Project site. The Knapdale Ranges are generally fairly inaccessible to the public as surrounding tracks are pastoral and exploration which require authorisation to use. In addition, there are no roadways or tracks into the ranges; they are currently only accessible by foot. Some views of the Knapdale Ranges and from the Knapdale Ranges are provided in Photo Plate 4.1 to 4.3 below.

The Knapdale Range mostly comprises Snappy Gum Open Woodland which favours hilly areas (Photo Plate 4.4). The flatter areas on the western side of the Knapdale Range contain areas of Cloncurry Box Open Woodland with patches of Gidgee Open Woodland (Photo Plate 4.5 and 4.6). In the far northern corner of MDL79 there is a small area of Silver Box / Cloncurry Box Open Woodland associated with a larger creek line. The flatter areas on the eastern side of the Knapdale Range contain areas of Cloncurry Box / Snappy Gum Mixed Woodland and River Red Gum Riparian Woodland (Photo Plate 4.7). Most creek lines on the Project site are small tributaries of Cabbage Tree Creek and the Dugald River. The creek lines on site consist mostly of Mixed Bloodwood Riparian Woodland (Photo Plate 4.8).

Photo Plate 4.1 View from the northern end of the Knapdale Ranges looking north-east

Photo Plate 4.2 View from the north-eastern end of the Knapdale Ranges looking south-east

Photo Plate 4.3 View into a valley - north-eastern end of the Knapdale Ranges

Photo Plate 4.4 Snappy Gum Open Woodland associated with the Knapdale Ranges

Photo Plate 4.5 Cloncurry Box Open Woodland associated with the Flatter Areas

Photo Plate 4.6 Gidgee Open Woodland

Photo Plate 4.7 River Red Gum Riparian Woodland and small creek line

Photo Plate 4.8 Mixed Bloodwood Riparian Woodland and small creek line

4.2.2 Potential Impacts and Mitigation Measures

Potential impacts on land from the Project may include:

- Land clearing may have the potential to impact on the environment through the following:
    - The temporary reduction of habitat for flora and fauna;
    - Loss of or alterations to areas of cultural heritage importance;
    - Topsoil removal, loss, compaction or diminished viability;
    - Increased soil erosion (wind and water);
    - Unauthorised vegetation clearing;
    - A reduction in pre-mine land suitability of the Project site, post mining; and
    - Increased soil erosion caused by land clearing and new mining landforms such as waste rock dumps;
- There is potential for land contamination through:
    - Spills of ore, concentrate or windblown dust from the mining and processing area;
    - Spills or stormwater runoff from ore, tailings, process water or concentrate from the mining and processing area;
    - Spills from the TSF or other contaminated water storages;
    - Spills from the sewage treatments plants;
    - Windblown rubbish from the waste disposal site;
    - Windblown dust from the processing area containing concentrate;
    - Spillage of chemicals or fuel; and
    - Acid and Metalliferous Drainage (AMD) from PAF waste rock materials brought to the surface.
- Infrastructure, particularly the powerline, may affect visual amenity for landholders in the local area; and
- Mining landforms that are constructed with steep outer slopes (i.e. waste rock dumps, ROM pads and ore stockpiles and TSF embankment walls) are the most likely areas to be eroded by wind and water.

4.2.2.1 Land Use Suitability

As discussed in Section 4.2.1.6 the current land use of the Project site is low intensity cattle grazing, mineral exploration and native habitat. For the low intensity grazing (beef cattle grazing) land use there is a mix of Land Suitability Class 4 and Class 5 that covers the Project site. These Land

Suitability Classes are shown in Figure 4.22, with the proposed Project infrastructure overlain. On closure and decommissioning of the Project, it is proposed to return the majority of disturbed land to a condition similar to the pre-existing condition of low intensity grazing, native habitat or an agreed beneficial use. Table 4.8 describes the pre-mining (current) and post mining land uses and land suitability for all areas that are expected to be cleared or disturbed for the Project.

The three main areas that will be disturbed on the main Project mining leases are the processing plant/mining area, the accommodation camp area and the TSF. Other corridor areas that will be disturbed include roads, the power transmission line and the water and tailings pipelines.

The TSF and the accommodation camp are in areas of Knapdale and Dale soil management units. These areas are currently undisturbed native vegetation and have severe limitations for cattle grazing due to slopes, rockiness, and lack of nutrients and PAWC. There were no areas of significant conservation value observed at the accommodation camp site. In the TSF valley a small area of Mixed Bloodwood Riparian Woodland was located. This vegetation community has some conservation value however assuming mitigation strategies are implemented, and disturbance is minimised, the community is unlikely to be significantly impacted at a regional scale.

The processing plant/mining area, which includes the ROM Pad and waste rock dumps, includes areas of Red Plains, Miners and Pocket soil management units. Red Plains and Pocket soils have severe limitations for cattle grazing due to low PAWC and nutrients. However these soil management units currently support low intensity cattle grazing. The Miners soil management unit has extreme limitations for cattle grazing due to rocky outcropping and low PAWC and nutrients. No flora species or vegetation communities of conservation significance were found in these areas.

As discussed above, and shown in Table 4.8 the majority of land disturbance on the Project site will be returned to its pre-mining land use and suitability on closure and decommissioning. The exception to this is the TSF area and NAF/PAF waste rock dump which will be returned to native habitat area only rather than a mix of native habitat and low intensity grazing. This is because these areas may be susceptible to increased erosion if grazing is allowed to occur on these final landforms. Most of the stormwater dams, sediments ponds and roads on site will be returned to their pre-mining land use and suitability unless the landholder wishes to retain these structures for grazing proposes through a written agreement with MMG. The stormwater dam downstream of the rehabilitated NAF/PAF waste rock dump and seepage pond downstream of the TSF will be retained to remove sediment from rainfall runoff from these permanent land forms. The water pipeline and power transmission line will be retained on mine closure as this infrastructure may be of beneficial use to the region or future mining operations.

As was discussed in Section 4.2.1.6 there is no good quality agricultural land identified on, or adjacent to, the Project site. There is also no land, adjacent to, or in the vicinity of the Project, currently used for urban development, recreation or tourism. The land surrounding the Project is covered by pastoral leases and exploration permits or mining leases. Pastoral use and mining are the predominant land uses in the region and there are no currently existing or potential land uses that might be incompatible with the final land uses proposed for the Project site.

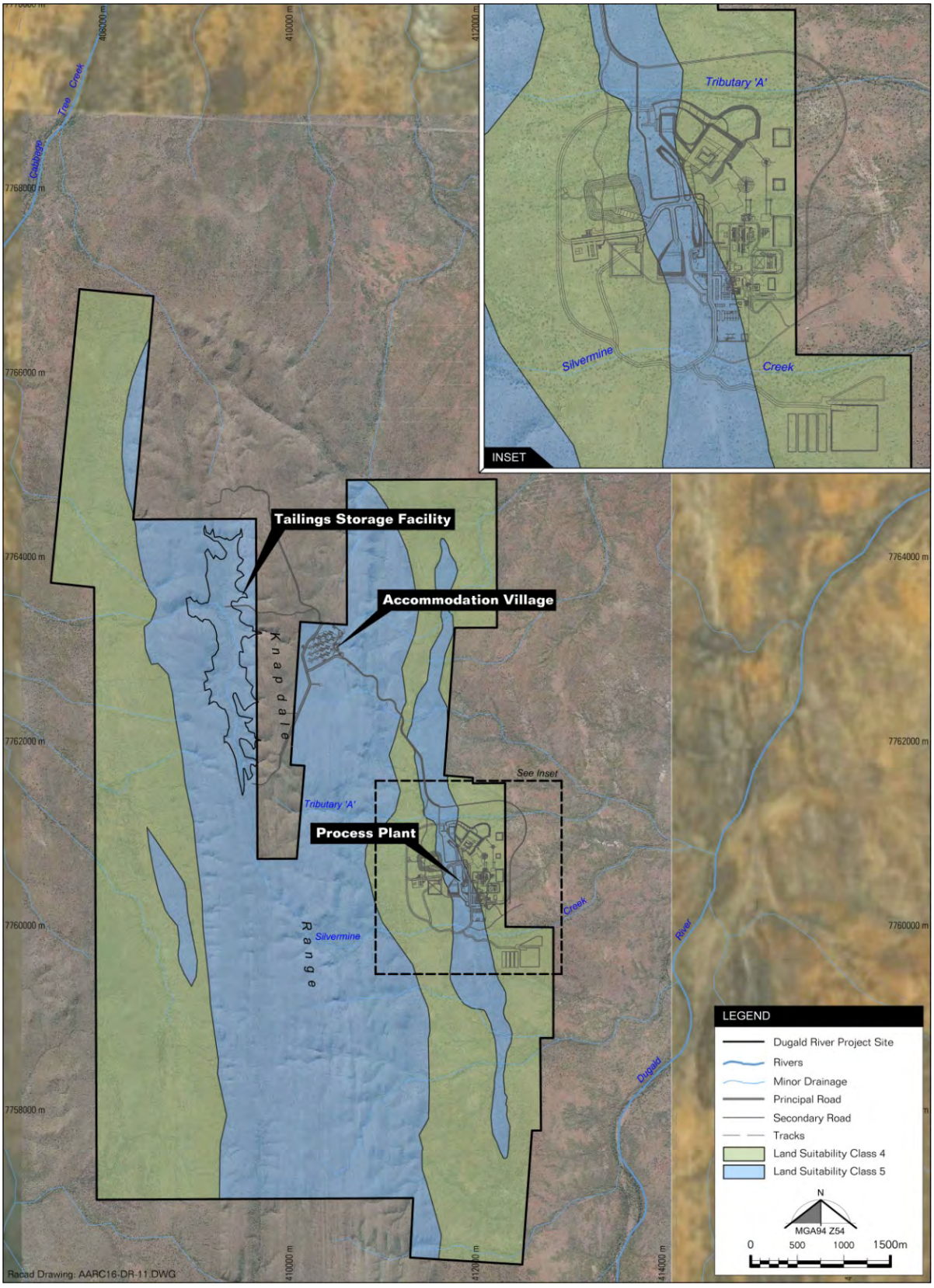


Figure 4.22 Pre-Mining Land Suitability Class Map (Beef Cattle Grazing) with Proposed Project Infrastructure

Table 4.8 Pre and Post Mining Land Use Suitability

Disturbance Type	Area (ha)	Pre-Mining		Post Mining	
		Land Use	Suitability Class	Land Use	Suitability Class
NAF/PAF Waste Rock Dump	6	Low Intensity Grazing/Native Habitat	4-5	Native Habitat	5
South Waste Rock Dump	2.5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
North PAF Stockpile	4.5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Lead/Zinc and Copper ROM Pads	5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Off ROM Ore Stockpile	3	Low Intensity Grazing	4	Low Intensity Grazing	4
Crushed Ore Stockpiles and Conveyors	6	Low Intensity Grazing	4	Low Intensity Grazing	4
Underground Declines	3	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Process Plant Areas (includes chemical and concentrate storages)	28.5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Tailings Storage Facility	91	Low Intensity Grazing/Native Habitat	4-5	Native Habitat	5
Longamundi Alternative Route	4	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
TSF Topsoil Stockpiles	5	Low Intensity Grazing	4	Low Intensity Grazing	4
Paste Fill Plant	1	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Stormwater Dams and Sediment Ponds	12.3	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat or Water Storage[1]	4-5
Process Water Pond	0.4	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat or Water Storage[1]	4-5
Roads and Tracks (on Main Project Mining Leases)	5	Low Intensity Grazing/Native Habitat/ Existing tracks	4-5	Low Intensity Grazing/Native Habitat or Roads[2]	4-5
Accommodation Camp	20	Native Habitat	4- 5	Native Habitat	4-5
Heavy Vehicle Workshop and Go	0.2	Low Intensity Grazing/Native	4-5	Low Intensity Grazing/Native	4-5

Disturbance Type	Area (ha)	Pre-Mining		Post Mining	
		Land Use	Suitability Class	Land Use	Suitability Class
Line		Habitat		Habitat	
Contractor Laydown Area and Workshops	2.5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Offices and Workshops	4	Low Intensity Grazing	4	Low Intensity Grazing	4
Rubbish Disposal Site	3	Low Intensity Grazing	4	Low Intensity Grazing	4
Gravel/Clay Borrow Pits and Stockpiles	12	Low Intensity Grazing	4	Low Intensity Grazing	4
Course Aggregate Borrow Pits and Stockpiles	0.4	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Topsoil Stockpiles (Processing and Mine Area)	10	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Exploration pads and Roads	5	Low Intensity Grazing/Native Habitat	4-5	Low Intensity Grazing/Native Habitat	4-5
Total	**234.3**				
Corridors					
Power line (assume 80 m width)	497.3	Low Intensity Grazing/Native Habitat	3-5	Retained for future use	5
Water Pipeline (assume 40 m width)	40.4	Low Intensity Grazing	3	Retained for future use	5
Access Road (assume 8 m width)	13.6	Low Intensity Grazing/ Existing Track	3 or 5	Access Road[2]	4-5
Access Road Borrow Pits	3	Low Intensity Grazing	3	Low Intensity Grazing	3
TSF Pipelines and Roads	3	Native Habitat	5	Native Habitat	5
Total	**557.3**				
TOTAL	**791.61 Project Site plus Corridors**				

[1] The stormwater dam downstream of the PAF/NAF waste rock dump and seepage pond downstream of the TSF will be retained on closure. Other Stormwater Dams or Sediment Ponds may also be retained on closure if a written agreement with the landholder allows.

[2] Some roads may be retained on closure for access by the landholder, if a written agreement with the landholder allows.

4.2.2.2 Land Disturbance

The construction and operational phases of the Project necessitates the disturbance of approximately 234.3 ha of low intensity grazing lands and native habitat areas on the main mining leases and 557.3 ha on the corridor mining leases and access road. Table 4.8 in Section 4.2.2.1 above outlines the infrastructure and mining activities that will cause land disturbance and the maximum expected area of disturbance resulting from the Project. Should additional land disturbance be required during the life of the Project, this will be detailed in the appropriate amendment to the Environmental Authority and Plan of Operations.

Land disturbance on the Project will be a temporary impact only during the construction and operational phases of the Project. All land disturbances on the Project will be rehabilitated either progressively if possible, or on decommissioning to minimise potential environmental impacts from land disturbance. Section 3.7 of this EIS and Appendix L – Final Land Use and Rehabilitation Plan thoroughly describe the full rehabilitation strategy to be employed for each land disturbance type, and rehabilitation completion criteria. Figures 3.60, 3.61 and 3.62 in Section 3.7 show the final contours, drainage and run-off management for the rehabilitated landforms including the waste rock dump and TSF.

Land disturbance on the Project may result in the following potential impacts:

- The temporary reduction of habitat for flora and fauna;
- Potential to impact on areas of cultural heritage importance or nature conservation;
- Topsoil removal, loss, compaction or diminished viability;
- Increased soil erosion (wind and water);
- Unauthorised vegetation clearing; and
- A reduction in pre-mine land suitability of the Project site, post mining.

Management strategies will be implemented to minimise the amount of land disturbance on the Project. These strategies will include:

- The minimum amount of land for the safe working of the Project will be cleared at any one time for the development infrastructure to reduce the risk of dust emissions, soil erosion and impacts on flora and fauna;
- The amount of land that will be disturbed and rehabilitated each year which will be outlined in the appropriate Plan of Operations for the Project and updated as necessary;
- Progressive rehabilitation will be conducted on the Project where possible and result in the reduction of water erosion, emissions of dust and gaining a better understanding of effective rehabilitation and revegetation methods prior to the decommissioning of the Project;
- On decommissioning of the Project all land disturbance areas, no longer required, will be rehabilitated. Section 3.7 of this EIS and Appendix L – Final Land Use and Rehabilitation Plan thoroughly describe the full rehabilitation strategy to be employed for each land disturbance type, landform design including drainage/run-off management, and rehabilitation completion criteria;

- Soil erosion control strategies will be implemented for all land to be disturbed or cleared as discussed in Section 4.2.2.4;

- A permit to authorise land disturbance on the Project will be implemented during the construction and operational phases of the Project to ensure that all land disturbance has been authorised by management, is conducted in a manner as to create the least environmental impact in regards to clearing of vegetation and impact on fauna, that erosion control measures are implemented and topsoil stripping and stockpiling activities are conducted appropriately. This permit will be detailed in the Plan of Operations for the Project; and

- Topsoil stripping will be conducted to ensure that the maximum volume of topsoil is recovered during land clearing and that it is stockpiled and utilised in rehabilitation in a manner to ensure its viability while preventing erosion and compaction. Methods of topsoil stripping and stockpiling on the Project are summarised below.

As described in Section 4.2.1.2 Geology, the geological conditions on the Project site are not of an age or type that significant fossil specimens may be uncovered during construction or operations.

Topsoil Management

Prior to the development of any infrastructure on the Project, topsoil and vegetation will be removed from the footprint area and stockpiled. Large vegetation will be pushed first and windrowed alongside the area where topsoil will later be stockpiled. Stockpiled vegetation may be chipped or used whole in revegetation works at a later date.

Smaller vegetation and grasses will be removed with the topsoil. Topsoil will be stripped to the following depths and stockpiled for later use in rehabilitation works:

- Red Plains Soil Management Unit – topsoil should be stripped to 50 cm where practicable, however rocky areas may only contain topsoil to 20 cm depth;

- Knapdale Soil Management Unit – topsoil should be stripped to 20 cm where practicable;

- Dale Soil Management Unit - topsoil should be stripped to 50 cm where practicable, however rocky areas may only contain topsoil to 20 cm depth;

- Miners Soil Management Unit - topsoil should be stripped to 20 cm where practicable;

- Prospectors Soil Management Unit - topsoil should be stripped to 20 cm where practicable; and

- Pocket Soil Management Unit - topsoil should be stripped to 20 cm where practicable.

As none of the soil management units on the Project site show a clear definition between the A and B horizons soils, both soil horizons (where they exists) will be stripped and stockpiled together.

Topsoil will be stripped using either scrapers or dozers and stockpiled in windrows with a maximum height of 2 m. This height allows oxygen to diffuse into the stockpile, thereby maintaining the viability of the seed bank and microorganisms within the stockpile. Topsoil will not be stripped during very wet conditions as this may cause significant compaction of the topsoil stockpile, destroy the natural structure of the soil and reduce oxygen diffusion into the stockpile.

Where possible, topsoil stockpiles will be located on relatively flat areas and will not be located on steep slopes. Rainfall run-off will directed away from stockpile areas, and runoff from the stockpile area itself will be controlled with either a small earthen bund or sediment ponds downstream.

Where topsoil stockpiles are to remain in place for an extended period (greater than 1 year) due to operational requirements, stockpiles will be ripped and seeded to encourage water infiltration, prevent erosion and maintain a viable seed bank. The stockpiles will be seeded with a quick establishment species. When used in rehabilitation the soil will require phosphate based fertiliser (at approximately 100 kg/ha) as the topsoil on the Project site is of low in fertility.

Topsoil will be respread on rehabilitation areas at an approximate thickness of 100 – 200 mm depending on the total topsoil reserves for the Project.

4.2.2.3 Land Contamination

Potential Contaminants

The Project has the potential to contaminate land through the following processes:

- Contamination from spills or stormwater runoff from ore, tailings, process water or concentrate from the mining and processing area;
- Potential overflows from the TSF or other contaminated water storages;
- Spills or overflows from the sewage treatments plants;
- Windblown rubbish from the waste disposal site;
- Windblown dust from the processing area containing concentrate;
- Spillage of chemicals or fuel; and
- AMD from PAF waste rock materials brought to the surface.

The following control measures will be undertaken to prevent land contamination.

- Sediment dams or stormwater dams will be installed for all areas downstream of the mine, waste rock dumps or processing infrastructure to contain any spills or contaminated stormwater runoff;
- The TSF will be designed to retain the rainfall runoff from a 1:100 Year ARI, 2 month wet season in addition to process inputs, therefore it is very unlikely this facility will overflow;
- Catchments on the Project site that have been designed potentially contaminated (see Section 3.5.4.1 for definitions) downstream of the processing area, will be designed with stormwater dams to withhold a 1:100 Year ARI, 2 month wet season or a 1;20 Year ARI, 2 month wet season and therefore are very unlikely to overflow;
- Sewage treatment plants will be designed to cater for the maximum number of personnel that can be accommodated on the site at one time. The plants will also be surrounded by an earthen bund wall so that if any overflows or spills do occur they will be contained;

- The rubbish disposal site will be covered on a regular basis (at least weekly) and fenced to prevent windblown rubbish causing land contamination;

- All chemical and hydrocarbon storage facilities will be appropriately bunded, spill kits available, and spills cleaned up immediately;

- Once the Project is operational a register and map of all potentially contaminated sites and any remediation details, will be kept on site and updated regularly;

- A Spillage Management Plan and an Emergency Plan for all hazardous materials stored on-site, together with a description of suitable equipment and training will be developed for the Project;

- Concentrate handling facilities will be fully enclosed;

- Disposal of PAF to underground voids will be made a priority, so sufficient NAF material will be available to fully encapsulate the PAF material on surface. At the end of the project life, it is estimated that the portion of material remaining on the surface that will be PAF will be only 14%;

- A purpose built waste rock dump will encapsulate all PAF waste rock material on surface. NAF materials with ANC will surround the PAF material. The PAF material will not be placed near the base or the slopes of the waste rock dump to ensure the PAF material is not exposed to oxidising conditions; and

- Rubbish disposal areas and sewage treatment sites on the Project will be rehabilitated so as to remove any surface land contamination or provide for safe and stable, self sustaining landforms as described in Section 3.7.

Preliminary Site Investigation

A Preliminary Site Investigation consistent with the DERM's "Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland" (1998) has been conducted for the Project site. The investigation was based on a review of metal concentrations in topsoil across the site and field inspection to identify any visible signs of contamination.

Levels of metals were tested in the soil samples in order to understand natural background levels. The Project area lies in a naturally mineralised zone and baseline levels of lead, silver, copper, zinc, iron, boron and manganese may be elevated in the Project's Soil Management Units. Metal levels will be discussed for each soil management unit and compared to the Investigation Thresholds for Contamination in Soils from the *Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland* in the Soil and Land Suitability Assessment available in Appendix M. A summary of the findings is presented below:

- The Red Plain Soil Management Unit generally has low levels of metals and does not exceed any of the threshold levels or background levels;

- The Knapdale Soil Management Unit found on the slopes of the Knapdale Ranges is generally low in trace metal concentrations;

- The Dale Soil Management Unit is found in very limited areas on the site and is low in all trace metals comparative to the rest of the site;

- The Miners Soil Management Unit is, as expected, high in trace metals, particularly lead recording up to 839 mg/kg in some areas. This soil management unit covers the area of the deposit lode outcropping and owes its high metal levels to this parent material. This high level of lead exceeds the Background, Environmental and Health Investigation levels for contaminants in soils, however this high level is considered a natural occurrence given the outcropping parent material;

- The Prospectors Soil Management Unit is on the western side of the Knapdale Ranges and covers an area of sloped terrain that abuts the steep Knapdale cliffs. This soil management unit does not exceed any of the investigations levels; and

- The Pocket Soil Management Unit is low in trace metals. This soil management unit does not exceed any of the investigations levels.

Environmental Management Register and Contaminated Land Register

The Environmental Management Register (EMR) and the Contaminated Land Register (CLR) were searched for the properties underlying the Project Site. The EMR and CLR are maintained by the DERM to identify properties at risk of becoming contaminated due to Notifiable Activities being undertaken on them, or properties that are proven to be contaminated through scientific investigation. These registers can be searched on a lot and plan basis. The results for the land underlying the Project Site are as follows:

- Lot 59 on TG40 is not included on the EMR or CLR; and

- Lot 3692 on PH2168 is not included on the EMR or CLR.

The Project will trigger three Notifiable Activities as described by Schedule 3 of the EP Act, which have the potential to cause land contamination. Therefore the land on the Project will be listed on the DERM's EMR. These relevant Notifiable Activities are:

- Mineral processing – chemically or physically extracting or processing metalliferous ores;

- Mine wastes – storage of hazardous mine or exploration wastes, including for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or exploring for, or mining or processing minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants; and

- Explosive production or storage - operating a factory under the Explosives Act 1999. *(An explosives factory means a place described in an explosives manufacturer licence where explosives are manufactured under the license).*

Upon the cessation of mining operations, a Site Contamination Assessment will be undertaken at all sites potentially contaminated during mining activities. The Site Contamination Assessment will be conducted in accordance with the DERM's "Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland, 1998", and will consist of the following:

- A review of site history and environmental management records for each site to ascertain the potential for land contamination;

- For sites potentially contaminated, a Stage 1 soil sampling program will be implemented to screen the site for contamination. If the investigation levels in the Guideline are not exceeded, then the site will be considered to be uncontaminated;

- If the Stage 1 soil sampling program identifies contaminant levels exceeding the investigation levels in the Guideline, then a Stage 2 soil sampling program will be designed and implemented;

- A site remediation plan will be developed to achieve land suitability targets nominated for the Project. This may include remediation plans already included in the Project's EA, such as that for the TSF and waste rock dumps;

- Validation sampling following full or partial remediation to demonstrate that contaminant concentrations have been reduced to the required levels to meet the nominated land suitability;

- If partial remediation is the intended target, such as for the TSF and waste rock dumps, a Site Management Plan will be prepared and the partially contaminated site will remain on the DERM's EMR; and

- A report will be prepared detailing the investigation methods, results and remediation methods, which will be submitted to the relevant authority.

4.2.2.4 Soil Erosion

Erosion Potential

All six soil management units identified on the Project area are non-sodic and thereby non-dispersive in nature, meaning they are not chemically predisposed to erosion. Most of the erosion potential on these soils originates from the short duration, high intensity rainfall events that can occur during the summer period.

In the areas of higher relief, the dominant soil types are Rudosols containing significant rock mulch cover, together with abundant rock outcrop. Although surface runoff from these areas may be rapid during high intensity rainfall events, the gravelly nature of the soils and the erosion resistant rock types limit the potentially high impact of surface sheet erosion and gullying.

The soil constituting the Red Plains Soil Management Unit is also characterised by a very low exchangeable sodium percentage, meaning that it is not chemically predisposed to erosion. These soils are also found on areas of lower relief on the Project area meaning that any surface flows are at a reduced rate as compared to the more sloped regions.

Areas to be cleared of vegetation and topsoil during the construction and operational phase of the Project and new landforms which will be constructed have potential to be eroded through the forces of wind and water. Mining landforms that are constructed with steep outer slopes are the most likely areas to be eroded by wind and water. These include the following landforms:

- Waste rock dumps;

- ROM Pads and ore stockpiles; and

- The TSF embankment walls.

Areas to be cleared for other infrastructure for the mine and processing area (including roads and crossings) may also have the potential to be effected by the forces or erosion but to less of a degree as these areas generally will not include sleep slopes.

Erosion Management

All significant rainfall runoff with potential to cause erosion and sedimentation from the Project area will be contained within the mining lease area. All rainfall runoff from disturbed areas of the Project will flow to stormwater dams or sediment ponds where sediment will settle out of the water before being discharged off site. The design and location of these sediment ponds is described in Section 3.5.4.1. This water management system will ensure that erosion from the Project area will be managed with minimal impact on downstream water quality. Wind and water erosion on disturbance areas cannot be eliminated completely, but measures will be taken to minimise the impact by:

- Only the minimum land required to be cleared for the safe operation of the Project at any one time will be conducted;
- The disturbed area of the Project will be rehabilitated progressively where possible;
- Reducing the catchment area of disturbed areas by diverting clean rainfall runoff around disturbed areas where possible;
- The outer slopes of waste rock dumps will be constructed at approximately 15 degrees and progressively rehabilitated where possible to prevent excessive erosion;
- A seepage collection pond will be constructed downstream of the TSF main embankment wall and will capture any sediment erosion off this area;
- Bank stabilisation works will be conducted for any vegetation clearing that is required at creek or river crossings for roads, pipelines or powerlines;
- Sediment ponds or stormwater dams will be installed for all cleared areas and areas of mine or processing infrastructure including downstream of ROM pads, stockpiles and waste rock dumps;
- Concentrate handling facilities will be fully enclosed;
- Regular monitoring of suspended solids in creeks downstream of disturbed areas to monitor the effectiveness of erosion reduction measures;
- Dust deposition monitoring (including metals analysis) at a number of locations surrounding the operations and at the nearest sensitive receiver; and
- An erosion monitoring program will be implemented on the Project and remedial works conducted on areas where excessive erosion is identified. This erosion monitoring program and remedial works will be conducted as described below.

Erosion Monitoring and Remedial Works

Erosion monitoring on the Project will be conducted at a number of locations, focusing on constructed landforms with steep outer slopes which provide the greatest erosion risk. Permanent photographic points will be set up to monitor slope areas of the following landforms on an annual basis:

- Waste rock dumps;
- ROM Pads and ore stockpiles; and
- The TSF embankment walls;

Photographs should be taken following each wet season in order to capture potential erosion caused by runoff. More than one photographic point will be required for some of these landforms to provide good photographic coverage of all slopes. The photographs will be compared to the previous years to determine any large areas of erosion that are increasing in size and may require remedial works. The photographs will also provide a good record of remedial works conducted and the success of these works.

Physical examination or erosion will be conducted together with the photographic monitoring. Examination will be undertaken by traversing the landforms on foot at mid slope, and recording on any erosion or rill lines deeper than 10 cm. The data to be collected at each erosion or rill line will include the following:

- GPS reading of location;
- General description of type of erosion (gully, rill line, circular failure, tunnelling etc) and possible causes;
- Depth of erosion;
- Width of erosion;
- Length of erosion;
- Where eroded material is being deposited;
- Whether the erosion line is being stabilised by vegetation; and
- Suggested remedial works if required.

Remedial works will generally be required for any erosion that is increasing in size from one year to another (i.e. has not stabilised on its own) or if the erosion is deeper than 1 m in depth or wider than 1 m in width. In some cases, if an erosion feature is larger than 1m in depth or 1 m in width and vegetation is currently established and stabilising the erosion feature, it is better to wait and see until after the next wet season rather than conduct remedial works immediately and cause vegetation destruction which could be counterproductive.

4.2.2.5 Landscape Character

The Project is not expected to significantly impact on the landscape character of the Project region. No aspects of the Project will be readily visible to any members of the public with the exception of the landholder traversing the pastoral lease.

Some broad scale changes to topography will result from Project operations. The main change will result from the valley-fill TSF. A significant portion of a deep valley in the north-western section of the Knapdale Range will be filled with tailings, and on closure of the mine covered with suitable rock/earth

and topsoil and revegetated. This area is accessible to the public and should not pose an issue to landscape character.

Waste rock dumps associated with the underground mine may initially stand out from the surrounding landscape, however it is the goal of the rehabilitation plan for the Project to re-grade these structures and revegetate them with native species. In addition most waste rock dumps will be temporary and will be used as rock-fill in the underground mine or for cover material for the TSF. It is anticipated that on Project closure there will only be one remaining waste rock dump (NAF/PAF waste rock dump) and it will rehabilitated to integrate with the surrounding landscape character.

4.2.2.6 Visual Amenity

Due to the remote location of the Project, the lack of public viewing points and the distance of Project from public transport routes, the visual impact of the Project is unlikely to be of major concern to the general public.

The only major public access road past the Project, the Burke Developmental Road, is approximately 10 km to the east of the Project. The majority of the Project's infrastructure will not be visible from this road due to Mount Rose Bee forming a visual barrier along the eastern border of the Project area.

The Knapdale Range borders the Project to the west and therefore provides a visual boundary on this side of the Project. There are no residences or public access roads in the region to the east of the Project.

The major features of the Project that will visible from a distance, mainly from the northern aspect of the Project and to some degree the south will be the processing facilities and the waste rock dumps. Processing facilities will be removed on decommissioning of the operations and therefore will only be a temporary addition to the landscape. Only one waste rock dump will remain at mine closure. Other inert waste rock material will be used to backfill the underground mine and also used in rehabilitation of the TSF.

The closest residence to the project area is the Mount Roseby Station (a pastoral homestead), which is located 6 km southeast of the processing area. The Dugald River and its associated tall vegetation and a catchment divide should assist in shielding the majority of the project from view from the homestead.

The surrounding Knapdale range and Mount Rose Bee rise to approximately 100 m above the plains of the Project Area. Therefore the processing facilities and waste rock dump should be much lower than these dominant natural features. The rehabilitation strategy for the waste rock dump will include reducing the slope of the faces of the dumps from the angle of repose to an overall slope of approximately 15°. This strategy will help prevent erosion of the slopes of the waste rock dump, promote the establishment of vegetation and assist with the blending of the waste rock dump with the surrounding topography. The waste rock dump will also be topsoiled and seeded with a variety of local plant species to establish native vegetation on the waste rock dump itself. Once vegetation has become established it is envisaged that the facility will blend into the natural surrounding landscape.

The TSF is to be located in the western section of the site in a bifurcated valley. The TSF will occupy approximately 91 ha of land and will not be visible to any landholders. On decommissioning, the surface of the tailings storage facility will be capped; topsoiled and the surface will be seeded with a variety of local plant species to establish native vegetation. As with the waste rock dumps, once this vegetation has been established it is envisaged that the facility will blend into the natural surroundings.

The accommodation camp will be situated on top of the northern end of the Knapdale Range and will have an associated access road; however there are no homesteads nearby and there are no public roads nearby. In addition, the camp will be constructed of demountable structures, to be sold on at the decommissioning of the Project. A Telstra tower may be visible as it will be located near the campsite.

All structures associated with the plant, workshop and accommodation village will be dismantled and removed on decommissioning. Areas of disturbance will be rehabilitated to their original condition. Exceptions to this are some roads traversing the Project site, which may remain at the request of the landholder.

4.2.2.7 Lighting

Lighting design on the Project will be in accordance with the requirements of International Electrotechnical Commission (IEC) Standard 60598 – General Requirements and Tests, and IEC Standard = 60598-2-3 – Luminaires for Road and Street Lighting. Emergency evacuation lighting will be in accordance with the requirements of IEC Standard 60598-2-22 – Luminaires for Emergency Lighting and Maintenance. The following specifications will be met:

- Light fittings will be located to provide adequate levels of illumination for safe access and observation of plant areas;
- Plant lighting will be provided by colour corrected high-pressure sodium fittings;
- Plant lighting will generally be mounted on existing steelwork but where this is not possible, mounting poles shall be used e.g. along conveyor walkways;
- Roadway lighting will generally not be provided except in specific areas of activity or vehicle traffic such as cathode stripping and shipping, crusher dump area;
- Lighting systems will be controlled by intelligent lighting control timer relays or by photoelectric sensors so that lights turn off and on automatically for day and night time situations; and
- In all circumstances, the lighting design will take into account the environment and luminaires shall be spaced at suitable intervals to provide the specified lighting levels based on:
    - Surrounding surfaces having poor reflective values;
    - Low maintenance factor (i.e. infrequent cleaning of fittings); and
    - 60% of available light output from any luminaire.

Increased and somewhat unusual fauna activity was noted to occur in response to the operational lighting associated with drill pads on site. Details of fauna activity are based on conversations made with drill machine operators as ecologists could not perform survey activities in the vicinity of the drilling machinery because of safety restrictions. Snakes were attracted to the ground vibrations caused by drilling and were noted to be particularly active in the vicinity of drill pads at night. Species could not be accurately identified, however they were described as being 'big brown snakes', suggesting an Elapid of some description, possibly the Common or Eastern Brown Snake (*Psuedonja textillis),* which is common in the surrounding region. This nocturnal behaviour is unusual for snakes and can be credited to a combination of curiosity, cool nightly temperatures and increased fauna activity/possible prey items also attracted to drill pads. High temperatures during the day and the

associated heat stress this causes ground-dwelling fauna, was deemed likely to suppress diurnal fauna activity on the Project site as discussed in Appendix S. Drill machine operators indicated small mammals were often seen scurrying in ground-cover however could not be accurately identified. Bats were notably active during night drilling, and individuals were seen airborne, swiftly targeting insects attracted by operational lighting.

The drill pad areas are small and surrounded by vegetation so the fauna's obvious curiosity to activity and appeal to prey items allured by night lights, is not thought to be a dependency that would develop in larger operations areas, such as the processing plant. Therefore fauna response to changed habitat conditions at night is not anticipated to be a significant impact in larger lit up operational areas.

4.2.2.8 Transport

The overall effect of the project on the road network, rail network, aviation facilities and sea ports is described in greater detail in Section 3.5.1 and Appendix F. Within Section 3.5.1, a comparison between the current transport conditions (road traffic, road conditions, rail network) is explained in greater detail in respects to if the Project was or wasn't implemented. The impact caused by natural occurrences (flooding) on the site access road and other roads within the Project site are detailed in Section 4.4.1.1.

Burke Developmental Road

The average amount of vehicles per day for the Burke Developmental Road over the two chainages (traffic sectors) which are affected by the Project site is approximately 301 per day. During the construction period of the project, traffic volume on the Burke Developmental Road will increase by approximately 7 vehicle movements per day. The increase in vehicle movements during the construction period constitutes a total traffic movement increase on the Burke Development Road of up to 3.28%. During the operational phase of the Project vehicle movement will increase by up to 16%, or 34 vehicle movements, to account for the transportation of product and supplies. Further, bus movements will increase vehicle movements by an additional 3.75%, or 8 vehicle movements.

DTMR completed upgrading the Burke Developmental Road from Cloncurry to the Burke and Wills Junction, which is some distance north of the MMG Project site, in June 2008 at a cost of $28 million.

Given the number of mining operations serviced by the Burke Developmental Road it is considered that this upgrade to a two lane, 8m wide sealed bitumen road will be capable of adequately servicing the Project. However, consultation is required with DTMR to ensure that the road is suitable for the intended volume of haulage.

According to DTMR Guideline for Assessment of Road Impacts of Development Applications (DTMR 2000), traffic increases of less than 5% are considered insignificant with regard to road capacity. Given that the increase in traffic is on the Burke Developmental Road from the proposed Project is greater than 5%, consultation with DTMR will be required to determine if further mitigation measures are required. As reviewed in Road Maintenance, below, MMG is required to notify the relevant road authority and provide compensation if required under the MR Act.

The Proponent will also undertake consultation with DTMR on the suitability of the proposed location and design of the intersection of the Project access road and the Burke Developmental Road. MMG proposes to construct the intersections during the construction phase of the Project, following further consultation with DTMR regarding design and timing.

Flinders Highway

Significant increases in traffic volumes along the entire length of the Flinders Highway will only occur during the 24 month construction period. Average vehicle movements will increase during the construction period by 7 heavy vehicle movements per day, a percentage increase that ranges from 0.14-2.0% along the 800 km of the Flinders Highway. During mine operation vehicle traffic along the Flinders Highway will see an 2.88% increase, but only between Cloncurry and Yurbi. Recent upgrades to the Flinders Highway should see these volumes of traffic handled safely.

Railway Street/Hensley Drive Bypass

Cloncurry Shire Council specifically refers to Hensley Drive and Railway Street as the heavy vehicle route bypassing the centre of town. As such it can be assumed that these road ways are capable of handling current and marginal increases in heavy vehicle traffic. Visual assessments of both Hensley Drive and Railway Street suggest that the existing road surface, wide road shoulders and unobstructed field of vision will provide a suitable and safe passage for heavy vehicle traffic.

Rail, Sea and Air Transport

Concentrate will be trucked from the Project site to the Yurbi Rail Loading Facility, where it will be stored in an enclosed shed and then loaded into rail wagons. At the peak of mining operation, approximately 523,000 tpa of concentrate will be delivered to the Yurbi Rail Loady Facility ready for transportation to Townsville via rail. Concentrate transportation will increase line usage by three trains per week. Annually this will lead to a 13% increase in hauled freight on the Cloncurry-Townsville rail line.

MMG will negotiate a commercial agreement with a rail haulage provider for the transport of Dugald River concentrates. The agreement will cover both ‘above-rail’ and ‘below-rail’ components. MMG have had preliminary discussions with QR Network Access (the controlling entity of the rail line who are responsible for the ‘below-rail’ component) and they have indicated that there is sufficient capacity in the existing line configuration to handle the additional haulage requirements of Dugald River.

MMG intend to negotiate a commercial agreement with BHP Billiton to expand capacity at their existing port facilities to allow the storage and handling of the additional Dugald River concentrates. Permits and approvals for extension of the existing facility will be dealt with independently to this study and will be subject to any agreement with BHP Billiton.

It is envisaged that concentrates will be shipped in 25,000 – 30,000 t parcels. With 20% of the concentrates being sold to domestic customers, the remaining approximately 385,000 tpa of concentrates will require approximately 13 to15 ship loads per year. This additional throughput would be able to be handled through BHP Billiton’s existing tipping and ship loading infrastructure at the Port of Townsville. However, as discussed previously, the storage facility will require extending.

Flight availability is likely to fluctuate with demand. Aviation companies have recently identified the Cloncurry region as an underserviced area and services were increased with the introduction of SkyAirWorld in 2008. However, these services ceased when the company was placed in voluntary administration in March 2009. The existing aviation services are insufficient to support the transport of the Project’s personnel during either the construction or operations phases.

The total number of mining personnel that are likely to be flying in and out of Cloncurry Airport for a given seven day week is expected to be approximately 134 persons per week during 2012, increasing to over 500 persons per week during 2027. As the proposed mine begins construction and then operation, personnel flying in and out will gradually increase.

MMG intend to negotiate a commercial agreement with an air services provider for dedicated charter flights between the commute base (nominally Townsville) and Cloncurry. In addition to the charter flights, during construction and intermittently during operations, existing commercial flights that currently service Cloncurry will be used. Impact on the existing aviation industry will therefore be minimal.

Wet and Dry Season Accessibility

The outlined haulage route for both the construction and operational phases off the project along Hensley Drive is not an all-weather road. It has been noted that the Hensley Drive causeway across the Cloncurry River is cut frequently during the wet season when the Cloncurry River flows (Figure 4.23). As an alternative route, further south the Barkley Highway bridge is cut much less often, although it too has been overtopped after particularly heavy rains.

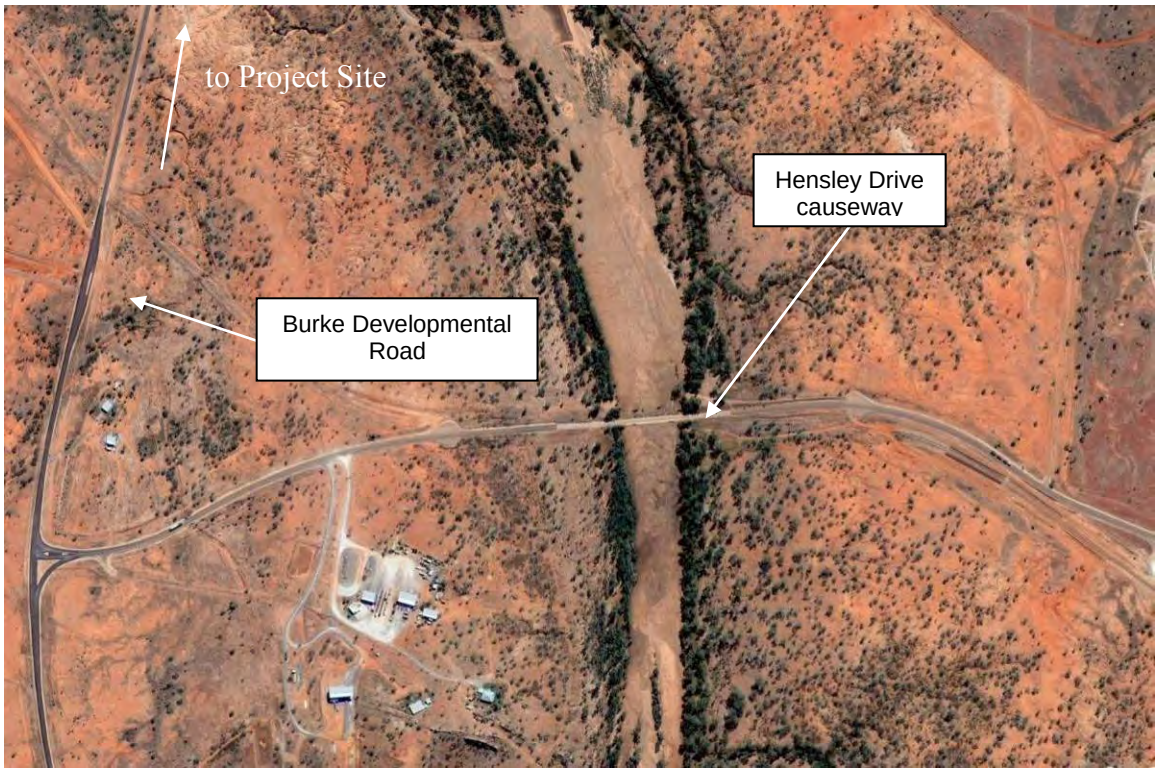


Figure 4.23 Hensley Drive turnoff and river crossing

Road Maintenance

Under the MR Act, the haulage plan proposed by MMG constitutes a *notifiable road use* as it exceeds an annual haulage rate of 50,000 tonnes. Under this arrangement, the mining tenement holder is liable to compensate the road authority for any cost, damage or loss it incurs, or will incur, which is caused by the notifiable activity. Examples of such costs include, but are not limited to, repair costs to rectify damage to the road caused by haulage operations; and, costs of unplanned upgrades of the road. Arrangements between the Proponent and the respective road authorities, DTMR and Cloncurry Shire Council, need to be made to satisfy the requirements of this Act.

Police Escort

AMF conducted a route survey as part of the Dugald River Project Options Study (Ausenco 2008). AMF recommended a maximum transport envelope of 46 m (length) x 6.6 m (width) x 5.5 m (loaded

height) for materials coming from Townsville. Anything over 5.5 m in width or 35 m in length will require a police escort. The number of planned loads that will require a police escort are less than 60 during the construction period with only intermittent loads (1 or 2 per year) expected to require an escort once the Project is in operations.

A permit will be required under Section 46 of the *Transport Operations (Road Use Management – Mass, Dimension and Loading) Regulations 2005* to transport oversize loads on public gazetted roads, this permit will outline requirements for transport including specific times that certain oversize loads can be transported. It is anticipated that transportation of staff, concentrate and materials will only occur during daylight hours and will occur 7 days a week,

Training and Chemical Management Systems

A Spillage and Emergency Management Plan will be included in site induction and training programs for staff and contractors. Details of this plan are described further in Section 4.12.2.2.

Proposed Mitigation Strategies

As described above and in the Transportation Assessment (see Appendix F), the following mitigation strategies will be implemented for potential impacts on road, rail, sea and air transport:

- Increased road traffic along the Flinders Highway as a result of the Project is not considered significant and it is expected that recent upgrades should see the predicted volumes of traffic handled safely;

- Further consultation will need to be undertaken with the DTMR for the proposed increase in traffic along the Burke Developmental Road during operations. The predicted increase of up to 19.75% is considered significant according to the *Guideline for Assessment of Road Impacts of Development Applications* (DTMR 2006);

- Surface works and an upgrade will be required along Railway Street to handle the expected increase in traffic from the Project. The capacity of Railway Street to handle the intended volume of haulage should be discussed with Cloncurry Shire Council;

- The Project will have a predicted 13% increase on current rail transportation along the Mount Isa System. MMG will negotiate a commercial agreement with a rail haulage provider for the transport of Dugald River Project concentrates. Preliminary discussions with QRN Network Access have indicated that there is sufficient capacity in the existing line configuration to handle the additional haulage requirements of the Project;

- MMG intend that the Dugald River mineral concentrates will be stored in the extended facilities of BHP Billiton's Townsville Port facility (subject to successful negotiation of a commercial agreement) and use the same facility's existing infrastructure for loading of ships. This additional throughput would be able to be handled through BHP Billiton's existing tipping and ship loading infrastructure at the Port of Townsville;

- Existing services to the region should adequately cater for the expected personnel movement; however, MMG intends to further secure air services by entering into a contract with one of the aviation service providers in the region. Both the Cloncurry and Mount Isa airports have the capacity to handle further increases in air services in the future;

- DTMR and Cloncurry Shire Council need to be presented with the intended haulage route, volumes and changes in traffic movements for response on the adequacy of the roads to deal with the additional movements;

- DTMR needs to be provided with detailed information on the planned intersection between the site access road and Burke Development Road;

- Under the *Mineral Resources Act 1989*, MMG will need to present an application to both DTMR and Cloncurry Shire Council as the planned concentrate haulage rates constitute a *Notifiable Road Use.* Negotiation maybe required regarding the establishment of a compensation agreement;

- Following further consultation with DTMR, MMG will be required to develop Road Impact Assessment Report to address the accelerated reduction of road pavements in accordance with *Guideline for Assessment of Road Impacts of Development Applications* (DTMR 2006). Mitigation of impacts identified in the Road Impact Assessment Report should be addressed in a Road Use Management Plan;

- Should a spill occur during transportation of goods that affects any road or road reserve, both the DTMR and the DERM should be immediately notified and the spill contained and cleaned up according to the appropriate Material Safety Data Sheets (MSDS) for the substance; and

- Roads or road reserves affected by any accidental spillage should be remediated in consultation with the DTMR, DERM and specialist consultants.

4.3 WASTE

4.3.1 Description of Environmental Values

As stated by Section 7 of the EPP (Waste Management) the environmental values to be enhanced or protected in regards to waste management on the Project should include:

(a) The life, health and wellbeing of people;

(b) The diversity of ecological processes and associated ecosystems; and

(c) Land use capability, having regard to economic considerations.

The main waste types to be produced by the Project are shown in Table 4.9, along with their potential to impact on environmental values as described in other sections of this EIS.

Table 4.9 Project Waste Streams

Waste Type	Potential Environmental Values Impacted	Reference to relevant Section of EIS
Waste Rock	Surface Waterways	Section 3.6.3 and Section 4.4.2.1
	Groundwater	Section 3.6.3 and Section 4.4.2.2
	Land Contamination	Section 4.2.2.3
	Visual Amenity	Section 4.2.2.6
Tailings / Paste fill	Surface Water	Section 3.6.4 and Section 4.4.2.1
	Groundwater	Section 3.6.4 and Section 4.4.2.2
	Soil/Land	Section 3.6.4 and Section 4.2.1.5
	Land Contamination	Section 4.2.2.3
Sewerage	Surface Water, Groundwater	Section 3.6.6.2 and Section 4.4.2
Process/Storm Water	Surface Water	Section 3.5.3.2
Air Emissions	Air Quality	Section 3.6.2 and Section 4.5
General Waste (Landfill)	Groundwater, Surface Water	Section 3.6.5.1
	Land Contamination	Section 4.2.2.3
Recyclable Wastes (batteries, tyres, waste oil/grease etc)	Land Contamination	Section 4.2.2.3

4.3.2 Potential Impacts and Mitigation Measures

This section describes the potential impacts on environmental values, and specific waste management and mitigation strategies for the various types of waste created on the Project site.

Possible impacts on the Project site from the creation or disposal of wastes include:

- Land, surface water and groundwater contamination from:
    - Landfill leachate run-off/seepage;
    - AMD from waste rock dumps;
    - Contaminated run-off/seepage from the tailings dam; and
    - Sewage;
- Accumulation of waste oil and grease, tyres and batteries causing land contamination;
- General littering from human habitation on the Project site;
- Increase in animal scavenging in the landfill area from fauna such as feral pigs, black rats, feral cats, native rodents and scavenging bird species;
- Potential harm or death to animals, particularly birds, landing in or looking for water at the TSF;
- Contribution to greenhouse gas emissions through burning fuels and consuming electricity; and
- Dust from the Project operations including TSP, $PM_{10,}$ $PM_{2.5}$ and metals contained in dust.

Waste rock generated from mining will be placed in waste rock dumps adjacent to the processing plant or placed back underground as rockfill. Geochemical characterisation of waste rock lithologies, including management strategies for the construction of waste rock dumps to prevent AMD, is detailed in Section 3.6.3.

Characterisation of tailings to be generated from the processing plant, including design details of the TSF and management strategies for tailings are provided in Section 3.6.4.

The landfill facility has been designed with reference to the specification outlined in *DERM Technical Guidelines: Landfill Siting, Design, Operation and Rehabilitation.* The landfill facility will be fenced off to prevent scavenging animals entering the waste facility. Detailed information on siting and design is described in Section 3.6.5.1.

Storage and disposal of material that could potentially cause land contamination like oily waste, tyres and batteries is discussed in Section 3.6.5.2. Details of the collection and storage of recyclable material is discussed in Section 3.6.5.3.

Air emissions and associated mitigation strategies are discussed in Section 4.5.2. The Greenhouse Gas Management Plan (Appendix O) provides mitigation strategies to reduce carbon dioxide emissions. This report is summarised in Section 4.5.2.3.

4.3.2.1 Waste Management Strategy

The objective of the Project waste management strategy is to ensure the integrity of ecological processes and environmental values such as water and air quality, which may be impacted by the generation of waste materials from Project operations.

A Waste Management Plan (WMP) will be developed prior to commencement of the Project which will detail and summarise exactly how each waste will be reused, recycled, disposed of or treated. This Waste Management Plan will be included in the Plan of Operations for the Project.

The WMP will be developed with respect to the *Environmental Protection (Waste) Policy 2000*, and will follow a five tiered waste management strategy according to practicalities and available markets, in preferential order:

- Waste avoidance;
- Waste re-use;
- Waste recycling;
- Energy recovery from waste; and
- Waste disposal.

Approximate quantities of waste generated by the Project, operational handling fate, on-site treatment, and methods of disposal are provided in Table 4.10.

4.3.2.2 Cleaner Production and Waste Minimisation

Under the *Environmental Protection (Waste) Policy 2000*, cleaner production programs are described as programs to identify and implement ways of improving a production process so that the process: a) uses less energy, water or another input, b) generates less waste, or c) generates waste that is less environmentally harmful.

The system of water usage in the processing circuit ensures the maximum practicable recycling of water. A description of technology for water recycling in the plant is described in Section 3.5.3.2 and the water balance is described in Section 3.5.3.1 and Figure 3.42.

To minimise airborne dust at the crushed ore stockpile, an induced-draft dust collector with reverse-pulse baghouse will maintain a suction draft in the primary crusher and crusher discharge chute. The dust will discharge from the dust collector onto the stockpile feed conveyor. Water sprays will be used at the ROM bin, primary crusher and transfer chutes to prevent fines from becoming airborne. This will ensure the crushing circuit produces less airborne waste.

The Project will initially draw power from diesel generators on site, however the Project will be connected to the regional northwest Queensland grid during construction and prior to the commencement of operations. The Project will be connected to the Chumvale sub-station which draws power from gas-fired power stations near Mount Isa. Gas fired power creates less waste and greenhouse gas emissions than coal or diesel fired power stations.

Energy efficiency has been included as a criterion in the design process for the process plant. This has primarily been done to reduce the plant operating costs but also has the benefit of reducing

greenhouse gas emissions. The largest consumer of electrical energy in the plant is in the grinding circuit, where the ore rocks are ground down to a fine sandy powder. A test work programme was carried out to optimise this circuit so that the amount of electrical energy consumed per ore tonne processed is minimised

The Project has developed a Greenhouse Gas Management Plan (Appendix O) which states that regular energy audits will be undertaken. This will ensure that any further opportunities for cleaner production and new technology introduction, in regards to air emissions and energy usage, will be recognised.

Finally, with regard to mine planning, the north and south declines to the underground mine will be situated as close as possible to the ROM pads to ensure the smallest distance will be traversed by the mining fleet to dump ore. This is not only cost effective, but ensures less greenhouse gas emissions from fuel combustion in transport.

If any future opportunities to create cleaner production arise during construction and operation, measures will be taken to ensure cleaner technologies and processes are used.

4.3.2.3 Mitigation Measures

General control strategies for waste will include:

- All waste hydrocarbons will be bunded or drummed and removed by a licensed waste transporter for disposal at a licensed waste facility;
- Waste tyres will be stockpiled and buried in waste rock dumps in a manner to maintain long-term dump stability;
- Putrescible and general waste will be covered on a regular basis (at least weekly) to reduce the food supply to feral animals e.g. cats and wild dogs, breeding of insects and minimise the generation of odour;
- Bulk ordering to minimise packaging waste;
- Waste batteries, oil and fuel drums, oil and solvents will be collected for recycling by a licensed contractor;
- Waste Tracking provisions as described under the EP (Waste Management) Regulation will be adhered to for any Trackable Waste greater than 250 kg removed form the Project site;
- Paper and aluminium will be recycled from the camp and work areas;
- Fauna monitoring will be undertaken in the early stages of tailings deposition, and if animal harm occurs, tailored management strategies will be implemented including fencing off access points and providing alternative drinking points; and
- Installation of a modular waste water treatment plant consisting of independent sewage and grey-water treatment facilities.

Strategies for the management of waste rock and tailings include:

- Design of dumps or stockpiles to minimise pyrite oxidation processes, such as:

- Isolation and encapsulation of PAF rock within cells within the core of a dump or stockpile;
- Prevention of convective air movement by constructing dumps in small, compacted lifts,
- Exclude PAF rock from the area under the outer slope of dumps where convective air movement tends to be greatest;
- Exclude PAF rock from the base layer of the waste rock dump and from existing drainage lines so that the under-drainage is not in contact with sulphidic mineralised rock. To the extent possible, limestone or calc-silicate should be placed in drainage lines to impart some alkalinity to drainage prior to emergence at the dump toe;
- Construction of intermediate or final barrier layers which limit oxygen diffusion. Progressive encapsulation of PAF rock using intermediate cover layers would reduce leaching of PAF rock during dump construction, and in the longer term such layers would also provide a source of alkalinity to any pore water moving down into PAF rock zones within a dump.

- In-situ neutralisation of acid generation by blending of PAF waste rock with other materials that are non-acid forming;
- Management of surface drainage from and surrounding dumps and stockpiles;
- Construction of a purpose-built TSF with sufficient capacity to contain the Design Storage Allowance plus the process water inputs; and
- Installation of a system of sub-regional groundwater monitoring bores to monitor the presence, depth, quality and flow direction of groundwater on a monthly basis.

Table 4.10 Waste Management Schedule

Waste Type	Approx. Quantity Total	Waste Management Strategy				
		Avoidance	Reuse/ Recycle	Treatment/ Destruction	Disposal/ Storage Sites	Comments
Waste rock	7,111,193 tonnes (lead/zinc ore only)		Rockfill for Underground, Rehabilitation of TSF		Disposed of to waste rock dumps and Rockfill Underground	Dumps to be designed to ensure stability, encapsulation of PAF and successful rehabilitation
Tailings	928,500 tpa of solids (1.6 Mt slurry) from Zn/Pb processing 887,500 tpa of solids (1.7 Mt slurry) from Cu processing (when commissioned)		Liquid pumped back to process plant for reuse. Pastefill for underground		Pumped to tailings storage facility or underground	TSF designed to appropriate size and stability standards
Domestic Waste	600 tpa	Bulk ordering to minimise packaging waste			Disposal to Landfill	Bins emptied regularly.
Domestic Waste - recyclables		Bulk ordering to minimise packaging waste	Recycling programs for paper, aluminium		Disposal to appropriate recycling facilities.	
Stormwater	473.56 Ml/yr (assumes all water storages full to capacity)		Reused as process water or left to evaporate.			
Process water	1094 m^3/yr		Pumped back to process plant for reuse			
Sewage	5.3-13.25 Ml/yr			Treated in on-site sewage treatment facility.	Solid waste removed by a licences contractor	

Waste Type	Approx. Quantity Total	Waste Management Strategy				
		Avoidance	Reuse/ Recycle	Treatment/ Destruction	Disposal/ Storage Sites	Comments
Grey Water	13.25 – 21.2 Ml/yr		Re-used for sub-soil irrigation of garden at the accommodation camp.	Treated in an on-site waste water treatment facility to standards defined in the Public Health Regulation, 2005.		
Scrap steel (steel balls, steel liners)	135 - 576 tpa		Collection by contractor for recycling			
Tyres	176 tyres	Regular maintenance of vehicles and equipment	May be used as road markers	-	Buried in Underground Mine	Management of waste tyres may be reconsidered should a viable recycling facility become available
Batteries	50tpa		Collect for recycling by licensed contractor.			
Oil and fuel drums			Collect for recycling by scrap steel dealer.			Bulk oil in use
Waste oils/ solvents			Collect for recycling or reuse by waste recycling contractor.		Disposal to an appropriate facility by licensed regulated waste contractor.	Solvents/oils are stored and management in accordance with appropriate standards.

4.4 WATER RESOURCES

4.4.1 Description of Environmental Values

4.4.1.1 Surface Waterways

The environmental values applicable to surface water on the Project site, as stated in the Environmental Protection (Water) Policy 2009, are as follows:

> Section 6 (2) (b) – for slightly disturbed waters - the biological integrity of an aquatic ecosystem that has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators; and
>
> Section 6 (2) (g) – for waters that may be used for agricultural purposes - the suitability of the water for agricultural purposes (cattle grazing).

Waterways and Catchments

Figure 4.24 shows the regional drainage network in the area of the proposed Project site. Three major ephemeral drainage systems drain through the Project site and access areas:

- The southern and eastern sections of the Project site are located in the Dugald River catchment and within a number of its tributary catchments, including Silvermine Creek;
- The western and northern sections of the Project site are located in the Cabbage Tree Creek catchment and within a number of its tributary catchments, including Blackard Creek and Vieuex Rose Creek; and
- A significant portion of the mine access road from Burke Developmental Road is located within the Cattle Creek catchment.

Dugald River runs in a north-easterly direction to the east of the Project site. Cattle Creek, which also runs in a north-easterly direction further east of the Project site, drains into Corella River. Both the Dugald and Corella Rivers are tributaries of the Cloncurry River, which in turn is a tributary of the Flinders River. The Flinders River flows into the Gulf of Carpentaria about 450 km north-east of the Project site.

The Dugald River catchment extends about 45 km to the south-west of the Project site and rises to elevations of over 500 m Australian Height Datum (AHD). The catchment commands an area of about 620 km^2 upstream of the Project site. Silvermine Creek and its tributaries, which drain the eastern section of the Project site, join Dugald River about 500 m downstream of the Clayton Creek confluence. The closest Dugald River stream gauging station to the Project site is located at the Railway Crossing (Figure 4.24), approximately 1.4 km upstream of where it is crossed by the Burke Developmental Road. The Dugald River catchment area to this gauging station is about 660 km^2.

The Knapdale Range, which rises in steep, deeply dissected escarpments, forms the drainage divide between the Dugald River and Cabbage Tree Creek within the Project site.

Cabbage Tree Creek, which runs in a northerly direction to the west of the Project site, joins Pinnacle Creek and then drains into Leichhardt River, which flows into the Gulf of Carpentaria about 400 km north-west of the Project site. The Cabbage Tree Creek extends about 25 km to the south-west of the

Project site and rises to elevations over 300 m AHD. It commands a catchment area of about 250 km^2 upstream of the Project site.

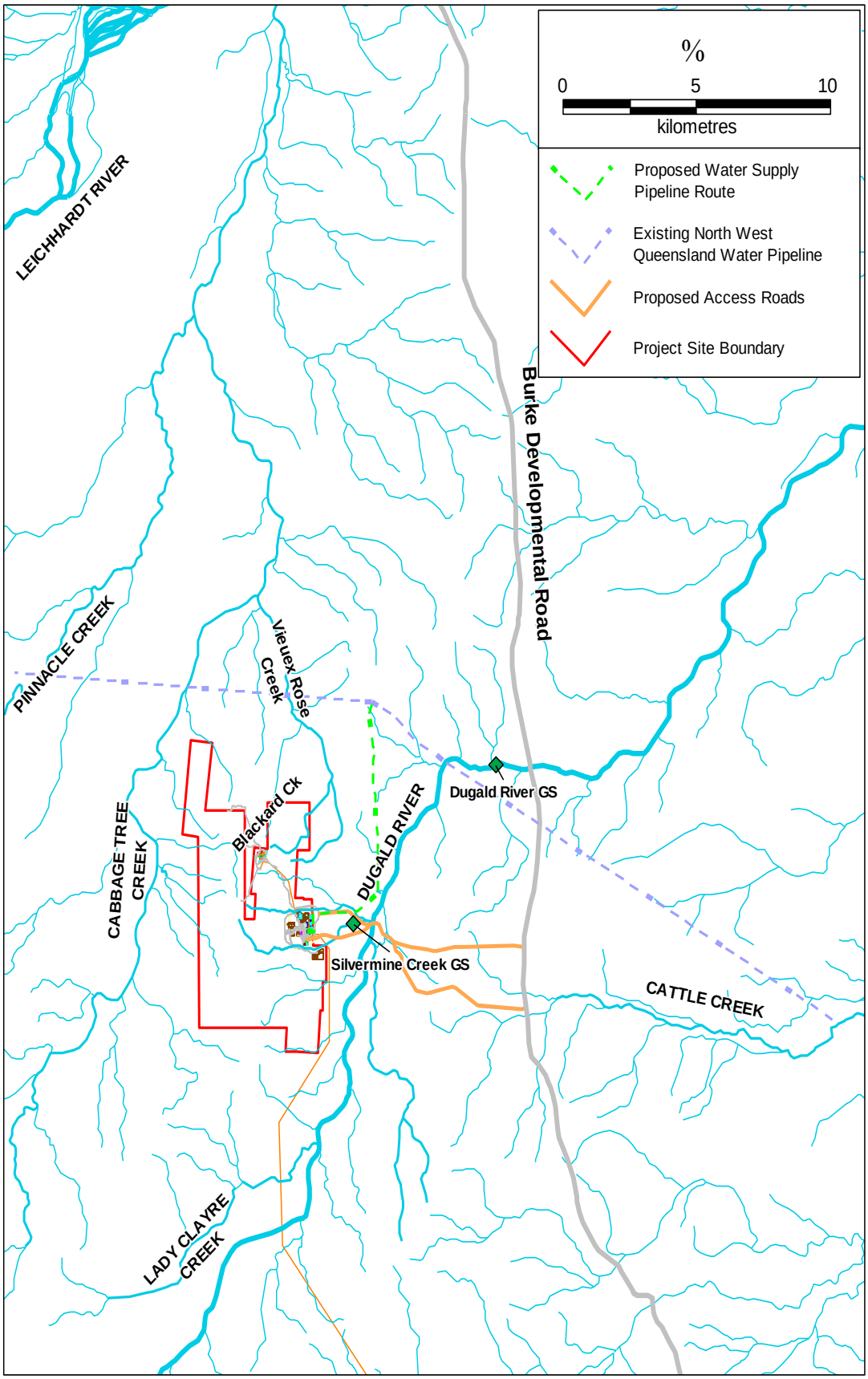


Figure 4.24 Regional Drainage Network in the Vicinity of the Project Site

Vieuex Rose Creek and Blackard Creek, two major tributaries of Cabbage Tree Creek, drain the north-eastern section of the Project site. In addition, several minor tributaries of Cabbage Tree Creek drain the western section of the Project site.

Rivers and creeks in the vicinity of the Project site normally flow only during, and for brief periods following, the wet season, generally between November and April. Isolated pools along these river and creek beds can persist through the dry season.

Downstream uses of surface water include:

- Cattle watering points; and
- Aquatic habitat.

Figure 4.25 also shows the conceptual operational and infrastructure layout on the Project site, including the water pipeline and access road routes. The following is of note:

- Most of the mining infrastructure is located within the catchment of Silvermine Creek between Silvermine Creek and Silvermine Creek Tributary A;
- The TSF is located within a minor unnamed tributary of Cabbage Tree Creek;
- The accommodation camp is located within the catchments of Vieuex Rose Creek (a tributary of Cabbage Tree Creek) and Silvermine Creek;
- The main access road from the Burke Developmental Road crosses the Dugald River, Silvermine Creek and an unnamed minor tributary of Dugald River;
- The road between the mine operational area and the accommodation camp crosses Silvermine Creek Tributary A and Tributary B and other unnamed tributaries of Silvermine Creek; and
- The water pipeline route (off the Ernest Henry/Lake Julius Pipeline) crosses Silvermine Creek Tributary A, and two minor unnamed tributaries of the Dugald River.

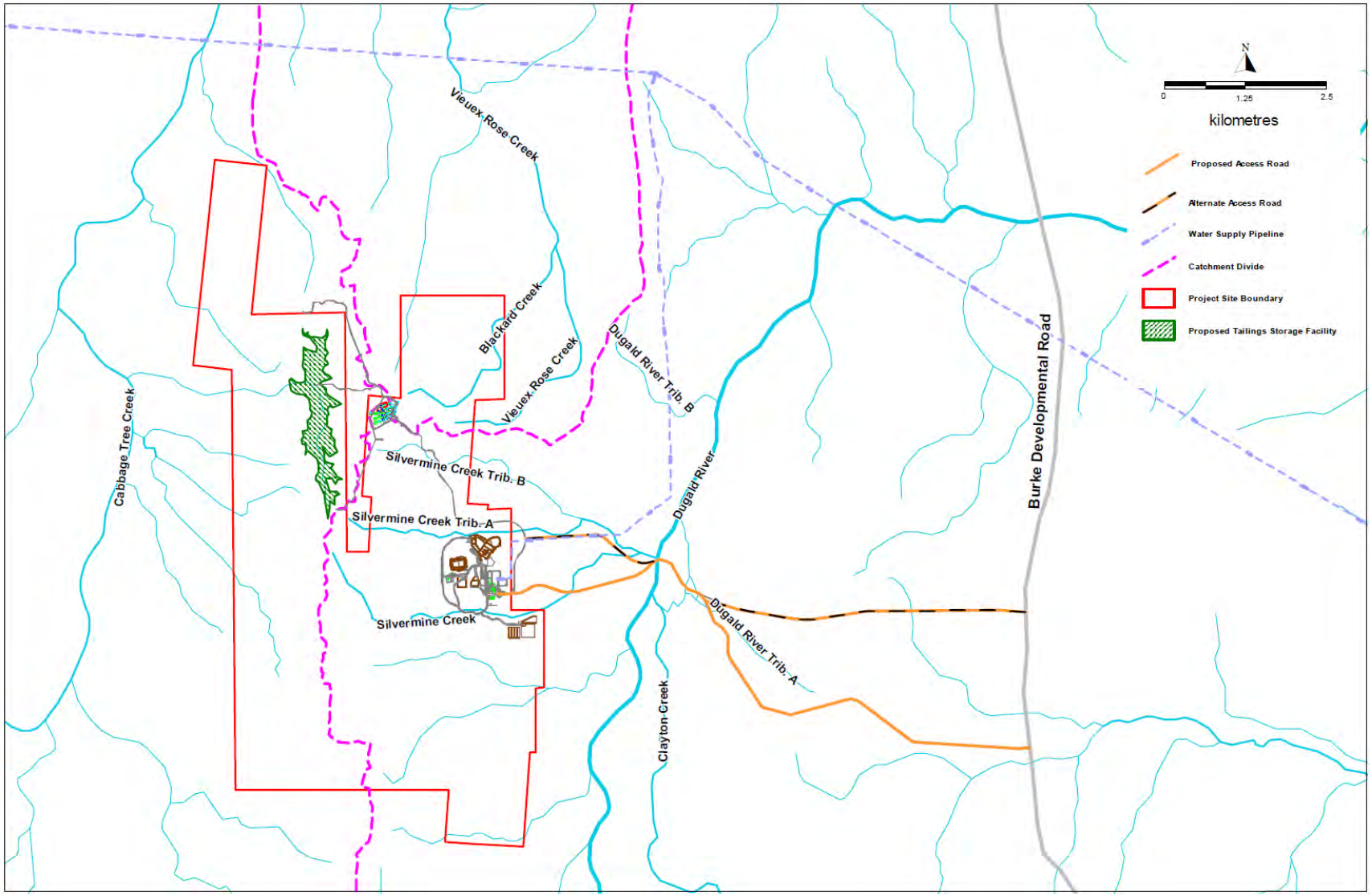
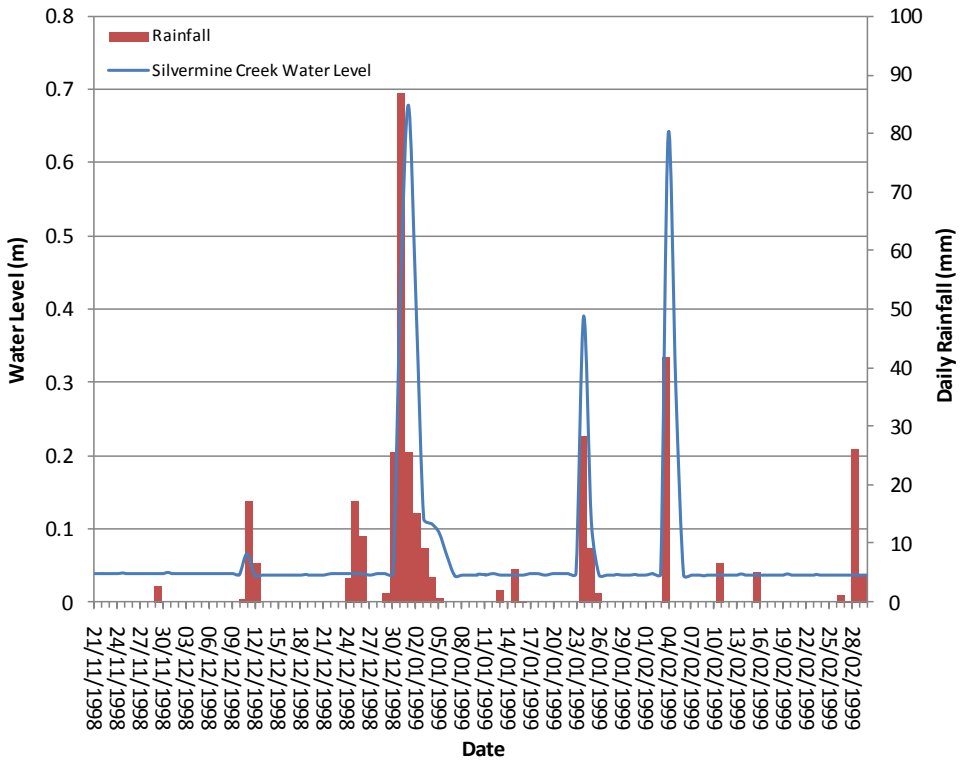


Figure 4.25 Local Catchments & Drainage Networks Affected by the Mine Operation

Stream Flow

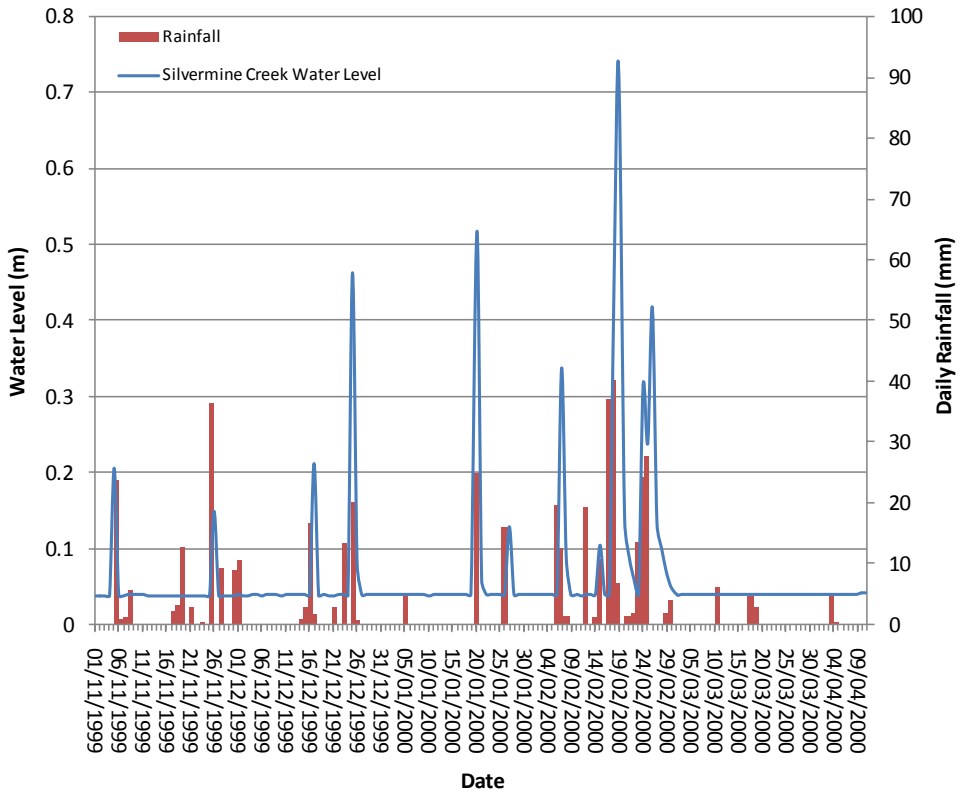
There is a stream gauging station located to the east of the Project site in Silvermine Creek. The location of this station is shown in Figure 4.24. Figure 4.26, Figure 4.27 and Figure 4.28 show plots of recorded Silvermine Creek rainfall and water levels for the 1998/1999,1999/2000 and 2008/2009 wet seasons. The following observations can be made regarding the runoff behaviour of Silvermine Creek based on available rainfall and water level data:

- Some runoff is generally produced when a rainfall event exceeds about 20 mm;
- Runoff response to rainfall is quite quick. Runoff occurs quickly after rainfall and normally peaks within a few hours of rainfall;
- Runoff events do not last very long, generally a few hours to a few days depending on the duration of the rainfall event; and
- During major flow events in the Dugald River (such as January/February 2009) Silvermine Creek water levels at the stream gauging station are affected by Dugald River backwater.



Source: WRM 2010

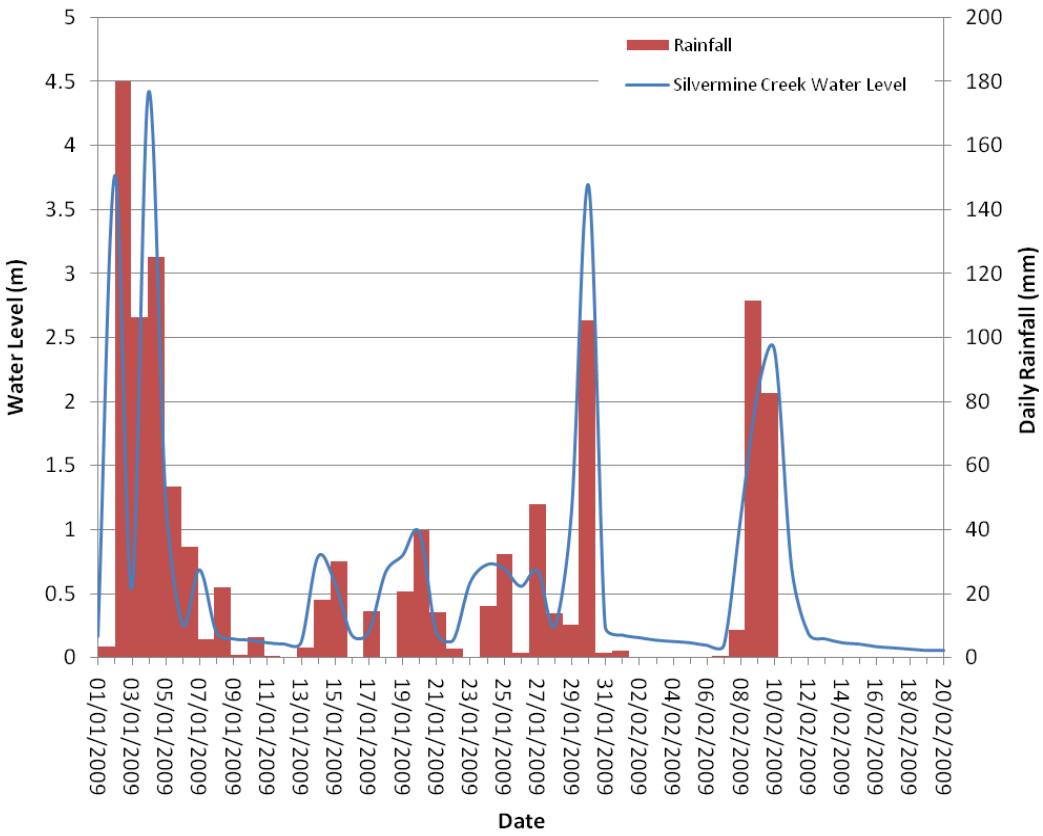
Figure 4.26 Silvermine Creek Recorded Rainfall and Water Levels (1998/1999)



Source: WRM 2010

Figure 4.27 Silvermine Creek Recorded Rainfall and Water Levels (1999/2000)

A stream gauging station has been operational in the Dugald River at the Railway Crossing (Figure 4.24) since 1969. There is a complete record of data at this station from 1969 to date, except for the period between 1988 and 1991, as this station was decommissioned in 1988 and then reactivated in 1991. Table 4.11 shows the average monthly and annual flows and runoff depths recorded at the Dugald River station during the period 1969 to 2006.



Source: WRM 2010

Figure 4.28 Silvermine Creek Recorded Rainfalls and Water Levels (2008/2009)

Table 4.11 Average Monthly Flow - Dugald River (1969-2006)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ave Monthly Flow (ML)	18486	12291	15814	1290	64.4	52.3	42.8	6.0	41.8	440	1234	4754
Ave Monthly Runoff (mm)	28.0	18.6	24.0	1.95	0.097	0.079	0.065	0.009	0.063	0.66	1.87	7.20

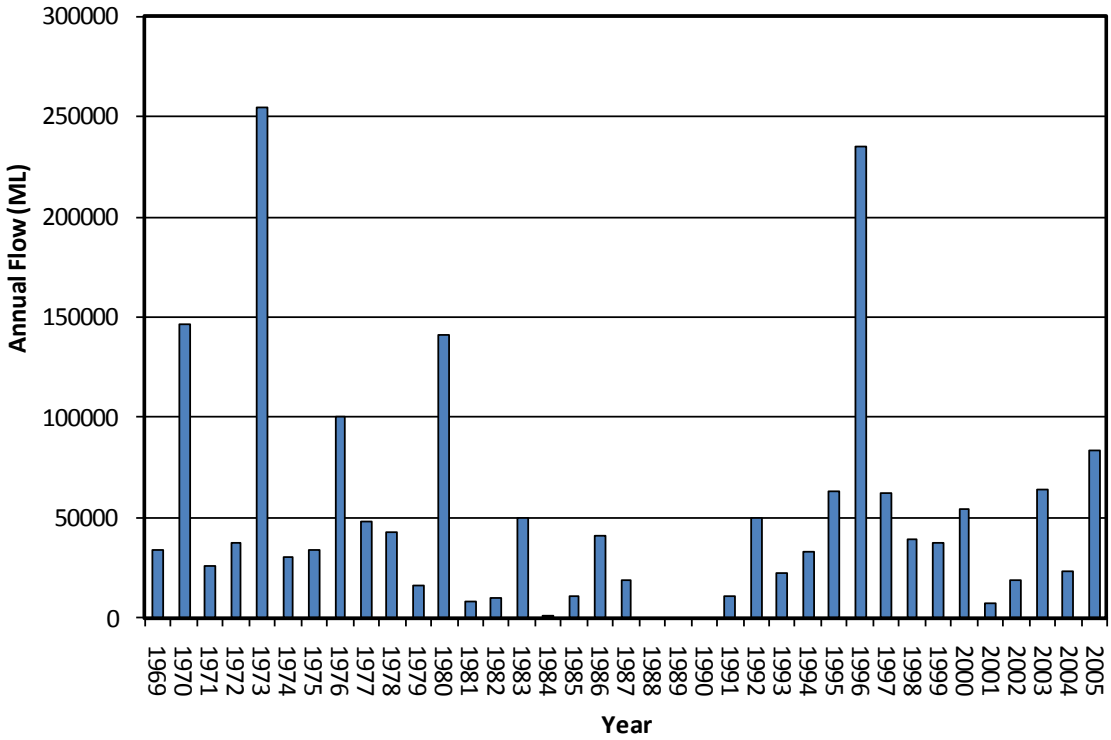
Based on the available data, the following observations can be made regarding the flows/runoff near the Dugald River Project site.

- The average annual flow in the Dugald River is about 55,000 ML. The annual flow volumes vary considerably from year to year. During the 34 years of record, the minimum and maximum annual flows near the Project Site were about 1000 ML and 250,000 ML respectively;
- The average annual volumetric runoff coefficient for the Dugald River at the Railway Crossing is about 8.3%;
- The average monthly flows in the Dugald River exhibit distinct wet (November to April) and dry (May to October) seasons during the year, with dry season a low of 6 ML in August to a wet season high of 18,000 ML in January. The wet season average monthly flows (1,200 ML

to 18,000 ML) are significantly higher than the equivalent dry season monthly flows (6 ML to 440 ML); and

- The Dugald River only flows 26% of the year or 95 days/yr on average. During the 34 year period of record, the daily flows have exceeded 10 m^3/s for 5.0% of the year (18 days/yr) and exceeded 100 m^3/s for 1.5% (5 days/yr) of the year on average. During the wet season (November through March), the river flows approximately 45% of the time. The daily flows during the wet season have exceeded 10 m^3/s and 100 m3/s for 10% of the season and 2.8% of the season respectively.

Figure 4.29 shows annual flows at the Dugald River station between 1969 and 2005.



Source: WRM 2010

Figure 4.29 Average Annual Flows at the Railway Crossing on the Dugald River

Flooding

The Project site itself is not susceptible to flooding from the Dugald River. However, the main access road to the Project site is susceptible to flooding from the Dugald River. During the period 1969-2010 several significant floods have been recorded in the Dugald River at the Railway Crossing, the most recent of which was the January 2009 event, which recorded a peak discharge of 1319 m^3/s at the Railway Crossing gauge. Based on observations during the event and recorded waste levels at Silvermine Creek gauge site, no part of the Project site was inundated during the January 2009 event; however access to the Project site from the Burke Developmental Road was cut intermittently for about 2 months.

Other significant historical floods include the 1971 flood with a peak discharge of 1330 m^3/s and the 1974 and 1997 flood events with peak discharges of 1108 m^3/s and 1148 m^3/s respectively. The next most significant flood event was recorded in 1995 with a peak discharge of 507 m^3/s. Based on a

flood frequency analysis, the ARI of the 2009 and 1971 event is between 50 and 100 years. The ARI of the 1974 and 1997 events is between 20 and 50 years. The ARI of the 1995 event is approximately 5 years.

A total flood event may last from a few hours to several days depending on the rainfall pattern. If the rainfall lasts for an extended period the resultant flood would be multi-peaked. However, the duration of each flood peak would be quite short. Most of the flood waters would rise and fall within a period of about 12-18 hours.

The HEC-RAS hydraulic model (USACE 2003) was used to investigate design 10 and 100 Year ARI flood levels in Silvermine Creek and Silvermine Creek Tributary A, and also in Dugald River and Dugald River Tributary A.

Design discharges for the 10 and 100 Year ARI flood events in Silvermine Creek, Silvermine Creek Tributaries A, B and other minor tributaries and Dugald River Tributaries A and B were estimated using the Rational Method as described in Australian Rainfall and Runoff (IEAust 1998).

Two discharge scenarios were adopted for investigation using the HEC-RAS model, and can be described as follows:

- Scenario 1: 100 Year ARI Discharge in Dugald River and 10 Year ARI discharges in Silvermine Creek, Silvermine Creek Tributary A and Dugald River Tributary A; and

- Scenario 2: 10 Year ARI Discharge in Dugald River and 100 Year ARI discharges in Silvermine Creek, Silvermine Creek Tributary A and Dugald River Tributary A.

The worst case extent of flooding is shown in Figure 4.30. The following is of note:

- Scenario 1 produces the worst case flood levels in Dugald River;

- Scenario 2 produces the worst case flood levels in the upper reaches of Silvermine Creek, Silvermine Creek Tributary A and Dugald River Tributary A. In the lower reaches of the tributaries Scenario 1 produces the worst case flood levels;

- Worst case flood levels in Dugald River range from 190.76 m to 181.55 m;

- Worst case flood levels in Silvermine Creek range from 218.12 m to 184.60 m;

- Worst case flood levels in Silvermine Creek Tributary A range from 213.06 m to 184.68 m; and

- Worst case flood levels in Dugald River Tributary A range from 186.51 m to 185.39 m.

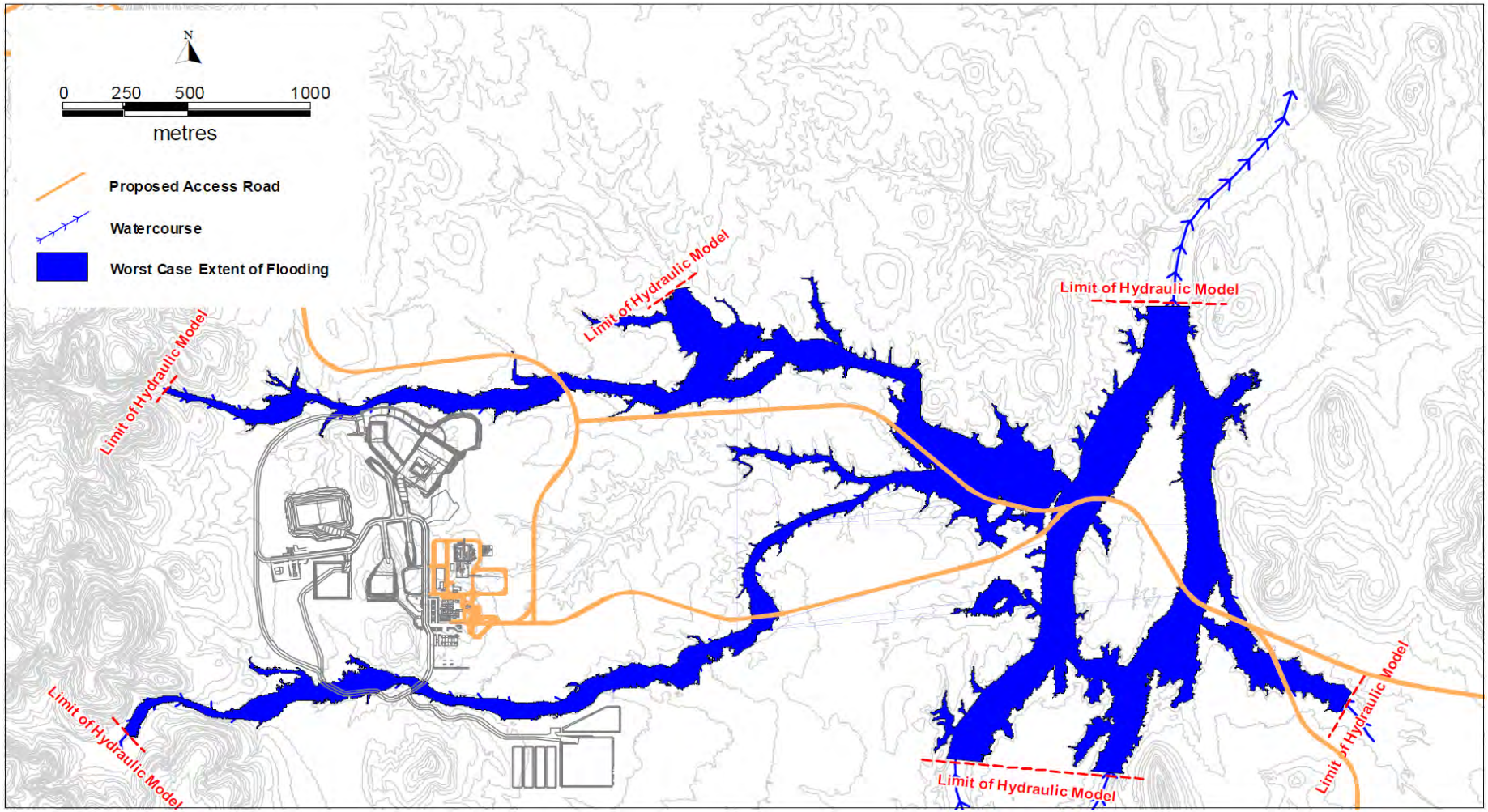


Figure 4.30 Worst Case Scenario Flooding

Background Water Quality

Rising Stage Samplers (RSS) were erected by MMG at seven of the eleven surface water sampling locations on the Project site (shown in Figure 4.31). Between installation in January 2008 and December 2008, there was insufficient rainfall to create any flowing waters in the creek systems where the RSS are situated. Heavy rains in January 2009 did result in stream flows, however inspection of the RSS showed that all sampling stations had been damaged by water and debris flows, and no samples were able to be collected. Grab samples were collected from seven of the surface water sampling sites between January and February 2010 when flowing waters existed.

The DERM recommends in their *Monitoring and Sampling Manual 2009* that Falling Stage Samplers are used for collection of surface waters in ephemeral watercourses in Queensland (DERM 2009, pp. 21). Falling Stage Samplers were installed alongside the RSS located on the Project site in January 2009, however there has since been insufficient flow for samples to be collected using this method.

The adjacent Roseby Copper Project site utilises twelve RSS to collect background water quality data. Eight of these RSS have been deemed appropriate to provide suitable baseline data for the Dugald River Project (see Figure 4.32). The Roseby Copper Project RSS were installed by the owners of the Project between 1999 and 2005, and have been collecting water quality data for up to 9 years.

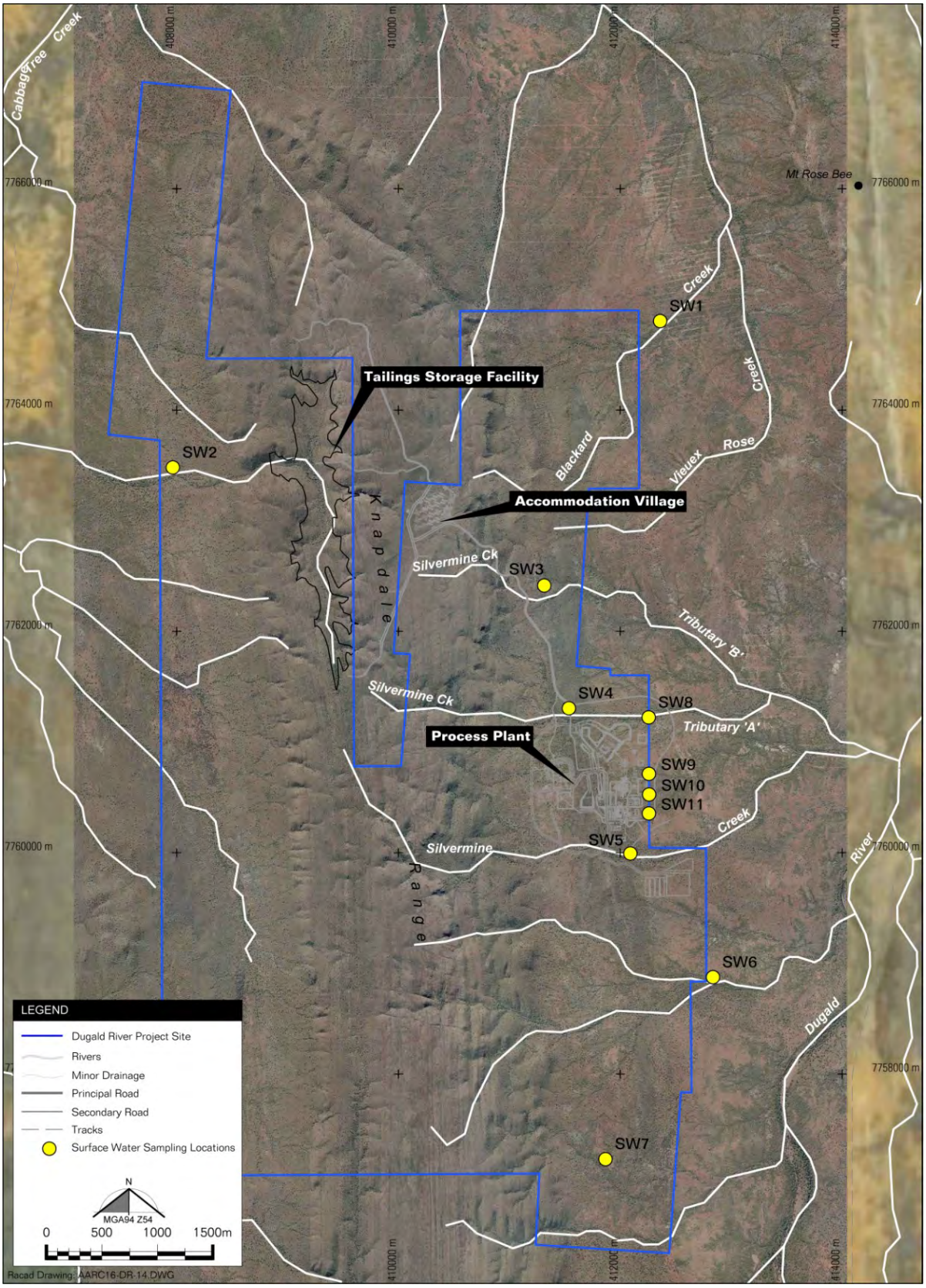


Figure 4.31 Surface Water Sampling Locations within the Dugald River Project Site

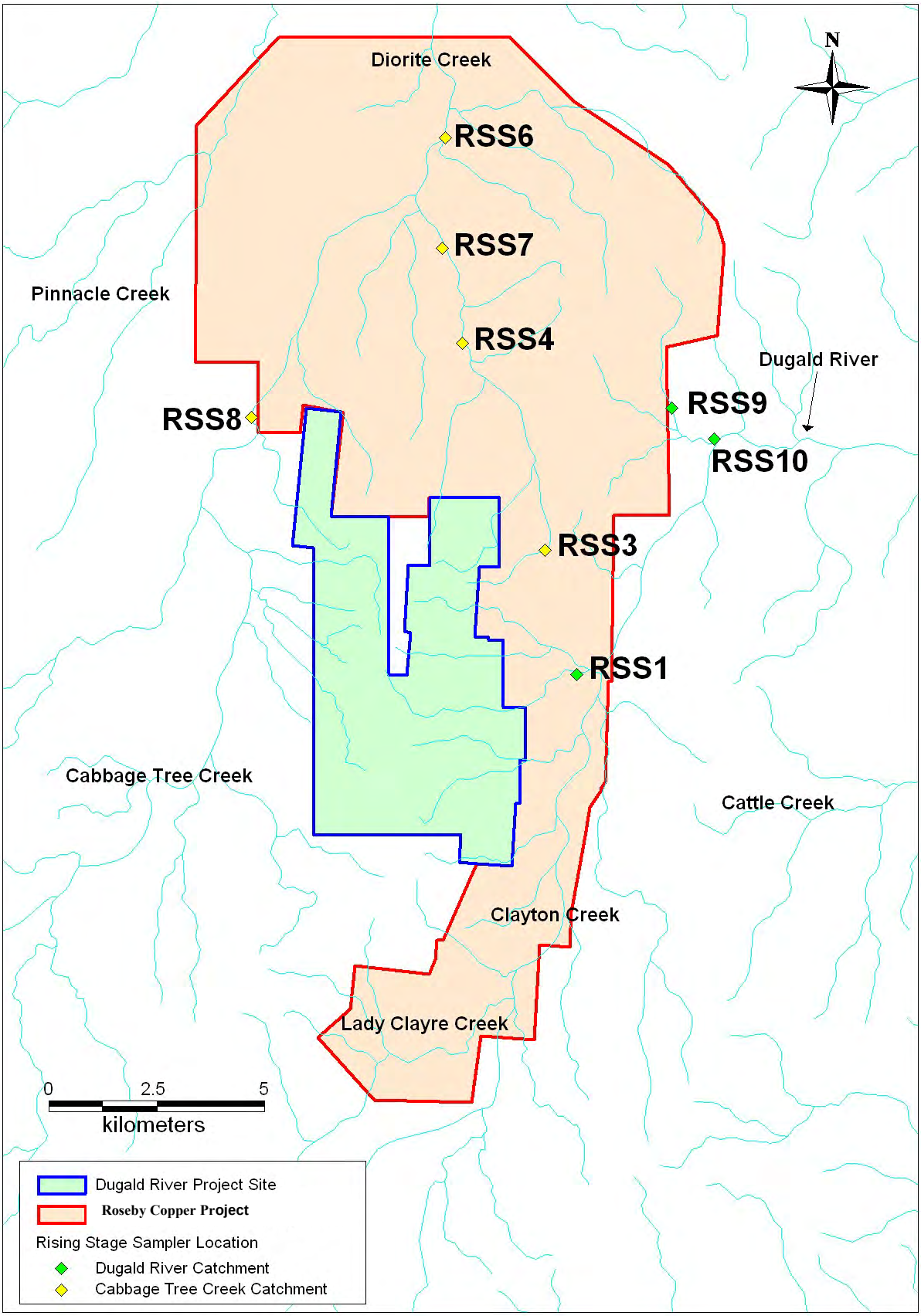


Figure 4.32 Surface Water Sampling Locations within the Roseby Copper Project Site

Surface water quality data was statistically analysed to determine the minimum, maximum, average, median, and standard deviation for each parameter for each catchment (Dugald River and Cabbage Tree Creek) and each sampling site.

Following completion of the statistical analysis, it was necessary to compare baseline water quality conditions to the Australian and New Zealand Environment and Conservation Council's (ANZECC) Guidelines for Fresh and Marine Water Quality (2000)[1], specifically the guidelines for Aquatic Ecosystems and Livestock Drinking Water. These guidelines were selected as they represent the environmental values of the surface water. A summary of this analysis for each catchment is presented in Table 4.12 and Table 4.13. Full details of this data compilation for each sampling site are supplied in the Surface Water Quality, Stream Morphology and Stream Sediments Report in Appendix Q.

The approach used in Table 4.12 and Table 4.13 compares dissolved metals and other toxicants to the ANZECC Guidelines for Aquatic Ecosystems 95% protection level, total metals to the ANZECC Guidelines for Livestock Drinking Water and physiochemical parameters to the relevant ANZECC Guidelines for Aquatic Ecosystems or ANZECC Guidelines for Livestock Drinking Water (in that order of preference). It must be noted that ANZECC Guidelines are only available for a limited selection of parameters.

The ANZECC Guidelines for Aquatic Ecosystems 95% protection level was selected as the most appropriate protection level because it represents slightly to moderately disturbed systems, such as the Dugald River and Cabbage Tree Creek catchments, which have been historically and more recently affected by minerals exploration, small historic mining operations and cattle grazing.

Dissolved metals have been compared to the ANZECC Guidelines for Aquatic Ecosystems 95% protection level because the major toxic effects of metals to aquatic ecosystems comes from the dissolved fraction (ANZECC Guidelines s3.4.3.2, pp. 3.4-15).

Parameters exceeding the Aquatic Ecosystems and Livestock Drinking Water guidelines from Table 4.12 for the Dugald River catchment include:

- pH
- conductivity
- nitrate as N
- total nitrogen as N
- total phosphorus as P
- turbidity
- aluminium (dissolved)
- cadmium (dissolved)
- chromium (dissolved)
- copper (dissolved)
- lead (dissolved)
- manganese (dissolved)
- nickel (dissolved)
- silver (dissolved)
- zinc (dissolved)
- lead (total)

[1] Herein called the ANZECC Guidelines

In addition to the parameters listed above, Cabbage Tree Creek catchment also recorded the following exceedances in Table 4.13:

- Aluminium (total)
- Chromium (total)
- Copper (total)
- Nickel (total)

Table 4.12 Surface Water Quality Analysis – Dugald River

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
pH		71	6.4	8.4	7.3	7.3	0.5	6.0 - 7.5
Conductivity	uS/cm	69	34	822	97	148	149	20 - 250
Alkalinity	mg/L	69	8	147	36	42	27	
Chloride	mg/L	74	1	144	3	8	18	
Dissolved Calcium	mg/L	67	1	124	9	15	20	1000
Dissolved Magnesium	mg/L	79	1	67	2	4	8	2000
Dissolved Potassium	mg/L	59	1	312	4	10	40	
Dissolved Sodium	mg/L	66	1	84	3	7	15	
Dissolved Sulphate	mg/L	76	1	359	2	9	42	1000
Fluoride	mg/L	36	0.1	1.1	0.1	0.2	0.3	2.0
Nitrate as N	mg/L	35	0.01	2.89	0.11	0.36	0.66	0.16
Nitrite + Nitrate as N	mg/L	28	0.01	2.06	0.07	0.26	0.52	
Nitrite as N	mg/L	30	0.01	0.04	0.01	0.01	0.01	9.12
Suspended Solids	mg/L	71	1	11300	160	874	1684	
Total Dissolved Solids	mg/L	74	22	487	90	101	72	4000
Total Nitrogen as N	mg/L	20	0.2	12.0	3.8	4.1	3.1	0.15
Total Phosphorus as P	mg/L	32	0.08	1.89	0.60	0.68	0.45	0.01
Turbidity	NTU	14	45	1600	185	335	421	2 - 5
Aluminium (dissolved)	mg/L	36	0.01	1.56	0.15	0.23	0.28	0.055
Antimony (dissolved)	mg/L	31	0.001	0.001	0.001	0.001	6.61×10^{19}	
Arsenic (dissolved)	mg/L	66	0.001	0.010	0.001	0.002	0.002	0.024
Barium (dissolved)	mg/L	43	0.006	0.417	0.023	0.043	0.073	
Beryllium (dissolved)	mg/L	27	0.001	0.001	0.001	0.001	6.63×10^{19}	
Boron (dissolved)	mg/L	39	0.02	0.10	0.05	0.06	0.02	0.37
Cadmium (dissolved)	mg/L	72	0.0001	0.0050	0.0001	0.0012	0.0019	0.0002

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
Chromium (dissolved)	mg/L	66	0.001	0.010	0.001	0.003	0.004	0.001
Cobalt (dissolved)	mg/L	31	0.001	0.003	0.001	0.001	3.59×10^{4}	
Copper (dissolved)	mg/L	75	0.001	0.345	0.010	0.022	0.054	0.0014
Iron (dissolved)	mg/L	73	0.01	9.10	0.14	0.66	1.79	
Lead (dissolved)	mg/L	73	0.001	0.170	0.001	0.008	0.025	0.0034
Manganese (dissolved)	mg/L	75	0.001	3.180	0.010	0.101	0.403	1.900
Molybdenum (dissolved)	mg/L	36	0.001	0.003	0.001	0.001	3.98×10^{4}	
Nickel (dissolved)	mg/L	64	0.001	0.026	0.001	0.004	0.005	0.011
Selenium (dissolved)	mg/L	36	0.01	0.01	0.01	0.01	3.52×10^{18}	0.011
Silver (dissolved)	mg/L	55	0.001	0.010	0.001	0.002	0.003	0.00005
Tin (dissolved)	mg/L	15	0.001	11300.000	316.000	1169.067	2856.703	
Vanadium (dissolved)	mg/L	32	0.009	0.029	0.010	0.011	0.005	
Zinc (dissolved)	mg/L	75	0.001	3.250	0.012	0.119	0.416	0.008
Mercury (dissolved)	mg/L	36	0.0001	0.0001	0.0001	0.0001	6.87×10^{20}	0.0006
Aluminium (total)	mg/L	34	0.01	630.00	0.61	31.90	128.08	5.00
Antimony (total)	mg/L	36	0.001	0.001	0.001	0.001	6.60×10^{19}	
Arsenic (total)	mg/L	43	0.001	0.011	0.002	0.003	0.002	0.500
Barium (total)	mg/L	43	0.009	0.179	0.031	0.042	0.039	
Beryllium (total)	mg/L	41	0.001	0.002	0.001	0.001	2.18×10^{4}	
Boron (total)	mg/L	28	0.05	0.05	0.05	0.05	2.12×10^{17}	
Cadmium (total)	mg/L	41	0.0001	0.0005	0.0001	0.0002	0.0001	0.0100
Chromium (total)	mg/L	41	0.001	0.072	0.001	0.007	0.015	1.000
Cobalt (total)	mg/L	46	0.001	0.045	0.001	0.006	0.010	
Copper (total)	mg/L	43	0.001	0.272	0.007	0.051	0.079	1.000
Iron (total)	mg/L	42	0.05	82.90	1.09	8.87	18.80	
Lead (total)	mg/L	43	0.001	0.123	0.001	0.013	0.026	0.100
Manganese (total)	mg/L	43	0.001	0.979	0.074	0.163	0.224	

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
Molybdenum (total)	mg/L	41	0.001	0.002	0.001	0.001	2.18×10^{4}	0.15
Nickel (total)	mg/L	41	0.001	0.040	0.001	0.005	0.009	1.000
Selenium (total)	mg/L	28	0.01	0.01	0.01	0.01	3.53×10^{18}	0.02
Silver (total)	mg/L	32	0.001	54.700	0.001	3.179	10.511	
Vanadium (total)	mg/L	29	0.001	0.010	0.010	0.010	0.002	
Zinc (total)	mg/L	43	0.005	1.640	0.034	0.176	0.326	20
Mercury (total)	mg/L	28	0.0001	0.0001	0.0001	0.0001	4.14×10^{20}	0.0020

Note: values shaded grey in the table above are exceedances of the relevant guideline

* ANZECC Guideline values can be found in the following sections/tables of the ANZECC Guidelines:

- pH, total nitrogen and total phosphorus – upland rivers in Table 3.3.4
- Conductivity and turbidity – upland & lowland rivers in Table 3.3.5
- Dissolved calcium – Section 4.3.3.1
- Dissolved magnesium – Section 4.3.3.2
- Dissolved sulphate – Section 4.3.3.4
- Nitrate as N – Table 3.4.1 using conversion factor in Section 4.3.3.3
- Nitrite as N – Section 4.3.3.3 using conversion factor
- Total dissolved solids – Table 4.3.1
- Dissolved metals – 95% protection level in Table 3.4.1
- Total metals and fluoride – Table 4.3.2

Table 4.13 Surface Water Quality Analysis – Cabbage Tree Creek

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
pH		128	4.6	8.1	7.1	7.0	0.6	6.0 - 7.5
Conductivity	uS/cm	112	11	561	68	91	83	20 - 250
Alkalinity	mg/L	108	1	1010	35	54	101	
Chloride	mg/L	116	1	95	1	3	9	
Dissolved Calcium	mg/L	127	1	120	8	15	20	1000
Dissolved Magnesium	mg/L	135	0.6	18.0	1.0	1.9	2.5	2000.0
Dissolved Potassium	mg/L	69	1	47	3	4	5	
Dissolved Sodium	mg/L	87	0.5	13.0	1.0	2.2	2.0	
Dissolved Sulphate	mg/L	120	1	57	1	2	5	1000
Fluoride	mg/L	43	0.1	1.0	0.1	0.1	0.2	2.0
Nitrate as N	mg/L	65	0.01	15.80	0.08	0.60	2.15	0.16
Nitrite + Nitrate as N	mg/L	60	0.01	142.00	0.09	3.01	18.38	
Nitrite as N	mg/L	64	0.01	149.00	0.01	2.36	18.62	9.12
Suspended Solids	mg/L	103	1	43600	500	1580	4833	
Total Dissolved Solids	mg/L	111	12	330	51	69	55	4000
Total Nitrogen as N	mg/L	26	0.1	20.0	0.8	2.5	4.5	0.15
Total Phosphorus as P	mg/L	55	0.03	3.66	0.38	0.53	0.65	0.01
Turbidity	NTU	0	-	-	-	-	-	2 - 5
Aluminium (dissolved)	mg/L	38	0.02	0.62	0.18	0.22	0.16	0.055
Antimony (dissolved)	mg/L	33	0.001	0.001	0.001	0.001	6.61×10^{19}	
Arsenic (dissolved)	mg/L	70	0.001	0.004	0.001	0.001	0.001	0.024
Barium (dissolved)	mg/L	53	0.003	0.463	0.017	0.047	0.093	
Beryllium (dissolved)	mg/L	8	0.001	0.001	0.001	0.001	0.000	
Boron (dissolved)	mg/L	47	0.01	0.11	0.10	0.08	0.03	0.37
Cadmium (dissolved)	mg/L	97	0.0001	0.0010	0.0001	0.0002	0.0003	0.0002

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
Chromium (dissolved)	mg/L	93	0.001	0.034	0.001	0.002	0.004	0.001
Cobalt (dissolved)	mg/L	19	0.001	0.260	0.001	0.018	0.059	
Copper (dissolved)	mg/L	116	0.001	0.650	0.009	0.038	0.092	0.0014
Iron (dissolved)	mg/L	111	0.05	139.00	0.16	4.15	18.63	
Lead (dissolved)	mg/L	109	0.001	0.216	0.001	0.008	0.026	0.0034
Manganese (dissolved)	mg/L	117	0.001	3.960	0.003	0.118	0.471	1.900
Molybdenum (dissolved)	mg/L	35	0.001	0.001	0.001	0.001	6.60×10^{19}	
Nickel (dissolved)	mg/L	75	0.001	0.029	0.001	0.002	0.005	0.011
Selenium (dissolved)	mg/L	35	0.01	0.01	0.01	0.01	3.52×10^{18}	0.011
Silver (dissolved)	mg/L	48	0.001	0.001	0.001	0.001	6.57×10^{19}	0.00005
Tin (dissolved)	mg/L	25	0.001	0.003	0.001	0.001	4.00×10^{4}	
Vanadium (dissolved)	mg/L	21	0.001	0.054	0.010	0.014	0.013	
Zinc (dissolved)	mg/L	115	0.003	2.130	0.028	0.137	0.302	0.008
Mercury (dissolved)	mg/L	38	0.0001	0.0001	0.0001	0.0001	6.87×10^{20}	0.0006
Aluminium (total)	mg/L	31	0.12	18.50	0.71	2.85	5.28	5.00
Antimony (total)	mg/L	62	0.001	0.001	0.001	0.001	6.56×10^{19}	
Arsenic (total)	mg/L	61	0.001	0.039	0.001	0.004	0.007	0.500
Barium (total)	mg/L	75	0.001	11.100	0.046	0.282	1.302	
Beryllium (total)	mg/L	61	0.001	0.081	0.001	0.003	0.010	
Boron (total)	mg/L	12	0.05	0.10	0.05	0.07	0.02	
Cadmium (total)	mg/L	64	0.0001	0.0032	0.0001	0.0002	0.0004	0.0100
Chromium (total)	mg/L	65	0.001	1.430	0.011	0.048	0.183	1.000
Cobalt (total)	mg/L	59	0.001	1.070	0.008	0.034	0.141	
Copper (total)	mg/L	75	0.002	13.400	0.070	0.294	1.539	1
Iron (total)	mg/L	64	0.05	1040.00	10.30	43.17	138.36	
Lead (total)	mg/L	70	0.001	0.362	0.018	0.031	0.049	0.100
Manganese (total)	mg/L	73	0.002	52.300	0.307	1.408	6.236	

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Guidelines*
Molybdenum (total)	mg/L	64	0.001	0.002	0.001	0.001	2.44×10^{4}	0.150
Nickel (total)	mg/L	58	0.001	1.340	0.010	0.043	0.178	1.000
Selenium (total)	mg/L	15	0.01	0.01	0.01	0.01	0.00	0.02
Silver (total)	mg/L	26	0.001	33.400	0.001	8.893	11.529	
Vanadium (total)	mg/L	9	0.01	0.01	0.01	0.01	0.00	
Zinc (total)	mg/L	75	0.005	1.600	0.202	0.355	0.381	20.000
Mercury (total)	mg/L	12	0.0001	0.0001	0.0001	0.0001	2.83×10^{20}	0.0020

Note: values shaded grey in the table above are exceedances of the relevant guideline

* ANZECC Guideline values can be found in the following sections/tables of the ANZECC Guidelines:

- pH, total nitrogen and total phosphorus – upland rivers in Table 3.3.4
- Conductivity and turbidity – upland & lowland rivers in Table 3.3.5
- Dissolved calcium – Section 4.3.3.1
- Dissolved magnesium – Section 4.3.3.2
- Dissolved sulphate – Section 4.3.3.4
- Nitrate as N – Table 3.4.1 using conversion factor in Section 4.3.3.3
- Nitrite as N – Section 4.3.3.3 using conversion factor
- Total dissolved solids – Table 4.3.1
- Dissolved metals – 95% protection level in Table 3.4.1
- Total metals and fluoride – Table 4.3.2

Stream Morphology

AARC undertook two surveys to collect baseline stream morphology data from the Project site and surrounding area between 2 and 7 June 2008 and 7 to 9 April 2010. Full details of these surveys are contained in the Surface Water Quality, Stream Morphology and Stream Sediments Report available in Appendix Q.

Locations of the stream morphology survey sites for both surveys are shown in Figure 4.34 (Project Site) and Figure 4.35 (Access Road).

To ensure that waterways of various sizes (i.e. stream orders) were sampled, a hierarchical ordering system was used (Conrick and Cockayne 2001). A second order stream is formed by the joining of two first order-streams, the junction of two second order streams forms a third order stream, and so on. This system is illustrated in Figure 4.33.

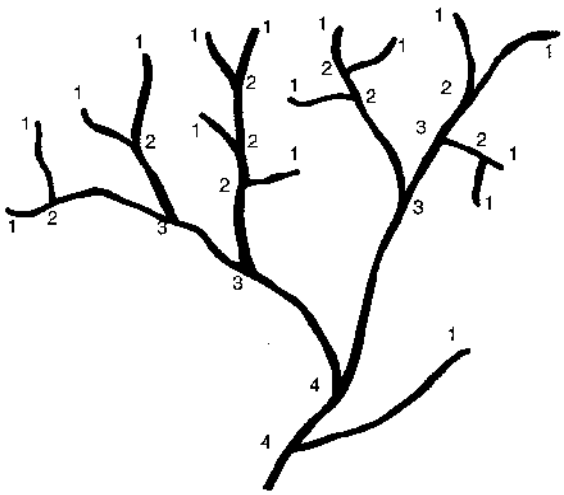


Figure 4.33 Method of Determining Stream Order

The Project site contains primarily small, narrow first order streams. Larger waterways (second, third and fourth order streams) exist to the east and west of the Project site.

Morphology data was collected by taking cross-sections of the watercourses. At each cross-section, the following details were noted:

- Depth of channel;
- Width of channel;
- Slope of banks;
- Stability of banks;
- Stream substrate type including a sediment sample;
- Details of water (if present) including colour, depth and a sample;
- Overhangs;

- Debris and tree roots; and
- Vegetation either within the channel or on the banks (i.e. the surrounding vegetation).

In addition, photographs were taken of the water channel cross-section described. These locations were recorded using GPS data and this arrangement will allow for direct comparison between this survey and any future monitoring activities.

All streams surveyed are classed as upland ephemeral streams, with moderate anthropogenic disturbances and associated impacts. First and second order streams were narrow in width and gently sloping, and often stabilised by established vegetation (see Photo Plate 4.9 and Photo Plate 4.10). Each stream consisted of sandy to rocky substrate within the creek beds and dry woodland type vegetation (Cloncurry Box or Snappy Gum open woodlands) along creek banks. First and second order streams generally occurred along the toe of hillslopes within the Project site.

A fourth order stream was indentified to the east of the Project within the Dugald River at one of the access road crossings. This stream contained sections of riffle and pool bed habitats. Bottom substrate was sandy and bank slopes were steeper than first and second order streams. Dominant woody vegetation at the fourth order stream was River Red Gum with associated Swamp Box and Weeping Teatree (see Photo Plate 4.11 and Photo Plate 4.12).

Stream morphology field data and a photo from each site from both surveys is provided in the full report available in Appendix Q.

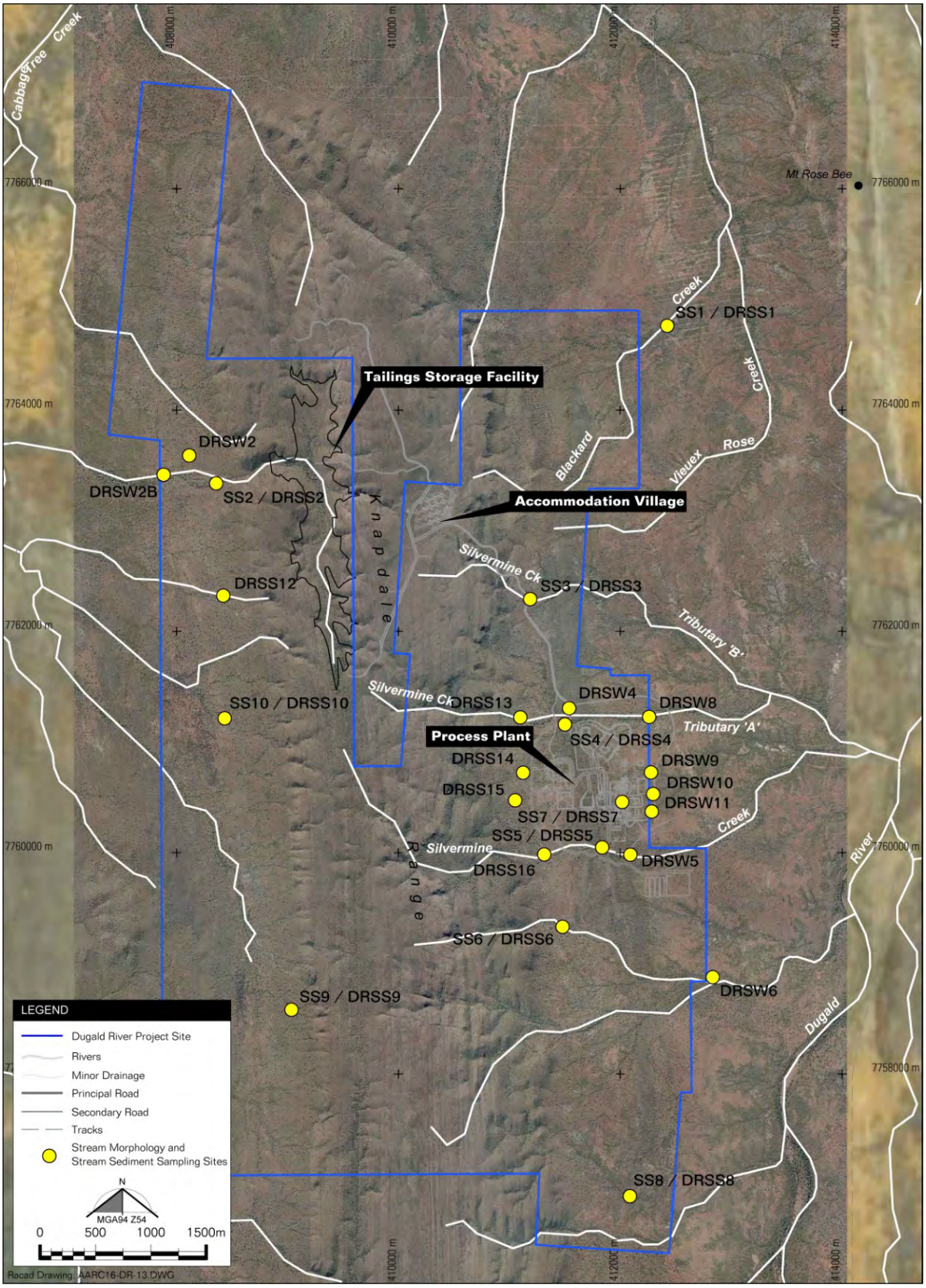


Figure 4.34 Stream Morphology and Stream Sediment Sampling Sites (Project Site)

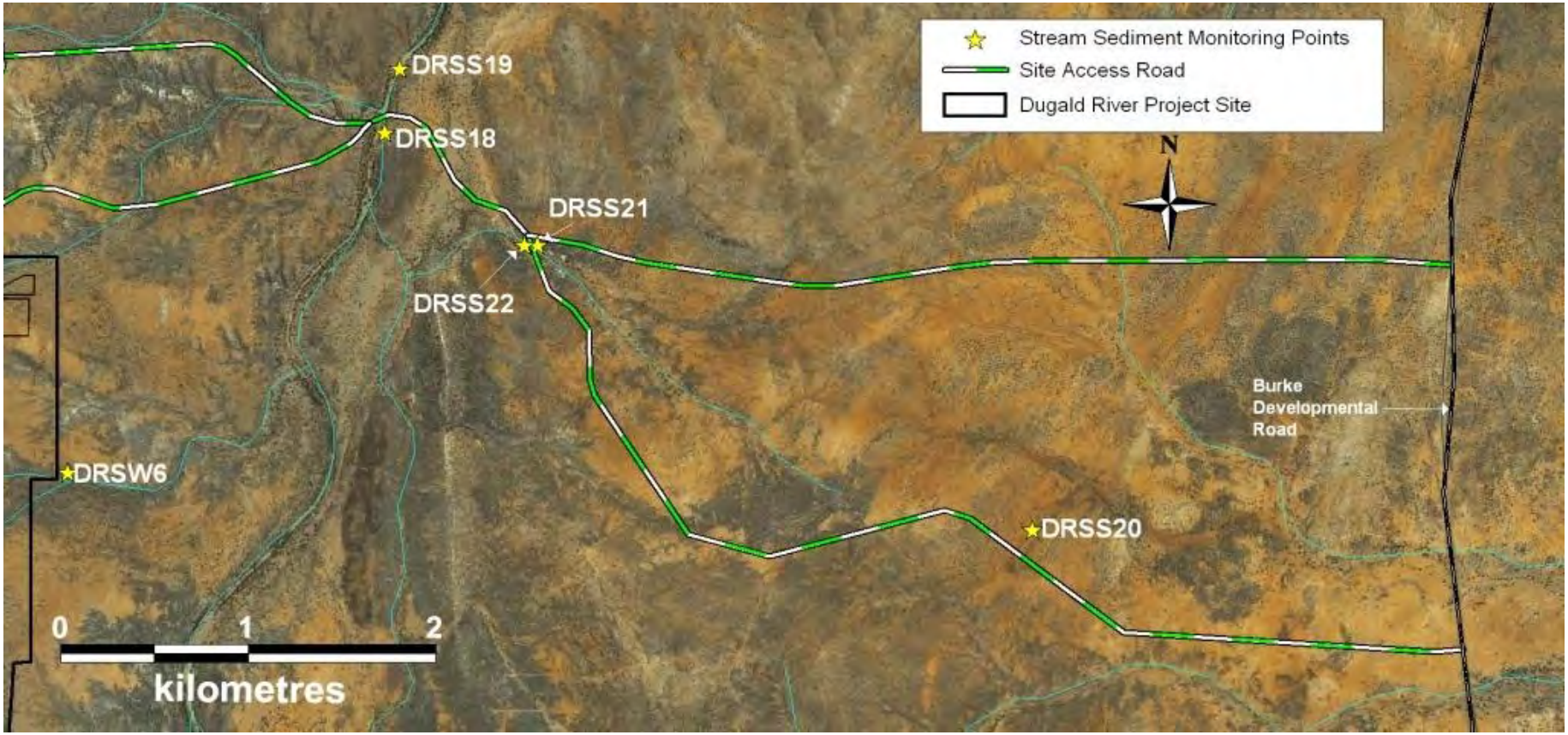


Figure 4.35 Stream Morphology and Stream Sediment Sampling Sites (Access Road)

Photo Plate 4.9 First Order Stream at Site DRSS15

Photo Plate 4.10 First Order Stream at Site DRSS9

Photo Plate 4.11 Fourth Order Stream – Dugald River near Powerline Corridor

Photo Plate 4.12 Fourth Order Stream at Site DRSS19

Stream Sediments

Baseline data on stream sediments within the Project site and access road corridor was collected during two surveys conducted from 2 to 7 June 2008 and 7 to 9 April 2010. Full details are contained in the Surface Water Quality, Stream Morphology and Stream Sediments Report available in Appendix Q.

Locations of the stream sediment sample survey sites for both surveys are shown in Figure 4.34 (Project Site) and Figure 4.35 (Access Road).

Stream sediment samples were collected by running a 100 m transect along the centre of the stream. A stream sediment sample of approximately 200 grams was collected every 20 m along each transect. The 5 samples taken from each sample site were combined in a bucket and thoroughly mixed to form a composite sample. All stream sediment samples were then sent to Australian Laboratory Services Group (ALS), a NATA registered laboratory, to be analysed for the following parameters:

- Antimony
- Arsenic
- Barium
- Beryllium
- Cadmium
- Chromium
- Cobalt
- Copper
- Lead
- Manganese
- Mercury
- Nickel
- Selenium (2010 samples only)
- Silver
- Thorium (2010 samples only)
- Uranium (2010 samples only)
- Vanadium
- Zinc
- Particle Size Analysis (% cobbles (2010 only), gravel, sand, silt and clay)

Statistical analysis was undertaken on the stream sediment toxicant results to determine the minimum, maximum, median, average and standard deviation for each parameter in the dataset. The analysis results were compared to the ANZECC Guidelines for Aquatic Ecosystems default stream sediment low and high triggers.

The rationale behind particle size analysis is that it will allow for the future comparison of monitoring results as a significant difference in distribution of particle sizes in sediment samples can distort the comparison of metal concentrations from one site to another. The particle size analysis was analysed as percentages of cobbles (2010 only) gravel, sand, silt and clay at each sample site.

The substrates of the streams within the Project site are typically medium sand to course gravel. This is reflected in the results of the particle size analysis assessment undertaken on the sediment samples taken during the surveys (Table 4.14).

The samples were taken from a range of creeks, streams and drainage lines across the site at the particle size analysis results are consistent with the type of watercourse sampled. Creeks and stream that were predominantly sand and/or gravel included Sites SS1, DRSS1, SS3, DRSS3, SS5 and DRSS5. Small drainage lines around the proposed processing plant and along the access road contained high percentages of silt and clay (Sites SS7, DRSS7, DRSW9, DRSW14, DRSS19 and DRSS20).

A summary of the results of the particle size analysis are shown in Table 4.14 below. The highlighted cells indicate the primary particle type. The full laboratory results are contained in the report in Appendix Q.

Table 4.14 Particle Size Analysis

Sample Site	Clay (<2 µm)	Silt (2-60 µm)	Sand (0.06-2.00 mm)	Gravel (>2mm)	Cobbles (>6cm)
SS1-A	0%	1%	15%	84%	0%
SS1-B	1%	1%	47%	51%	0%
DRSS1	5%	5%	69%	21%	0%
SS2-A	3%	5%	64%	28%	0%
SS2-B	3%	7%	65%	25%	0%
DRSS2	7%	2%	90%	1%	0%
DRSW2	6%	4%	82%	8%	0%
DRSW2B	7%	12%	55%	26%	0%
SS3-A	0%	2%	21%	77%	0%
SS3-B	1%	2%	32%	65%	0%
DRSS3	3%	2%	31%	64%	0%
SS4-A	0%	0%	7%	93%	0%
SS4-B	0%	1%	21%	78%	0%
DRSS4	5%	7%	62%	26%	0%
DRSW4	5%	7%	60%	28%	0%
SS5-A	1%	2%	29%	68%	0%
SS5-B	1%	3%	32%	64%	0%
DRSS5	5%	14%	40%	41%	0%
DRSW5	4%	7%	53%	36%	0%
SS6-A	1%	5%	33%	61%	0%
SS6-B	1%	5%	42%	52%	0%
DRSS6	10%	10%	78%	2%	0%
DRSW6	6%	5%	78%	11%	0%
SS7	16%	27%	51%	6%	0%
DRSS7	7%	30%	37%	26%	0%
SS8-A	1%	1%	38%	60%	0%
SS8-B	0%	2%	28%	70%	0%
DRSW8	5%	4%	78%	13%	0%
DRSS8	4%	13%	48%	35%	0%
SS9-A	2%	6%	48%	44%	0%
SS9-B	1%	2%	24%	73%	0%
DRSS9	13%	20%	65%	2%	0%
DRSW9	14%	29%	49%	8%	0%
SS10-A	2%	6%	54%	38%	0%
SS10-B	1%	3%	33%	63%	0%
DRSS10	10%	9%	79%	2%	0%

Sample Site	Clay (<2 µm)	Silt (2-60 µm)	Sand (0.06-2.00 mm)	Gravel (>2mm)	Cobbles (>6cm)
DRSW10	7%	21%	55%	17%	0%
DRSS11	6%	35%	44%	15%	0%
DRSS12	9%	13%	73%	5%	0%
DRSS13	16%	35%	36%	13%	0%
DRSS14	9%	28%	41%	22%	0%
DRSS15	5%	2%	75%	18%	0%
DRSS16	10%	10%	52%	28%	0%
DRSS18	6%	5%	83%	6%	0%
DRSS19	11%	8%	81%	0%	0%
DRSS20	14%	2%	81%	3%	0%
DRSS21	2%	0%	95%	3%	0%
DRSS22	4%	1%	94%	1%	0%

AAA Grey highlighted cells indicates the primary particle type

The results of the sediment metal analysis were compared to the ANZECC Guidelines default stream sediment quality guidelines from Table 3.5.1 of the guidelines. A summary of the results for each site are presented below and in Table 4.15. Full results are available in the Surface Water Quality, Stream Morphology and Stream Sediments Report provided in Appendix Q.

Results of the stream sediment analysis determined that:

- The level of mercury was below detectable limits for all the sediment samples analysed;
- The level of chromium was below ANZECC Guidelines default stream sediment low and high triggers;
- The levels of cadmium, copper and silver exceeded the ANZECC Guidelines default stream sediment low trigger only, as follows:
    - Cadmium – Sites SS5, DRSS5, SS7 and DRSS7;
    - Copper – DRSW4, DD5, DRSW6, SS7, SS8, SS9, DRSW9, SS10 and DRSW10; and
    - Silver low trigger exceedances were recorded at all sites however all results were also below the limit of reporting.
- The levels of arsenic, lead, nickel and zinc exceeded the ANZECC Guidelines default stream sediment low and high triggers, as follows:
    - Arsenic low trigger exceedances were recorded at DRSW2, DRSW4, SS5, DRSS5, SW5, SS8 and SS10. Arsenic high trigger exceedances were recorded at DRSW6, SS7, DRSS7 and DRSW10;
    - Lead low trigger exceedances were recorded at DRSW2, SS5, DRSW5, SS9 and SS10. Lead high trigger exceedances were recorded at DRSW4, SS7 and DRSW10;

- Nickel low trigger exceedances were recorded at SS5, SS7, SS8, SS9, DRSW9, SS10, DRSW10 and DRSS13. One nickel high trigger exceedance was recorded at SS10 ; and

- Zinc low trigger exceedances were recorded at DRSW4, DRSW2, DRSW8, SS9 and SS10. Zinc high trigger exceedances were recorded at SS5, DRSS5, DRSW5, SS7, DRSS7 and DRSW10.

- Barium, beryllium, cobalt, manganese, selenium, thorium, uranium and vanadium do not have corresponding ANZECC Guidelines default stream sediment low and high triggers.

Analysis of the results indicated that there was an outlier result in the zinc concentration (26,900 mg/kg zinc at site DRSS7 on 7/4/2010). The ANZECC (2000) Guidelines for Water Quality Monitoring and Report indicate in Section 6.2.2.2 that extreme outliers may be removed from the dataset. Extreme outliers are defined as “those that are four or more standard deviations from the mean”. Calculations indicate that the result in question is outside four standard deviations from the mean as shown in Figure 4.36. The extreme outlier has been removed from the dataset for further calculations.

A summary of the metal analysis results are presented in Table 4.15, without the extreme zinc concentration result recorded at DRSS7. Full details of all results are provided in the report in Appendix Q.

Table 4.15 Stream Sediment Quality Results

Parameter	Units	Data Points	Minimum	Maximum	Median	Average	Standard Deviation	ANZECC Low Trigger	ANZECC High Trigger
Arsenic	mg/kg	48	5	184	10	25	38	20	70
Barium	mg/kg	48	30	480	75	116	99	-	-
Beryllium	mg/kg	48	1.0	3.0	1.0	1.2	0.4	-	-
Cadmium	mg/kg	48	1.0	7.0	1.0	1.3	1.0	1.5	10
Chromium	mg/kg	48	6.0	36.0	16.5	17.3	5.8	80	370
Cobalt	mg/kg	48	3.0	49.0	11	15.7	11.9	-	-
Copper	mg/kg	48	5	219	31	55	54	65	270
Lead	mg/kg	48	5	747	12	68	155	50	220
Manganese	mg/kg	48	105	5350	631	1070	114	-	-
Mercury	mg/kg	48	0.1	0.1	0.1	0.1	0.0	0.15	1
Nickel	mg/kg	48	3.0	59.0	14.0	16.7	10.3	21	52
Selenium	mg/kg	29	5	5	5	5	0	-	-
Silver	mg/kg	48	2	2	2	2	0	1	3.7
Thorium	mg/kg	29	1.2	24.0	5.1	4.3	4.4	-	-
Uranium	mg/kg	29	0.2	2.6	1.0	0.9	0.6	-	-
Vanadium	mg/kg	48	14	86	36	39	16	-	-
Zinc	mg/kg	47	5	9630	20	627	1734	200	410

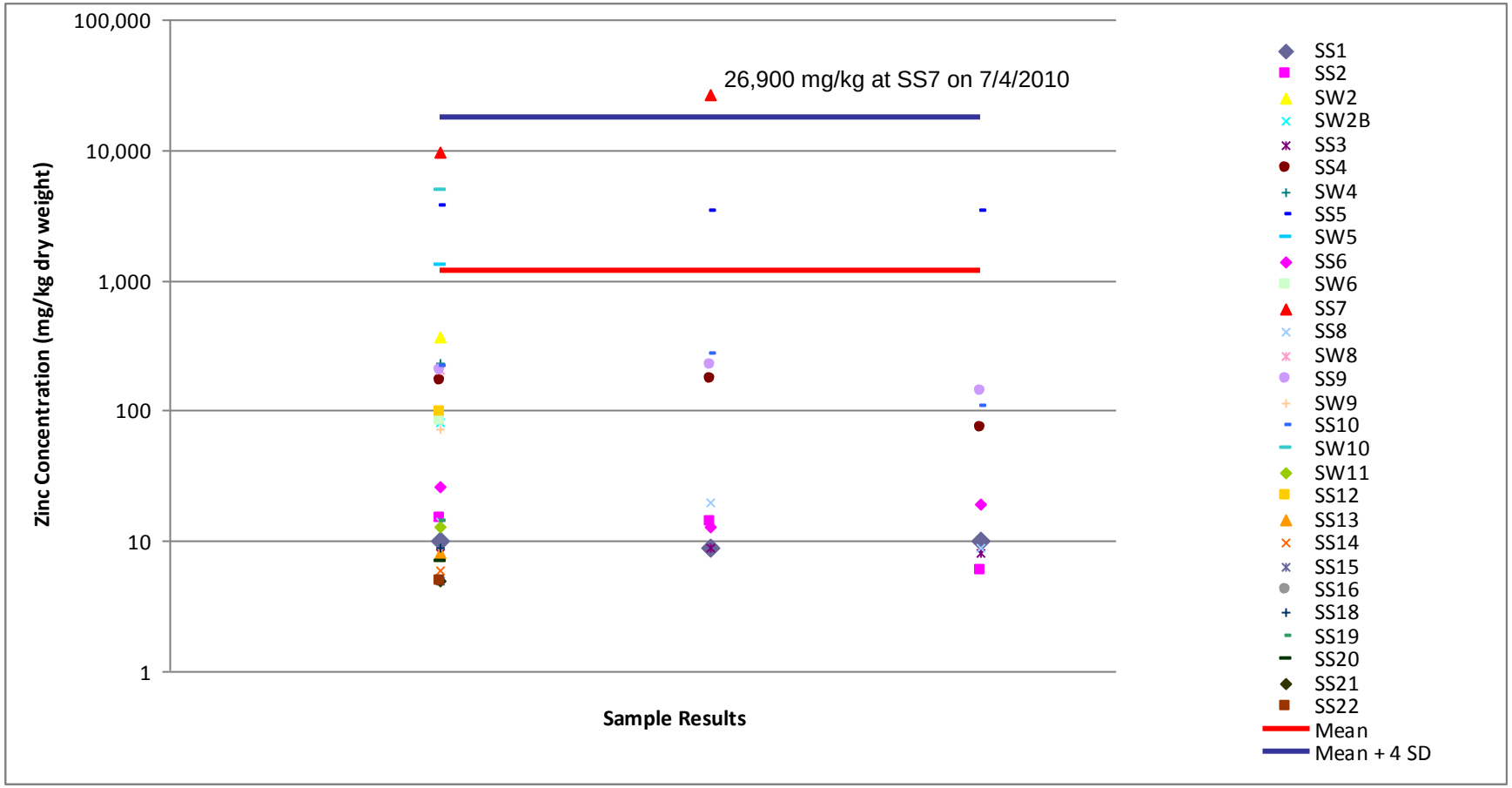


Figure 4.36 Graphical Representation of Zinc Outlier Results at DRSS7

4.4.1.2 Groundwater

A groundwater assessment was undertaken by Rob Lait and Associates and is contained in Appendix R of this EIS. The groundwater in the vicinity of the Project site is alkaline and slightly brackish as a result of the influence of calc-silicate rocks and the arid environment in which the groundwater occurs. Groundwater in the vicinity of the Project is used for cattle watering.

The environmental values applicable to groundwater on the Project Site, as stated in the *Environmental Protection (Water) Policy 2009*, are as follows:

> Section 6 (2) (g) – for waters that may be used for agricultural purposes - the suitability of the water for agricultural purposes (cattle grazing); and
>
> Section 6 (2) (i) – for waters that may be used for drinking water - the suitability of the water for supply as drinking water;

Regional Groundwater Bores

In order to gauge the extent of groundwater usage on a regional perspective, discussions were held with regional groundwater staff of DERM. These discussions, and data on registered bores in the district, were used to assess the level of groundwater usage in terms of extraction and enable a map to be compiled of groundwater bores within a 25 km radius of the project area.

In many cases the bores within a 55 km radius of the project area are quite old (some in excess of 90 years). Often the records for the bores are non-existent or very sketchy. A full chemical analysis exists for only one of the bores of the 45 bores for which records exist in the DERM groundwater database. Regardless of the patchy nature of the private bore data, useful background information was obtained from it:

- Bore depths range from 10.1 m to 230 m (although Bores 118753, 118754 and 118754 are converted mineral exploration bores);
- The median bore depth is 31.5 m;
- Groundwater supplies range from 0.13L/s to 9.3L/s with a median value of 0.98L/s;
- Groundwater supplies in excess of 2L/s are the exception rather than the rule; and
- The description of groundwater quality is very variable.

It is concluded from the private bore data that the geological formations within 25 km of the Project are not highly productive and the majority of the groundwater occurs at shallow depths.

A census of privately owned groundwater facilities (both bores and wells) was carried out in April 2008. This census permits an understanding of groundwater occurrence, groundwater use and groundwater quality in the Dugald River area.

Forty four (44) bores were visited during the census (Figure 4.37). Where possible the standing water level in the bores, and electrical conductivity and pH of the groundwater were measured. Many facilities in the surveyed area are unregistered but nevertheless provide valuable information on regional groundwater quality.

It can be seen from these results (Table 4.16) that generally the groundwater in the region is alkaline and slightly brackish, no doubt as a result of the influence of calc-silicate rocks and the arid environment in which the groundwater occurs.

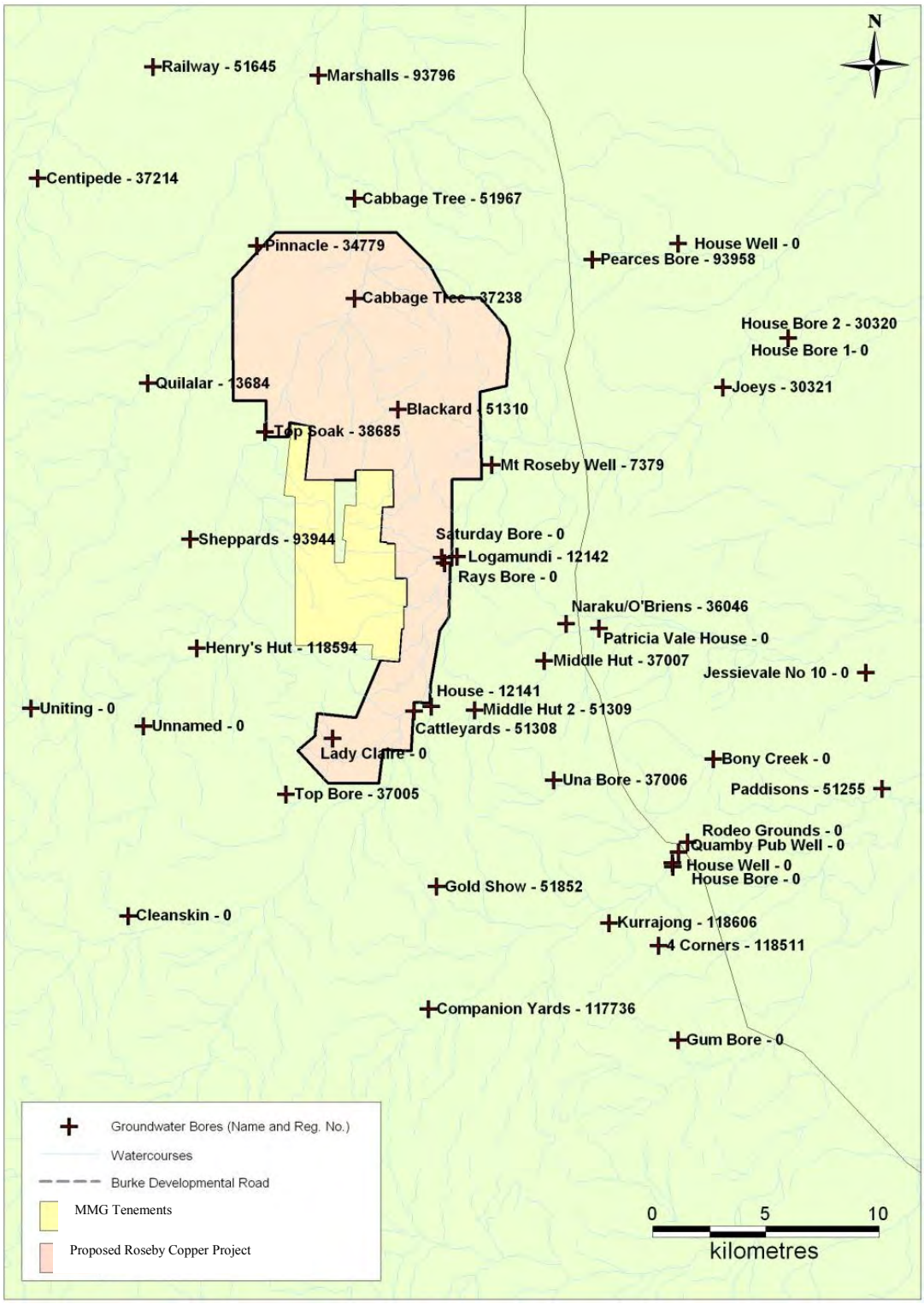


Figure 4.37 Locations and Registered Number of Bores Visited in 2008 Census

Table 4.16 Field Groundwater Quality Measurements – April 2008

Registered Number	Bore Name	Electrical conductivity (µS/cm)	pH
7379	Mt Roseby well	990	7.9
12142	Longamundi	1045	8.2
30320	House bore 1	459	7.01
30321	Joeys	781	8.42
34779	Pinnacle	1002	7.05
36046	Naraku/O'Briens	3390	8.24
37005	Top bore	1190	7.87
37006	Una bore	1990	8.33
37007	Middle hut	2030	8.12
37214	Centipede	1317	7.94
37238	Cabbage tree	571	7.83
38685	Top soak	501	8.01
51255	Paddisons	1007	8.89
51308	Cattleyards	1180	7.6
51309	Middle hut 2	1815	7.2
51310	Blackard	1444	7.05
51645	Railway	1068	7.78
51852	Gold show	2490	7.02
51967	Cabbage Tree	1890	7.44
93796	Marshalls	1390	8.4
93944	Sheppards	985	7.58
93958	Pearces bore	2480	8.3
118511	4 corners	1847	8.86
118594	Henrys hut	702	7.83
118606	Kurrajong	816	9.4
118736	Companion yards	1091	7.38
	House bore 2	459	7.01
	House well	886	8.02
	Patricia vale house	1063	8.7
	Bony Creek	853	8.5
	Rodeo Grounds	848	8.33
	Jessievale no. 1	2940	9.2
	Gum bore	4530	9.45
	House bore	688	7.62
	Uniting	1984	7.54
	Quamby Pub well	933	7.85

Local Groundwater Monitoring Bores

A suite of six additional groundwater monitoring bores (MB1 – MB6) was installed at the Dugald River Project late in 2008 to complement the data from the private bores in the area and previously drilled exploration bores (Figure 4.38).

Six of the groundwater monitoring bores (Froggy Bore (GWBF), Saturday Bore (SB1), MB1, MB2, MB3 and MB4) will monitor the more permeable aquifer zones within the Corella Formation and will surround the processing plant and other mining infrastructure to the east of the ore body (Figure 4.38).

The remaining two groundwater monitoring bores (MB5 and MB6) are alongside the drainage feature that exits the Knapdale Range to the west of the tailings storage dam (Table 4.25).

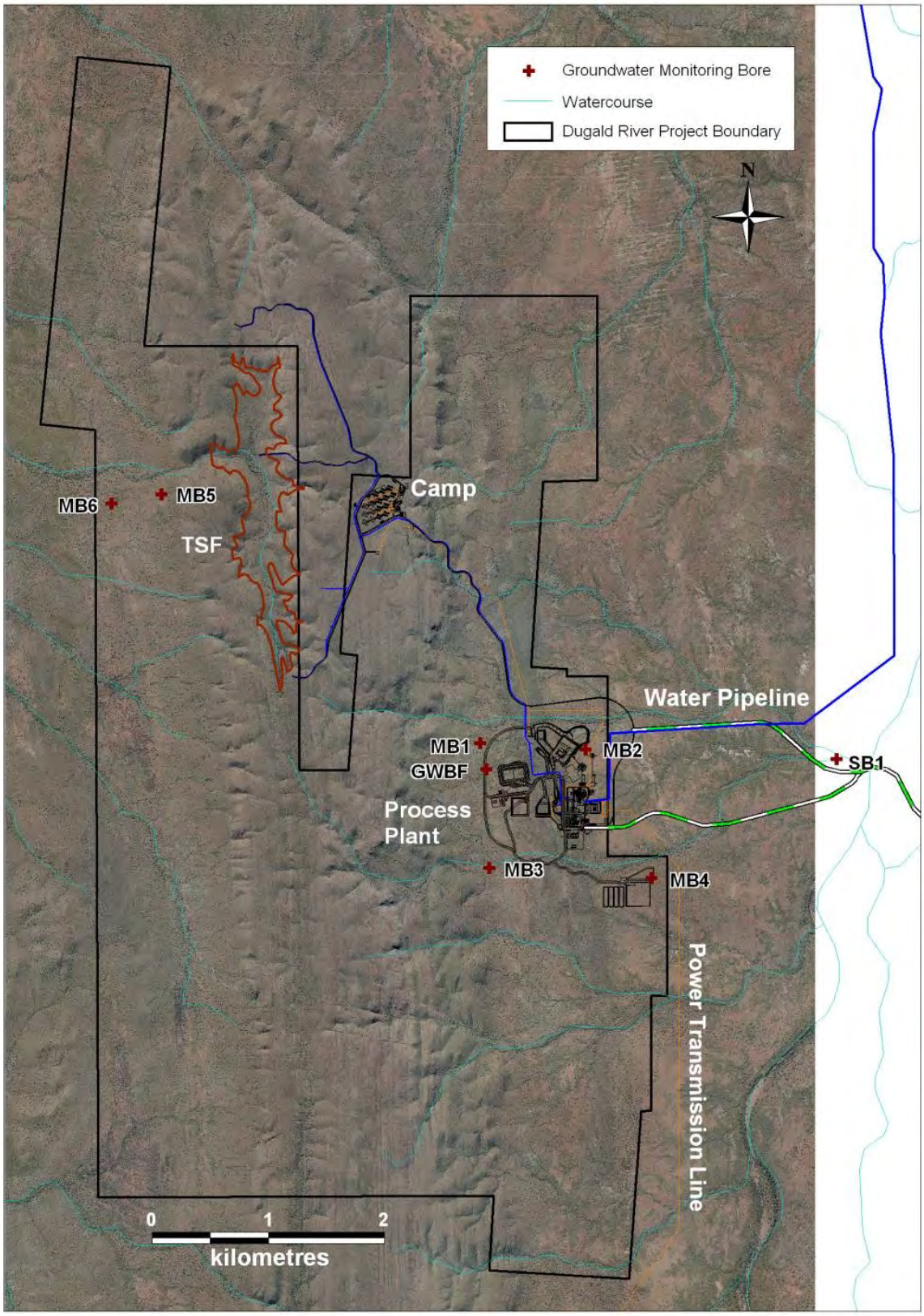


Figure 4.38 Groundwater Monitoring Bore Locations

During the site visit groundwater levels and groundwater quality were measured in a selected number of exploration bores on and surrounding the Project site and the following points were noted:

- The average depth to groundwater in March 2008 was 10.25 m below ground level. By July 2008 the average depth to groundwater was 12.93 m below ground level. The maximum depth of incision of the major watercourses is about 6 m. Therefore, the groundwater levels were generally approximately 4 m below the bed of the watercourses. No groundwater discharge to the watercourses can occur as a result;

- The production bores at the Project (GWBF, Saturday Bore, Ray's Bore, WB06 and DR349) were also assessed. All of these bores are located in close proximity to major watercourses at the site. None of the exploration bores that were drilled more than about 50m from the major watercourses intersected groundwater supplies of any significant quantity of quality. It is concluded that the aquifers at the Project are therefore structurally controlled; and

- According to the Site Senior Executive, Mr Tim Lane, the supplies from GWBF, WB06 and DR349 all decline after about 24 hours pumping and natural replenishment may take several days. This suggests that the production bores exploit aquifer sequences of low to moderate permeability.

Hydrogeological Regime

Based on historical groundwater studies and observations made during exploration drilling programs and the site inspection, the hydrogeological regime at the Dugald River Project site can be summarised as follows:

- The prime aquifer occurs within fractured calc-silicate rocks in the Corella Formation at the geological boundary between it and the Dugald River Slate above the mineralized zone. Groundwater occurs in fractures, joints, solution channels and along bedding planes (secondary porosity) to a depth of approximately 70m;

- Based on recent groundwater level and rainfall measurements it is considered that the prime aquifer is confined;

- It appears that there are no aquifers of any significance in the Lady Claire Dolomite, which as discussed is locally referred to as the Footwall Limestone. The dolomite is not karstic therefore solution channels and cavities do not occur. Significant groundwater neither occurs nor is expected in the Lady Claire Dolomite;

- Very minor supplies of groundwater occur in the Dugald River Slate, and the groundwater that is present is saline and highly mineralized. This suggests only minor intervals with low permeability and hydraulic connectivity. Consequently any groundwater which is present resides in the mineralized rocks long enough to tend towards equilibrium with the sulphide-rich rocks;

- Hydraulic connectivity occurs within the Corella Formation but the permeability of the fractured rock aquifer varies;

- Groundwater within the prime aquifer (the calc-silicate rocks of the Corella Formation) appears to be structurally controlled. Moderately successful production bores have been developed and they occur along Silvermine Creek and its Tributary 'A';

- Two watercourses (Silvermine Creek and its Tributary 'A') have developed along zones of structural weakness along the east – west faulting that dominates the area. As a result the aquifer beneath these creeks is a zone of higher permeability. The aquifer beneath the interfluve (i.e. the region of higher land between two streams that are in the same drainage system) is a zone of lower permeability; and

- The Longsight Sandstone and Wallumbiulla Formation are part of the Eromanga Basin sequence and are not in hydraulic connection with the Dugald River Project aquifers.

Groundwater Recharge

The only mechanism for recharge to the prime aquifer at the Project is infiltration and deep percolation of rainfall.

Rainfall around Cloncurry is dominated by summer storms and floods. Aquifers are therefore replenished by episodic or flood recharge. During a major rainfall event, 80% of water not lost by evaporation may discharge as surface runoff (AGE 2002). Deep drainage will occur only as a result of exceptional circumstances.

It is assessed that recharge will be zonal at the Project. As the aquifer is likely to be unconfined and there are preferentially permeable zones associated with Silvermine Creek and its Tributary 'A' to the north, recharge is likely to be greater along these creeks and less on the interfluve.

The following may be deduced in regard to recharge to the aquifers at the Project:

- Recharge will only occur in the months in which rainfall potentially exceeds evaporation. On average there are no months in which this is the case. Notwithstanding this, recharge obviously does occur as groundwater facilities in the area have been operating since the early 1900's; and

- Due to the skeletal nature of the soil, the high proportion of runoff and the outcropping lithologies, recharge to the aquifers is probably as low as 1% of the aggregate January – February rainfall (Table 4.17). This figure, although low, is consistent with similar areas in north western Queensland.

Table 4.17 Annual Recharge Estimates

Month	Mean Monthly Rainfall (mm)	Mean Monthly Evaporation (mm)	Rainfall > Evaporation	Evaporation Exceedance factor	Recharge at 1% of Rainfall (mm)
Jan	140.35	347.2	no	2.5	1.40
Feb	117.6	277.2	no	2.4	1.18
Mar	82	282.1	no	3.4	0.82
Apr	21.9	225	no	10.3	0.22
May	12.3	164.3	no	13.4	0.12
Jun	7.25	129	no	17.8	0.07
Jul	3.45	136.4	no	39.5	0.03
Aug	3.6	182.9	no	50.8	0.04
Sep	5.75	240	no	41.7	0.06
Oct	19.95	310	no	15.5	0.20
Nov	26.65	324	no	12.2	0.27
Dec	72.15	362.7	no	5.0	0.72
Annual	512.95	2980.8		5.8	5.13

Groundwater Discharge

There was no evidence of salinisation or groundwater discharge observed during the site inspection. It is interpreted that because of a combination of factors, namely the water table is naturally deep, recharge to the fractured rock aquifers is minimal and the depth of incision of watercourses is shallow, natural groundwater discharge does not occur in the immediate vicinity of the Dugald River Project.

Groundwater Flow Direction

It can be seen from Figure 4.39 that groundwater at the Dugald River Project generally flows to the east and north east i.e. towards Dugald River. The gradient of the potentiometric surface is 0.009 which is typical of a low bulk permeability aquifer sequence.

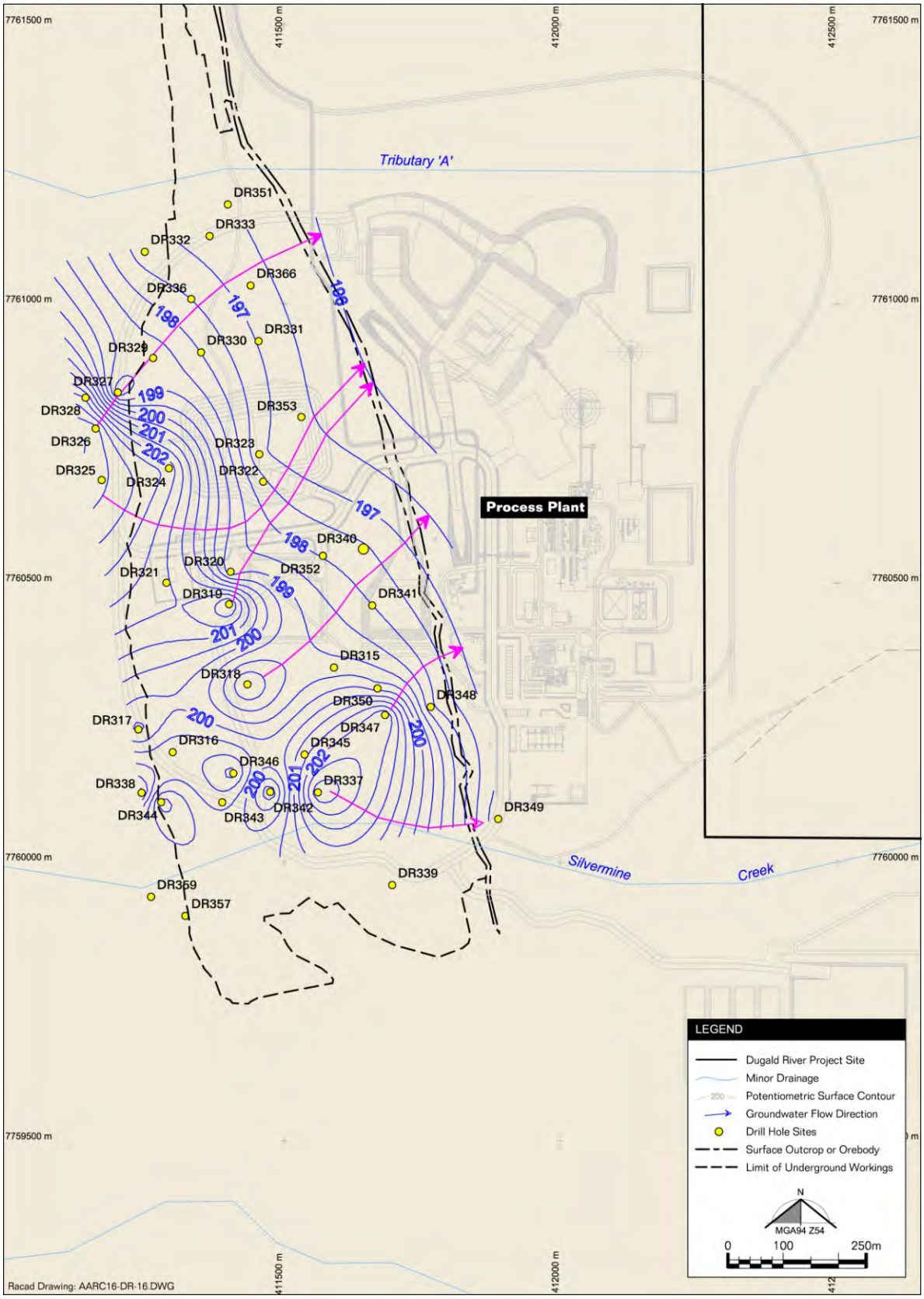


Figure 4.39 Potentiometric Surface Contour Map March 2008

Groundwater Quality

Groundwater quality parameters (pH and EC) were measured during the regional groundwater census. The results indicate that generally the groundwater in the region is alkaline and slightly brackish, probably as a result of the influence of calc-silicate rock and the arid environment.

The groundwater from the Corella Formation at the Project is dominantly of the Sodium – Bicarbonate type. The electrical conductivity of the groundwater varies from 590 to 1700 MircoSiemens per centimetre (µS/cm) and groundwater pH from 7 to 7.9. There is very little sulphate in the groundwater from these bores. The groundwater in the Dugald River Slate is saline and sulphate rich as it has come to chemical equilibrium with the ore body.

Groundwater samples have been retrieved from the dedicated groundwater monitoring bores on the Project at five individual monthly intervals since December 2009. The analyses of these samples shows that the groundwater quality varied very little over the 2009-2010 wet season. As there is such uniformity within the analysis results for each individual bore, only the groundwater analyses from the March 2010 sampling event are shown in Table 4.18. Total values for analytes are signified with the suffix –T. Filtered values for analytes are signified with the suffix –D. Full analysis certificates for the five sampling events are shown as an appendix to the report in Appendix R.

Table 4.18 Groundwater Analyses From Sampling Event Of 16th March 2010

Analyte	Units	ANZECC Livestock Guideline Value	Station							
			MB1	MB2	MB3	MB4	MB5	MB6	FB1	SB1
pH-LAB	pH units		7.69	7.60	7.84	7.79	7.15	7.45	7.59	7.36
EC-LAB	µS/cm		1010	880	1470	569	1550	931	1660	1650
TDS	mg/L	4000	NR*	543	999	433	1070	691	1070	1090
TSS	mg/L		6	8	6	4	8	4	2	6
Hydroxide Alkalinity	mg/L		< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1
Carbonate Alkalinity	mg/L		28	67	79	< 1	< 1	< 1	< 1	< 1
Bicarbonate Alkalinity	mg/L		401	297	449	241	561	492	627	571
Total Alkalinity	mg/L		429	364	528	241	561	492	627	571
Sulphate	mg/L	1000	32	47	89	20	147	8	47	109
Fluoride	mg/L	2	NA	NA	NA	NA	NA	NA	NA	NA
Chloride	mg/L		23	20	74	17	102	26	206	139
Ca-D	mg/L	1000	60	70	42	37	112	80	70	72
Mg-D	mg/L		44	33	72	14	91	29	64	48
Na-D	mg/L		76	60	172	61	84	84	194	215
K-D	mg/L		8	5	11	3	12	11	13	4
Mg-T	mg/L		NA	NA	NA	NA	NA	NA	NA	NA
Al-D	mg/L	5	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Sb-D	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
As-D	mg/L		< 0.001	< 0.001	0.001	0.001	0.003	0.002	0.003	0.002
Ba-D	mg/L		0.043	0.083	0.092	0.035	0.046	0.536	0.050	0.097
Be-D	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cd-D	mg/L		<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co-D	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001

Analyte	Units	ANZECC Livestock Guideline Value	Station							
			MB1	MB2	MB3	MB4	MB5	MB6	FB1	SB1
Cr-D	mg/L		< 0.001	< 0.001	0.001	< 0.001	0.004	0.001	0.003	0.004
Cu-D	mg/L		0.004	0.006	0.007	0.006	0.009	0.003	0.005	< 0.001
Hg-D	mg/L		0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mn-D	mg/L		0.006	0.070	0.002	0.003	0.916	0.634	0.005	0.357
Ni-D	mg/L		< 0.001	< 0.001	< 0.001	0.001	< 0.001	< 0.001	< 0.001	< 0.001
Pb-D	mg/L		0.003	0.004	0.018	0.004	0.006	0.004	< 0.001	0.002
V-D	mg/L		< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.04	0.01
Zn-D	mg/L		0.012	0.044	0.036	0.035	0.021	0.010	0.008	< 0.005
Mo-D	mg/L	0.15	0.010	0.002	0.007	0.001	0.006	0.012	0.002	0.005
Se-D	mg/L		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ag-D	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
B-D	mg/L	5	0.08	< 0.05	0.09	< 0.05	0.05	0.06	0.08	0.06
Fe-D	mg/L		< 0.05	< 0.05	< 0.05	< 0.05	0.06	0.18	< 0.05	0.16
Al-T	mg/L	5	0.04	0.02	0.02	< 0.01	0.12	0.03	< 0.01	< 0.01
Sb-T	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
As-T	mg/L	0.5	< 0.001	< 0.001	0.002	< 0.001	0.003	0.001	0.003	0.002
Ba-T	mg/L		0.046	0.085	0.098	0.034	0.048	0.558	0.050	0.104
Be-T	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cd-T	mg/L	0.01	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Co-T	mg/L	1	< 0.001	< 0.001	< 0.001	< 0.001	0.002	< 0.001	< 0.001	< 0.001
Cr-T	mg/L	1	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Cu-T	mg/L	1	0.007	0.018	0.018	0.008	0.018	0.008	0.008	0.001
Hg-T	mg/L	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mn-T	mg/L		0.03	0.075	0.004	0.004	0.973	0.662	0.005	0.383
Ni-T	mg/L	1	< 0.001	0.001	< 0.001	0.001	0.001	< 0.001	< 0.001	0.001
Pb-T	mg/L	0.1	0.005	0.006	0.023	0.010	0.011	0.006	< 0.001	0.003
V-T	mg/L		< 0.01	< 0.01	0.04	< 0.01	< 0.01	< 0.01	0.04	< 0.01
Zn-T	mg/L	20	0.014	0.052	0.030	0.036	0.031	0.016	0.009	0.008
Mo-T	mg/L	0.15	0.011	0.002	0.008	0.001	0.007	0.013	0.002	0.006
Se-T	mg/L		< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Ag-T	mg/L		< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
B-T	mg/L	5	0.08	< 0.05	0.08	< 0.05	< 0.05	0.06	0.08	0.06
Fe-T	mg/L		0.26	0.08	< 0.05	< 0.05	0.19	0.24	< 0.05	0.22

Notes: * NR = no result

None of the analytes shown in Table 4.18 exceeds the ANZECC livestock guideline values.

Permeability Testing

Pump out tests were conducted on the six new groundwater monitoring bores on the Project site (MB1 – MB6) in December 2009. Aquifer permeability was assessed from the drawdown and / or recovery measurements from those tests.

From the drilling results and the discussion of rainfall and groundwater level response presented previously, it is assessed that the aquifers in the dedicated groundwater monitoring bores are confined. So that there could be a basis for comparison between the drawdown data and recovery data the Theis and Jacob method for confined aquifers was used to assess aquifer permeability in

every case. This is valid as groundwater recovery is the equivalent of the aquifer or supplying water to the bore at an equivalent rate to the rate at which it was removed by pumping.

Table 4.19 shows the calculated values for aquifer transmissivity and aquifer permeability for the dedicated groundwater monitoring bores.

Table 4.19 Calculate Aquifer Transmissivity and Permeability Values

Bore Identifier	Aquifer Transmissivity m^2/day	Aquifer Permeability m/day	Aquifer Permeability m/second
MB1	5.88×10^{-4}	7.53×10^{-6}	8.71×10^{-11}
MB2	3.18×10^{1}	4.08×10^{-1}	4.72×10^{-6}
MB3	2.29×10^{1}	2.60×10^{-1}	3.01×10^{-6}
MB4	4.06×10^{0}	7.52×10^{-2}	8.70×10^{-7}
MB5	7.19×10^{0}	9.21×10^{-2}	1.07×10^{-6}
MB6	1.73×10^{-1}	2.23×10^{-3}	2.58×10^{-8}

The calculated values indicate that the aquifers adjacent to incised drainage features on the flood plain are of quite low permeability. The lowest permeability values for MB1 and MB6 are in accord with the driller's observations of meagre supplies in these bores.

ATC investigated foundations for the proposed tailings storage dam in December 2008[2]. During that investigation boreholes (BH1 to BH4) were drilled to depths of about 25m at four locations. The holes intersected the Knapdale Quartzite. Groundwater was intersected in two of the boreholes (BH1 and BH4) but standing water levels were unable to be measured accurately owing to water introduced into the holes. The ATC report estimates that the depth to standing groundwater is about 7m below ground surface.

A permeability testing program consisting of falling head tests in the upper part of the holes and packer tests in the lower part of the holes was undertaken. Table 4.20 shows the calculated permeability values of the Knapdale Quartzite from the ATC testing program.

[2] Australian Tailings Consultants, February 2009. DUGALD RIVER PROJECT FEASIBILITY STUDY TAILINGS STORAGE FACILITY PRELIMINARY GEOTECHNICAL INVESTIGATION.

Table 4.20 Calculated Permeability Values From Preliminary Geotechnical Investigation

Borehole Identifier	Easting (GPS)*	Northing (GPS)*	Borehole Elevation (m AHD)	Tested interval from – to (m)	Calculated permeability (m/second)
BH1	408953	7763331	206.5	0 – 6.1	2.4×10^{-7}
				10 - 15	3.5×10^{-6}
				15 - 20	3.7×10^{-7}
				20 - 25	4.6×10^{-7}
BH2	408935	7764252	212.0	0 – 2.5	1.0×10^{-5}
				2.5 – 4.7	4.9×10^{-7}
				5.5 – 10.1	4.9×10^{-6}
				10 – 15.9	7.8 x 10-6
				15 - 20	1.8×10^{-7}
BH3	408894	7763371	210.0	0 - 3	1.03×10^{-7}
				0 - 6	3.4×10^{-8}
				5 - 10	1.4×10^{-8}
BH4	408802	7763323	203.0	0 - 5	4.0×10^{-8}
				11.5 - 15	4.12×10^{-7}

Note: * datum not specified

ATC concluded that:

"in general the rock mass permeability of the quartzite rocks are considered low to moderate … Permeabilities were found to range from 10^{-5} to 10^{-7} metres/second in the upper foundation region (0 to 5m depth) to less that 10^{-7} metres/second in the more competent underlying rock. It is evident … that the rock mass permeability is independent of the weathering profile, with the degree of jointing and fracturing being the dominant factor.

It is considered likely that it (groundwater) *exists locally in the joints and defects within the rock mass, typically 10m below the surface of the gully floor."*

The results in Table 4.19 and Table 4.20 show that the permeability of the subsurface strata is consistent across the whole of the Project area. The same may be said for groundwater occurrence across the whole of the Project area.

4.4.2 Potential Impacts and Mitigation Measures

4.4.2.1 Surface Water and Watercourses

The potential surface water quality impacts from the Project's activities could include surface water run off containing contaminants (low pH/sediment/dissolved solids metals/bacteria) from:

- Stockpiles of waste rock, ore, and concentrate;
- Overflows from process water ponds, stormwater dams, sediment ponds and the TSF;
- Workshops and hydrocarbon/chemical storage areas; and
- Grey water and sewage treatment plant effluent.

Other potential impacts may include:

- Changes to the catchment areas of streams on the Project site could either increase or decrease their water flow volumes in rainfall events.

Surface Water Runoff

The general principles for the management of surface water are as follows:

- The fullest possible separation of 'clean', 'dirty' and 'contaminated' water runoff;
- Minimise the area of disturbance, thus minimising the volume of dirty or contaminated runoff;
- Clean surface runoff is from areas of the Project site where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas;
- Contain all dirty (non-toxic) water onsite (via sediment ponds) whenever possible. If not, release it in a controlled manner in compliance with adopted water quality criteria;
- Contain all dirty (low toxicity) water on site via low hazard dams. If necessary pump this water to the process plant without releasing it to the natural watercourses. This water will only be released downstream during an extreme rainfall event and after notification to the DERM; and
- Segregate, collect and contain all potentially contaminated (toxic and sub-lethal) water onsite via significant and high hazard dams. If necessary pump this water to the process plant without releasing it to the natural watercourses. This water will only be release downstream during an extreme rainfall event and after notification of DERM.

Each catchment area of the processing and mining area has been segregated into either a potentially contaminated or dirty catchment status (Table 3.24 and Table 3.43 in Section 3.5.4). The storages have been classified as sediment ponds, low, significant or high hazard storages in accordance with *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* (DME 1995). Sediment ponds correspond with non-toxic runoff, low hazard dams with low-toxicity runoff, significant hazard dams contain sub-lethal runoff and high hazard dams control toxic runoff.

Surface water management of the different types of runoff and different storage types are discussed in detail in Section 3.5.4.

Diversion Drains

Clean water diversion drains are required to the west of the processing plant and mining area to divert clean stormwater from the western catchment area to the north and south of the processing and mining area. The diversion that flows to the south will discharge to Silvermine Creek and the diversion to the north to a northern tributary of Silvermine Creek (Tributary 'A'). The standard design dimensions for the clean water diversion banks and channels to be constructed on the Project are discussed in Section 3.5.4.2. Figure 4.40 shows the locations of the proposed 'clean' surface water management system elements and controls on the Project site.

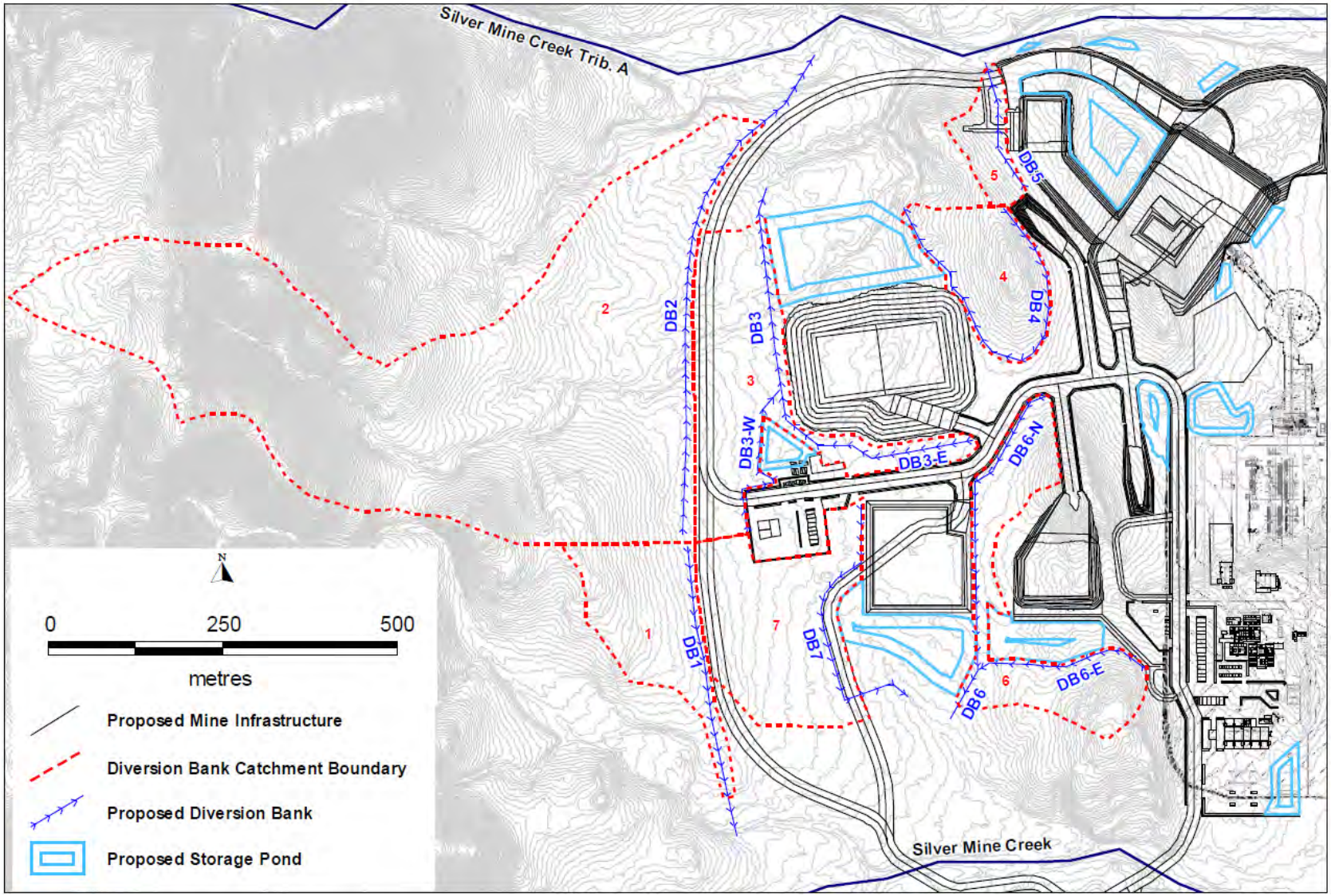


Figure 4.40 Proposed 'Clean' Surface Water Management Controls

Causeways and Creek Crossings

The proposed designs for where roads and tracks will cross watercourses will enable the normal range of aquatic organisms to be maintained. For a full description of culvert design specifications and creek crossings see Section 3.2.1.3 and 3.5.4.4.

The most significant watercourse in this respect is the Dugald River which will permit water flow through the culverts in periods of low flow and unimpeded flows over the road in periods of high flows.

Disturbance to Surface Water Flows

With appropriate control measures in place, the impact of the Project on flows and water quality in downstream waterways will be insignificant. Only approximately 230 ha out of the 3,370 ha Project site will be disturbed by the Project. Further, the areas of disturbance within the local and regional catchments caused by the Project are minimal.

The biggest impact will be on Silvermine Creek flows. Mining operations and infrastructure would disturb approximately 9.5% of the Silvermine Creek catchment area (13.2 km^2). This area is only about 0.2% of the Dugald River catchment area (620 km^2) at the confluence with Silvermine Creek. The TSF occupies an area of about 90 ha, which is only about 0.3% of the Cabbage Tree Creek catchment area (250 km^2) upstream of the TSF.

The area disturbed by the accommodation camp is approximately 20 ha, approximately 50% of which is located in the Blackard Creek catchment area. The remaining portion of the accommodation camp area drains to SIlvermine Creek (37.5%) and Cabbage Tree Creek (12.5%). The area disturbed by the accommodation camp represents less than 5% of the Blackard Creek catchment (3.7 km^2), and insignificant amounts of the Silvermine Creek and Cabbage Tree Creek catchments.

The areas disturbed by the water pipeline and the access roads are not significant.

Mitigation Measures

The following surface water and stream sediment control strategies are proposed:

- The area of surface disturbance within the Project site will be minimised;
- Clean water within the Project site will be separated to the fullest extent and diverted away from disturbed areas. Measures will be employed so as not to significantly increase the volume or flow velocities of waters being diverted;
- Contaminated surface water will be collected and contained within the disturbed area of the Project site via stormwater dams. Contaminated water will not be released out of the Project site, except in extreme rainfall events;
- All other disturbed areas (dirty water) will be drained via sediment ponds with a capacity for a 1:10 Year, 24 hours event;
- The Tailings Storage Facility will be designed to contain extreme rainfall events up to 1:100 year ARI (critical 2 month wet period). Therefore the likelihood of contaminated water overflowing into Cabbage Tree Creek is extremely low;
- Land disturbance within the streams and adjacent to their banks will be minimised and vegetative cover will be maintained wherever possible to reduce potential erosion;

- Treated sewage effluent from the accommodation village and production facilities area and treated grey water from the processing plant area will be disposed of to the TSF. Treated grey water from the accommodation camp will be used for sub-surface irrigation of garden areas;

- Protocols and procedures will be established for management of all hydrocarbon and chemical spills and spill kits containing absorbent material for hydrocarbons and chemicals will be provided;

- Fuel and chemical storage facilities will be bunded in accordance with regulatory requirements;

- Monitoring of surface water quality and stream sediments will be conducted for all streams downstream of any mining or infrastructure related disturbances once construction has commenced. Construction contractors will be required to comply with prescribed runoff management procedures; and

- Should the surface water monitoring or stream sediment monitoring program detect concentrations downstream of mining activities higher than the trigger or limit values in the Environmental Authority an investigation into the likely causes should be initiated. The results of the investigation and mitigation strategies will be reported to the DERM.

4.4.2.2 Surface Water and Stream Sediment Monitoring Program

The surface water quality and stream sediment monitoring program will consist of the parameters, equipment and monitoring frequencies detailed in Table 4.21 at the locations detailed in Table 4.22 and shown in Figure 4.41.

Monitoring locations represent both reference sites (upstream of Project infrastructure) and potential impact sites (downstream of Project infrastructure).

The proposed surface water triggers and limits applicable to the Dugald River Catchment (monitoring sites 4 – 13) are detailed in Table 4.25. The proposed surface water triggers and limits applicable to Cabbage Tree catchment (monitoring sites 1 – 3) are detailed in Table 4.26. Proposed stream sediment triggers for the entire Project site (monitoring sites 1 – 13) are detailed in Table 4.27.

Surface water and stream sediment sampling and monitoring will be conducted in accordance with the Monitoring and Sampling Manual 2009 (DERM). All samples will be analysed by NATA accredited laboratories.

Table 4.21 Surface Water and Stream Sediment Monitoring Program

Monitoring Program	Analytes	Equipment	Frequency
Surface Water Quality	• pH • Aluminium • Arsenic • Cadmium • Copper • Lead • Manganese • Nickel • Silver • Zinc Metals should be filtered in the field and analysed as dissolved metals.	pH and temperature meter for field measurements. Falling Stage Samplers at each monitoring location. Develop and document a standard sampling procedure in an Environmental Monitoring Manual.	Samples from Falling Stage Samplers - each flow event during the wet season.
Stream Sediments	• Arsenic • Cadmium • Chromium • Copper • Lead • Manganese • Nickel • Silver • Zinc • Particle size analysis	Develop and document a stream sediment sampling procedure in an Environmental Monitoring Manual.	Annually at the end of the wet season.

Table 4.22 Surface Water and Stream Sediment Monitoring Sites

ID	Description of Location	**Easting** (AMG84 Zone 54)	**Northing** (AMG84 Zone 54)	Catchment
MS1	East of the northeast corner of the Project boundary, downstream of the accommodation camp	412032	7764373	Cabbage Tree Creek
MS2	West of Knapdale Ranges on the northwest Project boundary, downstream of the TSF	407604	7763149	Cabbage Tree Creek
MS3*	West of the Knapdale Ranges in the southern portion of the Project site, on the Project boundary	407759	7760559	Cabbage Tree Creek
MS4	In the northeast portion of the Project site, near the access road, downstream of the accommodation camp	411060	772611	Dugald River
MS55	South of proposed processing plant, east of the Knapdale Ranges, downstream of the processing plant	412504	7759843	Dugald River

ID	Description of Location	Easting (AMG84 Zone 54)	Northing (AMG84 Zone 54)	Catchment
MS6*	East of the Knapdale Ranges on the south eastern Project boundary	412639	7758673	Dugald River
MS7*	In the south eastern corner of the Project site, east of the Knapdale Ranges	411963	7756722	Dugald River
MS8	Downstream of proposed processing plant on the Project boundary	412132	7761046	Dugald River
MS9	Downstream of the proposed processing plant on the Project boundary	412137	7760536	Dugald River
MS10	Downstream of the proposed processing plant on the Project boundary	412143	7760349	Dugald River
MS11	Downstream of the proposed processing plant on the Project boundary	412134	7760177	Dugald River
MS12*	Upstream of the proposed processing plant and MS4 and MS8	410851	7760804	Dugald River
MS13*	Upstream of the proposed processing plant and MS5	411068	7759730	Dugald River

* Reference sites

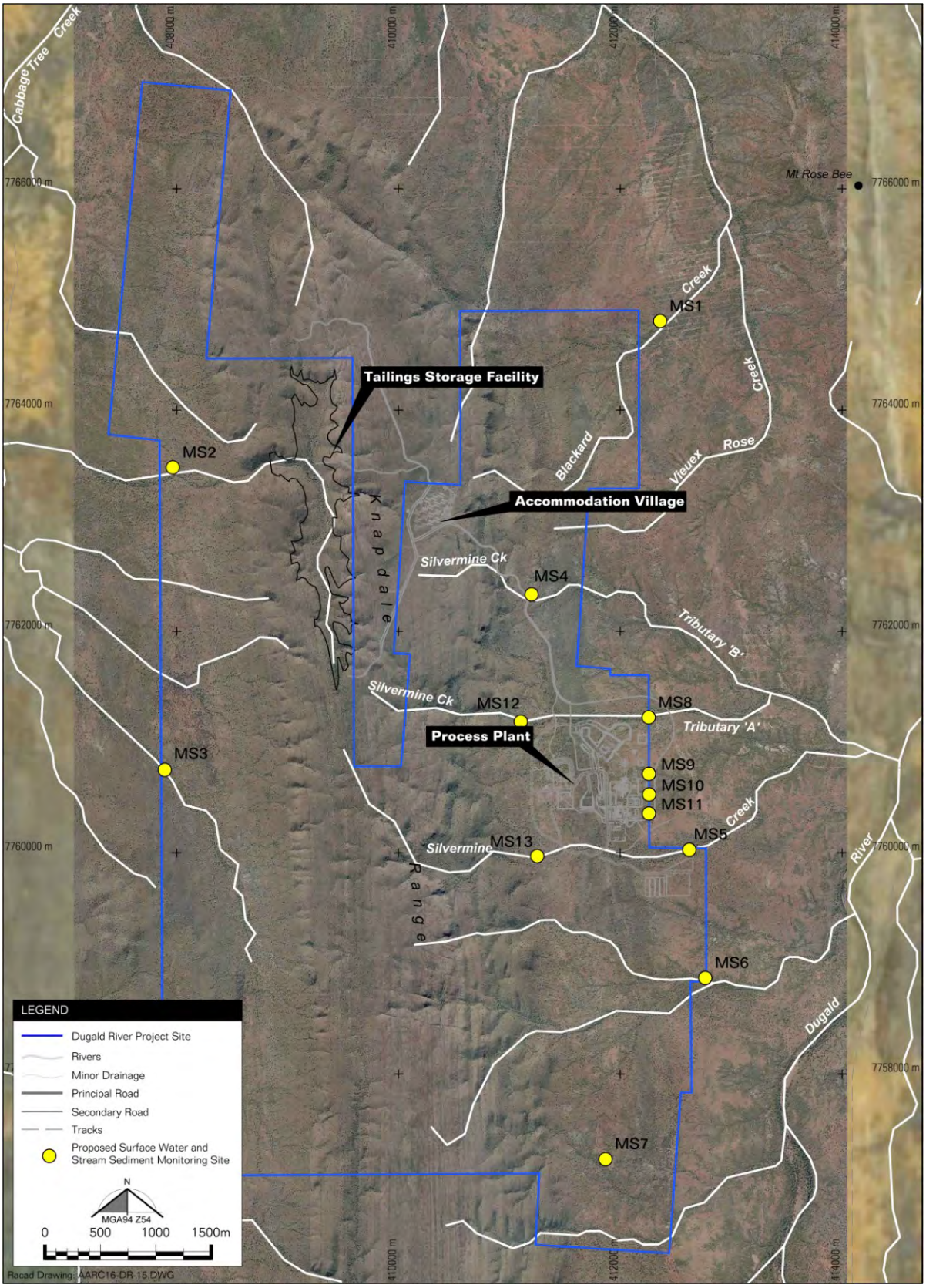


Figure 4.41 Proposed Dugald River Surface Water and Stream Sediment Monitoring Sites

Proposed Surface Water Triggers and Limits

The number of exceedances of the ANZECC Guidelines as presented in Section 4.4.1.1 indicates that the ANZECC Guidelines do not provide suitable triggers or limits for the Dugald River Project as pre-mining baseline conditions are already in exceedance for most parameters. These exceedances are considered normal for an ephemeral system in a highly mineralised area such as the Mount Isa Inlier.

In cases where the ANZECC Guidelines are not suitable, the Queensland Water Quality Guidelines[3] (DERM 2009a) and the ANZECC Guidelines recommend new trigger values be calculated from background or baseline data. The ANZECC Guideline recommends collecting 24 monthly samples at each site (s7.4.4.1, pp. 7.4-5). This is not readily achievable at the Project Site, as waters are not permanently flowing and it is only possible to take water samples when flows occur in the wet season from November to April (see stream flow data in Section 4.4.1.1). The QWQ Guidelines recommend a minimum of 18 samples are collected at each site over a minimum of 12 months (s4.4.3.1, pp. 76).

The parameters of concern for calculating trigger and limits have been selected as those identified from the waste rock (Section 3.6.3) and tailings characterisation studies (Section 3.6.4) for the Project (elements that showed enrichment against geochemical abundance indices) or showed a preference for leaching during water or acid extraction tests or leach column testing.

Whilst there is total metals data and dissolved metals data available for most parameters of concern, the ANZECC Guidelines recommend that it is more appropriate to use dissolved metals for trigger values (s3.1.5, pp. 3.1-17) as the major toxic effects of metals to aquatic ecosystems come from the dissolved fraction and total concentrations are likely to overestimate the bioavailable fraction (s3.4.3.2, pp. 3.4-15).

Also, whilst there were two environmental values of surface water identified in Section 4.4.1, it is more appropriate to use the ANZECC Guidelines for Aquatic Ecosystems (which uses dissolved metals) rather than the ANZECC Guidelines for Livestock Drinking Water (which uses totals metals) because the ANZECC Guidelines for Aquatic Ecosystems are more stringent.

It was considered pertinent to set triggers and limits for the two different catchments that exist under the Project site (Dugald River and Cabbage Tree Creek catchments) to account for any differences that exist in the two datasets.

The QWQ Guidelines and ANZECC Guidelines discuss the use of a single default trigger value, however it is deemed necessary to provide both a trigger value and a maximum limit value in accordance with Schedule C – Table 2 of QEPA) *Guideline 8 – Preparing and Environmental Management Overview Strategy (EMOS) for Non-Standard Mining Projects* (2003)[4], which requires a contaminant trigger and limit to be proposed for receiving waters.

The ANZECC Guidelines for Aquatic Ecosystems 95% protection level was selected as the trigger because it represents a slightly to moderately disturbed system, such as the Dugald River and Cabbage Tree Creek catchments. The 80% protection level was selected as the limit in the absence of specific acute toxicity data because it still provides protection from chronic effects to 80% of species. The ANZECC Guidelines do present some acute toxicity figures in Volume 2 Section 8.3.7 and these are generally higher than the 80% protection level.

[3] Herein called the QWQ Guidelines
[4] Herein called QEPA Guideline 8

The QWQ Guidelines recommend that site-specific triggers are calculated using the 20th and 80th percentiles of background data (sA.1.3) and supports the use of the 5th and 95th percentiles as limits (sD.2.2). Table 4.23 and Table 4.24 show the 5th, 20th, 80th and 95th percentile calculations compared to the fore-mentioned triggers from Table 3.4.1 of the ANZECC Guidelines for Aquatic Ecosystems for the Dugald River and Cabbage Tree Creek catchments respectively.

Table 4.23 Water Quality Percentile Calculations for Dugald River

Parameter	Units	Data Points	Percentiles				ANZECC Guidelines	
			20th	80th	5th	95th	95% Protection Level	80% Protection Level
pH*		71	7.0	7.7	6.6	8.2	6.0 - 7.5	
Aluminium (dissolved)	mg/L	36	-	0.340	-	0.573	0.055	0.150
Arsenic (dissolved)	mg/L	66	-	0.003	-	0.0095	0.024	0.360
Cadmium (dissolved)	mg/L	72	-	0.0026	-	0.0050	0.0002	0.0008
Copper (dissolved)	mg/L	75	-	0.0150	-	0.0867	0.0014	0.0025
Lead (dissolved)	mg/L	73	-	0.0020	-	0.0542	0.0034	0.0094
Manganese (dissolved)	mg/L	75	-	0.03	-	0.41	1.9	3.6
Nickel (dissolved)	mg/L	64	-	0.01	-	0.01	0.011	0.017
Silver (dissolved)	mg/L	55	-	0.001	-	0.010	0.00005	0.00020
Zinc (dissolved)	mg/L	75	-	0.063	-	0.524	0.008	0.031

* ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia from Table 3.3.4

Table 4.24 Water Quality Percentile Calculations for Cabbage Tree Creek

Parameter	Units	Data Points	Percentiles				ANZECC Guidelines	
			20th	80th	5th	95th	95% Protection Level	80% Protection Level
pH*		128	6.7	7.5	6.1	7.9	6.0 - 7.5	
Aluminium (dissolved)	mg/L	38	-	0.298	-	0.550	0.055	0.150
Arsenic (dissolved)	mg/L	70	-	0.001	-	0.001	0.024	0.360
Cadmium (dissolved)	mg/L	97	-	0.0001	-	0.0010	0.0002	0.0008
Copper (dissolved)	mg/L	116	-	0.0270	-	0.1905	0.0014	0.0025
Lead (dissolved)	mg/L	109	-	0.0040	-	0.0320	0.0034	0.0094
Manganese (dissolved)	mg/L	117	-	0.07	-	0.46	1.9	3.6
Nickel (dissolved)	mg/L	75	-	0.001	-	0.012	0.011	0.017
Silver (dissolved)	mg/L	48	-	0.001	-	0.001	0.00005	0.00020
Zinc (dissolved)	mg/L	115	-	0.161	-	0.654	0.008	0.031

* ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia from Table 3.3.4

The proposed water quality triggers and limits for the separate catchments on the Project are presented in Table 4.25 and Table 4.26 below. The methodology behind development of the triggers and limits is discussed in the following sections.

Table 4.25 Proposed Dugald River Triggers and Limits

Parameter	Units	Data Points	Minimum Trigger	Maximum Trigger	Minimum Limit	Maximum Limit
pH[1]		71	6	7.7	6	8.2
Aluminium (dissolved)[2]	mg/L	36	-	0.34	-	0.58
Arsenic (dissolved)[3]	mg/L	66	-	0.024	-	0.36
Cadmium (dissolved)[2]	mg/L	72	-	0.003	-	0.005
Copper (dissolved)[2]	mg/L	75	-	0.015	-	0.09
Lead (dissolved)[2]	mg/L	73	-	0.01[5]	-	0.06
Manganese (dissolved)[3]	mg/L	75	-	1.9	-	3.6
Nickel (dissolved)[3]	mg/L	64	-	0.011	-	0.017
Silver (dissolved)[4]	mg/L	55	-	0.01	-	0.01
Zinc (dissolved)[2]	mg/L	75	-	0.06	-	0.5

NOTES:

1 Lower trigger and limit taken from ANZECC trigger values for upland rivers in Tropical Australia (ANZECC 2000 Table 3.3.4), as 20th percentile and 5th percentile of background data respectively was within aforementioned ANZECC trigger range. The upper trigger and limit were raised to 80th percentile and 95th percentile of background data respectively, as per QWQG (2009) sA.1.3 and sD.2.2.

2 Site-specific trigger generated using 80th percentile value as the trigger and 95th percentile value as the limit, as per ANZECC Guidelines (2000) s7.4.4 and QWQ Guidelines (2009) sA.1.3 and sD.2.2.

3 ANZECC Guidelines (2000) for Aquatic Ecosystems – 95% and 80% protection level trigger values from Table 3.4.1 as the trigger and limit respectively.

4 Background data did not present any results above LOR, yet LOR exceeds or is close to ANZECC (2000) triggers from Table 3.3.4, therefore trigger and limit has been raised to a factor of ten (10) above the LOR as recommended by ALS.

5 The site-specific trigger value that was calculated was within a factor of ten above the LOR, hence the trigger was raised to be a factor of ten above the LOR as recommended by ALS (see Appendix E of the report in Appendix Q).

Table 4.26 Proposed Cabbage Tree Creek Triggers and Limits

Parameter	Units	Data Points	Minimum Trigger	Maximum Trigger	Minimum Limit	Maximum Limit
pH[1]		128	6	7.5	6	7.9
Aluminium (dissolved)[2]	mg/L	38	-	0.3	-	0.55
Arsenic (dissolved)[3]	mg/L	70	-	0.024	-	0.36
Cadmium (dissolved)[4]	mg/L	97	-	0.001	-	0.001
Copper (dissolved)[2]	mg/L	116	-	0.03	-	0.2
Lead (dissolved)[2]	mg/L	109	-	0.01[5]	-	0.03
Manganese (dissolved)[3]	mg/L	117	-	1.9	-	3.6
Nickel (dissolved)[3]	mg/L	75	-	0.011	-	0.017
Silver (dissolved)[4]	mg/L	48	-	0.01	-	0.01
Zinc (dissolved)[2]	mg/L	115	-	0.016	-	0.66

NOTES:

1 Lower trigger and limit and upper trigger taken from ANZECC trigger values for upland rivers in Tropical Australia (ANZECC 2000 Table 3.3.4), as 20th percentile, 5th percentile and 80th percentile of background data respectively was within aforementioned ANZECC trigger range. The upper limit was raised to 95th percentile of background data, as per QWQG (2009) sD.2.2.

2 Site-specific trigger generated using 80th percentile value as the trigger and 95th percentile value as the limit, as per ANZECC Guidelines (2000) s7.4.4 and QWQ Guidelines (2009) sD.2.2.

3 ANZECC Guidelines (2000) for Aquatic Ecosystems – 95% and 80% protection level trigger values from Table 3.4.1 as the trigger and limit respectively.

4 Background data did not present any results above LOR, yet LOR exceeds or is close to ANZECC (2000) triggers from Table 3.3.4, therefore trigger and limit has been raised to a factor of ten (10) above the LOR as recommended by ALS.

5 The site-specific trigger value that was calculated was within a factor of ten above the LOR, hence the trigger was raised to be a factor of ten above the LOR as recommended by ALS (see Appendix E of the report in Appendix Q).

Methodology for Development of Surface Water Triggers and Limits for Physiochemical Parameters

For physiochemical properties where the 20th and/or 80th percentile values of the dataset complied with the ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia from Table 3.3.4, the ANZECC Guidelines were used as the minimum and/or maximum triggers.

If the 20th and/or 80th percentile values for the dataset did not comply with the ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia (Table 3.3.4), the 20th and/or 80th percentile value was used as the minimum and maximum triggers.

For physiochemical parameters where the 5th and/or 95th percentile values of the dataset complied with the ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia from Table 3.3.4, the ANZECC Guidelines were used as the minimum and/or maximum limits.

If the 5th and/or 95h percentile values for the dataset did not comply with the ANZECC Guidelines for Aquatic Ecosystems default trigger values for upland rivers in Tropical Australia (Table 3.3.4), the 5th and/or 95th percentile value was used as the minimum and maximum limits.

In Table 4.24, the 80th percentile value for pH (7.516) exceeds the ANZECC Guidelines for Aquatic Ecosystems default upper trigger value (7.5), however, due to rounding, the maximum trigger value in Table 4.26 has been selected as the ANZECC Guidelines for Aquatic Ecosystems default upper trigger value (7.5).

Methodology for Development of Surface Water Triggers and Limits for Toxicants (Metals)

For toxicants (dissolved metals) where the 80th percentile value of the dataset (see Table 4.23 and Table 4.24) complied with the ANZECC Guidelines, the ANZECC Guidelines for Aquatic Ecosystems 95% protection level (Table 3.4.1) was used as the trigger value and the 80% protection level was used as the limit value.

For toxicants (dissolved metals) where the 80th percentile value of the dataset (see Table 4.23 and Table 4.24) exceeded the ANZECC Guidelines, a site-specific trigger and limit has been generated. It is recommended in Section A.1.3 of the QWQ Guidelines and Section 7.4.4.2 of the ANZECC Guidelines that the new trigger is the 80th percentile of background data. The use of the 95th percentile of background data as the new limit is supported by Section D.2.2 of the QWQ Guidelines

For cadmium and silver the background data did not present any results above the Limit of Reporting (LOR), yet the LOR is close to or exceeds the ANZECC Guidelines (Table 3.4.1). In this situation the trigger and the limit have been selected as a factor of ten above the LOR as recommended by ALS (see Appendix E in the report in Appendix Q). Since the trigger and the limit are the same it is recommended that if, during monitoring, a result is recorded that is above the trigger, an investigation should be initiated and ultra-trace analysis (which can achieve a lower LOR) should be used for any re-analysis work.

For lead the site-specific 80th percentile trigger value that was calculated was within a factor of ten above the LOR, hence the trigger value has been selected as the value that is a factor of ten above the LOR as recommended by ALS (see Figure 4.42). The background data presented enough results to calculate a reasonable site-specific 95th percentile limit.

> The ANZECC (2000) guidelines for protection of aquatic species to the 95th and 99th percentile are very strict and ALS recommends that the method employed for analysis has an LOR around 10x lower than that of the guideline trigger level (where possible). This is due the degree of error that is inherit with any analysis where the result can fall within 5x the LOR.

Figure 4.42 Extract from "Limits of Reporting" letter from ALS

Proposed Stream Sediment Triggers and Limits

The ANZECC Guidelines state that in some areas natural mineralisation of stream sediments will mean that levels of some metals will be higher than the default low trigger values or even the high trigger values (see Table 3.5.1 of the guidelines) without any human interference. In these cases, site specific stream sediment triggers and limits should be determined from background data. The stream sediment metal concentrations in this report have been used to determine site specific trigger and limit values if any of the ANZECC Guidelines stream sediment default guidelines are exceeded. The site specific triggers and limits will form part of the proposed Environmental Authority monitoring conditions for the Project site.

The parameters of concern for calculating trigger and limits have been selected as those identified from the waste rock (Section 3.6.3) and tailings characterisation studies (Section 3.6.4) for the Project (elements that showed enrichment against geochemical abundance indices) or showed a preference for leaching during water or acid extraction tests or leach column testing.

Based on the ANZECC Guidelines and the results in described in Section 4.4.1.1 and Table 4.15, the low and high trigger values for arsenic, cadmium, copper, lead, nickel, silver and zinc have been reviewed and adjusted, where necessary, to be site specific. The low trigger values have been adjusted to 80% of twice the maximum background level and the high trigger values have been adjusted to twice the existing maximum background level in accordance with the process outlines in QEPA Guideline 8.

The ANZECC Guidelines for Aquatic Ecosystems default sediment low and high triggers are proposed as the trigger and limit for chromium in Table 4.27.

In the case of manganese, the low and high level triggers are set based on QEPA Guideline 8, as no ANZECC Guideline triggers exist for this metal.

In the case of barium, beryllium, cobalt, mercury, selenium, thorium, uranium and vanadium no triggers are proposed as these metals are not elements of concern for the Project.

The proposed triggers and limits for the Project are presented in Table 4.27.

Table 4.27 Proposed Stream Sediment Triggers and Limits

Parameter	Units	Data Points	Trigger	Limit
Arsenic *	mg/kg	48	294	368
Cadmium *	mg/kg	48	11	14
Chromium #	mg/kg	48	80	370
Copper *	mg/kg	48	350	438
Lead *	mg/kg	48	1,195	1,494
Manganese *	mg/kg	48	8,560	10,700
Nickel *	mg/kg	48	94	118
Silver *	mg/kg	48	3.2	4.0
Zinc *	mg/kg	47	15,408	19,260

* Site-specific trigger generated using 80% of twice the maximum value as the trigger and twice the maximum value as the limit, as per QEPA Guideline 8 (s3.3.4)
# ANZECC Guidelines for Aquatic Ecosystems (2000) – recommended sediment quality guidelines (Table 3.5.1)

4.4.2.3 Groundwater Impacts

A summary of the groundwater values and potential threats to those values associated with the Project is provided below.

- Groundwater bores in the Project region have the following economic, hydrological and environmental values:
    - Bores are used in the region are used for stock-watering;
    - Groundwater in Corella Formation may contribute to flow of Silvermine Creek and Tributary 'A" Creek in wet season; and
    - Groundwater – surface water exchange.
- Potential threats to groundwater quality from the Project activities could include the following:
    - Groundwater contamination from chemical and hydrocarbon spills, waste rock dumps, ore stockpiles, stormwater/process water dams and the TSF;
    - Reduction in available groundwater resource for stock-watering;
    - Dewatering during mining may impact on groundwater levels; and
    - Contaminated groundwater discharge may impact on surface water.

Mine Dewatering Impacts

A long, narrow, deep cone of depression will result in and around the mine itself during dewatering of the mine. This cone of depression will be elongated along strike and is not expected to extend more that about 500m normal to the strike of the ore body. The lack of long term sustainable supplies evidenced by bores pumping out within 24 hours at very low discharge rates, followed by many days to recover, indicates that the cone of depression caused by dewatering of the mine should not impact on privately owned groundwater facilities.

The cone of depression resulting from dewatering of the mine is not expected to induce drawdown or promote seepage from the TSF through the massive low permeability Knapdale Quartzite and the mylonite zone that occurs at the geological boundary between the Knapdale Quartzite and the Corella Formation.

Groundwater Contamination

Since all major mining infrastructure will be contained in the interfluve between Silvermine Creek and its Tributary 'A' to the north there exists the potential for groundwater contamination from unmanaged chemical spills or from infiltration of leachate directly from the ROM pad, waste rock dump(s) and water containment dams.

Based on the rainfall – groundwater level relationships in the dedicated groundwater monitoring bore suite and the permeability tests on that suite of bores the aquifers beneath the interfluve, are both confined and of quite low permeability. Therefore this area is considered to have a low vulnerability to groundwater contamination. By contrast the aquifers within about 50m of Silvermine Creek and its Tributary 'A' to the north are more highly permeable and relatively quickly recharged by rainfall. These corridors will be more vulnerable to groundwater contamination.

There is also a potential risk of groundwater contamination from the TSF which will be constructed to the west of the mining and processing area and will be contained in a valley within the Knapdale Range. As previously discussed the Knapdale Range is comprised of quartzite and siltstone. A walkover of the site of the TSF was undertaken during the site inspection. The floor and valley sides of the TSF consist essentially of outcropping quartzite. There is very little soil development except immediately adjacent to the drainage feature that exits to the west.

From visual inspection during that site visit it appeared that the potential for infiltration of tailings leachate to the Knapdale Quartzite will be low. Groundwater monitoring bores MB5 and MB6 were sited to assess groundwater conditions in the Knapdale Quartzite and the most likely discharge outlet of the TSF catchment. The groundwater levels in these two monitoring bores are essentially static, even through periods of intensive rainfall.

ATC permeability testing showed that permeabilities immediately below the proposed tailings storage dam site ranged from 10^{-5} to 10^{-7} m/s in the upper foundation region (0 to 5m depth) to less that 10^{-7} m/s in the more competent underlying rock. The measured permeabilities in MB5 and MB6 were 1.07 x 10^{-6} m/s and 2.58 x 10^{-8} m/s respectively. All these permeability measurements are quite low and there is a high degree of consistency in the permeability measurements in the Knapdale Quartzite both immediately beneath the proposed TSF and further to the west.

ATC also found that the degree of fracturing is the dominant factor that controls the permeability of the Knapdale Quartzite. The upper 5m of the subsurface profile is the most highly fractured zone in the Knapdale Quartzite. The degree of fracturing diminishes markedly from 5 to 10m depth and by a depth of 15m there is very little fracturing evident.

ATC have recommended a program of foundation curtain grouting to a depth of 10 to 15m prior to construction of the tailings storage dam embankment because of near surface fracturing in the Knapdale Quartzite. This is a prudent and responsible measure that should effectively preclude down-valley transmission of leachate from the tailings storage dam.

It is assessed from the groundwater level behaviour in MB5 and MB6 and the uniform low permeability across the Knapdale Quartzite (as measured independently during separate phases of the technical investigation) that the likelihood of contaminant transport from a filled tailings storage dam through the Knapdale Quartzite is low. Subject to the installation of the foundation curtain grouting as discussed above, it is considered that the TSF will not represent an environmental risk to the hydrogeological regime

Groundwater contamination can largely be precluded if the source of contaminants at the surface is minimised or eliminated.

4.4.2.4 Groundwater Mitigation Measures

The following hydrogeological mitigation measures should be implemented at the Dugald River Project:

- Chemical storage and handling areas will be bunded to contain accidental spills;
- Bulk petroleum products will be loaded and unloaded a designated area, which will include appropriate spillage management features in its design;
- A formal network of groundwater monitoring bores have been installed and these will be monitored on a regular basis;

- Minimal use of groundwater where practicable;
- No infrastructure that can cause groundwater contamination, will be constructed, or limited to only that which is absolutely necessary, in a corridor that extends 50m either side of Silvermine Creek and North Creek;
- If there is any possibility of leachate runoff to these creeks, bund walls will be installed to divert flow to holding storage ponds for pumping back as processing water; and
- Surface runoff management ponds that contain waters classified as 'potentially contaminated' (either 'Toxic', or 'Sub-lethal') will be lined with a HDPE liner.

4.4.2.5 Groundwater Monitoring Program

A suite of six additional groundwater monitoring bores has been installed at the Dugald River Project to complement the two existing bores. The additional groundwater monitoring bores will complement historical groundwater monitoring and have been sited to aid in the assessment of the following essential parameters:

- Subsurface geology and stratigraphy;
- Bedding competence and degree of fracturing including evidence of fault brecciation;
- Location and depth of the water table;
- Ambient groundwater quality away from the ore zone for comparison with groundwater quality data from the existing groundwater exploration bores within the ore zone;
- Groundwater flow direction and gradient;
- Relationship of the water table to surface water features, both natural (streams) and man-made (dams, ponds etc); and
- Aquifer permeability.

Four of the new groundwater monitoring bores (MB1, MB2, MB3 and MB4) will monitor the more permeable aquifer zones within the Corella Formation and will surround the processing plant and other mining infrastructure to the east of the ore body (Figure 4.43).

The remaining two new groundwater monitoring bores (MB5 and MB6) are alongside the drainage feature that exits the Knapdale Range to the west of the tailings storage dam (Figure 4.43).

Table 4.28 provides the location and intended purpose of the bores in the monitoring program.

Table 4.28 Locations and Purposes of Proposed Groundwater Monitoring Bores

Bore name	Easting (AGD84)	Northing (AGD84)	Intended Purpose
MB1	411160	7761020	Monitoring of groundwater in zone of structural weakness close to ore body along North Creek
MB2	412070	7760970	Monitoring of groundwater in zone of structural weakness remote from ore body along North Creek
MB3	411240	7759940	Monitoring of groundwater in zone of structural weakness close to ore body along Silvermine Creek
MB4	412635	7759854	Monitoring of groundwater in zone of structural weakness remote from ore body along Silvermine creek
MB5	408420	7763180	Monitoring of groundwater downstream of tailings storage dam
MB6	407990	7763100	Monitoring of groundwater downstream of tailings storage dam
Froggy Bore (GWBF	411216	7760796	Monitoring of groundwater in the Corella Formation above the ore body, assessment of potential dewatering impacts
Saturday Bore	414227	7760882	Monitoring of groundwater quality impacts in Corella Formation towards Dugald River

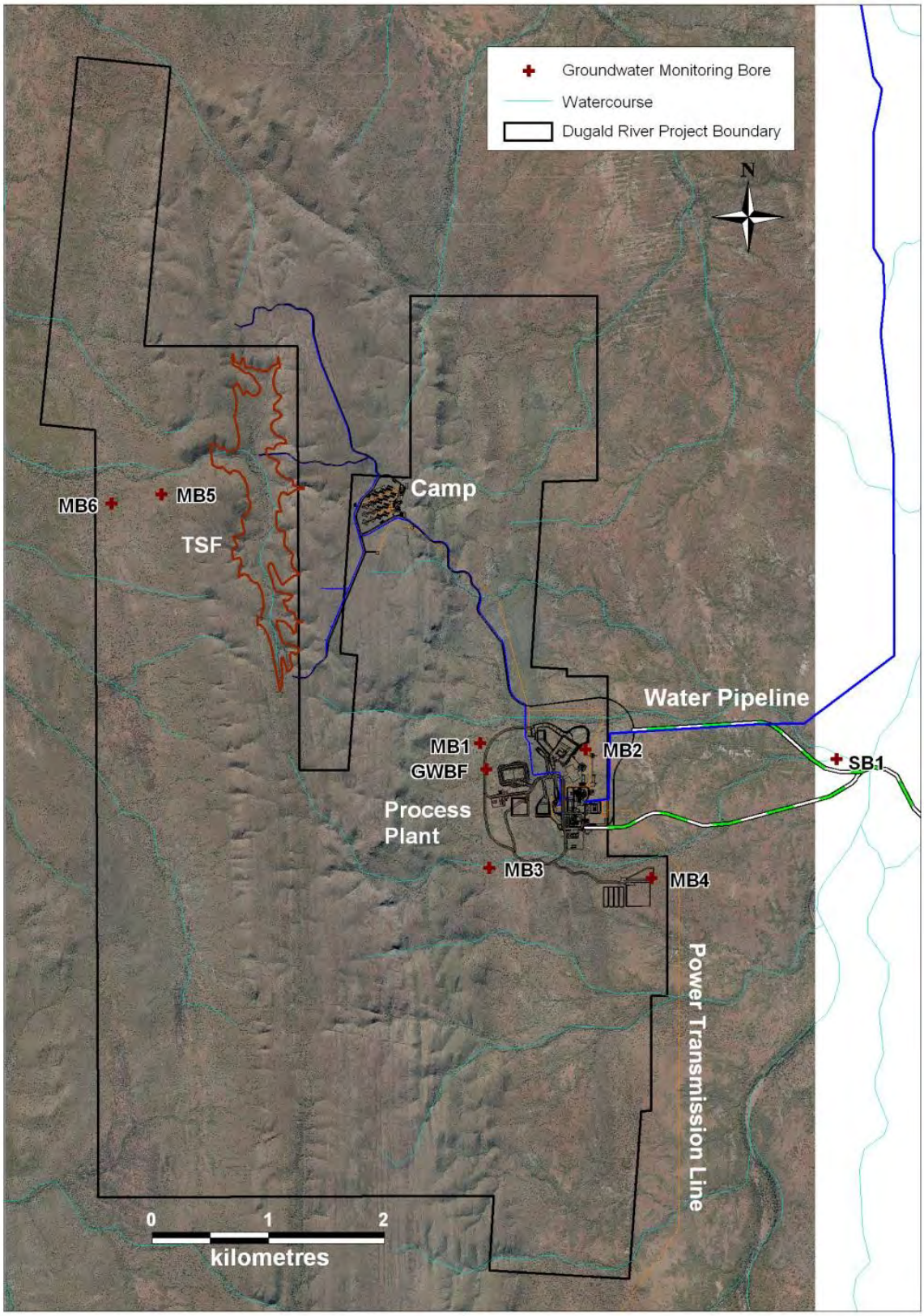


Figure 4.43 Groundwater Monitoring Bore Locations

The following monitoring strategy will be implemented by MMG:

Table 4.29 Dugald River Groundwater Monitoring Strategy

Monitoring Location	Parameters	Frequency
GWBF Saturday Bore MB1 MB2 MB3 MB4 MB5 MB6	• Groundwater levels • pH • Electrical conductivity • Bicarbonate • Total Alkalinity • Sulphate • Calcium (total) • Magnesium (total) • Sodium (total) • Potassium (total) • Arsenic (total) • Cobalt (total) • Copper (total) • Iron (total) • Lead (total) • Silver (total) • Zinc (total)	Monthly
MB3 MB4	Groundwater level using automatic water level data loggers	Daily (to start before November 2010)

In addition to collection of the data as described in Table 4.29 above, the following actions should also be undertaken:

- Once sufficient data exists, statistical analysis should be undertaken to determine trigger and contaminant limits for inclusion in the Project's Environmental Authority;
- Bores will be sampled in accordance with the Water Quality Sampling Manual produced by DERM [5].
- The data from the groundwater monitoring bores will be reviewed at minimum six-monthly intervals; and
- An annual borefield performance review report should be undertaken.

[5] Queensland Department of Environment and Resource Management, Monitoring and Sampling Manual 2009, Version 1, September 2009.

4.5 AIR

4.5.1 Description of Environmental Values

The air quality values to be enhanced or protected for the Project as described by the EPP (Air) include:

(a) The qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems;

(b) The qualities of the air environment that are conducive to human health and wellbeing;

(c) The qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and

(d) The qualities of the air environment that are conducive to protecting agricultural use of the environment.

Katestone Environmental has prepared an air quality impact assessment of the Project (Appendix N). The air quality impact assessment has estimated the impacts of the Project on dust levels at the nearest sensitive location (Roseby Homestead) and adopted regulatory dispersion modelling techniques. The following sections summarise the findings of the report.

Existing Environment

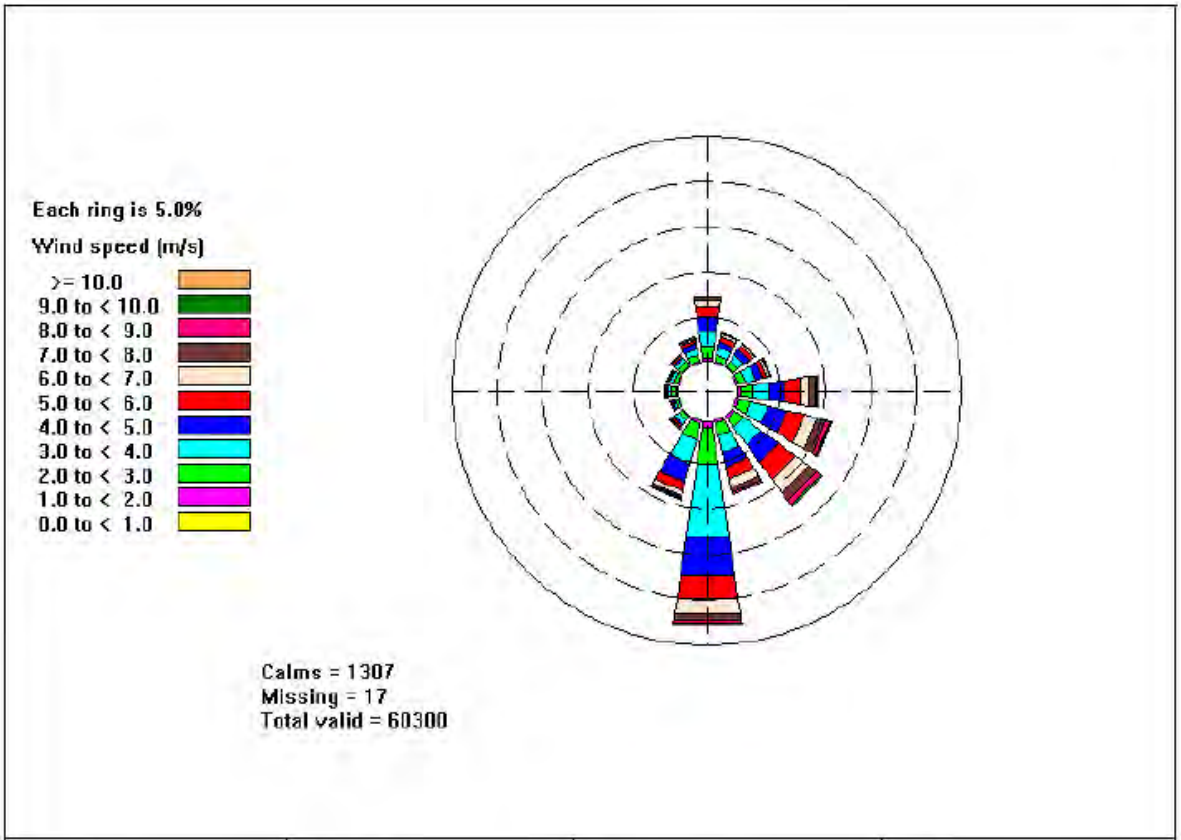
The surrounding area is mostly uninhabited land with sparse vegetation and limited ground cover. The nearest residential dwelling is located approximately 2.5 km to the south-southeast of the Project boundary and approximately 6 km to the south-southeast of the processing plant. The next nearest residences are located within the towns of Kajabbi and Quamby, more than 30 km from the boundary of the proposed Dugald River Project. The accommodation camp for the proposed Roseby Copper Project is located 11 km from the Dugald River processing plant.

Climate Data

Climatic data sufficient for the air quality assessment was not available for the Project site. The climate and meteorology of the Dugald River Project are expected to be similar to that of Cloncurry (65 km to the south-east); therefore data from the nearest Bureau of Meteorology monitoring site at Cloncurry has been used to describe the local climatic conditions (see Section 4.1). Site specific meteorological data has been developed from detailed meteorological simulations covering the mine site and surrounding region for use in dispersion modelling.

The wind flows at a mine site are an extremely important factor for understanding dust emissions and transport. Locations that are downwind of the mine site will experience higher dust concentrations than locations that are upwind. Wind speed is also important for dust emissions from a mine site. Exposed dust sources, such as stockpiles or exposed land, will have higher dust emissions during strong winds than during light winds. During strong winds dust particles are more likely to be lifted by the wind and carried further off-site than during light winds.

Moderate strength winds from the southerly sector dominate. The majority of winds are light to moderate in strength. Strong winds that are greater than 9 m/s occur infrequently (0.3 % of the time) (Figure 4.44).



Location:	Period:	Data source:	Units:
Cloncurry	March 2001 to April 2008	Bureau of Meteorology	Metres per second for wind speed Degrees for wind direction
Type:	**Averaging period:**	**Prepared by:**	**Date:**
Wind rose	1-hour	Lena Jackson	September 2008

Figure 4.44 Annual Windrose

Atmospheric Stability

Atmospheric stability class and mixing heights have been extracted from the The Air Pollution Model (TAPM) simulations for the proposed Dugald River Project location. Stability classification is a measure of the stability of the atmosphere. The stability classes range from A class, which represents very unstable atmospheric conditions that may typically occur on a sunny day to F class stability which represents very stable atmospheric conditions that typically occur during light wind conditions at night. Unstable conditions (Classes A to C) are characterised by strong solar heating of the ground that induces turbulent mixing in the atmosphere close to the ground. This turbulent mixing is the main driver of dispersion during unstable conditions. Dispersion processes for the most frequently occurring Class D conditions are dominated by mechanical turbulence generated as the wind passes over irregularities in the local surface. During the night, the atmospheric conditions are generally stable (often classes E and F).

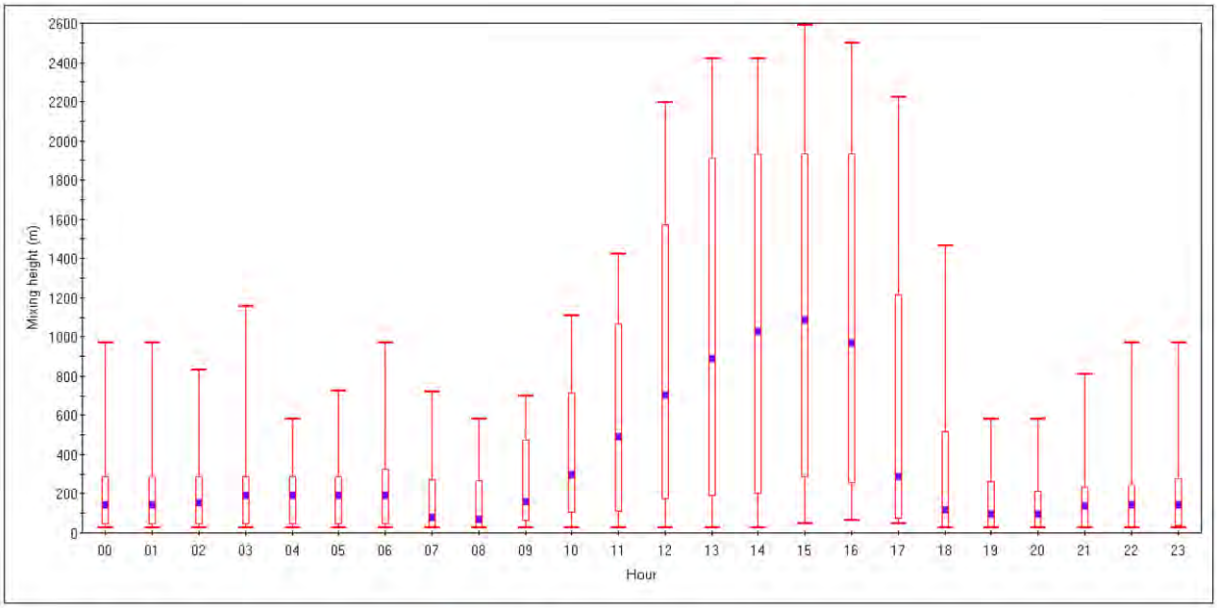
Table 4.30 shows the percentage of stability classes determined from TAPM. The high proportion of D class stability is due to the high frequency of moderate to high velocity winds that are predicted at the site.

Table 4.30 Frequency of Occurrence (%) of Surface Atmospheric Stability Conditions

Pasquill-Gifford Stability Class	Frequency (%)	Classification
A	1.4	Extremely Unstable
B	8.3	Unstable
C	19.7	Slightly Unstable
D	31.6	Neutral
E	25.6	Slightly Stable
F	13.4	Stable

Note: Class A represents the most unstable conditions

The mixing height refers to the height above ground within which the air pollutants can mix with ambient air. The mixing height is not a major factor for ground-based fugitive emission sources such as predominantly exist at the proposed Project. The mixing height is a more important factor for stack emission sources. Figure 4.45 shows a diurnal profile of mixing heights for the proposed Project. This plot shows a typical profile with the mixing height increasing from 9.00 a.m. with highest mixing heights generally occurring from 2.00 to 4.00 p.m.



Whisker: Low=Min, High=Max; Box: Low=5%, High=95%

Middle: 50%

Figure 4.45 Atmospheric Mixing Heights

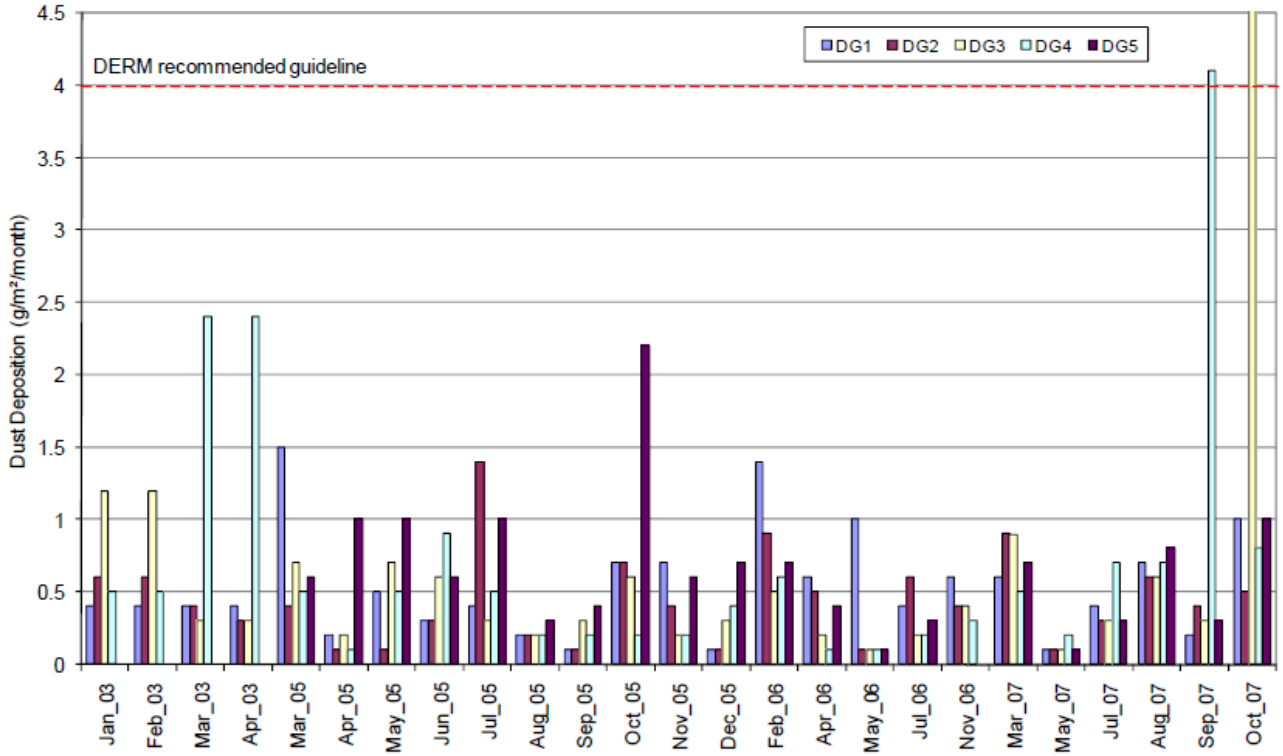
During stable atmospheric conditions (night time) the mixing height (inversion) is often quite low whilst during the day, solar radiation heats the air at the ground level and causes the mixing height to rise. The air above the mixing height during the day is generally colder. The growth of the mixing height is dependent on how well the air can mix with the cooler upper levels of air and therefore depends on

meteorological factors such as the intensity of solar radiation and wind speed. During strong wind speed conditions the air will be well mixed, resulting in a high mixing height.

Dust Deposition

Dust deposition monitoring has been intermittently conducted from January 2003 through to October 2007 at the proposed Project site.

Figure 4.46 summarises the dust deposition rates that have been measured at the Project site since January 2003. The DERM's recommended guideline is included in this plot and shows two exceedances of the guideline have occurred, one at DG 4 in September 2007 and one at DG 3 in October 2007. For most of the time the dust deposition rate is less than 1 g/m²/month. DG 5 is likely to be the most representative of dust deposition rates at the nearest residence (Roseby Homestead). The annual average dust deposition rate recorded at this site is 0.6 g/m²/month.



Location: Dugald River Project	**Averaging period:** Monthly	**Data source:** AARC	**Units:** g/m²/month
Type: Bar chart	**Guideline:** 4 g/m²/month	**Prepared by:** Natalie Shaw	**Date:** May 2010

Figure 4.46 Monthly Dust Deposition Rates Measured at the Proposed Dugald River Project

TSP and PM_{10}

There are no known air quality monitoring stations in the Dugald River region that measure concentrations of TSP and Particulate Matter less than 10 microns (PM_{10}) and Particulate Matter less than 2.5 microns ($PM_{2.5}$). The area surrounding the proposed mine is mostly uninhabited land. The main sources of ambient dust in the region are likely to be due to wind erosion of exposed soil surfaces and due to grass seeds and pollens. The nearest anthropogenic dust generating activity is the Ernest Henry mine, over 50 kilometres to the southeast of the proposed Dugald River Project.

The closest known publicly available monitoring data that may be representative of concentrations of PM_{10} at the proposed Dugald River Project is from the DERM ambient air quality monitoring stations located at Mackay and Townsville. The monitors are located in commercial precincts of Mackay and Townsville and as such levels of PM_{10} are likely to be higher than would be expected in the region surrounding Dugald River.

The background level for PM_{10} for this project has been taken as the 70th percentile of 24- hour average PM_{10} concentrations measured at Mackay and Townsville. At Mackay, the 24-hour average, 70th percentile PM_{10} concentration is 23.5 $\mu g/m^3$ and the annual average ranges from 17.2 to 28.4 $\mu g/m^3$. The 24-hour average, 70th percentile PM_{10} concentration in Townsville is 24.0 $\mu g/m^3$ and the annual average ranges from 19.7 to 26 $\mu g/m^3$.

There are no known measurements of TSP in the region. Previous assessments by Katestone Environmental and standard conversion ratios detailed in the National Pollutant Inventory (NPI) Handbooks, have found that PM_{10} is usually 50% of the TSP concentration. This ratio has been employed here, giving an annual background level of 56.7 $\mu g/m^3$ for TSP based on the maximum PM_{10} annual average measured at Mackay and Townsville.

$PM_{2.5}$ occurs mainly as a result of combustion and through chemical reactions of gaseous air pollutants in the atmosphere. With the exception of bushfires, sources of $PM_{2.5}$ in the vicinity of Dugald River are likely to be minimal. DERM measures PM_{10} and $PM_{2.5}$ in southeast Queensland (Toowoomba, Rocklea and Springwood). Whilst these measurements will be affected to a greater degree by urban sources of $PM_{2.5}$ than at Dugald River and surrounds, the level of $PM_{2.5}$ is expected to be indicative. Data from Toowoomba is used to represent $PM_{2.5}$ levels for this study. The 24-hour average, 70th percentile $PM_{2.5}$ concentration in Toowoomba is 7.4 $\mu g/m^3$ and the annual average is 6.6 $\mu g/m^3$.

4.5.1.1 Greenhouse Gas Emissions

The major activities at the mine that are likely to produce greenhouse gas emissions are:

- Direct emissions: Consumption of diesel in the generators during the construction phase of the Project and consumption of diesel by vehicles during all stages, but particularly during operations for the hauling of ore to the surface; and

- Indirect emissions: Emissions from electricity use at the mine. Electricity will be supplied by the gas-fired Mica Creek Power Station during the operational phase of the Project.

Table 4.31 summarises the greenhouse gas emission factors used to quantify greenhouse gas emissions from the consumption of diesel in generators, from the consumption of diesel by vehicles at the mine site, from waste disposed in landfills and from the consumption of fuel in the preparation of explosives.

Table 4.31 Greenhouse Gas Emission Factors for Diesel Consumption and Landfill

Activity/Source	Energy Content Factor	Emission Factor Kg CO_{2-e}/GJ			
		CO_2	CH_4	N_2O	Total
Transport – Diesel fuel consumption[1]	38.6 GJ/kL	69.2	0.2	0.5	69.9
Generators – Diesel fuel combustion	38.6 GJ/kL	69.2	0.1	0.2	69.5
Landfill – Municipal solid waste	-	1.0	-	-	1.0
Explosives – Fuel combustion	-	0.17	-	-	0.17

Source: NGA Factors (2009)
[1] heavy vehicles conforming to Euro design standards – Euro i

Electricity for the mine will be generated at the Mica Creek Power Station, or a similar gas-fired facility in the region. Mica Creek is not located on the national electricity grid, but has its own grid. The emission factor for the power station is 0.65 kg CO_{2-e}/kWh (supplied by the Mica Creek Power Station).

The greenhouse gas emissions have been calculated for the maximum mining capacity of 2 Mtpa of lead/zinc ore and 1 Mtpa of copper ore with four gensets giving a total output of 4.5 MVA. The generators will power the mine and plant construction activities, as well as the onsite accommodation facilities for workers for the first two years of construction activities, prior to the commencement of operations and connection to the northwest Queensland regional grid. Electricity will be consumed from the grid after the first two years. A summary of the greenhouse gas emissions calculated for the consumption of diesel fuel by the gensets and the vehicles, electricity is shown in Table 4.32.

Table 4.32 Greenhouse Gas Emissions for Project Operations (by year)

Year	Transport – Diesel (t CO_2-e)	Generators – Diesel (t CO_2-e)	Electricity Consumption (t CO_2-e)	Explosives (t CO_2-e)	Landfill	Total (t CO_2-e)
2012		19,991	-	-	910	19,991
2013	1,513	19,991	-	34	910	22,447
2014	4,972	-	84,032	157.59	910	90,071
2015	7,771	-	147,328	194.31	910	156,203
2016	9,865	-	157,391	289.85	910	168,457
2017	11,462	-	184,575	289.85	910	197,236
2018	13,439	-	209,700	289.85	910	224,339
2019	14,005	-	211,136	289.85	910	226,340
2020	14,549	-	211,695	289.85	910	227,444
2021	15,372	-	212,126	289.85	910	228,698
2022	15,740	-	212,397	289.85	910	229,337
2023	16,469	-	212,487	289.85	910	230,157
2024	17,404	-	212,505	289.85	910	231,109
2025	18,405	-	212,505	289.85	910	232,110
2026	18,857	-	212,505	289.85	910	232,562
2027	21,780		212,505	289.85	910	235,485
2028	22,583	-	212,505	289.85	910	236,288
2029	17,731		212,505	229.84	910	231,376
2030	6,164		212,505	95.37	910	219,674

Source: Air Quality Assessment of Dugald River Project (Katestone Environmental 2010)

The highest annual total greenhouse gas emission for the mine is 236.288t CO_2-e. Australia's assigned amount of greenhouse gas emissions under the Kyoto Protocol for the period 2008 - 2012 is 108% of Australia's estimate emissions for 1990 of 598,075.71 Gg (598 Mt CO_2-e). Total emissions from the mine are 0.04% of Australia's assigned amount under the Kyoto Protocol.

4.5.2 Potential Impacts and Mitigation Measures

The proposed Roseby Copper Mine is to be located directly to the east of the proposal. The emissions from the proposed Roseby Copper Mine have been included in this assessment and are based on the emissions presented in the Environmental Impact Study for the project (Katestone Environmental, 2006). The emissions for the year 7 scenario were included as these are the highest emission rates across the years assessed.

The major air quality issues and impacts that are commonly associated with underground mining activities and that are important for the Dugald River Project include:

- Emissions of oxides of nitrogen, carbon monoxide and fine particulates from the operation of the diesel generators in the first two years;
- Dust emissions associated with extracting and transporting large quantities of waste rock and ore and wind erosion of cleared areas and stockpiles. Dust emissions can result in elevated ground-level concentrations of dust, metals and dust deposition downwind;
- Dust emissions associated with the transport of ore via conveyor and stockpiling;
- Dust emissions associated with the crushing and milling processes at the ore processing plant producing the lead/zinc and copper concentrate; and
- Greenhouse gas emissions from fuel, electricity usage and waste disposed of in landfills.

Vehicle movements on-site will produce oxides of nitrogen, carbon monoxide, sulphur dioxide and fine particles. The emission rates of these air pollutants are unlikely to be large enough to cause adverse air quality impacts at the nearest residence or to result in regional air quality problems such as acid rain or photochemical smog. No further assessment of these pollutants is necessary.

There are trace amounts of lead, manganese, nickel, arsenic and cadmium in the ore and waste rock. Whilst the emissions of the metals due to the Project are expected to be small, emissions of metals have been included in this assessment for completeness.

4.5.2.1 Dust Emission Rates

For each year of mine operation the operating activities will be very similar. The mining will occur underground and the annual throughputs of material will also be similar. Therefore it is anticipated that for each year of operation of the mine the emissions will be similar. Only one mine scenario has therefore been considered which is for the mining of 2 Mtpa of lead/zinc ore and 1 Mtpa of copper ore.

Dust emission rates of $PM_{2.5}$, PM_{10} and TSP were calculated from emission factors published by the USEPA including:

- AP42, Fifth Edition, Volume 1: Stationary Point and Area sources:
    - Chapter 11.9 Western Coal Mining (1998);

- Chapter 11.24 Metallic Minerals Processing; and
- Chapter 13.2.2 Unpaved Roads (2006).

- Dust emissions from conveying were estimated from GHD Oceanics (1975) and Witt et al (1999)

The dust emissions rates were calculated assuming the dust controls specified in Table 4.33. The results of the emission rate calculations are presented in Table 4.34 for $PM_{2.5}$, PM_{10} and TSP and in Table 4.35 for the metals. The most significant sources of dust are from the stockpiles and trucks haling ore and waste rock.

The loads of all trucks carrying concentrate or bulk material from the site will be covered. This management technique reduces drying of the surface and dust lift-off due to wind erosion. Compared to uncovered loads, the emission rate of dust from the loads would be essentially negligible and therefore have not been considered in this assessment.

Table 4.33 Potential Emission Control Factors for Dust Control Measures

Source	Control Measures	Level of Control	Reference
Haul Roads	Watering	50%	NPI for Mining Version 2.3 (2001) – Level 1 Watering Assumed
Loader in Concentrate Shed	Full Enclosure	99%	NPI for Mining Version 2.3 (2001)

Table 4.34 Dust Emission Rates of TSP, PM_{10} and $PM_{2.5}$ for the Dugald River Project

Activity	Emission rate (g/s)		
	TSP	PM_{10}	$PM_{2.5}$
Graders	0.13	0.04	0.004
Waste Stockpile – dumping, wind erosion and dozer	0.46	0.15	0.041
Trucks on unpaved road from portal to ROM	1.76	0.50	0.050
ROM – Trucks dumping ore, wind erosion and loader	1.86	0.88	0.043
Primary Crusher	0.95	0.38	0.071
Crushed ROM Copper and Processing – material handling, wind erosion, dozer and conveyor	2.75	1.20	0.213
Crushed ROM lead/zinc and processing – materials handling, wind erosion, dozer and conveyor	2.59	1.09	0.201
Concentrate Shed – Loader and Conveyor	0.65	0.30	0.048

Table 4.35 Dust Emission Rates of Metals for the Dugald River Project

Activity	Emission rate (g/s)				
	Lead	Arsenic	Cadmium	Manganese	Nickel
Graders	0.00003	0.00002	0.00000	0.0002	0.000003
Waste stockpile – dumping, wind erosion and dozer	-	-	-	-	-
Trucks on unpaved road from portal to ROM	0.04	0.0003	0.0003	0.007	0.00003
ROM – trucks dumping ore, wind erosion and loader	0.02	0.0001	0.0001	0.003	0.00001
Primary crusher	0.05	0.0004	0.0004	0.010	0.00004
Crushed ROM copper and processing – material handling, wind erosion, dozer and conveyor	0.05	0.0003	0.0004	0.009	0.00004
Crushed ROM lead/zinc and processing – material handling, wind erosion, dozer and conveyor	0.01	0.0001	0.0001	0.003	0.00001
Concentrate shed – loader and conveyor	0.00003	0.00002	0.00000	0.0002	0.000003

Metal Concentrations

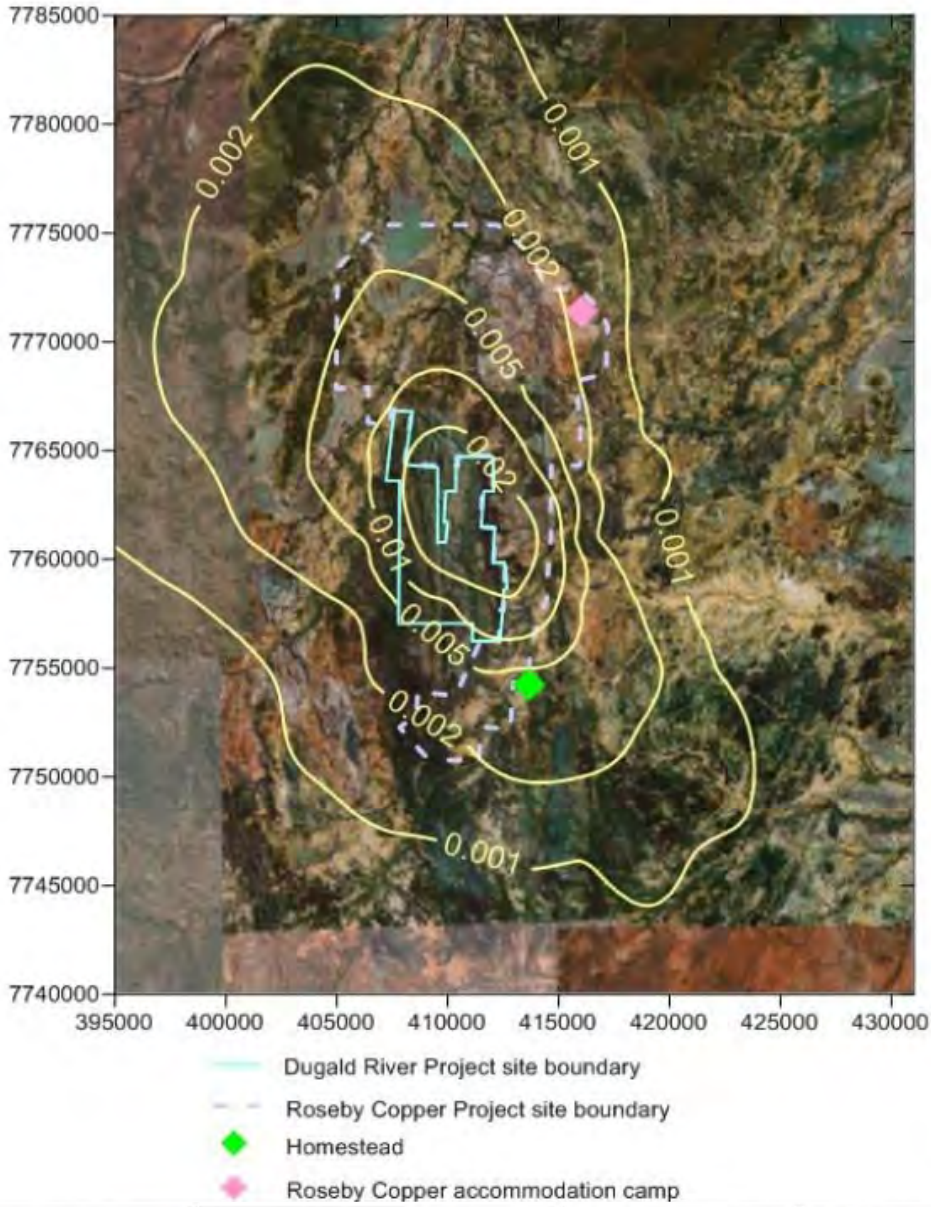
Whilst metals occur naturally in the environment, levels are generally low where there are no anthropogenic sources. As there is no data available regarding expected ambient levels of metals at this site, predicted ground-level concentrations of metals due to the Dugald River Project have been presented as increments without the inclusion of a background level.

Modelling results for the annual average ground-level concentrations of various metals are also presented in Table 4.36 for the nearest homestead and for the Roseby Copper accommodation camp. Results indicate that:

- The predicted annual average ground-level concentrations of lead, arsenic, cadmium, manganese and nickel as an increment are well below the EPP (Air) objectives at both sites;
- Ground-level metal concentrations at these sites are unlikely to exceed the EPP (Air) objectives even with inclusion of a background level; and
- A contour plot of annual average ground-level concentrations of lead due to the Dugald River project in isolation is presented in Figure 4.47 and shows that levels decrease rapidly with increasing distance from the Dugald River Project site.

Table 4.36 Predicted Ground-level Concentrations at the Homestead and the Roseby Copper Accommodation Camp due to the Dugald River Project

Location	Predicted annual average ground-level concentrations				
	Lead (µg/m³)	Arsenic (ng/m^3)	Cadmium (ng/m^3)	Manganese (µg/m³)	Nickel (ng/m^3)
Nearest homestead	0.004	0.054	0.054	0.0014	0.006
Roseby Copper accommodation camp	0.002	0.027	0.027	0.0007	0.003
Objective	**0.5**	**6**	**5**	**0.16**	**20**



Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Annual contours	EPP(Air) 0.5 µg/m³	Natalie Shaw	May 2010

Figure 4.47 Predicted Annual Average Ground-level Concentration of Lead for the Proposed Dugald River Project

4.5.2.2 Air Quality Modelling

Methodology

The modelling assessment has been undertaken using the Integrated Source Complex (ISCST3) model developed by the United States EPA (USEPA, 1998), (EPRI, 1997). The ISC model has been accepted by the DERM for modelling mining emissions in Queensland.

Dispersion modelling has been undertaken using plume depletion. The plume depletion option allows for the removal of particles via gravitational settling. The calculation of the deposition velocity includes explicit parameterisations of the effects of Brownian motion, inertial impaction and gravitational settling. Dispersion modelling has been conducted over a 3 km grid across an area 35 km wide and 45 km long.

The dispersion modelling was conducted assuming constant emission rates from all sources as detailed above and accounting for the range of atmospheric characteristics that are likely to occur over a twelve month period including worst-case meteorological conditions.

The predicted dust and metal levels for the Project as assessed in this section have been compared against the air quality goals/guidelines in Table 4.37.

Table 4.37 Existing Ambient Air Quality Goals and Guidelines Applicable to the Project

Indicator	Averaging period	Objective
Particulates as $PM_{2.5}$	24-hour	25 µg/m^3
	Annual	8 µg/m^3
Particulates as PM_{10}	24-hour[1]	50 µg/m^3
Particulates as TSP	Annual	90 µg/m^3
Dust deposition rate for total insoluble solids	Annual	4 g/m^2/month
Lead and compounds (measured as total metal in TSP)	Annual	0.5 µg/m^3
Arsenic and compounds (measured as total metal in PM_{10})	Annual	6 ng/m^3
Cadmium and compounds (measured as total metal in PM_{10})	Annual	5 ng/m^3
Nickel and compounds (measured as total metal in PM_{10})	Annual	20 ng/m^3
Manganese and compounds (measured as total metal in PM_{10})	Annual	0.16 µg/m^3
Nitrogen dioxide	1-hour	250 µg/m^3 (0.12 ppm)
	Annual	62 µg/m^3 (0.03 ppm)
Carbon monoxide	8 hour	11000 µg/m^3 (9 ppm)
Note: [1] Five allowable exceedances		

Construction Results – On-site Generators

The power station proposal is for two generators, a 1.5 MVA and a 1.0 MVA, to be located near the village and for two 1.0 MVA units to be located at the mine site. These diesel generators are proposed to only be used in the first two years of construction and start up until the site is added to the electricity transmission grid. The exact details of the generators are not yet known but should be similar to the details provided by Cummins Power Generation (for further details see http://www.cumminspower.com/ap/products/generators/diesel#results). A summary of the stack and emission information is presented in Table 4.38.

Table 4.38 Summary of Stack and Emission Characteristics for the Proposes Gensets

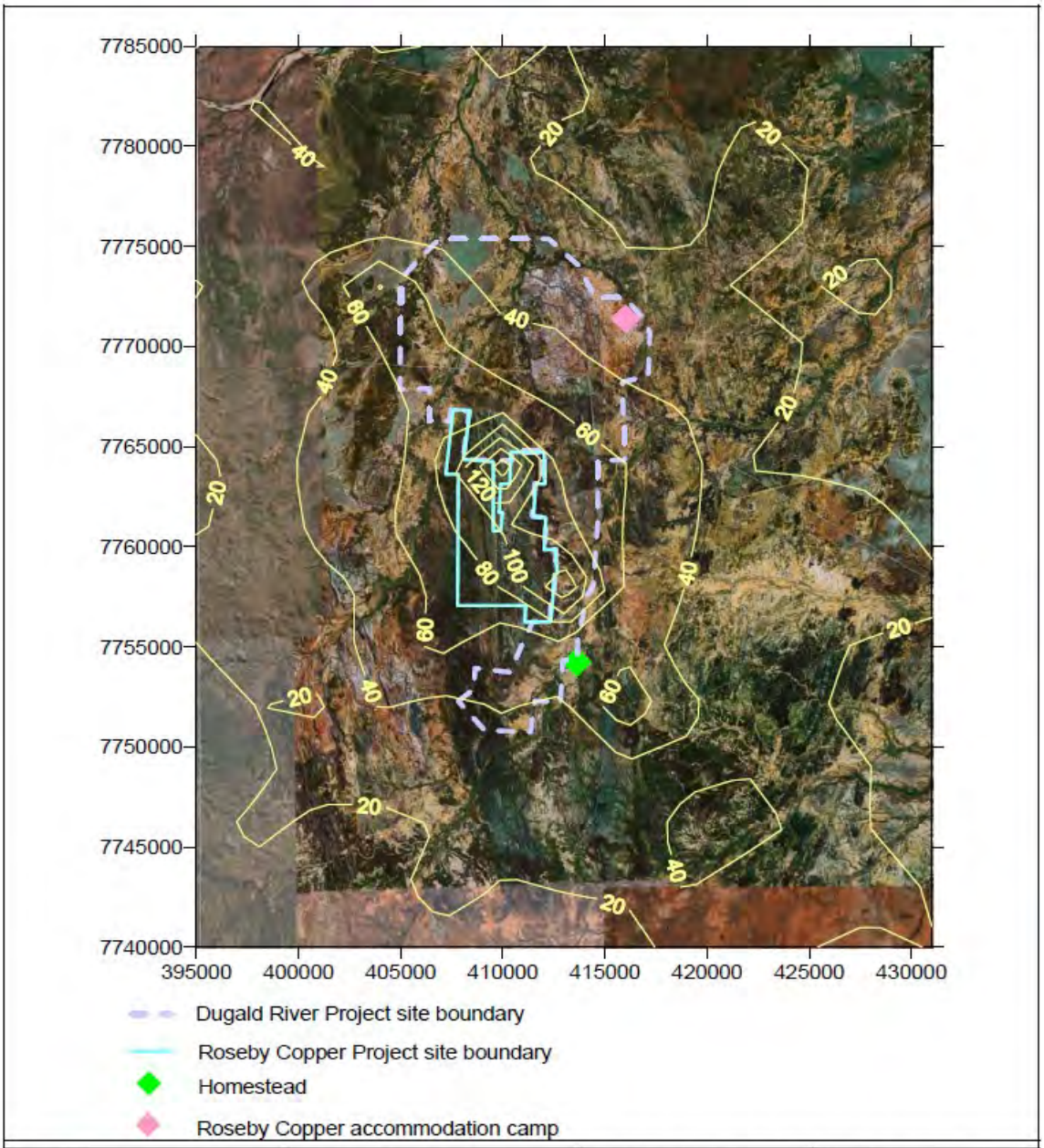
Parameter	Units	1.5 MVA	1.0 MVA
Number of Gensets	-	1	3
Stack Height	m	2.23	2.25
Stack Diameter	m	0.52	0.48
Exit Temperature	°C	475	525
Exit Velocity	m/s	20	20
Oxides of Nitrogen	g/s	2.26	1.80
Carbon Monoxide	g/s	1.23	0.98
Particulates	g/s	0.07	0.06

The predicted ground-level concentrations of $PM_{2.5}$, PM_{10}, carbon monoxide and nitrogen dioxide are presented in Table 4.39 for the nearest homestead. The modelling results indicate that all ground-level concentrations are well below the EPP (Air) goals. The results for nitrogen dioxide are conservative, as a 100% conversion of oxides of nitrogen to nitrogen dioxide has been assumed. In reality, this ratio is likely to be 30-50%. The results for the $PM_{2.5}$ are also conservative as it has been assumed that all emissions of PM_{10} are in the form of $PM_{2.5}$.

Whilst background concentrations have not been included, the ground-level concentrations are so low that even if a background was included the concentrations would still be well below the relevant air quality goals. Figure 4.48 shows the predicted contour of the 1-hour average nitrogen dioxide concentration with highest concentrations occurring onsite and below the EPP(Air) objective.

Table 4.39 Predicted Ground-Level Concentrations of $PM_{2.5}$, PM_{10}, Carbon Monoxide and Nitrogen Dioxide at the Homestead due to the Gensets (First Two Years)

Description	$PM_{2.5}$ (µg/m^3)		PM_{10} (µg/m^3)	Carbon monoxide (µg/m^3)	Nitrogen dioxide (µg/m^3)	
	24-hour	Annual	24-hour	8-hour	1-hour	Annual
Dugald River Gensets	0.2	0.01	0.2	7.6	50.6	0.3
Objective	**25**	**8**	**50**	**10,000**	**250**	**62**



Location:	Averaging period:	Data source:	Units:
Dugald River Project	1-hour	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	250 µg/m³	Lena Jackson	September 2008

Figure 4.48 Predicted 1-hour Average Ground-level Concentrations of Nitrogen Dioxide for the Proposed Dugald River Project Gensets Only (background levels not included)

Whilst background concentrations have not been included, the ground-level concentrations are so low that even if a background was included the concentrations would still be well below the relevant air quality goals.

Operation Results

Predicted ground-level concentrations of dust are presented in Table 4.40 for the nearest sensitive receiver (Roseby Homestead) and in Table 4.41 for the accommodation camp for the proposed Roseby Copper Project.

Table 4.40 Predicted Ground-level Concentrations at Roseby Homestead

Description	24-hour average		Annual average		
	PM_{10}[1] (µg/m^3)	$PM_{2.5}$ (µg/m^3)	$PM_{2.5}$ (µg/m^3)	TSP (µg/m^3)	Dust Deposition rate (g/m^2/month)
Dugald River Only	2.7	1.3	0.04	0.2	0.01
Dugald River and Roseby Copper Project	39.2	10.4	0.7	5.9	0.2
Dugald River, Roseby Copper Project and Background Levels	63.2	17.8	7.3	62.6	0.8
Objective	**50**	**25**	**8**	**90**	**4**
Note: [1] 6th highest concentration					

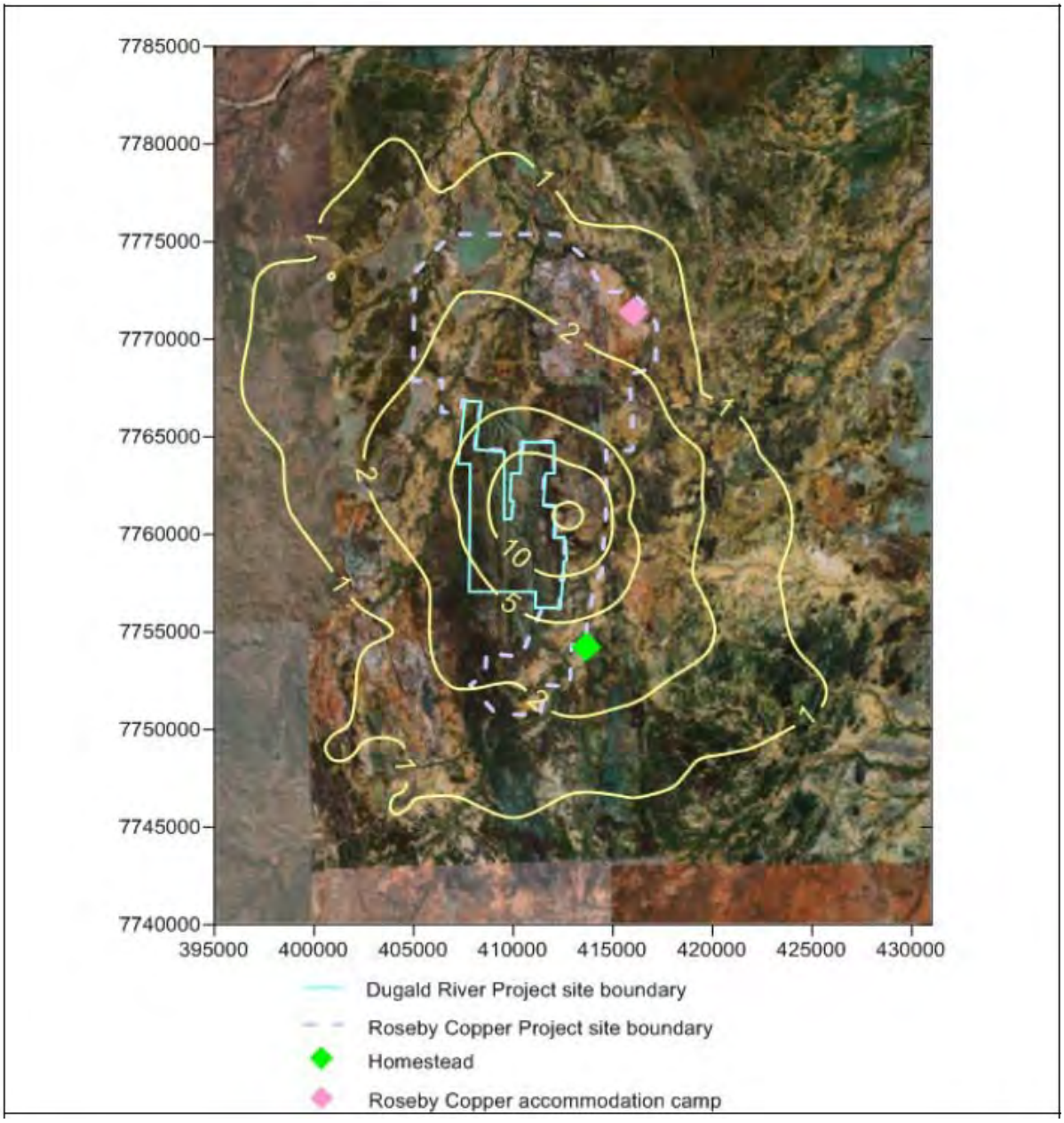
Table 4.41 Predicted Ground-level Concentrations at the Roseby Copper Accommodation Camp

Description	24-hour average		Annual average		
	PM_{10}[1] (µg/m^3)	$PM_{2.5}$ (µg/m^3)	$PM_{2.5}$ (µg/m^3)	TSP (µg/m^3)	Dust deposition rate (g/m^2/month)
Dugald River Project only	1.4	0.8	0.02	0.1	0.01
Dugald River and Roseby Copper Project	14.3	9.0	0.4	2.1	0.1
Dugald River, Roseby Copper Project and background levels	38.3	16.4	7.0	58.8	0.7
Objective	**50**	**25**	**8**	**90**	**4**
Note: [1] 6th highest concentration					

The 24-hour average PM_{10} objective allows for five exceedances per year. Therefore modelling results for the 6th highest 24-hour average ground-level concentrations of PM_{10} are presented to account for this. Figure 4.49 and Figure 4.50 present contour plots of the 6th highest 24-hour average ground- level concentrations of PM_{10} due to the Dugald River Project in isolation and including the Roseby Copper Project and background, respectively.

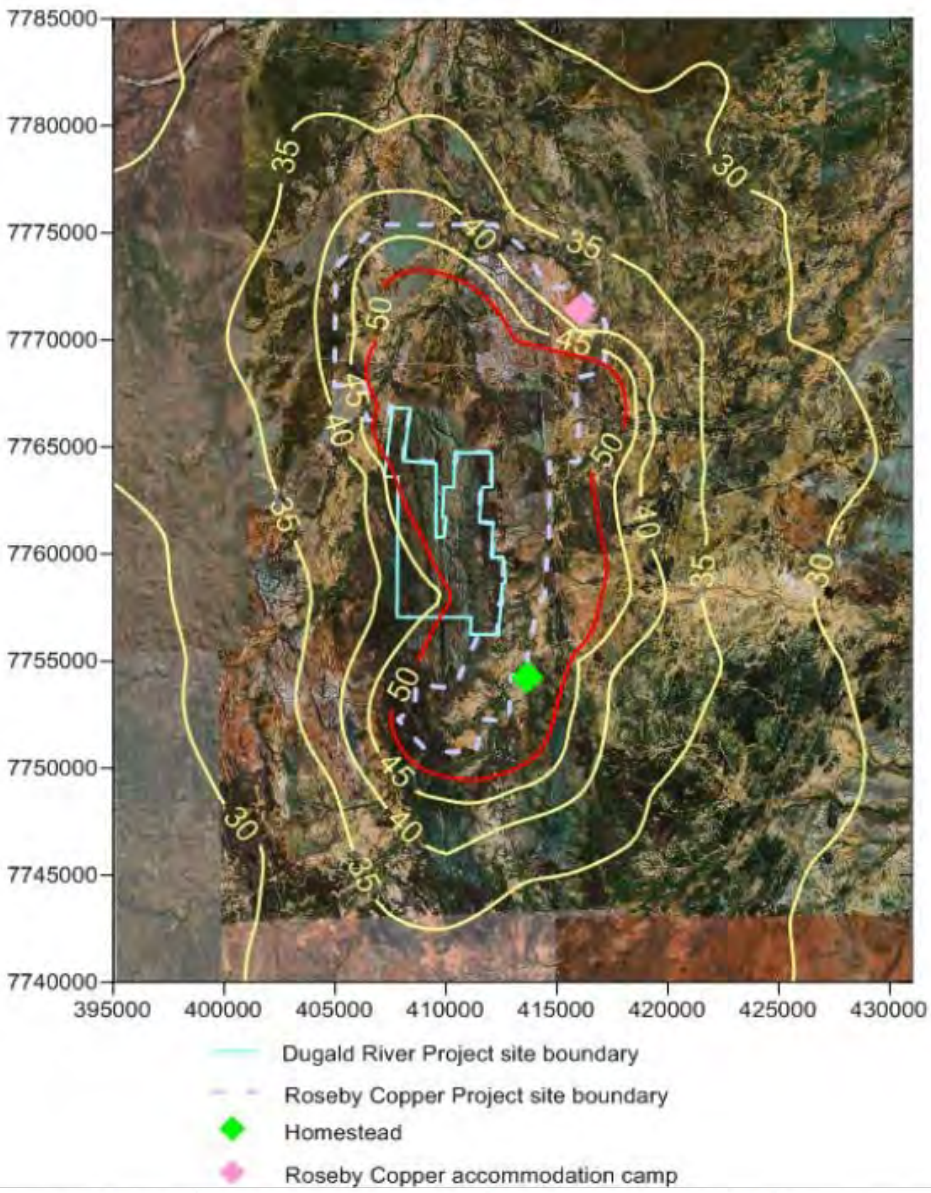
Figure 4.51 and Figure 4.52 present contour plots of the maximum 24-hour average ground- level concentrations of $PM_{2.5}$ due to the Dugald River Project in isolation and including the Roseby Copper Project and background, respectively. Figure 4.53 and Figure 4.54 present contour plots of the annual average ground-level concentrations of $PM_{2.5}$ due to the Dugald River Project in isolation and with the Roseby Copper Project and background.

Contour plots of the annual average ground-level concentrations of TSP due to the Dugald River Project in isolation and with the Roseby Copper Project and background are presented in Figure 4.55 and Figure 4.56, respectively. Contour plots of the annual average dust deposition rate due to the Dugald River Project in isolation and with the Roseby Copper Project and background are presented in Figure 4.57 and Figure 4.58.



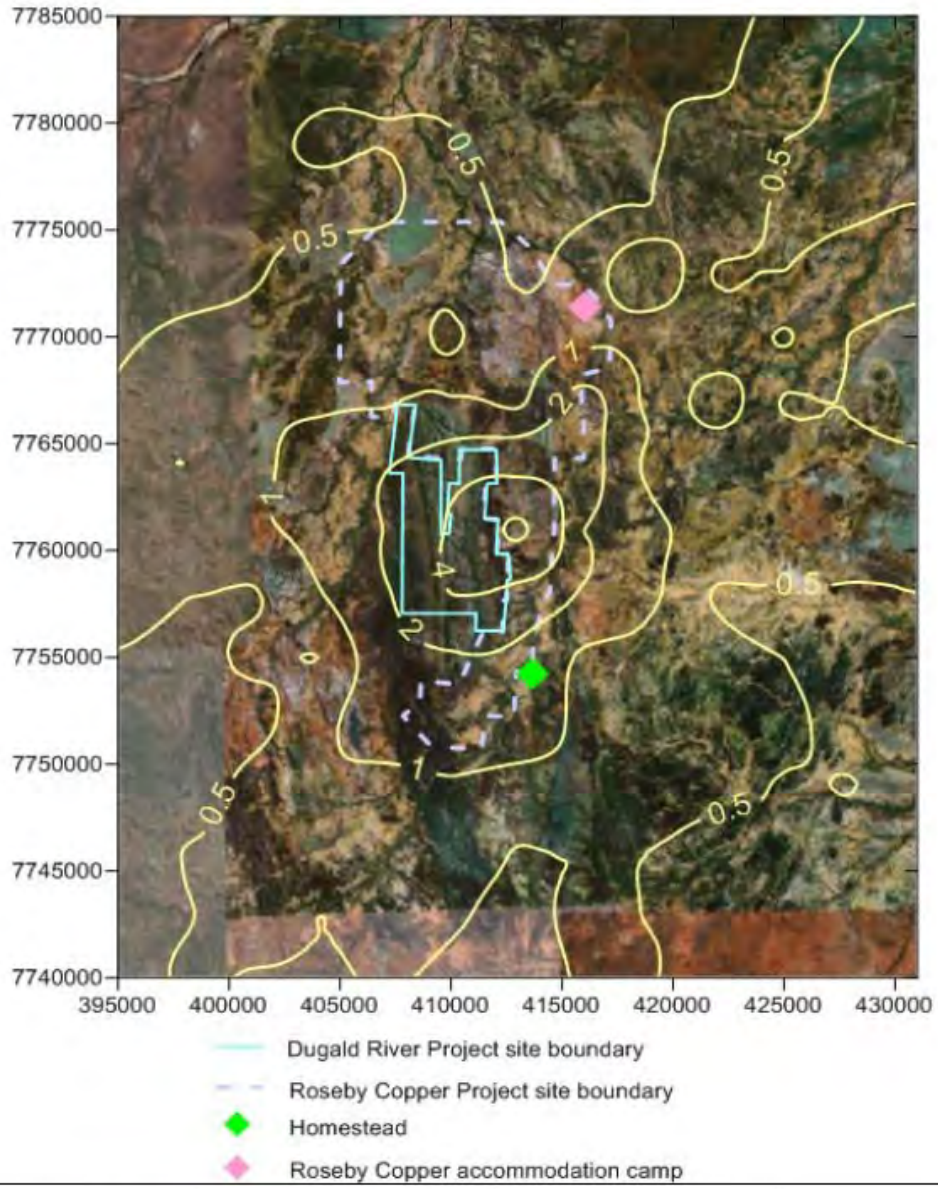
Location: Dugald River Project	**Averaging period:** 24-hour	**Data source:** ISC	**Units:** µg/m³
Type: 6th highest contours	**Objective:** EPP(Air) 50 µg/m³	**Prepared by:** Natalie Shaw	**Date:** May 2010

Figure 4.49 Predicted 6th Highest 24-hour Average Ground-level Concentration of PM_{10} for the Proposed Dugald River Project



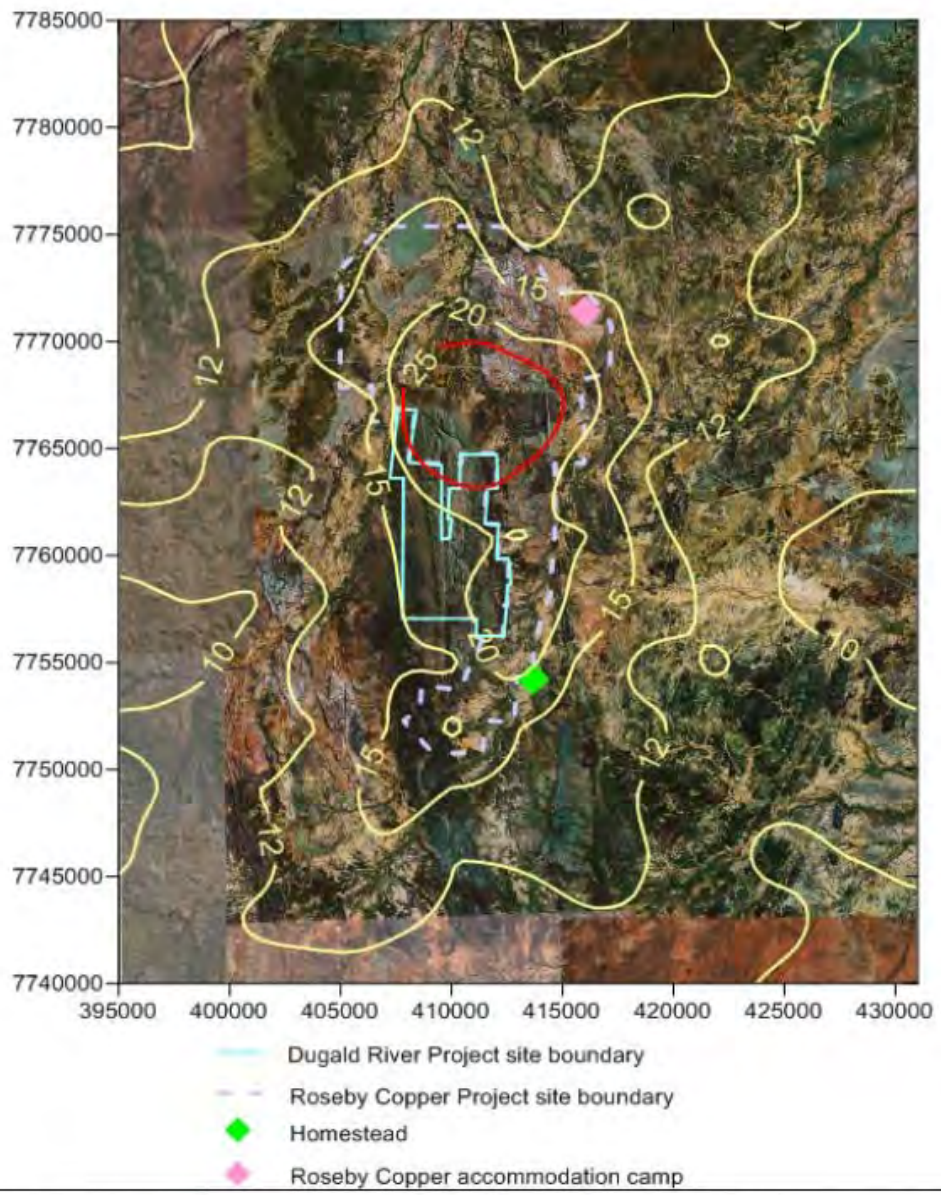
Location:	Averaging period:	Data source:	Units:
Dugald River Project	24-hour	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
6th highest contours	EPP(Air) 50 µg/m³	Natalie Shaw	May 2010

Figure 4.50 Predicted 6th Highest 24-hour Average Ground-level Concentration of PM_{10} for the Proposed Dugald River Project, Roseby Copper Project and Background.



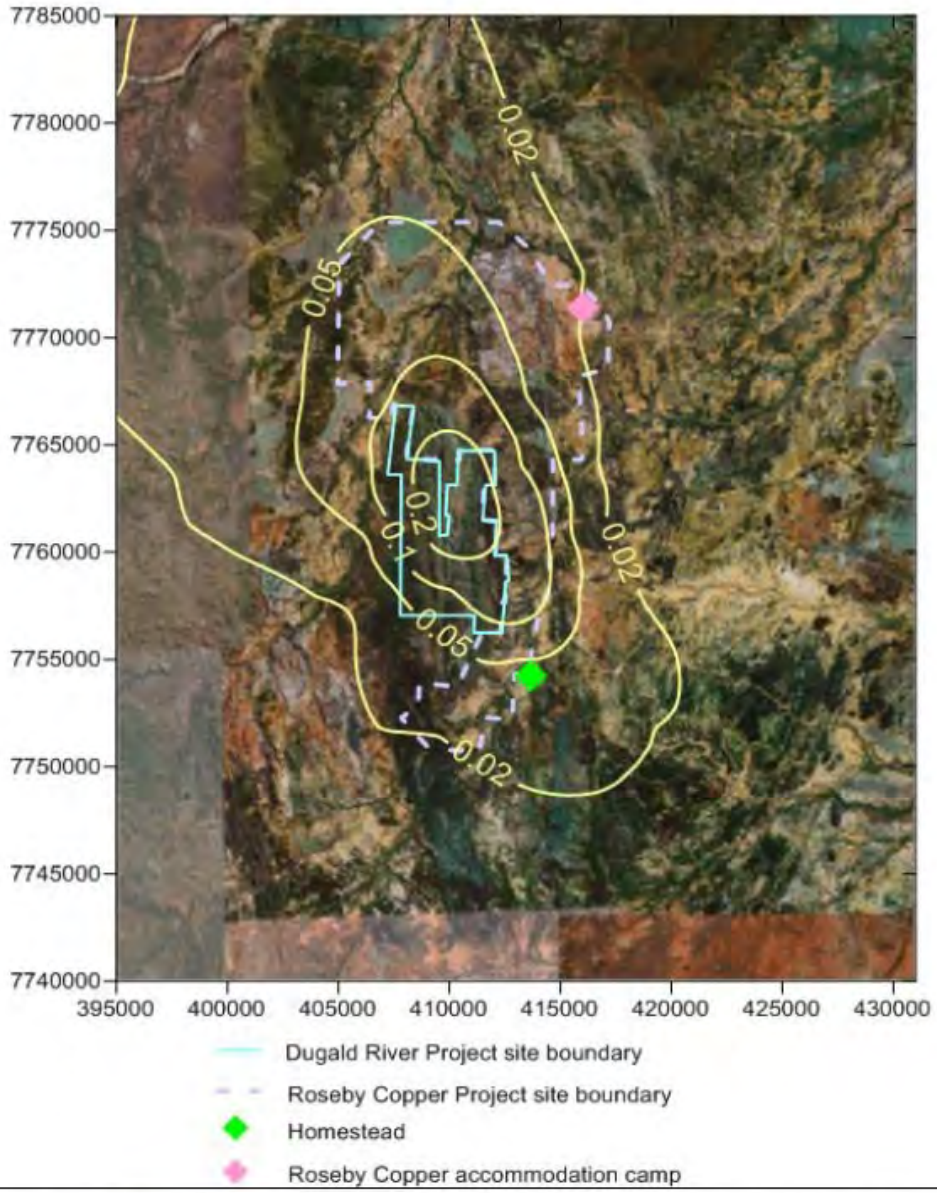
Location:	Averaging period:	Data source:	Units:
Dugald River Project	24-hour	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	EPP(Air) 25 µg/m³	Natalie Shaw	May 2010

Figure 4.51 Predicted Maximum Ground-level Concentration of 24-hour average $PM_{2.5}$ for the Proposed Dugald River Project



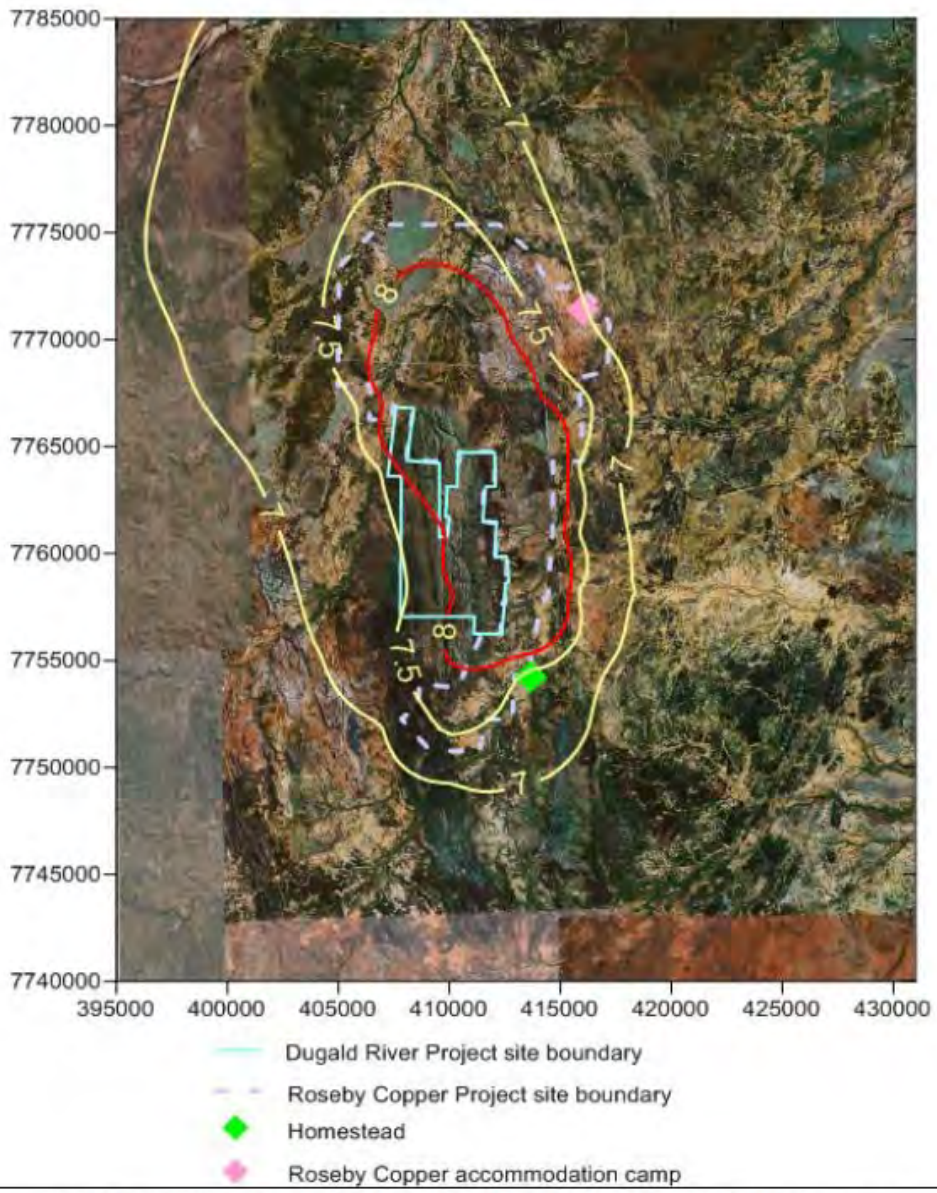
Location:	Averaging period:	Data source:	Units:
Dugald River Project	24-hour	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Maximum contours	EPP(Air) 25 µg/m³	Natalie Shaw	May 2010

Figure 4.52 Predicted Maximum Ground-level Concentration of 24-hour average $PM_{2.5}$ for the Proposed Dugald River Project, Roseby Copper Project and Background.



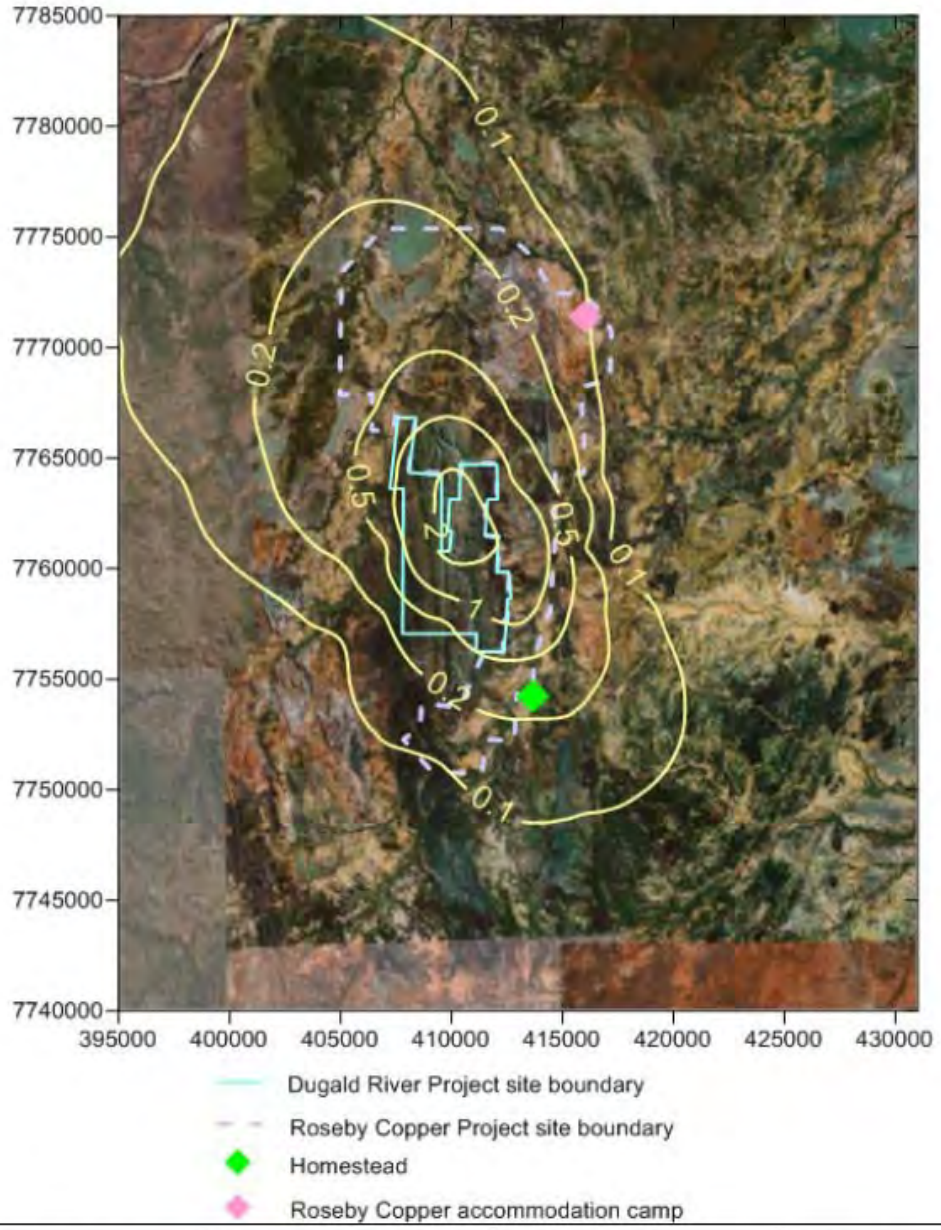
Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Annual contours	EPP(Air) 8 µg/m³	Natalie Shaw	May 2010

Figure 4.53 Predicted Annual Average Ground-level Concentrations of $PM_{2.5}$ for the Proposed Dugald River Project



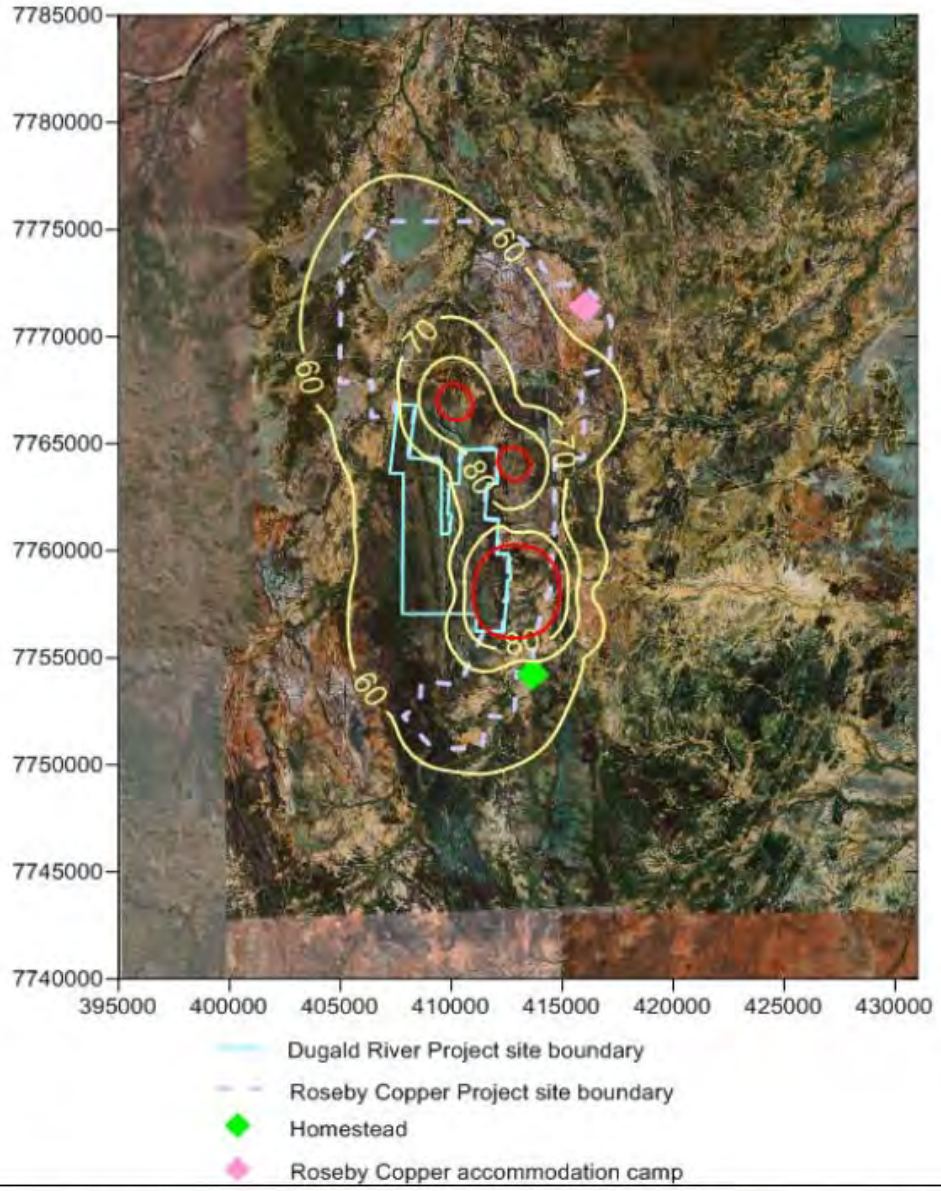
Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Annual contours	EPP(Air) 8 µg/m³	Natalie Shaw	May 2010

Figure 4.54 Predicted Annual Average Ground-level Concentrations of $PM_{2.5}$ for the Proposed Dugald River Project, the Roseby Copper Project and Background.



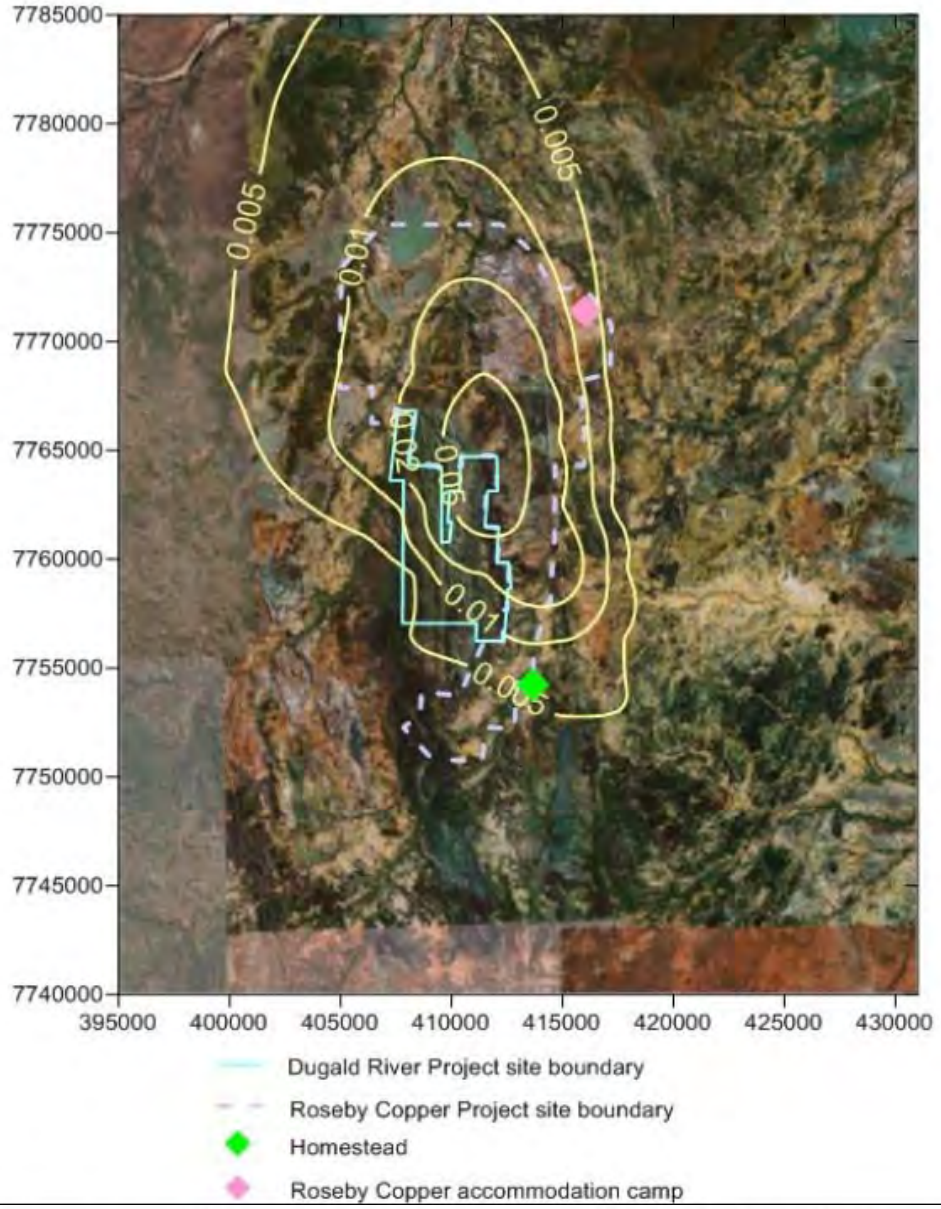
Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Annual contours	EPP(Air) 90 µg/m³	Natalie Shaw	May 2010

Figure 4.55 Predicted annual average ground-level concentrations of TSP for the Proposed Dugald River Project



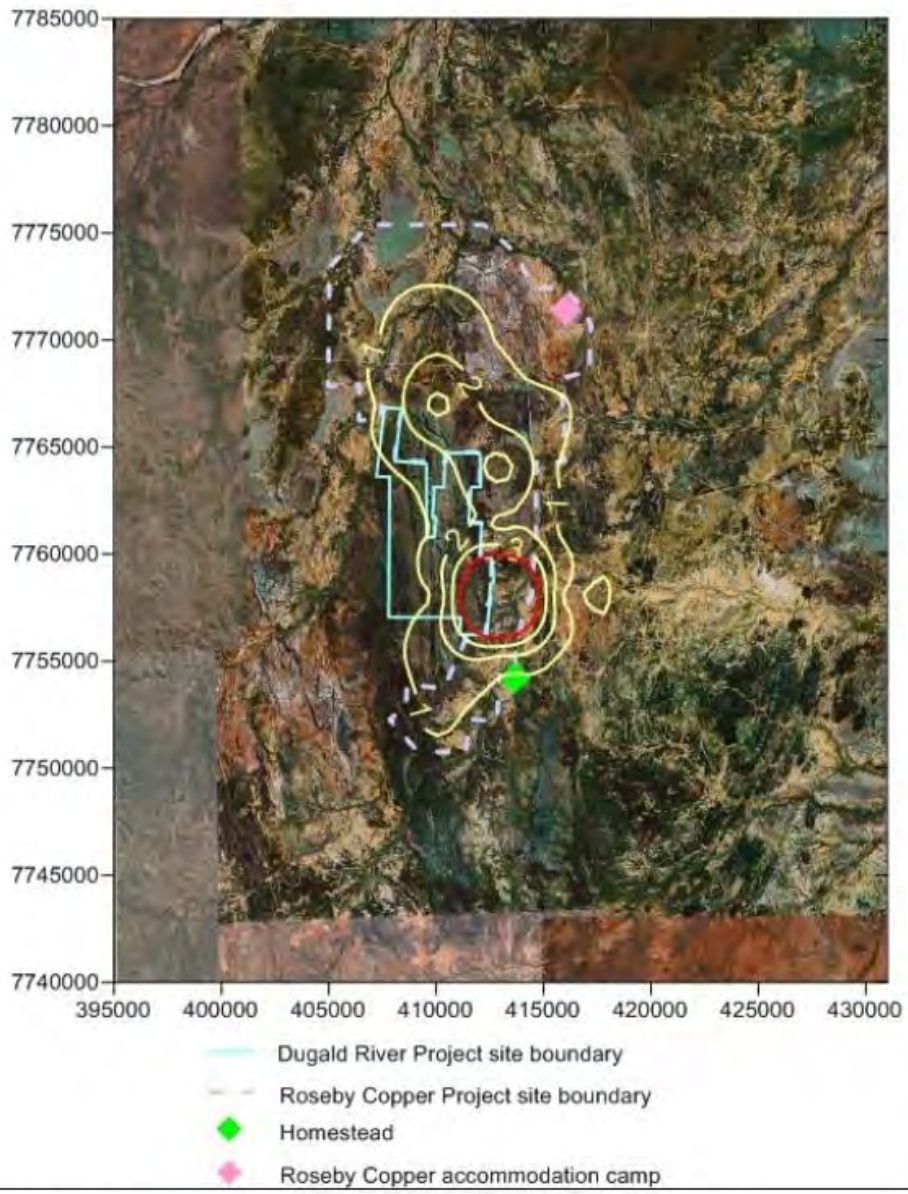
Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	µg/m³
Type:	**Objective:**	**Prepared by:**	**Date:**
Annual contours	EPP(Air) 90 µg/m³	Natalie Shaw	May 2010

Figure 4.56 Predicted Annual Average Ground-level Concentrations of TSP for the Proposed Dugald River Project, the Roseby Copper Project and Background.



Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	g/m²/month
Type:	**Recommended guideline:**	**Prepared by:**	**Date:**
Annual contours	DERM 4 g/m²/month	Natalie Shaw	May 2010

Figure 4.57 Predicted Annual Average Dust Deposition Rate for the Proposed Dugald River Project



Location:	Averaging period:	Data source:	Units:
Dugald River Project	Annual	ISC	g/m²/month
Type:	**Recommended guideline:**	**Prepared by:**	**Date:**
Annual contours	DERM 4 g/m²/month	Natalie Shaw	May 2010

Figure 4.58 Predicted Annual Average Dust Deposition Rate for the Proposed Dugald River Project, the Roseby Copper Project and Background.

The modelling results for the 6th highest 24-hour average ground-level concentrations of PM_{10} indicate that:

- The 6th highest 24-hour average ground-level concentration of PM_{10} due to the Dugald River Project in isolation is predicted to be 2.7 µg/m^3 at the Roseby Homestead and 1.4 µg/m^3 at the Roseby Copper accommodation camp;

- The 6th highest 24-hour average ground-level concentration of PM_{10} at the Roseby Homestead is predicted to be 63.2 µg/m^3 with the incorporation of the Roseby Copper Project as well as a background level of 24 µg/m^3. Concentrations of PM_{10} due to the Project represent less than 5 % of the ground-level concentration;

- The EPP(Air) 24-hour average PM_{10} objective of 50 µg/m^3 is predicted to be exceeded in the later years of the Roseby Copper Project when the operations are closer to the location of the homestead; and

- At the Roseby Copper accommodation camp, the 6th highest 24-hour average ground-level concentration of PM_{10} is predicted to be 38.3 µg/m^3 with the incorporation of the Roseby Copper Project as well as a background level of 24 µg/m^3. Concentrations of PM_{10} due to the Project represent less than 4 % of the ground-level concentration.

Modelling results for the 24-hour and annual average ground-level concentrations of $PM_{2.5}$ indicate that:

- The maximum 24-hour average ground-level concentration of $PM_{2.5}$ due to the mine in isolation is predicted to be 1.3 µg/m^3 at the Roseby Homestead and 0.8 µg/m^3 at the Roseby Copper accommodation camp;

- The maximum 24-hour average ground-level concentration of $PM_{2.5}$ at the homestead is predicted to be 17.8 µg/m^3 with the incorporation of the Roseby Copper Project as well as a background level of 7.4 µg/m^3. The Dugald River Project is predicted to contribute 7.3 % to this concentration. This complies with the EPP(Air) objective of 25 µg/m^3;

- The maximum 24-hour average ground-level concentration of $PM_{2.5}$ at the Roseby Copper accommodation camp is predicted to be 16.4 µg/m^3 with the incorporation of the Roseby Copper Project as well as a background level of 7.4 µg/m^3. The Dugald River Project is predicted to contribute 0.6 % to this concentration. This complies with the EPP(Air) objective of 25 µg/m^3;

- The annual average ground-level concentration of $PM_{2.5}$ due to the mine in isolation is predicted to be 0.04 µg/m^3 at the Roseby Homestead and 0.02 µg/m^3 at the Roseby Copper accommodation camp; and

- The annual average ground-level concentration of $PM_{2.5}$ at the homestead is predicted to be 7.3 µg/m^3 and 7.0 µg/m^3 at the Roseby Copper accommodation camp with the incorporation of the Roseby Copper Project as well as a background level of 6.6 µg/m^3. This complies with the EPP(Air) objective of 8 µg/m^3.

Modelling results for the annual average ground-level concentrations of TSP and the annual average dust deposition rate (including metals) indicate that:

- The predicted annual average ground-level concentration of TSP is well below the EPP(Air) objective of 90 µg/m^3 at both sites. Even with the addition of the Roseby Copper Project and an estimated background of 56.7 µg/m^3, the predicted concentrations at the sensitive receptors are unlikely to exceed the objective;

- The recommended guideline of 4 g/m^2/month for dust deposition rate is not exceeded even with the incorporation of the Roseby Copper Project as well as a background level of 0.6 g/m^2/month. The increment due to the Dugald River Project is approximately 1.3 % of the recommended guideline at both the Roseby Homestead and Roseby Copper accommodation camp;

- The predicted annual average ground-level concentrations of lead, arsenic, cadmium, manganese and nickel as an increment are well below the EPP (Air) objectives; and

- Ground-level metal concentrations are unlikely to exceed the EPP (Air) objectives even with inclusion of a background level.

Summary of Assessment

- The main sources of dust emissions from the mine will be from the stockpiles and the transport of ore and waste rock on haul roads;

- The contribution from the Dugald River Project to air pollutant concentrations at the location of sensitive receptors is predicted to be minor compared with background levels and the contribution from the Roseby Copper Project;

- There is compliance with the EPP(Air) objectives for predicted 24-hour and annual average ground-level concentrations of $PM_{2.5}$, annual average ground-level concentrations of TSP and annual average dust deposition rates at the nearest homestead residence and the Roseby Accommodation Camp due to operations at the Dugald River Project, Roseby Copper Project and ambient background levels;

- The EPP(Air) objective for 24-hour average ground-level concentrations of PM10 is predicted to be exceeded at the nearest homestead residence in the later years of the Roseby Copper Project when the Roseby Copper Project operations are closer to the location of the homestead. However, levels at the Roseby Accommodation Camp are predicted to comply with the EPP(Air) objective; and

- Predicted annual average ground-level concentrations of lead, arsenic, cadmium, manganese and nickel due to the Dugald River Project as an increment are well below the EPP(Air) objectives at the nearest homestead residence and the Roseby Accommodation Camp. Concentrations at these sites are unlikely to exceed the EPP(Air) objectives even with inclusion of a background level.

The following mitigation measures to control dust will be implemented at the Dugald River Project. These have been included as base assumptions in the dust modelling presented in this report:

- Watering of the haul roads;

- Using conveyors minimises dust compared with haulage; and
- Minimising handling of materials wherever possible.

The modelling has shown that the proposed dust controls will be effective in avoiding adverse impacts.

In addition, the following control strategies will also be implemented to minimise dust and odours on the Project:

- A complaints register will be maintained to record and investigate all bona fide complaints;
- Ongoing rehabilitation and revegetation of the site;
- Minimisation of disturbed areas;
- Limited vehicle speed within infrastructure areas and mine access roads;
- Reporting and minimisation of greenhouse gas emissions from the Project as per a Greenhouse Gas Management Plan that has been developed for the Project (Section 4.5.2.3); and
- Putrescible waste will be covered on a regular basis (at least weekly) to reduce odour.

4.5.2.3 Greenhouse Gas Abatement

Management Objectives

The fourth assessment report of the Intergovernmental Panel on Climate Change has declared that warming of the climate system is unequivocal and that most of the observed increase in global average temperatures is very likely due to the observed increase in anthropogenic greenhouse gas concentrations. In light of this, MMG is committed to effectively manage greenhouse gas emissions associated with the Dugald River Project. As the Dugald River Project is still in the design phase, MMG proposes to incorporate a number of features into the Project to reduce the greenhouse gas emissions from the outset of the Project. Through a Greenhouse Gas Management Plan (GGMP) contained in Appendix O, MMG will ensure that opportunities to reduce the Project's emissions further during operations will also be pursued.

The specific management objectives for the GGMP include the following:

- To design and construct the Project, where practicable, utilising best practice technologies to reduce energy consumption and subsequent greenhouse gas emissions;
- To improve operations, where practicable, by implementing best practice technologies to reduce energy consumption and subsequent greenhouse gas emissions;
- To regularly measure, monitor, audit and review the effectiveness of greenhouse gas emission reduction strategies;
- To undertake reporting responsibilities under the NGER Act; and
- To undertake reporting responsibilities under the *Energy Efficiency Opportunities Act 2006*.

Requirements under *National Greenhouse and Energy Reporting Act 2007 (Cth)*

The legislative requirement for the Project will be to report under the NGER Act. The NGER Act establishes a national framework for Australian corporations to report greenhouse gas emissions, reductions, removals and offsets and energy consumption and production as of 1 July 2008.

Under the NGER Act corporations are required to register and report if they emit greenhouse gases, produce energy or consume energy at or above the specified thresholds as follows:

- They control facilities that emit 25 kilotonnes or more of greenhouse gas, or produce/consume 100 terajoules or more of energy; or

- Their corporate group emits 50 kilotonnes or more of greenhouse gas, or produce/consume 200 terajoules or more of energy by 2010/2011.

The Dugald River Project will exceed those thresholds and will need to report under the NGER Act. This Act dictates the manner in which reporting needs to be undertaken, and is further discussed below.

Requirements under the *Energy Efficiency Opportunities Act 2006 (Cth)*

The Project will operate under the Commonwealth's *Energy Efficiency Opportunities Act 2006*, which aims to "encourage large energy-using businesses to improve their energy efficiency". In accordance with the programme MMG will routinely assess and report on cost effective energy savings opportunities.

The Project proposes to acquire electricity initially from four gensets giving a total output of 4.5 MVA. The generators will power the mine and plant construction activities, as well as the onsite accommodation facilities for workers for the first two years of construction activities, prior to the commencement of operations and connection to the northwest Queensland regional grid. Electricity will be consumed from the grid after the first two years. A summary of the greenhouse gas emissions can be found in Section 4.5.1.1.

The extent to which the GGMP achieves the management objectives outlined above will be measured by the performance targets and indicators presented in the Table 4.42 for the construction phase of the Project and Table 4.43 for the operating phase of the Project.

As the GGMP is a continual improvement and abatement program it is intended that the Action Plans will form a dynamic document which is subject to ongoing adjustment taking into consideration the outcomes of the annual Greenhouse Gas auditing process and review into best practice methods for reducing emissions.

In developing the greenhouse gas reduction actions for the accommodation camp and offices, reference has been made to the *Improving Sustainable Housing in Queensland – Discussion Paper* (DIP, 2008).

Table 4.42 Action Plan for Reducing Greenhouse Gas Emissions - Construction Phase

Overriding Objective	Actions to Achieve Objective	Indicators to Measure Progress	Target
To design and construct the Project, where practicable, utilising best practice technologies to reduce energy consumption and subsequent greenhouse gas emissions.	Timers/motion sensors to be installed on all air-conditioning units at the accommodation camp	Percentage of air-conditioners with timers/motion sensors installed	95% of all air-conditioners
	Photovoltaic and motion sensors on outdoor lighting (i.e. will only operate in low light conditions and when someone walks past) around offices and the accommodation camp	Percentage of outdoor lights with photovoltaic and motion sensors	70% of all outdoor lighting (excluding permanent lighting required to conduct safe operations)
	Ceiling fans installed in common areas of the accommodation camp to reduce reliance on air-conditioning	Percentage of common areas with ceiling fans	70% of all common areas
	Install only energy efficient light bulbs in the accommodation camp and offices	Percentage of light bulbs that are energy efficient	100% of all light bulbs
	Install 3 star/AAA rated shower roses and tap wear at the accommodation camp and all offices/ablutions.	Percentage of shower roses and tap wear that is 3 star/AAA rated	At least 95% of all tap wear or shower roses
	Install 3 star rated duel flush toilets at the accommodation camp and all offices/ablutions.	Percentage of toilets that are duel flush 3 star rated	At least 95% of all toilets
	Accommodation camp buildings insulated with a R rating of at least 2 in the walls and 2.5 in ceilings	Percentage of accommodation buildings insulated to R rating standard	At least 80% of all buildings
	Installation of new, more efficient, IsaMills™ for fine grinding in the processing plant	IsaMills installed	100% of ore ground by IsaMills

Table 4.43 Action Plan for Reducing Greenhouse Gas Emissions – Operations Phase

Overriding Objective	Actions to Achieve Objective	Indicators to Measure Progress	Target	Audit Process/Timeframe
To improve operations, where practicable, by implementing best practice technologies to reduce energy consumption and subsequent greenhouse gas emissions	Reusing water from the tailings system as process water to limit pumping from Lake Julius	Percentage of water recycled from the TSF	50% of annual process plant water supply to be sourced from tailings decant, where actual rainfall conditions permit	By the end of the first year of operations.
	Recycle treated grey water from the accommodation camp for sub-irrigation of gardens	Percentage of grey water used for sub-irrigation	At least 70% of all grey water	
	For each major processing or mining activity that produces greenhouse gases, a target greenhouse gas intensity should be identified at the end of the first year of operations	Greenhouse gas intensities calculated and targets set	Targets set for all major processing and mining activities	
	Use of Euro Tier 3 engines in underground loading and hauling equipment to reduce greenhouse gas emissions	Percentage of underground load and haul equipment using Euro 3 engines	Underground load and haul equipment fleet using Euro 3 engines - 50% in first full year of operations, ramping up to 90% by the fourth full year of operations	
To regularly measure, monitor, audit and review the effectiveness	Annual public reporting of greenhouse gas emissions in the companies Annual Sustainability Report	Annual reports complete	Annual reports complete	Annually

Overriding Objective	Actions to Achieve Objective	Indicators to Measure Progress	Target	Audit Process/Timeframe
of greenhouse gas emission reduction strategies.	Energy audit conducted within first two years of Project operation.	Energy audit report	One energy audit completed every two years	Within first two years of operations
	Review this GGMP annually during the operating phase of the Project to identify improvements for greenhouse gas mitigation and reduction strategies.	New GGMP developed annually	New GGMP developed annually	Annually
To undertake reporting responsibilities under the NGER Act	Annual report submitted using the Online System for Comprehensive Activity Reporting (OSCAR).	Annual report submitted	Annual report submitted	Annually
To undertake responsibilities as required under the EEO Act	• Undertake detailed energy assessments • Identify opportunities to improve efficiency in energy use	• Prepare and submit an assessment and reporting schedule • Complete first assessments • Results of assessments reported to the public	• Prepare and submit an assessment and reporting schedule • Complete first assessments • Results of assessments reported to the public	Assessment and reporting schedule - 18 months after trigger year Complete first assessments – 24 months after trigger year. Publically report – 30 months after trigger year

Reporting Requirements – NGER Act

It is a legislative requirement under the NGER Act that a Corporation register and report annual greenhouse emissions if reporting thresholds are exceeded. Reporting and record keeping should be conducted in accordance with the National Greenhouse and Energy Reporting Guidelines (2008).

If registered, MMG must, in accordance with the Act, provide a report to the Greenhouse and Energy Data Officer relating to the greenhouse gas emissions, energy production, and energy consumption from the Project during that financial year. This annual report must fulfil the requirements set out in the *National Greenhouse and Energy Reporting Regulations 2008* (*Cth*) and report on the quantity of each greenhouse gas emitted during the reporting year. Reports can also be submitted relating to greenhouse gas abatement and reduction projects undertaken as part of the Dugald River Project, if the Project meets the requirements set out in the NGER Act.

Data and information pertaining to the accurate completion of the annual report must be retained for a period of 7 years from the end of the year in which the activities have taken place. These records must allow for the Greenhouse and Energy Data Officer to ascertain whether obligations under the Act have been fulfilled. Reports can be submitted using the Online System for Comprehensive Activity Reporting (OSCAR).

Reporting Requirements – EEO Act

MMG will be required to assess their energy use and report publicly on the results of the assessment under the EEO Act. The programme operates on a five-year cycle and allows for participants to be responsible for decisions associated with energy efficiency opportunities.

The assessment framework involves corporations looking at multiple factors influencing energy use, including management and policy.

There are five steps that corporations using more than 0.5 petajoules of energy per year must follow and occur with in the five year cycle. These steps are:

1. Determine whether the corporation has to participate in Energy Efficiency Opportunities;
2. Register with the Department of Resources, Energy and Tourism;
3. Prepare and submit an assessment and reporting schedule;
4. Conduct assessments; and
5. Report on assessment outcomes and business response.

4.5.2.4 Climate Change Adaptation

The overall vulnerability of the project to climate change is low. Given the Project's central north-west Queensland location, rises in sea level are unlikely to impact on the operation of the Project. The Australian Government Department of Climate Change and Energy Efficiency has identified the following trends in the region of the Project:

- Since 1900, slight increase in rainfall in the vicinity of 5 mm per 10 years; and
- Since 1910, slight increase in temperature in the vicinity of 0.05-0.10 degrees Celsius per 10 years.

The TSF has been designed to hold at least a 1:100 Year 2 month wet season. Extensive hydraulic modelling has been undertaken to ensure that the TSF can cope with extreme rainfall events. Any changes to the rainfall or hydrology patterns due to climate change can be accommodated by the TSF.

Given the minimal extent of these variations, if the trends outlined above were to continue into the future it is unlikely that the Project will suffer from any climate change induced shortcomings which would diminish its potential to provide a full return to the community.

Even with this favourable assessment there is ample opportunity to take into consideration any recommendations made under the Australian Government National Climate Change Adaptation Programme during the construction, operation, and decommissioning phases of the project.

4.6 NOISE AND VIBRATION

ASK Consulting Engineers (ASK) was commissioned to carry out the noise and vibration impact assessment for the construction and operation of the proposed Dugald River Project. This report is contained in Appendix P of this EIS. In this assessment ASK have also determined what the noise impact would be at the Roseby Homestead of the Project operating at the same time as the proposed adjacent Roseby Copper Project.

4.6.1 Description of Environmental Values

The environmental values applicable to noise on the Project site, as stated in the *Environmental Protection (Noise) Policy 2008*, are as follows:

Section 7 (a) – Qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems

Section 7 (b) – Qualities of the acoustic environment that are conducive to human health and wellbeing, including by ensuring a suitable acoustic environment for individuals to do any of the following:
(i) Sleep
(ii) Study or learn
(iii) Be involved in recreation, including relaxation and conversation

Section 7 (c) Qualities of the acoustic environment that are conducive to protecting the amenity of the community

4.6.1.1 Background Noise Conditions

The nearest sensitive locations are summarised in Table 4.44 and shown in Figure 4.59 including the approximate distances from the main processing plant.

Table 4.44 Nearest Sensitive Receivers

Name	Receiver Type	Location Coordinates (AMG Zone 54, AGD 84)		Distance from Processing Plant (Km)
		East	North	
Roseby	Homestead	413454	7754153	6 km
Granada	Homestead	433791	7777948	28 km
Hillside	Homestead	421466	7732788	29 km
Carsland	Homestead	428490	7732524	32 km
Roseby Copper Project Accommodation camp	Campsite	415796	7771726	11 km

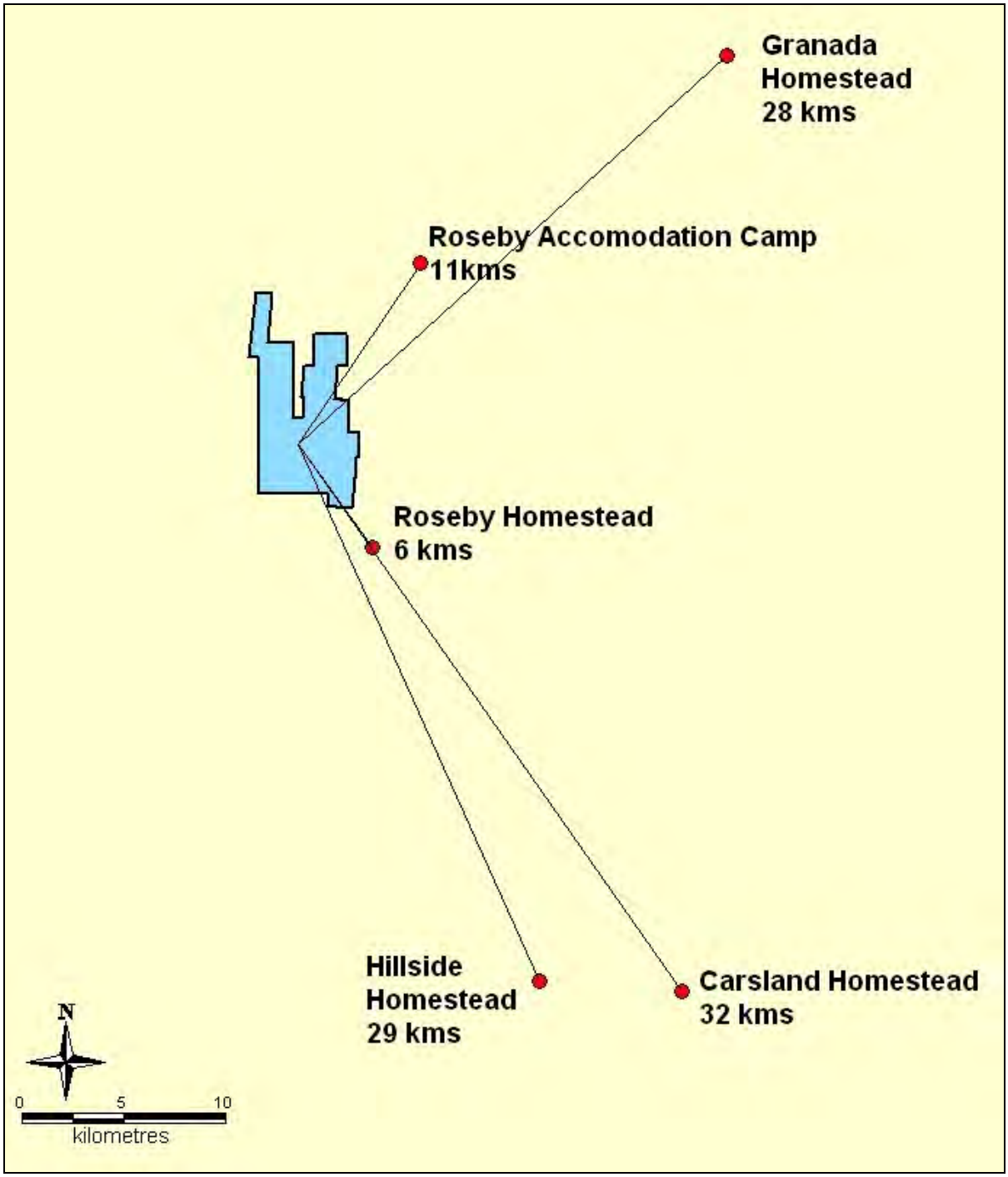


Figure 4.59 Noise Sensitive Places

Based on the separation distances in Table 4.44, only the Roseby Homestead is potentially impacted upon by the Project. The Roseby Homestead is also the most noise-affected receptor for the proposed adjacent Roseby Copper Project.

Noise monitoring was undertaken by AARC on behalf of ASK for the Project. Noise monitoring was conducted from Tuesday 3rd to Saturday 14th June 2008. The monitoring was conducted with a Larson Davis LD831 Type 1 sound level meter. The instrument was setup at the Roseby Homestead.

A plot of the noise levels is included in Figure 4.60. The noise levels obtained are expressed in terms of the Leq, L_{10}, and L_{90}. The L_{10} and L_{90} are respectively the A-weighted noise levels exceeded 10%, and 90% of the time. The L_{90} is commonly referred to as the background noise level. The Leq is the energy average noise level containing the same acoustic energy as the actual fluctuating noise level. A plot of the background noise levels (L_{90}), by time of day, is shown in Figure 4.61.

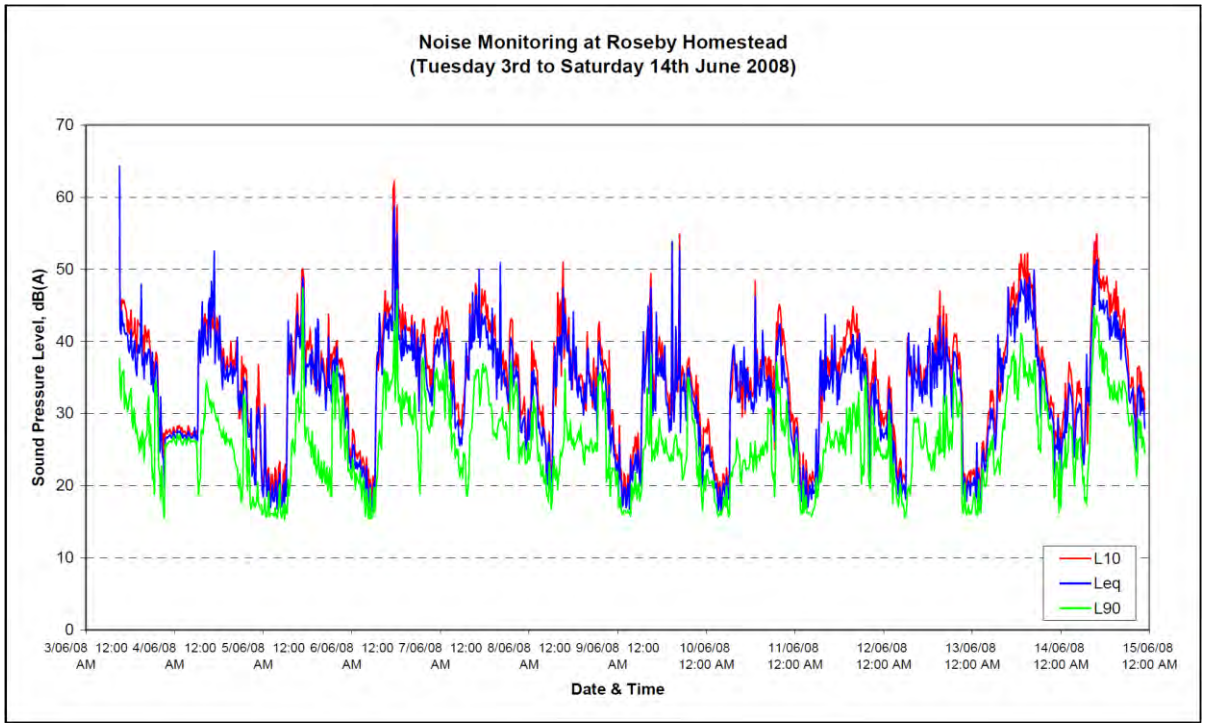


Figure 4.60 Plot of Noise Monitoring Results

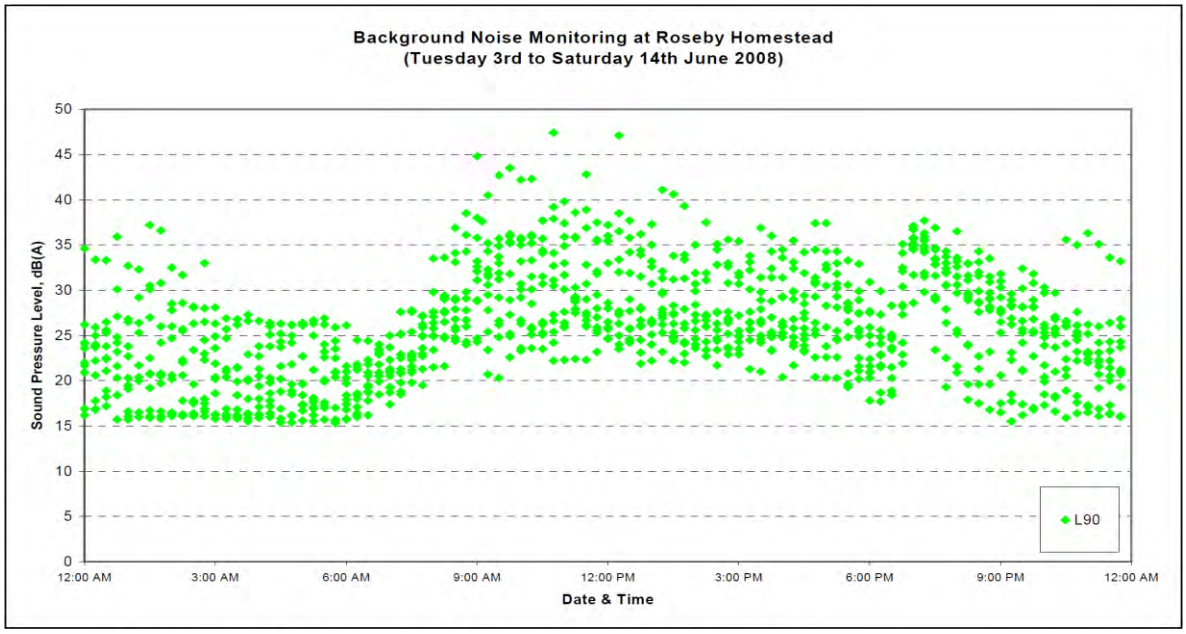


Figure 4.61 Plot of Background Noise Monitoring Results

The noise data indicates that minimum background noise levels are relatively low during daytime, evening and night periods. This is typical of rural regions of Australia. In addition to monitoring noise levels, the logger was setup to record 10 second audio snapshots for every 15 minute period. The audio files were reviewed, with the following points noted:

- Around 6.30 a.m., noise from birds is evident, and this increases over the following few hours;
- Around 8.00 a.m. and later in the day, some farm machinery noise is audible; and
- Around 6.45 p.m. there is a sharp rise in insect noise, which decays in level over the following few hours.

The noises noted in the audio files match the change in background noise levels shown in Figure 4.61. The Leq, L_{10}, and L_{90} noise levels for each measured period (day, evening and night) are summarised in Table 4.45.

Table 4.45 Summary of Measured Noise Levels

Statistic	Day			Evening			Night		
	L_{10}	L_{90}	L_{eq}	L_{10}	L_{90}	L_{eq}	L_{10}	L_{90}	L_{eq}
Maximum	62	47	59	45	38	42	45	37	43
Top 10%	47	36	45	41	35	38	36	27	36
Average	**40**	**28**	**38**	**35**	**28**	**33**	**27**	**22**	**26**
Bottom 10%	34	23	32	28	19	26	20	16	19
Minimum	26	18	27	20	16	19	17	15	16

From Table 4.45 it can be seen the noise levels are relatively low, and representative of a quiet rural location. The median background noise levels (minL_{A90}) are not reported in Table 4.45. They are calculated using the method in the EcoAccess guidelines, and are 23 dB(A), 21 dB(A) and 16 dB(A) for the day, evening and night periods respectively. The background noise level of 16 dB(A) at night was probably limited by the noise floor of the noise logger.

A background noise level of 25 dB(A), the lowest acceptable background noise level in the *EcoAccess guidelines – Planning for Noise Control* is considered appropriate for the day, evening and night periods.

4.6.1.2 Site Specific Noise Criteria

The DERM has set draft specified noise limits for the adjoining Roseby Copper Project, which are to be achieved at the Roseby Homestead. As the Roseby Homestead will also be affected by this Project, the DERM draft proposed noise criteria are considered relevant for the Dugald River Project. The proposed DERM draft noise limits are shown in Table 4.46.

Table 4.46 DERM Proposed Draft Noise Limits for Roseby Homestead from Roseby Copper Project

Location	Critical Health Effects	LA_{eq} (dB(A))	Time Base (hours)	$LA_{max, fast}$ (dB)
Outdoors	Annoyance	50	16	-
Indoors*	Speech intelligibility, moderate annoyance, daytime and evening	35	16	-
Bedrooms*	Sleep disturbance, night time	30	8	45

* Note: Typical noise reduction due to housing is taken as 10 dB(A). See Planning for Noise Control DERM 2004

The DERM has noted a typical noise reduction of 10 dB(A) from outdoors to indoors, thus internal noise limits of 30 dB(A) LAeq, 8hours[1] & 35 dB(A) LAeq, 16hours[2], correspond to external noise limits of 40 dB(A) LAeq, 8hours & 45 dB(A) LAeq, 16hours respectively. The calculated external noise limit of 45 dB(A) LAeq, 16hours effectively undercuts the outdoor noise limit of 50 dB(A) shown in Table 4.46. The internal noise limit of LAmax, fast 45 dB(A) corresponds to an external noise limit of LAmax, fast 55 dB(A).

4.6.2 Potential Impacts and Mitigation Measures

Potential sources of noise from the Project, which may impact on the Roseby Homestead could include noise from:

- Light and heavy vehicles on the Project site and accessing the Project site;
- Hauling and dumping operations;
- Crushing; and
- Ore processing.

4.6.2.1 Noise Modelling

Noise modelling was carried out using the PEN computer program. It is a digital terrain noise model (i.e. the calculations of the propagation take into account the ground surface and surface type). For a full description of the noise modelling methodology see Appendix P.

The Dugald River Project will process the following:

- Scenario 1: years 2014 to 2016 approximately 2 Mt of lead and zinc ore per year; and
- Scenario 2: years 2017 to 2031 an additional 1 Mt of copper ore per year.

Equipment for both mining scenarios is shown in Table 4.47 below.

[1] The LAeq,8hours limit is based on the logarithmic average LAeq noise level over the 8 hour period from 10pm to 6am.
[2] The LAeq,16hours limit is based on the logarithmic average LAeq noise level over the 16 hour period from 6am to 10pm.

Table 4.47 Mining Equipment

Machine and Model (Tonnage and Power Rating)	Scenario 1		Scenario 2	
	Number	Hours per Day on Surface (per unit)	Number	Hours per Day on Surface (per unit)
Underground Mining Fleet Lead/Zinc 2 Mtpa:				
Trucks: Cat AD55 (50t, 485 kW)	8	2.2	10	1.9
Boggers (large): Cat R2900 (17t, 269 kW)	4	0.7	4	0.5
Boggers (small): Cat R1700 (12t, 231 kW)	2	0.7	2	0.5
Graders: Cat 140H (N/A, 123 kW)	2	4.0	2	4.0
Water Cart: 20t Truck (N/A, 165 kW)	1	6.0	1	6.0
Light Vehicles Landcruiser (N/A, 85 kW)	25	1.5	25	1.5
Underground Mining Fleet Copper 1 Mt				
Trucks: Cat AD55 (50t, 485 kW)	-	-	5	1.9
Boggers (large): Cat R2900 (17t, 269 kW)	-	-	2	0.5
Boggers (small): Cat R1700 (12t, 231 kW)	-	-	1	1.5
Graders: Cat 140H (N/A, 123 kW)	-	-	1	4.0
Water Cart: 20t Truck (N/A, 165 kW)	-	-	1	6.0
Light Vehicles Landcruiser (N/A, 85 kW)	-	-	13	1.5
Underground Mine Fixed Plant – On Surface				
Primary Vent Fans: Electrical (N/A, 550 kW)	3	23.8	3	23.8
Air Compressor: Electrical (N/A, 345 kW)	1	23.8	1	23.8
ROM Operations				
Loader 1: Cat 988H (11.4 t, 414 kW)	1	15.9	1	10.8
Loader 2: Cat 988H (11.4 t, 414 kW)	0	0.0	1	10.8
Loader 3: Cat 988F Series II (10.7 t, 357 kW)	1	4.5	1	5.5
Lighting Plants: Diesel Generator (N/A, 50 kW)	3	10.8	3	10.8
Processing Plant – Zinc (2 Mtpa)				
Primary Crusher: Electrical (310 tpa, 200 kW)	1	22.2	1	22.2
SAG Mill: Electrical (250 tph, 4000 kW)	1	22.2	1	22.2
Ball Mill: Electrical (625 tph, 8000 kW)	1	22.2	1	22.2
Other Drives: Electrical (N/A, 19278 kW)	1	20.4	1	20.4
Processing Plant – Copper (1 Mtpa)				
Primary Crusher: Electrical (155 tpa, 200 kW)	0	0	1	22.2
SAG Mill: Electrical (250 tph, 3000 kW)	0	0	1	22.2
Ball Mill: Electrical (625 tph, 2500 kW)	0	0	1	22.2
Other Drives: Electrical (N/A, 4500 kW)	0	0	1	20.4

The model includes the propagation effects of air absorption, ground reflection, meteorology, barriers and forest. A digital terrain noise model of the site and surroundings was set up using the PEN environmental noise model. The terrain data was obtained from data supplied by the proponent. The terrain contours were inserted into the model and form the topographic basis for the investigation. The computer model also requires identification of ground types, tree zones, surface roughness estimates and meteorological data. For all cases a surface roughness for grasslands of 0.023 m was used, which is considered representative of sparse natural vegetation.

It is possible to measure noise variations of the order of 15 to 20 dB(A) due to changes in meteorology. This needs to be carefully considered, as it is considered that compliance with noise limits needs to be achieved under 'most' conditions. There is no strict definition for 'most' conditions,

but we would expect that designing to achieve DERM noise limits for 90% of all day and night meteorological conditions during a typical year is an acceptable target. Upon achieving compliance with the DERM's project-specific LAeq criteria for 90% of meteorological conditions, it is predicted that the noise levels for all meteorological conditions during a typical year would readily easily achieve the DERM's project-specific night maximum limit (LAmax).

The mining noise levels at the residential receptors will vary significantly depending on the meteorology and the mining activities. The DERM Ausplume meteorology data file for Mt Isa (location of the nearest data set which is 90 km southwest of the Project site) has been used to model noise levels with a typical year of half-hourly meteorology conditions. That is, for each mining scenario the noise levels are calculated for approximately 17,000 different meteorology conditions.

For a full description of the equipment sound power levels that were used in the PEN program and from where these sound power levels were sourced, see Appendix P.

Modelled Scenario Results

Noise levels have been calculated for an entire year of meteorological data based on the DERM meteorological data for Mt Isa (location of the nearest data set which is 90 km southwest of the Project site). Table 4.48 shows that Scenario 1 noise levels at Roseby Homestead generally averages 29 dB(A). At other homesteads the predicted noise levels are up to 29 dB(A). For scenario 2 it can be seen that the noise levels at Roseby Homestead generally average 31 dB(A). At other homesteads the predicted noise levels are up to 32 dB(A). This is shown diagrammatically in Figure 4.62 and Figure 4.63.

Table 4.48 Predicted Noise Levels for Mining Scenarios

Meteorological Condition	Predicted Noise Level at Roseby Homestead (L_{max}, T, dB(A))		Predicted Noise Level at other Homesteads (L_{max}, T, dB(A))	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2
Noisiest 10%	31	34	8-25	10-28
Average case	29	31	0-7	0-10
Quietest 10%	26	29	0	0

Both A-weighted, in dB(A), and Un-weighted, in dB, noise levels have been predicted for adverse meteorological conditions (equivalent to the 'Noisiest 10%' condition in Table 4.48), to determine the low frequency contribution to the noise levels. The results for mining scenarios 1 and 2 are shown in Table 4.49 and Table 4.50.

Table 4.49 Predicted Noise Levels for Scenario 1 with Adverse Meteorological Conditions

Receptor	Predicted Noise Level (L_{max}, T,)		Difference
	dB(A)	dB	dB – dB(A)
Mount Roseby	31	50	19
Granada	9	33	24
Hillside	10	35	25
Carsland	8	33	25
Roseby Project Campsite	21	42	21

From Table 4.49 it can be seen that the un-weighted noise level is 19 to 25 dB higher than the A-weighted noise level. This indicates that there is a significant proportion of low frequency sound in the predicted noise levels – as is usually expected for mining equipment located in a rural area.

Table 4.50 Predicted Noise Levels for Scenario 2 with Adverse Meteorological Conditions

Receptor	Predicted Noise Level (L_{max}, T,)		Difference
	dB(A)	dB	dB – dB(A)
Mount Roseby	34	52	18
Granada	11	35	24
Hillside	13	37	24
Carsland	10	35	25
Roseby Project Campsite	23	44	19

From Table 4.50 it can be seen that the un-weighted noise level is 18 to 25 dB higher than the A-weighted noise level, indicating that there is a significant proportion of low frequency sound in the predicted noise levels – as is usually expected for mining equipment located in a rural area. These results show that the background noise spectrum includes a reasonable proportion of mid to high frequency sound. Therefore, when the background noise level is added to the predicted noise levels the relative proportion of low frequency sound would be reduced.

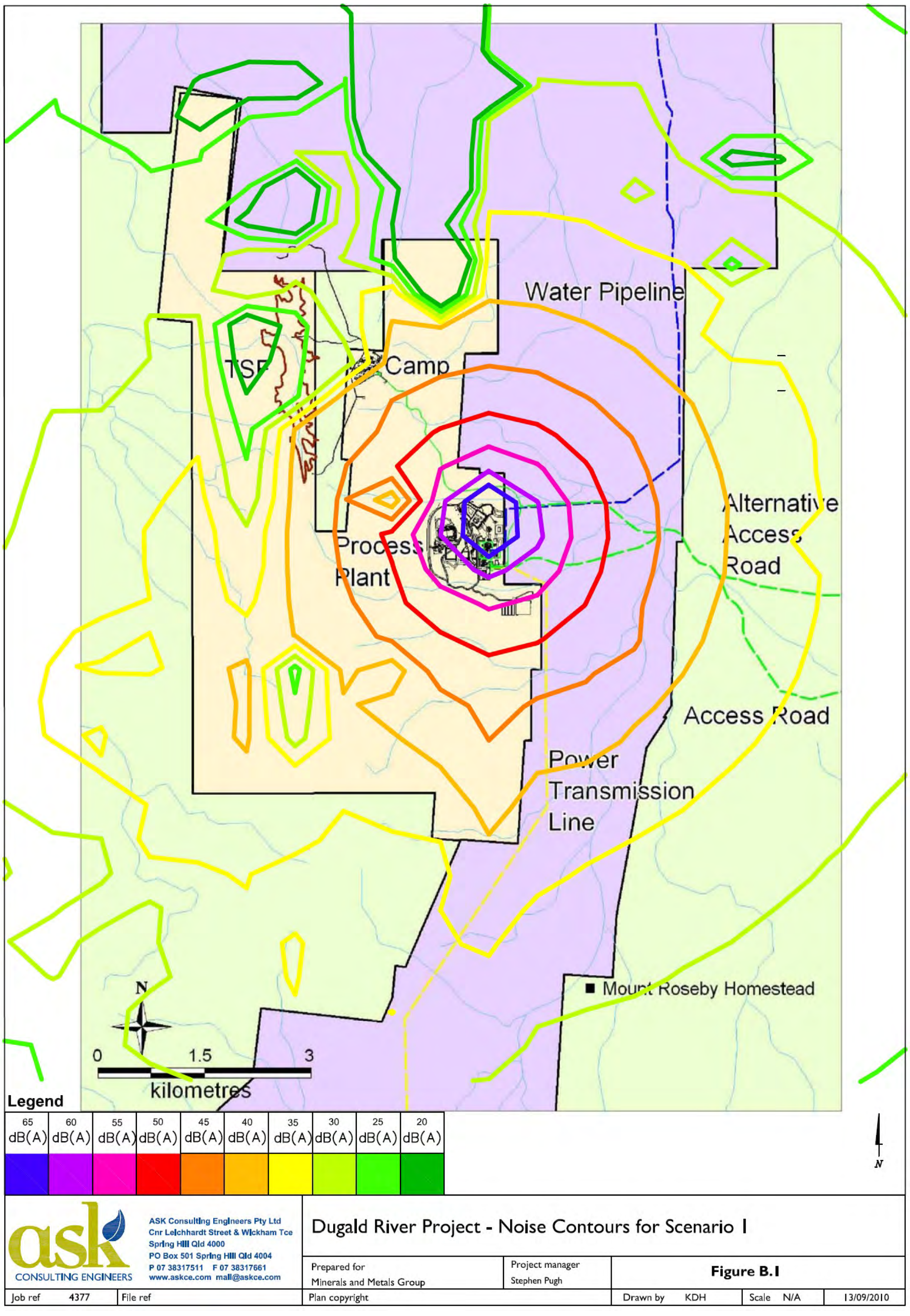


Figure 4.62 Noise Contours for Scenario 1

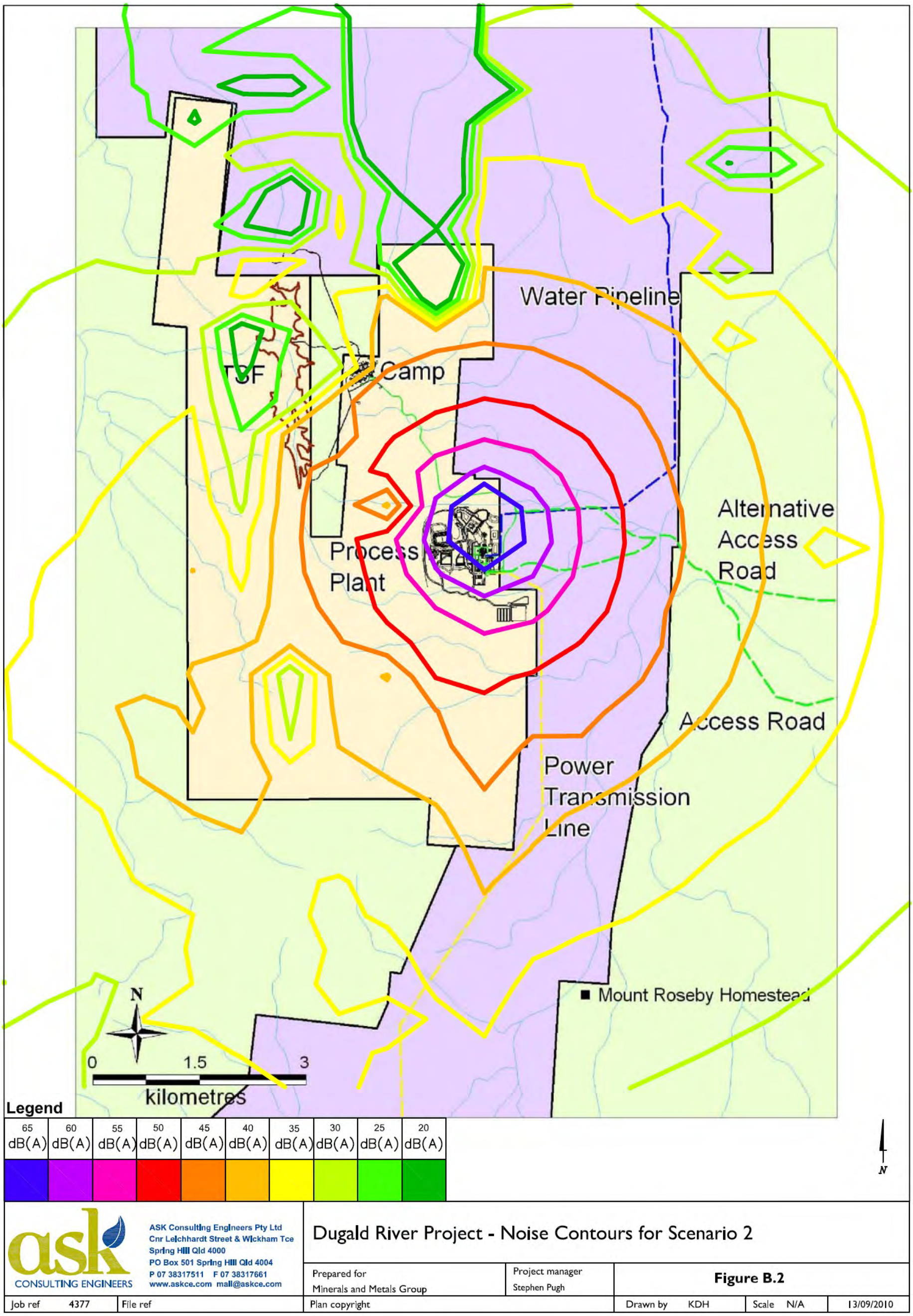


Figure 4.63 Noise Contours for Scenario 2

4.6.2.2 Compliance with Noise Limits

Site Specific Noise Limits

The calculated noise levels in Table 4.48 have been compared with the external noise criteria discussed in Section 4.6.1.2. The criteria in Section 4.6.1.2 were proposed by the DERM for the Roseby Homestead as draft conditions for the adjoining proposed Roseby Copper Project.

The DERM proposed external noise limits are 40 dB(A) LAeq, 8 hours & 45 dB(A) LAeq, 16 hours during the day and night respectively. The calculated noise levels in Table 4.46 are all below 40 dB(A), and on average are predicted to be around 30 dB(A).

The predicted noise levels are considered compliant with the DERM proposed criteria for the Roseby Homestead.

In terms of the combined impact from this Project and the adjoining proposed Roseby Copper Project if both were operating simultaneously, the combined noise level is not predicted to exceed the DERM proposed draft noise limits. Even if both projects were to generate noise levels of 40 dB(A) LAeq, 8 hours & 45 dB(A) LAeq, 16 hours during the day and night respectively, then the combined noise level would be approximately 43 dB(A) LAeq, 8 hours & 48 dB(A) LAeq, 16 hours, i.e. a 3 dB(A) exceedance. This relatively small exceedance could likely be ameliorated with noise control measures. Alternatively, the two mining companies could liaise to determine a project timing schedule that does not result in both projects being simultaneously mined near the Roseby Homestead. Either way, it is considered that both projects could operate with the DERM draft noise limits being achieved.

Sleep Disturbance

The calculated noise levels in Table 4.48 show that the World Health Organisation short-term event sleep disturbance goals and the night-time sleep annoyance goal are predicted to be met for all meteorological conditions at all receptors. The night-time sleep disturbance goal of 37 dB(A) for continuous noise is predicted to be met during Scenario 1 and 2 operations for the noisiest 10% of meteorological conditions.

Ecoaccess Noise Limits

The calculated noise levels in Table 4.48 have been compared with the EcoAccess Design Noise Guideline Levels. The EcoAccess Design Noise Guideline Levels are 33, 31 & 28 dB(A) during the day, evening and night respectively.

For Scenario 1 the results are assessed as follows:

- The EcoAccess daytime limit of 33 dB(A) is predicted to be met for more than 90% of meteorological conditions;
- The EcoAccess evening limit of 31 dB(A) is predicted to be met for 90% of meteorological conditions; and
- The EcoAccess night limit of 28 dB(A) is predicted to be met for approximately 30% of meteorological conditions. The limit is predicted to be exceeded for temperature inversion conditions.

The predicted noise levels for Scenario 1 operations are considered compliant with the EcoAccess criteria for the daytime and evening, however, the night-time limit is predicted to be exceeded for 70% of meteorological conditions. This may not be significant however given the above compliance with the site specific noise levels.

For Scenario 2 the results are assessed as follows:

- The EcoAccess daytime limit of 33 dB(A) is predicted to be met for more than approximately 80% of meteorological conditions;
- The EcoAccess evening limit of 31 dB(A) is predicted to be met for approximately 40% of meteorological conditions; and
- The EcoAccess night limit of 28 dB(A) is predicted to be met for approximately 5% of meteorological conditions. The limit is predicted to be exceeded for temperature inversion conditions.

The predicted noise levels for Scenario 2 operations are considered compliant with the EcoAccess criteria for the daytime, however, the evening and night-time limits are predicted to be exceeded for 60% and 95% of meteorological conditions respectively. This may not be significant given the above compliance with the site specific noise levels.

Low Frequency Noise

Both A-weighted and Un-weighted noise levels have been predicted for adverse meteorological conditions, to determine the low frequency contribution to the noise levels.

From Table 4.51 it can be seen that the un-weighted noise level for scenario 1 is 19 to 25 dB higher than the A-weighted noise level. For scenario 2 the un-weighted noise level is 18 to 25 dB higher than the A-weighted noise level. This indicates that there is a significant proportion of low frequency sound in the predicted noise levels, as is usually expected for mining equipment located in a rural area. It should be noted that the background noise spectrum includes a reasonable proportion of mid to high frequency sound. Therefore, when the background noise level is added to the predicted noise levels the relative proportion of low frequency sound would be reduced.

The predicted noise levels at Roseby Homestead under adverse meteorological conditions result in un-weighted noise levels of 50 dB and 52 dB for Scenario 1 & 2 respectively. The difference between the un-weighted and weighted noise levels was predicted to be 19 dB for both Scenarios 1 and 2. Based on external noise levels of up to 52 dB, the internal noise levels would be expected to be less than the 50 dB criterion and are therefore considered compliant with the EcoAccess low frequency criterion under worst-case meteorological conditions.

Table 4.51 Predicted Low Frequency Noise Levels with Adverse Meteorological Conditions

Meteorological Condition	Scenario 1			Scenario 2		
	Predicted Noise Level (L_{max}, T)		Difference	Predicted Noise Level (L_{max}, T)		Difference
	dB(A)	dB	dB – dB(A)	dB(A)	dB	dB – dB(A)
Mt Roseby	31	50	19	34	52	18
Granada	9	33	24	11	35	24
Hillside	10	35	25	13	37	24
Carsland	8	33	25	10	35	25
Roseby Copper Camp Site	21	42	21	23	44	19

Underground Blasting

Vibration impacts from blasting in the underground mining operations have been assessed as part of the ASK Consulting Engineers report (Appendix P). The vibration impacts are discussed below. As there is no surface mining or blasting proposed for the Project, fly rock from the Project is not an issue and therefore has not been assessed.

Ground vibration can be calculated at various distances from blasts using the following formula:

$$PPV = k\,(D/\sqrt{m})^{e}$$

Where:

PPV = peak particle velocity (mm/s)

m = charge mass per hole (kg)

D = distance (m)

e = site exponent or attenuation rate

k = site constant

$D/\sqrt{m}$ = scaled distance

Ground vibration from blasting generally increases with an increase in charge mass and reduces with distance. A site exponent (attenuation rate) of –1.6 has been assumed for the site, whilst the site constant (k) was assumed to be in the range 800 to 1600. Table 4.52 contains the separation distances required to achieve the ground vibration levels (mm/s) nominated.

Table 4.52 Separation Distance to Achieve Nominated Ground Vibration Levels

PPV (mm/s)	Separation Distance from Mine (m)	
	K = 800	K = 1600
10.0	148	229
5.0	229	353
2.0	406	626
1.0	626	965
0.5	965	1488

Table 4.52 shows that the EcoAccess 5 mm/s peak particle velocity criterion would be achieved at distances greater than 0.5 km from the blast. This is considered realistic, as for an underground mine, the quantity of explosives used per hole and blast is much smaller than for open pit coal or hard-rock operations. The nearest residences to the proposed underground mine is approximately 6 km away, thus the vibration levels are acceptable.

Construction Noise

Noise from construction of the Project is expected to include steady or quasi-steady noise sources (e.g. motors, pumps etc) and intermittent noise sources (e.g. earthmoving equipment, site vehicles etc).

It is common practice that noise limits are relaxed during daytime construction works, where it may not be practicable to achieve operational noise limits. The reasons for the relaxation of limits include (i) construction activities are not a long-term noise source, (ii) operational noise can be controlled within enclosures or buildings, whereas these buildings are not completed during the construction phase. Never-the-less the Project's noise criteria should be considered a goal during construction phase where it can be practically achieved.

Noise from mobile equipment, and other intermittent noise sources (e.g. hammering), is recommended to comply with the Project's noise criteria in and the sleep disturbance criteria at night-time.

It is expected that the proposed construction noise limits will be able to be met, without any additional attenuation measures, due to the large separation distances between plant and receptors. Never-the-less during construction of the mine a record should be kept of any noise complaints, and any complaints are to be addressed as a priority.

Summary of Noise Assessment Findings

Noise levels from the mine operations were predicted at the nearest noise sensitive receptors for different meteorological conditions. The noise levels were assessed against numerous DERM noise criteria with the following results:

- DERM recently proposed draft criteria for the Roseby Homestead: These criteria are predicted to be readily achieved due to the reasonable separation distance of approximately 6 km. As the predicted noise levels are well below the criteria, it is

considered likely that the cumulative impact of this Project and the adjoining Roseby Copper Project will also comply with the criteria;

- DERM EcoAccess Design Noise Guideline Levels: These criteria are predicted to be met in the day, but exceedences are predicted to occur in the evening and night, as discussed above;
- DERM Sleep Disturbance & Annoyance Criteria: These criteria are predicted to be met;
- DERM Low Frequency Noise Criteria: These criteria are predicted to be met; and
- DERM Blasting Criteria: These criteria are predicted to be met due to the reasonable separation distance of approximately 6 km.

In terms of the combined impact from this project and the adjoining Roseby Copper Project, the combined noise level is predicted to achieve the DERM proposed noise limits, as discussed above. Overall, the DERM criteria proposed for the Roseby Homestead are predicted to be readily achieved with the proposed Scenario 1 & 2 mining operations. Other non-project specific DERM criteria will be exceeded on occasions as noted above.

Mitigation Strategies

Compliance with noise and vibration requirements will be managed by:

- Ensuring that mufflers fitted to mobile equipment are properly maintained;
- Undertaking continuous noise monitoring at the Mount Roseby homestead during construction and operations to determine compliance with the Project noise criteria; and
- Maintaining a complaints register during all phases of the Project and investigating all noise related complaints.

4.7 NATURE CONSERVATION

4.7.1 Description of Environmental Values

Four field surveys for flora and fauna were undertaken by AARC on the following dates:

- Wet Season Flora and Fauna and Aquatics Assessment – 27th March to the 4th April 2008;
- Dry Season Flora and Fauna Assessment with Additional Corridor Mapping – 4th to the 13th August 2008;
- Vegetation Mapping of Infrastructure Corridors – 1st to the 3rd October 2008; and
- Vegetation Mapping of Infrastructure Corridors – 7th to the 9th April 2010.

The full Terrestrial and Aquatic Flora and Fauna Assessment is contained in Appendix S.

4.7.1.1 Environmental Values

The following flora and fauna environmental values have been identified for the Project:

- The River Red Gum Riparian Woodland and Mixed Bloodwood Riparian Woodland provide refuge for fauna by providing water, shade and larger tree species with hollows;
- The River Red Gum Riparian Woodland is floristically the most diverse vegetation community within the local area of the project and it helps maintain the environmental integrity of watercourses by stabilising the banks with the root system and preventing erosion during flooding events;
- Rocky outcrops within the Cloncurry Box Open Woodland and Snappy Gum Open Woodland provide microhabitat for certain fauna;
- Silver Box / Cloncurry Box Open Woodland, Gidgee Open Woodland, River Red Gum Riparian Woodland and Mixed Bloodwood Riparian Woodland are listed are 'Of Concern' or 'Endangered' under DERM's Biodiversity Status. These intact stands contribute to overall preservation of threatened ecosystems;
- The presence of intact stands of poorly represented communities within protected areas, including Gidgee Open Woodland (RE 1.3.4) and Cloncurry Box Open Woodland (RE 1.11.3) can be considered regionally significant.

4.7.1.2 Listed Species and Species of Special and Ecological Note

This section discusses species of conservation significance that are known from the broader region, their habitat and their likelihood of occurring on the Project site.

Environmentally Sensitive Areas

Database searches and literature review searches were conducted to determine whether or not the Project overlays any environmentally sensitive areas.

The EPBC Act online database search returned no areas of environmental significance, including no World Heritage Properties, National Heritage Places, Wetlands of International Significance (Ramsar sites), Commonwealth Marine Areas or Threatened Ecological Communities.

The DERM Maps of ESAs identified no National parks, Conservation Parks, Forest Reserves, State Forests, Timber Reserves, Heritage Register Places, Fish Habitat Areas, Wilderness or Habitat Corridors, Wild Rivers or Important Wetlands within or adjacent to the Project site. No areas of critical habitat under the *Nature Conservation Act 1992*, areas listed with high nature conservation values or areas particularly vulnerable under the *Vegetation Management Act 1999* have been identified. In addition, no areas proclaimed, or under consideration for proclamation, under the *Nature Conservation Act 1992* or *Marine Parks Act 1982* have been identified as being on or adjacent to the Project site. One 'Category B' ESA was identified within and adjacent to the Site, 'Endangered Regional Ecosystem' under the Queensland Biodiversity Status. This Endangered Regional Ecosystem is defined as RE 1.3.7 – Red Gum (*Eucalyptus camaldulensis*) woodland on channels and levees. Riverine wetlands or fringing riverine wetlands are identified within this RE. This RE was identified within the Project site and associated infrastructure corridors, and is described in Section 4.7.1.4.

The Australian Natural Resources Atlas (ANRA) provides biodiversity assessments for each bioregion within Queensland. The Project site is within the Mount Isa Inlier bioregion. The bioregion is divided into three subregions; the Project site is located within the Mount Isa Inlier subregion. Special values of this bioregion include caves and sinkholes that house significant breeding colonies of bats. No sites of geomorphological significance, including lava tubes or karst, have been identified on or adjacent to the Project site. A number of regional ecosystems are endemic to the subregions, with a total of 57% of REs listed as threatened on state listings (ANRA, 2002). Perennial watercourses are important refugia for both flora and fauna species.

One wetland of national significance lies within the Mount Isa Inlier bioregion, Lake Moondarra (ANRA, 2002). This is not listed as a Ramsar wetland. Lake Moondarra is an artificial lake which was creating by damming a valley of the Leichhardt River. Lake Moondarra is located 16 km downstream from the township if Mount Isa, and approximately 70 km west southwest of the Project site. This wetland will not be impacted by Project activities, as each are located in separate catchments.

Although a number of avian species listed as Migratory and/or Marine under the EPBC Act have been identified within database searches (Table 4.53) and during field surveys, no species is at the range of its distribution. No significant habitat or relevant birds flight paths for these species has been identified within or immediately adjacent to the Project.

No areas of palaeontologic significance have been identified on or adjacent to the Project site. The discovery of potential fossils is discussed in Section 4.2.1.2 of this EIS.

The DIP has published a *North West Regional Plan* (August 2010), which aims to shape future prospects of rural and mining communities in the region by providing a consistent and contemporary regional land use planning framework across all of Queensland. Although this document is designed to meet requirements of the *Sustainable Planning Regulation 2009* (Schedule 1, Part 3), regional strategies and policies can be applied to the mining sector as well. A section of the plan identifies biodiversity conservation values and provides land use policies relating to these values. It identifies that the North West region has mostly avoided the widespread clearing of native vegetation for cropping and pastoral development, which has taken place elsewhere in the state. The low, dispersed population and limited access to much of the land further contributes to reasoning for maintenance of high biodiversity levels. Grazing has been identified as the predominant land use in the region, and impacts include loss of pasture productivity, soil erosion and weed invasion, where poor management

practices are used (DIP, 2010). Land Use Policies included within the *North West Management Plan* are:

- Avoid or minimise urban development occurring outside urban zoned land, and in areas of high ecological significance, unless it can be demonstrated that there is an overriding public need;
- Avoid or minimise impacts of infrastructure on areas of high ecological significance, through appropriate location and responsive design and management;
- Development adjacent to areas of high ecological significance is designed, constructed and operated to avoid or mitigate adverse impacts on ecological values;
- Where development impacts on high ecological values cannot be avoided, prioritise the use of offset strategies to minimise regional impact; and
- Development for urban purposes in areas of general ecological significance is designed and operated to minimise adverse impact on ecological values.

Fauna

A list of fauna species of conservation significance have been identified from database searches (Appendix S) and scientific literature searches from the broader region of the Project (Table 4.53). The following databases were searched for historical records of fauna of conservation significance within the vicinity of the Project site:

- Wildlife Online Database (DERM): This database uses records collected from previous surveys, including the Queensland Museum surveys as well as records from the public. A 20 km search radius was used to cover the Project site. As the Wildlife Online database has a maximum search buffer of 20 km, multiple search central coordinate points were utilised to cover the entire area.
- EPBC Act Online Database: The search includes species if their distribution overlaps the broader Cloncurry region and it is likely that suitable habitat is nearby. The database only pertains to species listed under the EPBC Act. A 30 km search radius was used to cover the Project site. As noted above, the EPBC Act Online Database has a maximum search buffer distance, therefore multiple searches were conducted along the powerline route;
- Historic flora and fauna survey report conducted by Woodward-Clyde in 1991;
- Roseby Copper Project Terrestrial Flora and Fauna Assessment, prepared for Universal Resources Limited by AARC 2006; and
- Roseby Copper Project Aquatic Flora and Fauna Assessment, prepared for Universal Resources Limited by AARC 2006.

Table 4.54 provides an assessment of the likelihood of species of conservation significance that may occur in the region utilising the Project site. The assessment is based on the knowledge and opinion of AARC staff, information obtained from the current field surveys, scientific literature, and communications with relevant experts or interest groups.

A species of cultural significance which may inhabit the Project site is the echidna (*Tachyglossus aculeatus*). The echidna inhabits a wide range of terrestrial habitats, wherever prey is available. They have no fixed nest or shelter sites and breeding takes place in the spring season, for two to three

months. Other species of cultural significance, which do not have potential to inhabit the Project site are the platypus (*Ornithorhynchus anatinus*) and the koala (*Phascolarctos cinereus*). The Project site is further west than either of these species' range.

Flora

Review of the EPBC Act Online Database, the Queensland Herbarium HERBREC Database and Wildlife Online indicated one flora species of conservation significance has been identified in the vicinity of the Project site. The EPBC Act Online Database contained a 25 km buffer surrounding a central point within the Project site and another three searches along the power line corridor. The Wildlife Online contained a 20 km radius at a central point within the Project site and at two central points within the power line corridor. The HERBREC Database search was conducted with a radius of 20 km from a central location on the Project site and with a 10 km radius along the entire length of the power line corridor. The HERBREC Database listed species was:

- Bottle Tree – *Brachychiton collinus* – Rare (NCWR). The NCWR was amended in May 2010, and the Bottle Tree is no longer listed as being of conservation significance. The Bottle Tree is currently listed as Least Concern.

A previous baseline survey conducted by Woodward-Clyde in 1991 identified two species of conservation significance that may occur in the Project region, being the:

- Morning Glory Vine – *Ipomea antonschmidii* – Near Threatened (NCWR); and
- Mulla mulla – *Ptilotus macohochiei* –Near Threatened (NCWR).

These Rare species may occur on the Project site given similar landforms and the numerous other surveys conducted by AARC. Hence to ensure the survey team were familiar with these species, research into their growth form, ecology and appearance was undertaken prior to field surveys.

Table 4.53 provides an assessment of the likelihood of species of conservation significance that may occur in the region utilising the Project site.

Table 4.53 Threatened Fauna from the Region Not Observed on the Project Site

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Heteromunia pectoralis Pictorella Mannikin	-	Near Threatened	Prefers tall grass in Acacia woodlands near water and grassy flats and occasionally Spinifex tuffs. Distributed in tropical northern Australia, noted to migrate coastward in dry season and inland in wet (Menkhorst & Knight 2004).	Some suitable habitat may occur on Site. However given the amount of surrounding habitat it is unlikely the Site constitutes critical habitat range. Furthermore, given the species range, it is unlikely the Project will have an adverse impact on this species should it occur intermittently.
Ephippiorhynchus asiaticus Black-Necked Stork	-	Near Threatened	Prefers open freshwater environments, including the margins of swamps, shallow floodwaters over grasslands, wet shorelines, margins of mangroves, mudflats and estuaries (Morcombe 2002).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.
Melithreptus gularis Black Chinned Honey Eater	-	Near Threatened	The Black-chinned Honeyeater is found on mainland Australia from the Gulf Country of Queensland south to Cloncurry and is widespread in central and eastern Queensland. It is found in the upper levels of open eucalypt forests and woodlands dominated by box and ironback eucalypts. It is often found along waterways, especially in arid and semi-arid areas (Birds in Backyards).	Suitable habitat occurs on Site. Although unlikely, given its scarcity, it is possible that this species may intermittently occur on Site.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Petrogale purpureicollis Purple-necked Rock-wallaby	Vulnerable	Vulnerable	All Rock-wallabies favour habitat with cliffs, rocky slopes and outcrops or boulder piles. They are often found in outcrop formations, in association with dry Eucalypt (*Eucalyptus sp*.) and Wattle (*Acacia sp*.) woodlands and Spinifex (*Triodia sp.*) grasslands (Van Dyck and Strahan 2008).	Suitable habitat potentially exists along sections of the Knapdale Range. Although no individuals were identified within the Project site, it is possible populations may inhabit remote sections within the Knapdale Range. Individuals were sighted within the proposed powerline route.
Rostratula australis Australian Painted Snipe	Vulnerable/ Migratory/ Marine	Vulnerable	This species inhabits shallow inland wetlands, either permanent or temporary (Marchant and Higgins 1993).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.
Sminthopsis douglasi Julia Creek Dunnart	Endangered	Endangered	Known only from Mitchell Grass downs country between Julia Creek and Moorrinya National Park, north Qld (Menkhorst & Knight 2004).	No Mitchell Grasslands communities are present on site and the Project is outside of the species' currently known range, therefore it is unlikely this species inhabits the Project site.
Pristis microdon Freshwater Sawfish	Vulnerable	-	A bottom-dweller of estuaries and the lower reaches of large river systems; sometimes penetrating substantial distances upstream (Allen et al 2003).	No suitable habitat occurs on the Project site nor is likely to occur in the event of seasonally high rainfall.
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory/ Marine	-	White-bellied Sea-Eagles are a common sight in coastal and near coastal areas of Australia. Often seen perched high in a tree, or soaring over waterways and adjacent land (Birds in Backyards).	Unlikely to occur on Site given the range of the species and Project distance from the coast.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Merops ornatus Rainbow Bee-eater	Migratory/ Marine	-	The Rainbow Bee-eater is found throughout mainland Australia, as well as eastern Indonesia, New Guinea and, rarely, the Solomon Islands. In Australia it is widespread, found in open forests, woodlands and shrublands, and cleared areas, usually near water (Birds in Backyards).	Suitable habitat occurs on Site. However, the Project is located outside of the species range so unlikely to occur on Site.
Ardea alba Great Egret, White Egret	Migratory/ Marine	-	Great Egrets occur throughout most of the world. They are common throughout Australia, with the exception of the most arid areas. Known to prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands (Birds in Backyards).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.
Ardea ibis Cattle Egret	Migratory/ Marine	-	In Australia it is most widespread and common in north-eastern Western Australia across the Top End, Northern Territory, and in south-eastern Australia from Bundaberg, Queensland to Port Augusta, South Australia, including Tasmania. The species is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Will also forage at garbage dumps, and is often seen with cattle and other stock (Birds in Backyards).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory/ Marine	-	The Oriental Plover has been recorded in all states but most common in coastal areas across northern Australia. The species is found generally inland; in open grasslands in arid and semi-arid zones; and less often in estuarine or littoral environments. Known to prefer flat inland plains, sparsely vegetated short grass with hard bare ground including claypans, playing fields, lawns and cattle camps (Birds in Backyards).	May intermittently occur on Site, however given the species range, the Project is unlikely to constitute an ecologically proportion of its habitat.
Glareola maldivarum Oriental Pratincole	Migratory/ Marine	-	The Oriental Pratincole are birds of open country, and are often seen near water in the evening, hawking for insects. They are found in warmer parts of south and east Asia, breeding from northern India across to China and Europe, wintering in India, Indonesia and northern Australia (Birds in Backyards).	Unlikely to occur on Site given the lack of preferred habitat and highly transient behaviour.
Numenius minutes Little Curlew, Little Whimbrel	Migratory/ Marine	-	Prefers open country and grassy flats.	Unlikely to occur on Site given the lack of preferred habitat and highly transient behaviour.
Rostratula benghalensis s. lat Painted Snipe	Migratory/ Marine	-	Occurs in terrestrial shallow freshwater wetlands, ephemeral waterbodies, dams and permanent lakes etc (Marchant and Higgins 1993).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability
Apus pacificus Fork-tailed Swift	Migratory/ Marine	-	Pacific Swifts breeds from central Siberia eastwards through Asia, wintering south to Australia. They are aerial birds.	May seasonally occur on Site, however despite extensive searches during the dry season survey, no species were observed.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Crocodylus johnstoni Freshwater Crocodile	Marine	-	Known to inhabit freshwater lagoons, billabongs, lakes and ephemeral watercourses throughout N. Australia.	No suitable habitat occurs on Site and therefore is unlikely to occur.

Table 4.54 Threatened Flora Species from the Region Not Observed on the Project Site

Botanical Name Common Name	Conservation Status		Habitat Description	Comment
	EPBC Act	NCWR		
Ipomea antonschmidii Morning Glory Vine	Not Listed	Near Threatened	Only four records exist for this vine species in the surrounding area of the Project Site, all of which are near creek lines or Lake Julius. The closest record is at the Lake Julius Dam Pumping Station, approximately 50 km west of the Project Site. This species typically grows on shallow, red, stony soils in *E. leucophloia* woodland (Johnson 1986).	The habitat range for this species is not near the Project Site. This species is unlikely to occur on the Project site.
Ptilotus macohochiei Mulla Mulla	Not Listed	Near Threatened	Eucalyptus spp. woodland or open woodland not otherwise specified (Thomas and McDonald 1989)	Habitat for this species is available on the Project site; however it was not identified despite extensive field surveys.

4.7.1.3 Methodology

Seasonal surveys are imperative for a methodical and scientifically valid ecological assessment. Wet season and dry season surveys are conducted to ensure species that are migratory, transient or responsive to particular environmental conditions are captured, in addition to identifying seasonal variation in both species diversities and abundances. In AARC's experience, survey timing is based on conceptual seasonal months. That is, they correspond to historic rainfall data and known weather patterns. Often however, the yearly weather cycle is more than wet and dry and includes the build up period before the wet season that brings high humidity as moisture builds up in the air and post wet season as waterholes and creeks slowly dry up and dry winds strengthen. These transitional periods in combination with localised ecological response produce an environment that is continually adapting and adjusting. It is imperative that these periods be included, in combination with consideration to changing weather pattern behaviours when determining timing of wet and dry surveys as part of any seasonal flora and fauna assessment. More to the point, the window of survey often needs to be adjusted to suit local conditions.

Survey timing for the Dugald River Project is considered to be scientifically sound and more than adequate to detect a comprehensive species list and highlight seasonal variation.

The following methodologies are a summary of the methods of collecting and compiling data for the flora and fauna assessment. For a full discussion of methodologies see Appendix S.

Flora

The field survey involved a baseline study of the Project area using all standard floristic survey methods. Methods used were in accordance with the Queensland Herbarium's *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland, Version 3.1*.

A survey of all REs on the Project was required to supplement the Queensland Herbarium RE mapping. Consequently, the following methods were used:

- A number of representative Secondary transects (50 x 20 m plot) in each vegetation type were selected and a detailed floristic inventory of the dominant and associated woody plants (i.e. trees and shrubs) was undertaken. Secondary plots were positioned in vegetation representative of the community as a whole;

- In addition to the Secondary transects, a number of Quaternary transects were also surveyed in order to assist with the mapping of REs;

- An assessment of the condition of the vegetation type with regard to quality and conservation value was undertaken at each transect; and

- The mapping of the REs was undertaken through the use of aerial photographs, geological maps, and the use of a GPS in association with the findings of the field survey.

A minimum of three Secondary sites per vegetation community were surveyed. Sampling was conducted to the Queensland Herbarium's recommended guidelines for 1:25,000 scale mapping. Additional sites were surveyed until substantial number of additional species and structural variation did not occur. The recommended number of ground observations for a 1:25,000 scale survey is 4 per km^2. As the Project Site is approximately 34 km^2, a total of 136 ground observations is recommended. This recommended number of ground samples was not undertaken during the survey, as vegetation structure and landform was fairly homogonous. The minimum mappable area was followed in

vegetation mapping, both in the field and when creating the vegetation community map, and was identified through a combination of aerial photography pattern identification and field information. This minimum mappable area is 0.25 hectares per vegetation community polygon and 25 m for linear features.

When a habitat suitable for a species of conservation significance was located, a specific survey for that species was undertaken. The method that was used in this survey was the random meander technique. As its name suggests, this technique involves traversing areas of suitable habitat in no set pattern whilst searching for the particular plant species. If there was any uncertainty in identifying the species, a specimen is collected for confirmation by the Queensland Herbarium. Incidental observations of flora species were recorded with notes on the vegetation community as they were encountered. Areas of disturbance such as roadsides, dams and creek crossings were also investigated as they often provide a foothold for a number of different species, particularly invasive weeds.

Fauna

The fauna sampling methodology for the Project site was based on standard survey techniques that are used to sample terrestrial and aquatic fauna. Sampling of terrestrial vertebrate fauna was conducted primarily along transects established in each of the major vegetation communities and at additional secondary sites. These secondary sites provide important information on fauna species associated with preferred habitat, as well as increasing the chances of finding species of conservation significance. Their inclusion in the assessment provides a more robust survey methodology and greater survey coverage. Study locations were replicated throughout the dry and wet season surveys where possible, to aid the identification of seasonal variation in species diversities and abundances.

Sampling of aquatic vertebrate fauna was conducted at two locations on the Dugald River, the Dan Lynch Bridge and Longamundi Waterhole. Sampling for aquatic macro-invertebrates has previously being undertaken at these locations by AARC for the adjacent Roseby Copper Project. The results from these previous surveys are also discussed in this report.

The following methods were used to sample terrestrial and aquatic fauna:

- Scats and Tracks Searches;
- Habitat Searches;
- Spotlighting;
- Avian Observation;
- ANABAT Recording;
- Pitfall Trapping;
- Elliot Trapping;
- Incidental Recordings; and
- Crab Pots and Box traps for aquatic sampling.

For further description of these sampling techniques see Appendix S.

Corridors

Proposed corridors for the Project access road, water pipeline and power line corridor were assessed for species of conservation significance. Each corridor was fully traversed and features of conservational significance were noted at each site in particular:

- Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat; and
- River Red Gum crossings (RE 1.3.7 a).

The proposed power line corridor begins at the Chumvale sub-station and tracks 68 km north to the Project site. AARC's survey scope included a 400 m wide assessment of vegetation condition with regard to features of conservational significance, in particular Purple-neck Rock Wallaby habitat and River Red Gum Creek Crossings. Any areas of conservational significance were surveyed on foot along the 400 m wide corridor, while areas not of conservational significance were surveyed from vehicle. In addition, a weed survey was conducted, which entailed identifying any LP Act listed weeds or introduced flora species found along the corridor.

The primary access route corridor follows along an existing track for approximately 9 km from the Project Site. At the eastern end of the primary access route corridor, the primary access route diverts from the existing track for 1 km along a straight route across open terrain to join up with the Burke Developmental Road. An alternate access road route is being proposed and may be used in the foreseeable future. This route follows the primary access road route from the Project Site for 4 km, and then diverts directly east for 5 km, ultimately joining the Burke Developmental Road.

It may also be necessary to use a temporary access road deviation (called the Longamundi Deviation), if mining activity occurs on adjacent tenures. This deviation will divert the access road from the Project Site around the Longamundi mineral deposit. The deviation will commence at the Project Site approximately 850 m north of the primary access route. The deviation is approximately 2 km in length and connects with the primary access track at Creek Crossing 2 before the alternate access road diversion (see Figure 13).

The proposed water pipeline commences in the Project site, runs through the Roseby Copper Project and connects up with the Lake Julius Ernest Henry Pipeline. AARC's scope of works for the water pipeline corridor included a 40 m wide assessment of the condition of the vegetation type with regard to quality and conservation value and the mapping of the REs through the use of aerial photographs, geological maps, and the use of a GPS in association with the findings of the field survey. As the water pipeline corridor travels close to the base of Mount Rose Bee, potential Purple-neck Rock Wallaby habitat, scats were collected for analysis and outcrops were walked to determine extent of habitat.

4.7.1.4 Terrestrial Flora – Project Site

Six vegetation communities inhabited the Project site with a total of 125 flora species identified. For a full species list see Appendix S. No flora species identified are of conservational significance and five species are introduced.

The six communities were classed as Remnant Vegetation as defined in the VM Act. Associations within the communities reflect different vegetation structures and compositions, which occur on different geophysical locations. The corresponding Queensland Herbarium RE classifications are noted for each of the described remnant vegetation communities.

The six vegetation communities include:

- Community 1 – Snappy Gum (*Eucalyptus leucophloia*) Open Woodland;
- Community 2 – Cloncurry Box (*Eucalyptus leucophylla*)Open Woodland;
- Community 3 – Mixed Bloodwood Riparian Woodland;
- Community 4 – River Red Gum (*Eucalyptus camaldulensis*) Riparian Woodland;
- Community 5 – Gidgee (*Acacia cambagei*) Open Woodland; and
- Community 6 – Silver Box (*Eucalyptus pruinosa*) / Cloncurry Box (*Eucalyptus leucophylla*) Open Woodland.

Figure 4.64 maps the location of vegetation communities on the Project site.

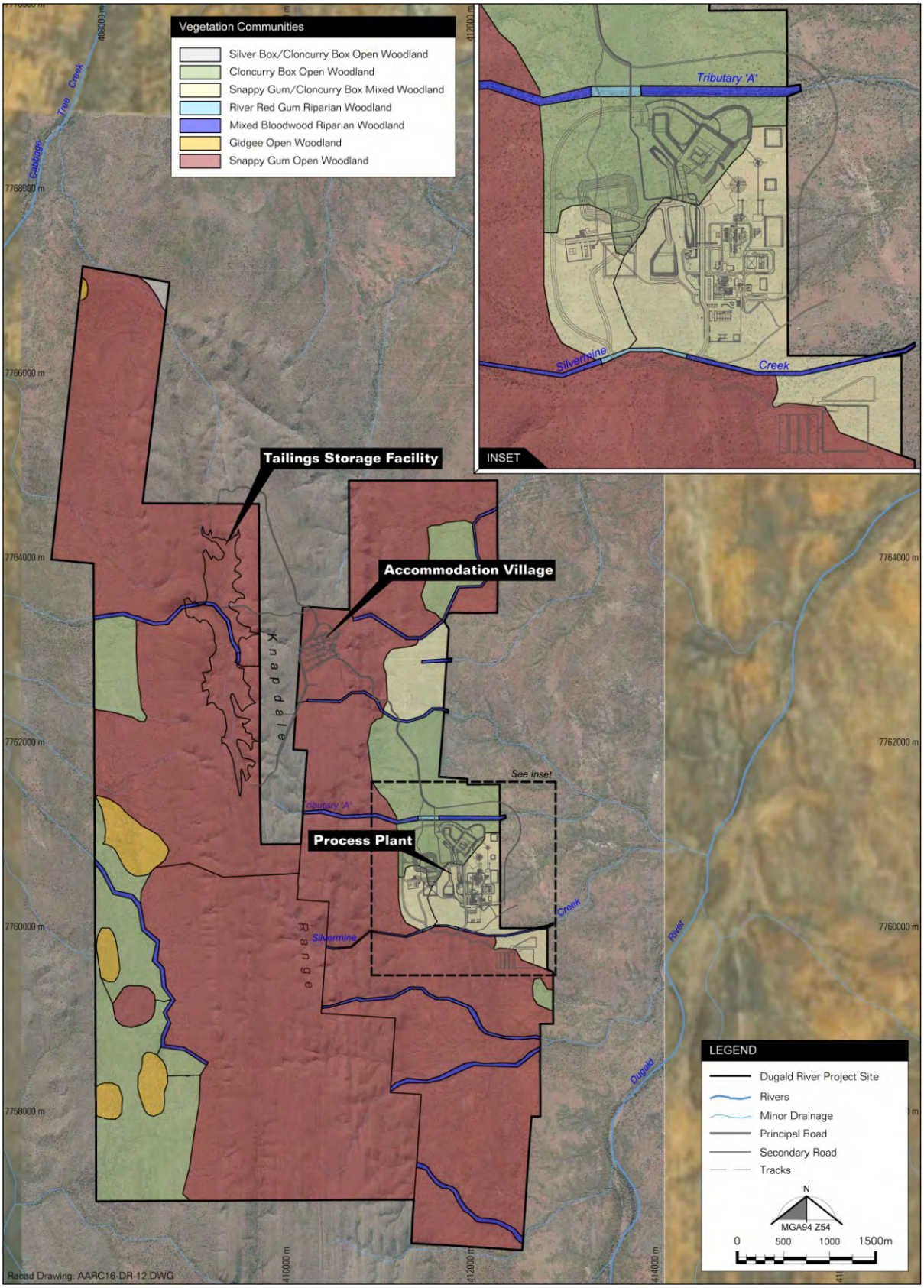


Figure 4.64 Vegetation Communities on the Project site

Community 1 – Snappy Gum Open Woodland

The Snappy Gum community is located on skeletal soils along steep hills and skirting edges (refer to Photo Plate 4.13). Snappy Gum Open Woodland was the dominant community, spanning over approximately 76.7% (2,726 hectares ha) of the entire Project site. The Snappy Gum community was intermixed with the Cloncurry Box community on occasion, particularly on the eastern side of the Project site (refer to Figure 4.64). The Cloncurry Box / Snappy Gum mix consisted of 152 ha of the Project site.

The Snappy Gum open woodland is dominated by a Snappy Gum (*Eucalyptus leucophloia)* open canopy, a moderate to dense shrub layer of Turpentine (*Acacia lysiphloia*) and a grassy layer of Soft Spinifex (*Triodia pungens*) (Photo Plate 4.17). Other canopy trees include the Western Bloodwood (*Corymbia terminalis*) and Cloncurry Box (*Eucalyptus leucophylla)*, with an occasional sparse understory of Arid Peach (*Terminalia aridicola subsp. aridicola*). On elevated hill slopes, Chisholm's Wattle (*Acacia chisholmii*) is present. Groundcover consists of 45% Soft Spinifex (*Triodia pungens*), 4% bare ground, 1% leaf litter and 50% rock. Canopy cover is approximately 3% with an average height of 5.5 m. Average species recorded along a Secondary transect in the Snappy Gum open woodland is 9. A full list of species is presented in Appendix S.

Photo Plate 4.13 Snappy Gum Open Woodland

The corresponding REs for the Snappy Gum open woodland are detailed below in Table 4.53. These REs occur on lateric red earths and skeletal soils derived from pre-Cambrian rock.

RE 1.11.2a is classed as land zone 11, which is classed as hills and lowlands on metamorphosed sedimentary rocks, which are generally moderately to strongly deformed. Land zone 11 includes low- to high-grade and contact metamorphics such as phyllites, slates, gneisses of indeterminate origin and serpentinite, and interbedded volcanics (DERM, 2004).

RE 1.5.3 is included in land zone 5, which is defined as plains and plateaus on Tertiary land surfaces. Landforms are near level or undulating, with Cainozoic sands or loams.

Table 4.53 Corresponding REs for the Snappy Gum Open Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.11.2a	Low open-woodland of *Eucalyptus leucophloia* often with *Corymbia spp.*, *Terminalia aridicola and E. leucophylla* with shrub layer of *Acacia spp.* and ground layer of *Triodia spp*. Occurs on steep hills and strike ridges	Not Listed	Least Concern	Not of Concern
1.5.3	Low open-woodland of *Eucalyptus leucophloia* sometimes with a shrubby understory dominated by *Acacia spp.*and a *Triodia spp.* dominated ground cover. Occurs on lateric red earths and skeletal soils	Not Listed	Least Concern	Not of Concern

No weed species, listed under the LP Act, were observed within the Snappy Gum open woodland. However one species, Buffel Grass (*Pennisetum ciliare*), is an introduced exotic and was noted to be present in the grass layer community during the wet season survey but only made up a very small percentage of the vegetation cover observed.

No species of conservational significance were identified within this community. This community does not entail high habitat diversity or a high level of endemism.

The Snappy Gum open woodland (RE 1.11.2a and 1.5.3), is listed as 'Least Concern' under the VM Act, 'Of No Concern at Present' under the DERM Biodiversity Status and is not listed under the EPBC Act. The Project is included in the Northwest Highlands bioregion. Areas in which RE 1.11.2a is protected within the Northwest Highlands bioregion, include Lawn Hill (Gregory) Resources Reserve and the Boodjamulla (Lawn Hill) National Park. Areas within the bioregion in which RE 1.5.3 is protected include the Camooweal Caves National Park, Boodjamulla (Lawn Hill) National Park and the Lawn Hill (Gregory) Resources Reserve.

Overall, the condition of Snappy Gum open woodland on the Project site is healthy. In-tact stands of this community are abundant in the region and it is unlikely disturbance within the Project site will significantly impact on the regional occurrence of this community.

Community 2 – Cloncurry Box Open Woodland

Cloncurry Box open woodland occurs as the second most dominant vegetative community, covering approximately 14.7% (523 ha) of the Project site. This community tends to inhabit level areas away from steep hill slopes. Intermittently, the Cloncurry Box community was intermixed with the Snappy

Gum community particularly on the eastern side of the Project site (refer to Figure 4.64). The Cloncurry Box / Snappy Gum mix consisted of 152 ha of the Project site.

The Cloncurry Box open woodland is dominated by a low canopy of Cloncurry Box (*Eucalyptus leucophylla*), with occasional Western Bloodwoods (*Corymbia terminalis*) and Snappy Gums (*Eucalyptus leucophloia*) and an infrequent understory of Whitewood (*Atalaya hemiglauca*) (Photo Plate 4.14). The shrub layer is sparsely dominated by Chisholm's Wattle (*Acacia chisholmii*) and Soal Bush (*Acacia holosericea*). Groundcover consists of 70% grass, 10% rock, 15% bare ground and 5% leaf litter. Canopy cover averages 11% with a height of 4 m. Floristic diversity was relatively low, with an average of 6 species recorded along each Secondary transect. Grasses were predominantly Buffel Grass (*Pennisetum ciliare*) and Soft Spinifex (*Triodia pungens*). A full list of species is presented in Appendix S.

Photo Plate 4.14 Cloncurry Box Open Woodland

The corresponding REs for the Cloncurry Box open woodland are detailed below in Table 4.54. These REs are found on hills, rises, dolerite, skeletal soils and sometimes shallow loams.

Both 1.11.3b and 1.11.3x1 are classed within landzone 11, which is hills and lowlands on metamorphosed sedimentary rocks, which can form ranges, hills and lowlands.

Table 4.54 Corresponding REs for the Cloncurry Box Open Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.11.3b	Low open-woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* often with *E. leucophloia* with a sparse shrub layer dominated by *Acacia chisholmii* and a sparse ground layer dominated by *Triodia pungens*. Occurs on hills, rises: dolerite	Not Listed	Least Concern	Not of Concern
1.11.3x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *E. leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	Not of Concern

Targeted searches for species of conservation significance determined that no species of conservation significance inhabit the Cloncurry Box Open Woodland. This community does not hold high habitat diversity or areas of high endemism.

No weed species, listed under the LP Act, were observed within Cloncurry Box Open Woodland. Four introduced species were identified. Buffel Grass (*Pennisetum ciliare*) and Cloncurry Buffel (*Cenchrus pennisetiformis*) are both naturalised species and were noted to be dominant in the grass layer community in some areas. Two other introduced species; Mimosa (*Acacia farnesiana*) and Kapok Bush (*Aerva javanica)* were also noted within this community.

Although RE 1.11.3 is not protected within the Northwest Highlands bioregion, intact stands are abundant throughout this Queensland bioregion. The state-wide extent of this RE prior to clearing from pastoral development was 408,155 ha and in 2005 was 404,456 ha, which indicates a 0.9% reduction in this community state wide. The Cloncurry Box Open Woodland community is not under threat from clearing and is considered abundant within the region.

Overall, the condition of Cloncurry Box open woodland on the Project site is healthy; however four introduced species are present in the community. In-tact stands of this community are abundant in the region and it is unlikely disturbance within the Project site will significantly impact on the regional occurrence of this community.

Community 3 – Mixed Bloodwood Riparian Woodland

The Mixed Bloodwood Riparian Woodland community occurred on most watercourses within the Project site (refer to Figure 4.64), covering approximately 1.9% (67 ha) of the entire site.

This community is dominated by the Northern Swamp Box (*Lophostemon grandiflorus subsp. grandiflorus*) and Arid Peach (*Terminalia aridicola* subsp. *aridicola*), with associated Western Bloodwood (*Corymbia terminalis*) and North-west Ghost Gum (*Corymbia aparrerinja*) (Photo Plate 4.15). Other species occasionally found in this community include the Bauhina (*Lysiphyllum cunninghamii*), Net-veined Wattle (*Acacia retveinea*) and Soap Bush (*Acacia holosericea*). Ground cover consisted of 45% bare ground, 20% rock, 5% leaf litter and 15% co-dominant Soft Spinifex (*Triodia pungens*) and *Cyperus dactylotes* (in wet season). Trees and shrubs cover approximately 15%, with an average crown cover of 24%. The average number of flora species identified along a Secondary transect within this community is 11. A full list of species is presented in Appendix S.

Photo Plate 4.15 Mixed Bloodwood Riparian Woodland

The corresponding RE for the Mixed Bloodwood riparian woodland is detailed below in Table 4.55 This RE (classed within land zone 3) occurs on terraces and floodplains on Quaternary alluvium, alluvial soils, some earths and deep yellow podzolics.

Table 4.55 Corresponding RE for Mixed Bloodwood Riparian Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.3.6	Woodland and low woodland of *Corymbia aparrerinja* and *C. terminalis. Acacia victoriae* may dominate heavier soils. Occurs on terraces and floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics.	Not Listed	Not of Concern	Of Concern

No weed species listed under the LP Act were observed within Mixed Bloodwood Riparian Woodland. However, one introduced species, the Flannel Weed (*Sida cordifolia*) was noted to inhabit the area. This vegetation community does not hold a high level of endemism. ANRA identifies this RE holds valuable fauna habitat due to the number and size of tree hollows. A presence of hollows was noted during field surveys within this community, although the abundance of hollows was relatively low (in comparison with the River Red Gum Riparian Community).

As detailed in Table 4.55, Mixed Bloodwood Riparian Woodland (RE 1.3.6) has been given an 'Of Concern' DERM Biodiversity status due to a high grazing pressure, changed fire regimes and subjection to Buffel Grass invasion. It is listed as being 'Least Concern' under the VM Act and is not listed under the EPBC Act. Areas within the Northwest Highlands bioregion where RE 1.3.6 is protected include the Boodjamulla (Lawn Hill) National Park, Lawn Hill (Gregory) Resources Reserve, Camooweal Caves National Park and Lawn Hill (Gregory River Base) Resources Reserve.

Overall, the condition of Mixed Bloodwood Riparian Woodland on the Project Site is healthy, with a relatively higher diversity of species comprising the community. Intact stands of this community are abundant within this Queensland bioregion, with the total regional mapped extent of this RE compromising of 160,810 ha in 2005.

Overall, the condition of Mixed Bloodwood riparian woodland on the Project site is healthy, with a relatively higher diversity of species comprising the community. In-tact stands of this community are abundant in the region and it is unlikely disturbance within the Project site will significantly impact on the regional occurrence of this community.

Community 4 – River Red Gum Riparian Woodland

The River Red Gum Riparian Woodland was restricted to two areas along creek lines and was predominantly associated with the Mixed Bloodwood Riparian Woodland community. Community 4 comprises 1.81 ha of the Project site (refer to Figure 4.64).

The River Red Gum Riparian Woodland (Photo Plate 4.16) is dominated by the River Red Gum (*Eucalyptus camaldulensis*), with associated Northern Swamp Box (*Lophostemon grandiflorus subsp. grandiflorus*), North-west Ghost Gum (*Corymbia aparrerinja*) and Bauhinia (*Lysiphyllum cunninghamii*) trees (Table 4.53). A shrubby understory is composed of the Whitewood (*Atalaya hemiglauca*), Corkwood Wattle (*Acacia bidwilli*) and Sandpaper Fig (*Ficus opposita*). Groundcover averages 60%

rock, 20% leaf litter and 10% grass. Trees and shrubs comprise 10% of the community coverage, with approximate canopy coverage of 19%. The average number of species recorded in a Secondary transect is 12. Dominant grasses within this community are Buffel Grass (*Pennisetum ciliare*) and Cloncurry Buffel (*Cenchrus penniseteformis*). A full list of species is presented in Appendix S.

Photo Plate 4.16 River Red Gum Riparian Woodland

The corresponding REs for the River Red Gum Riparian Woodland are detailed below in Table 4.56. This riverine community occurs on recent levees and channel deposits of watercourses and tributaries. The River Red Gum Riparian Woodland is classed within land zone 3, which is defined as Quaternary alluvial systems.

Table 4.56 Corresponding REs for the River Red Gum Riparian Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.3.7a	Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *M. argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries.	Not Listed	Least Concern	Endangered

Targeted searches for species of conservation significance determined that no species of conservation significance were present within River Red Gum Riparian Woodland. This vegetation community held the highest diversity of flora species within the Project site, although no species are endemic to the region.

No weed species listed under the LP Act were observed within the River Red Gum Riparian Woodland. However three species, Buffel Grass (*Pennisetum ciliare*), Cabbage Tree (*Calotropis procera*) and Cloncurry Buffel (*Cenchrus pennisetiformis*) are introduced and considered to be noxious weeds.

River Red Gum Riparian Woodland (RE 1.3.7a) is listed as 'Least Concern' under the VM Act and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being 'Endangered'. The Endangered listing is due to severe degradation from high grazing pressure. Protected areas within the Northwest Highlands bioregion in which RE 1.3.7 occurs include the Boodjamulla (Lawn Hill) National Park, Lawn Hill (Gregory) Resource Reserve and Lawn Hill (Gregory River Base) Resource Reserve. These protected areas assist in preserving the diversity and health of floral and faunal species which thrive in this riverine community. The state-wide extent of RE 1.3.7a, as of 2005, is 74,181 ha.

Overall, the condition of River Red Gum Riparian Woodland is reduced by grazing and weed invasion. In tact stands of this community are present throughout the greater region. This community holds functional ecological value locally as a seasonal refugia by holding water and regionally as a corridor for fauna. RE 1.3.7a is endemic to the Mount Isa Inlier subregion (ANRA, 2002).

Community 5 – Gidgee Open Woodland

The Gidgee Open Woodland is found in small patches, predominantly on the western side of the Project site (refer to Figure 4.64), covering approximately 80 ha.

The open canopy is comprised of Gidgee (*Acacia cambagei*) trees, with an understory consisting of the Limestone Cassia (*Senna artemisioides subsp. oligophylla*) and Crimson Turkey Bush (*Eremophila latrobei*) and a very sparse grass layer of Buffel Grass (Photo Plate 4.17). Groundcover consists of 1% grass, 40% leaf litter, 15% rock and 35% bare ground. The remaining 6% is comprised of trees and shrubs. Canopy cover averages 22% and the community has a relatively low diversity of flora, averaging 5 species per Secondary transect. A full list of species is presented in Appendix S.

Photo Plate 4.17 Gidgee Open Woodland

The corresponding RE for the Gidgee open woodland is detailed below in Table 4.57. This community inhabits alluvial plains and valley bottoms between ranges formed on strongly folded pre-Cambrian rocks. RE 1.3.4 is located within land zone 3, which is defined as Quaternary alluvial systems.

Table 4.57 Corresponding REs for Gidgee Open Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.3.4	Low open-woodland and low woodland of *Acacia cambagei* over annual grasses. Occasional *Atalaya hemiglauca, Hakea lorea subsp. lorea, Grevillea striata and Acacia excelsa*. Occurs on red or brown earths and clays.	Not Listed	Least Concern	Of Concern

No weed species, listed under the LP Act, were observed within the Gidgee open woodland. However one species, Buffel Grass (*Pennisetum ciliare*), is introduced and was noted to be dominant within the grass layer of this community. This community does not entail a high level of endemism or species biodiversity.

The Gidgee, and much of the surrounding vegetation, is subject to low intensity cattle grazing. The impact of disturbance is obvious in the ground flora that inhabits the community, with the displacement of native species by weed species. The state-wide extent of the Gidgee Open

Woodland RE was 48,094 ha prior to clearing for pastoral development, and 47,466 ha in 2005, totalling an overall decline of 1.3%. This RE is not protected in any State or Commonwealth reserves.

The dominance of Buffel Grass within this community degrades the overall health of the community. Gidgee open woodland ecosystems are abundant throughout the greater region. It is unlikely that disturbance within the Project site will affect the regional occurrence of this community.

Community 6 - Silver Box / Cloncurry Box Open Woodland

The Silver Box / Cloncurry Box open woodland is restricted to one pocket in the north western corner of the Project site (refer to Figure 4.64). Approximately 4.7 ha of the Project site is covered by this community.

The Silver Box / Cloncurry Box community consists of a co-dominant canopy of the Silver Box (*Eucalyptus pruinosa*) and Small-fruited Bloodwood (*Eucalyptus dichromophloia*), with emergent North-west Ghost Gums (*Corymbia aparrerinja*) and associated Cloncurry Box (*Eucalyptus leucophylla*) trees (Photo Plate 4.18). The scattered shrub layer consists of Bootlace Oak (*Hakea cordophylla*), Conkerberry (*Carissa lanceolata*) and Turpentine *(Acacia lysiphloia*). Groundcover consists of 20% rock, 10% leaf litter, 20% bare ground and 40% grasses. The dominant groundcover species included Soft Spinifex (*Triodia pungens*) and Buffel Grass (*Pennisetum ciliare*). Trees and shrubs, having an average canopy cover of 5%, consist of the remaining 10%. The average number of flora species identified within this community is eight. A full species list can be found in Appendix S.

Photo Plate 4.18 Silver Box / Cloncurry Box Open Woodland

The corresponding RE and conservation status for the Silver Box / Cloncurry Box community is detailed below in Table 4.58. This RE occurs on gravelly red plains. RE 1.5.4x3 is classed within land zone 5, which is defined as plains and plateaus on Tertiary land surfaces, generally with medium to

coarse textured soils. Landform includes extensive, uniform near level or gently undulating Cainozoic plains with sandy or loamy soils and may include dissected remnants of these surfaces.

Table 4.58 Corresponding RE for Silver Box / Cloncurry Box Open Woodland

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VM Act	DERM Biodiversity Status
1.5.4x3	Open tussock grassland of *Aristida contorta, A. inaequiglumis, Enneapogon spp.*, often with *Triodia pungens* wooded with low trees including *Atalaya hemiglauca, Eucalyptus pruinosa, Lysiphyllum spp., Acacia cambagei, E. leucophylla* and *Corymbia aparrerinja*. Includes substantial areas of bare ground. Occurs on gravelly red plains	Not Listed	Least Concern	Of Concern

Mimosa (*Acacia farnesiana*), an introduced species, inhabits the Silver Box / Cloncurry Box community.

The Silver Box / Cloncurry Box Open Woodland community is listed as 'Least Concern' under the VM Act and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being 'Of Concern'. The 'Of Concern' listing is due to Cloncurry Buffel Grass invading the ecosystem and changing its floristics and structure. Protected areas within the Northwest Highlands bioregion in which this regional ecosystem occurs includes the Camooweal Caves National Park, Boodjamulla (Lawn Hill) National Park and Lawn Hill (Gregory) Resources Reserve.

The Silver Box / Cloncurry Box community is in a relatively healthy condition, with little invasion of introduced species. Intact stands of this community are abundant in the region. The total area mapped throughout Queensland prior to clearing for pastoral development was 445,639 ha and in 2005 it was 442,499 ha, resulting in a 0.7% decline in the state-wide occurrence of this RE.

Summary of Conservation Significance

Targeted searches revealed no species of conservation significance to be present within the Project site. A summary of the conservation significance of all REs occurring on the Project site is provided below in Table 4.59.

Table 4.59 Summary of the Conservation Significance of Regional Ecosystems

Vegetation Community	Regional Ecosystem Equivalents	EPBC Status	Queensland VM Act	DERM Biodiversity Status
Snappy Gum Open Woodland	1.11.2a 1.5.3	Not Listed	Least Concern	Not of Concern
Cloncurry Box Open Woodland	1.11.3b 1.11.3x1	Not Listed	Least Concern	Not of Concern
Mixed Bloodwood Riparian Woodland	1.3.6	Not Listed	Least Concern	Of Concern
River Red Gum Riparian Woodland	1.3.7a	Not Listed	Least Concern	Endangered
Gidgee Open Woodland	1.3.4	Not Listed	Least Concern	Of Concern
Silver Box/ Cloncurry Box Open Woodland	1.5.4 x 3	Not Listed	Least Concern	Of Concern

One RE on the Project site (RE 1.3.7a – River Red Gum Riparian Woodland) is listed as 'Endangered' under the DERM Biodiversity Status due to severe degradation and high grazing pressure. The overall condition of this RE on the Project site is reduced by cattle grazing and weed invasion. Based on proposed disturbance plans for the Project, additional clearing of RE 1.3.7a will be required. Assuming mitigation strategies are implemented and disturbance is minimised, the Project is unlikely to significantly impact this community at a regional scale. Refer to Section 4.7.2 for recommended mitigation strategies.

The Gidgee Open Woodland (RE 1.3.4) is listed as 'Of Concern' under the DERM Biodiversity Status is to due to high grazing pressure and weed invasion. The overall condition of this RE on the Project site is reduced by cattle grazing and weed invasion. Based on proposed disturbance plans for the Project, no significant additional clearing of RE 1.3.4 will be required.

The Silver Box/Cloncurry Box Open Woodland (RE 1.5.4 x 3) is listed as "Of Concern" under the DERM Biodiversity Status due to high grazing pressure and weed invasion. On the Project site the overall condition of this RE is reduced by cattle grazing and weed invasion. Based on proposed disturbance plans for the Project, no clearing will be required in this community.

The Mixed Bloodwood Riparian Woodland (RE 1.3.6) is listed as "Of Concern" under the DERM Biodiversity Status due to high grazing pressure and weed invasion. Based on the proposed plans for the Project, a TSF will be constructed within an area of this community, which will require clearing. Assuming mitigation strategies are implemented and disturbance is minimised, the community is unlikely to be significantly impacted at a regional scale. Refer to Section 4.7.2 for mitigation strategies.

No weed species, listed under the LP Act, were recorded during the survey.

Although not declared under the LP Act, introduced species of Buffel Grass (*Pennisetum ciliare*), Cloncurry Buffel (*Cenchrus pennisetiformus*), Mimosa (*Acacia farnesiana*), Flannel Weed (*Sida cordifolia*), Kaopk Bush (*Aerva javanica*) and the Cabbage Tree (*Calotropis procera*) were found occasionally throughout the Project site. Management of invasive weed species is discussed in Section 4.7.2 of this report.

4.7.1.5 Terrestrial Fauna – Project Site

In total, six primary transects and two secondary transects (only one secondary transect was used during each seasonal survey) were established for terrestrial fauna monitoring on the Project site. Transects were positioned to maximise the potential for sampling all wildlife present by targeting the full range of habitat types present on site.

Results

A combined total of 65 vertebrate fauna species were identified on the Project site during the dry and wet season surveys, comprising 9 reptiles, 34 birds, 18 mammals and 4 fish. A complete list of all observed fauna species is provided in Appendix S.

Amphibians

Amphibian habitat on the Project site varies seasonally due to the ephemeral nature of creeks and associated drainage lines. During the dry season (May-October), stock watering stations and sandy drainage lines offer the only potential habitat. During the wet season (November-April), habitat variation and suitability increases in response to increased rainfall.

No amphibians were recorded on the Project site during the wet or dry season surveys. Habitat value was considered poor on site, due to the lack of standing water, inconsistency of rainfall events and limited substrate suitable for burrowing.

No amphibians of conservation significance have been previously recorded within the region (Appendix S). It is considered highly unlikely that any amphibian species of conservation significance occur on the Project site.

Reptiles

The Project site provides a variety of habitat types thought to be suitable for reptile species occurring in the region. Micro-habitats such as those associated with tree hollows, vegetated watercourses, open woodlands scattered with fallen timber, grasslands and rocky outcrops may suit a variety of reptile species.

A total of 9 reptile species were observed on the Project site during the wet and dry season surveys. All reptile species recorded on the Project site are listed in Appendix S.

Skinks were the most diverse reptile group encountered and was represented by four species, comprising the Gravelly-soil Ctenotus (*Ctenotus lateralis*), Leopard Ctenotus (*Ctenotus pantherinus*), Northern Soil-crevice Skink (*Proablepharus tenuis*) and the Centralian Blue-tongue (*Tiliqua multifasciata*).

The remaining five reptile species observed on the Project site were the Gilbert's Dragon (*Amphibolurus gilberti*), Two-lined Dragon (*Diporiphora australis*) (Photo Plate 4.19), Spotted Gecko (*Gehyra nana*), Black-headed Python (*Aspidites melanocephalus*) and an unidentified *Furnia* spp.

Photo Plate 4.19 Two-lined Dragon was observed during the Wet Season Survey

No reptiles of conservation significance were observed on the Project site during the wet or dry season surveys and none have been previously recorded within the region (Appendix S). Therefore, it is considered unlikely that any reptile species of conservation significance occur on the Project site.

Birds

A combined total of 34 bird species were recorded on the Project site during the wet and dry season surveys, with all species considered common throughout the region. All bird species recorded on the Project site are listed in Appendix S.

Granivorous (seed eating) birds were well represented on Site with the Peaceful Dove (*Geopelia striata*), Spinifex Pigeon (*Geophaps plumiferal*), Crested/Spinifex Pigeon (*Ocyphaps lophotes*), Common Bronzewing (*Phaps chalcoptera*), Sulphur-crested Cockatoo (*Cacatua galerita*), Galah (*Cacatua roseicapilla*), Painted Finch (*Emblema pictum*), Double-barred Finch (*Taeniopygia bichenovii*) and Zebra Finch (*Taeniopygia guttata*) commonly observed.

Four true raptor species were observed on the Project site during the surveys, including the Wedge-tail Eagle (*Aquila audax*), Black Falcon (*Falco subniger*), Whistling Kite (*Haliastur sphenurus*) and the Black Kite (*Milvus migrans*). All species, collectively from the Accipitridae family, are listed under the EPBC Act as Migratory. In addition to these species several other birds were detected that are known to feed on vertebrate species, including the Azure Kingfisher (*Alcedo azurea*), Laughing Kookaburra (*Dacelo novaeguineae*), and Tawny Frogmouth (*Podargus strigoides*) (Photo Plate 4.20).

No bird species of conservation significance under the NCWR were observed on the Project site during the wet or dry season surveys.

Five Migratory species listed under the EPBC Act were observed on the Project site during the surveys. These included the Wedge-tail Eagle, Black Falcon, Whistling Kite, Black Kite; Black-fronted Dotterel (*Elseyornis melanops*) and the Brolga (*Grus rubicundus*). The distributions of these species

are widespread throughout eastern Queensland, and the local populations observed on the Project site are unlikely to constitute an 'ecologically significant proportion' of the total population of these species. Furthermore, the Project site is not at the limit of these species' range, nor are these species considered to be declining within the region. Therefore, it is unlikely the Project will have a significant impact on the regional populations of these species.

No Marine species listed under the EPBC Act were observed on the Project site during the wet and dry season surveys.

Photo Plate 4.20 The Tawny Frogmouth was observed on Site during a Spotlighting Activity

Mammals

In total, 17 mammal species were observed on the Project site during the wet and dry season surveys, comprising 12 native and four introduced species.

Three of the introduced species are classified as Class 2 pest animals under the LP Act, comprising the Dingo (*Canis familiaris dingo*), Feral Cat (*Felis catus*) and Feral Pig (*Sus scrofa*), with the House Mouse (*Mus musculus*) classified as a Class 1 pest. All mammal species recorded on the Project site are listed in Appendix S.

Four mammal species commonly observed on the Project site included the Delicate Mouse (*Pseudomys deliculatus*) (Photo Plate 4.21), Common Rock Rat (*Zyzomys argurus*), Common Wallaroo (*Macropus robustus*) and Red Kangaroo (*Macropus rufus*).

Photo Plate 4.21 The Delicate Mouse was commonly observed on the Project site

A total of seven micro-bat species were identified on the Project site. Three species, being the Northern Free-tailed Bat (*Chaerephon jobensis*), Little Broad-nosed Bat (*Scotorepens greyii*) and Hoary Wattled Bat (*Chalinolobus nigrogriseus*) were positively identified from echolocation calls recorded at the exploration camp. It is likely bats opportunistically feed on the supply of insects attracted to camp by the night lights. The Hoary Wattled Bat was also positively identified at the second ANABAT site, being a disused mine shaft.

The remaining four bat species were identified as 'probable' and 'possible' in terms of their calls being evident on the ANABAT recordings, and included the Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*), Eastern Little Free-tailed Bat (*Mormopterus loriae ridei*), Gould's Wattled Bat (*Chalinolobus gouldii*), and an unknown Long-eared Bat (*Nyctophilus spp.*). Appendix S details ANABAT analysis results.

No mammals of conservation significance were observed on the Project site during the wet and dry season surveys.

Pest Species

Four introduced species, listed as pest species under the LP Act, were detected on the Project site during the wet and dry season surveys. Species observed included:

1. House Mouse listed as a Class 1 pest under the LP Act;
2. Dingo listed as a Class 2 pest under the LP Act;
3. Feral Cat listed as a Class 2 pest under the LP Act; and
4. Feral Pig listed as a Class 2 pest under the LP Act.

Each of the Class 2 pests is discussed below, while Appendix S details DEEDI Pest Fact Sheets for all observed pest species.

Dingoes can carry diseases such as distemper, parvovirus as well as parasites and are known to prey on native fauna and farm species, causing both ecological and economic damage. Dingoes were observed during routine assessment activities during both daylight hours and during spotlighting events. They were considered common on site and are known from the broader region.

The Feral Cat is listed as a Class 2 pest under the LP Act. Most active at night, with peak hunting occurring soon after sunset and in the early hours before sunrise, cats display a distinct green eyeshine under spotlight. Cats were observed whilst spotlighting on the Project site. Known to cause ecological harm, via habitat destruction, disease distribution and native species predation, cats are present Australia wide, thriving under all climatic conditions and in vastly different types of terrain.

Wild Pigs will eat almost any available plant material, but prefer succulent green herbage. They wallow in mud along watercourses, destroy habitat for native animals, and spread weed seeds. They damage almost all crops from sowing to harvest, damage pastures by grazing and rooting and carry many diseases and parasites. And their destructive nature is often a hindrance to any re-vegetation/ rehabilitation plans. Pigs were observed only once on site. They were not considered a resident population given the lack of water on site and subsequent available habitat.

4.7.1.6 Infrastructure Corridors

Three corridors were assessed by AARC; the Project access road, water pipeline and power line corridor. Each corridor was fully traversed, with specific widths listed below. Features of conservational significance were noted at each site in particular:

- Purple-neck Rock Wallaby (*Petrogale purpureicollis*) habitat; and
- River Red Gum crossings (RE 1.3.7a).

Power Line

The power line corridor spans 68 km, from the Chumvale sub-station north to the Project site. A width of 400 m has been assessed to define vegetation communities, identify and map features of conservational significance and identify and locate weed species. Features of conservational significance inhabiting the power line corridor include the River Red Gum riparian community and Purple-neck Rock Wallaby habitat.

Six vegetation communities inhabit the power line corridor (refer to Figure 4.65, Figure 4.66 and Figure 4.67 for community locations). Each community is briefly described, with corresponding conservation status in Table 4.60 below.

As noted in Table 4.60, the River Red Gum Riparian Woodland community is listed as 'Endangered' under the DERM Biodiversity Status. This community is considered the most diverse within the local area of the Project Site and helps maintain the environmental integrity of watercourses in the region. Specific mitigation strategies have been developed for the preservation and management of this community within the power line corridor as described in Section 4.7.2.2.

In addition as detailed in Table 4.60, Gidgee Open Woodland, Mixed Bloodwood Riparian Woodland and Silver Box Open Woodland are listed as being 'Of Concern' under the DERM Biodiversity Status. Based on proposed disturbance plans for the Project, additional clearing of these communities will be

required. It is unlikely this disturbance within the power line corridor will significantly impact on the regional occurrence of this community.

Table 4.60 Vegetation Communities and Conservation Significance on the Powerline Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VM Act	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.5.3	Low open-woodland of *Eucalyptus leucophloia* sometimes with a shrubby understory dominated by *Acacia spp.*and a *Triodia spp.* dominated ground cover. Occurs on lateric red earths and skeletal soils	Not Listed	Least Concern	Not of Concern
Cloncurry Box Open Woodland / 1.3.11x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *E. leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	Not of Concern
River Red Gum Riparian Woodland / 1.3.7a	Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *M. argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries.	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.3.4	Low open-woodland and low woodland of *Acacia cambagei* over annual grasses. Occasional *Atalaya hemiglauca, Hakea lorea subsp. lorea, Grevillea striata and Acacia excelsa*. Occurs on red or brown earths and clays.	Not Listed	Least Concern	Of Concern

Vegetation Community / RE	Community Description	EPBC Status	Queensland VM Act	DERM Biodiversity Status
Mixed Bloodwood Riparian Woodland / 1.3.6	Woodland and low woodland of *Corymbia aparrerinja* and *C. terminalis. Acacia victoriae* may dominate heavier soils. Occurs on terraces and floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics.	Not Listed	Least Concern	Of Concern
Silver Box Open Woodland / 1.5.4 x 3	Open tussock grassland of *Aristida contorta, A. inaequiglumis, Enneapogon spp.*, often with *Triodia pungens* wooded with low trees including *Atalaya hemiglauca, Eucalyptus pruinosa, Lysiphyllum spp., Acacia cambagei, E. leucophylla* and *Corymbia aparrerinja*. Includes substantial areas of bare ground. Occurs on gravelly red plains	Not Listed	Least Concern	Of Concern
Non-remnant Grassland	Cleared woodlands with species composition different than prior to clearing.	Not Listed	Not Listed	Not Listed

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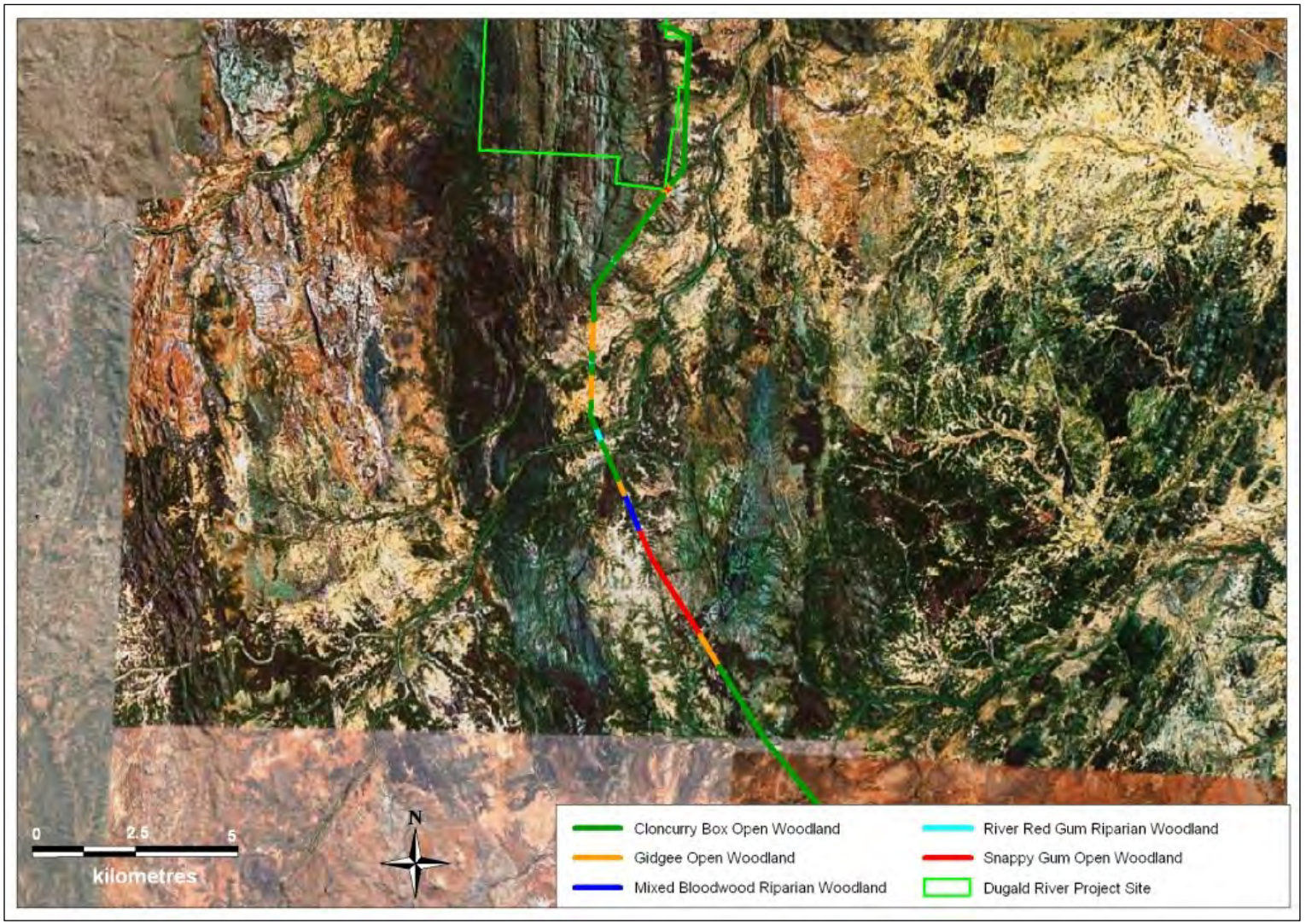

Figure 4.65 Vegetation Communities within the Northern Section of the Power Line Corridor

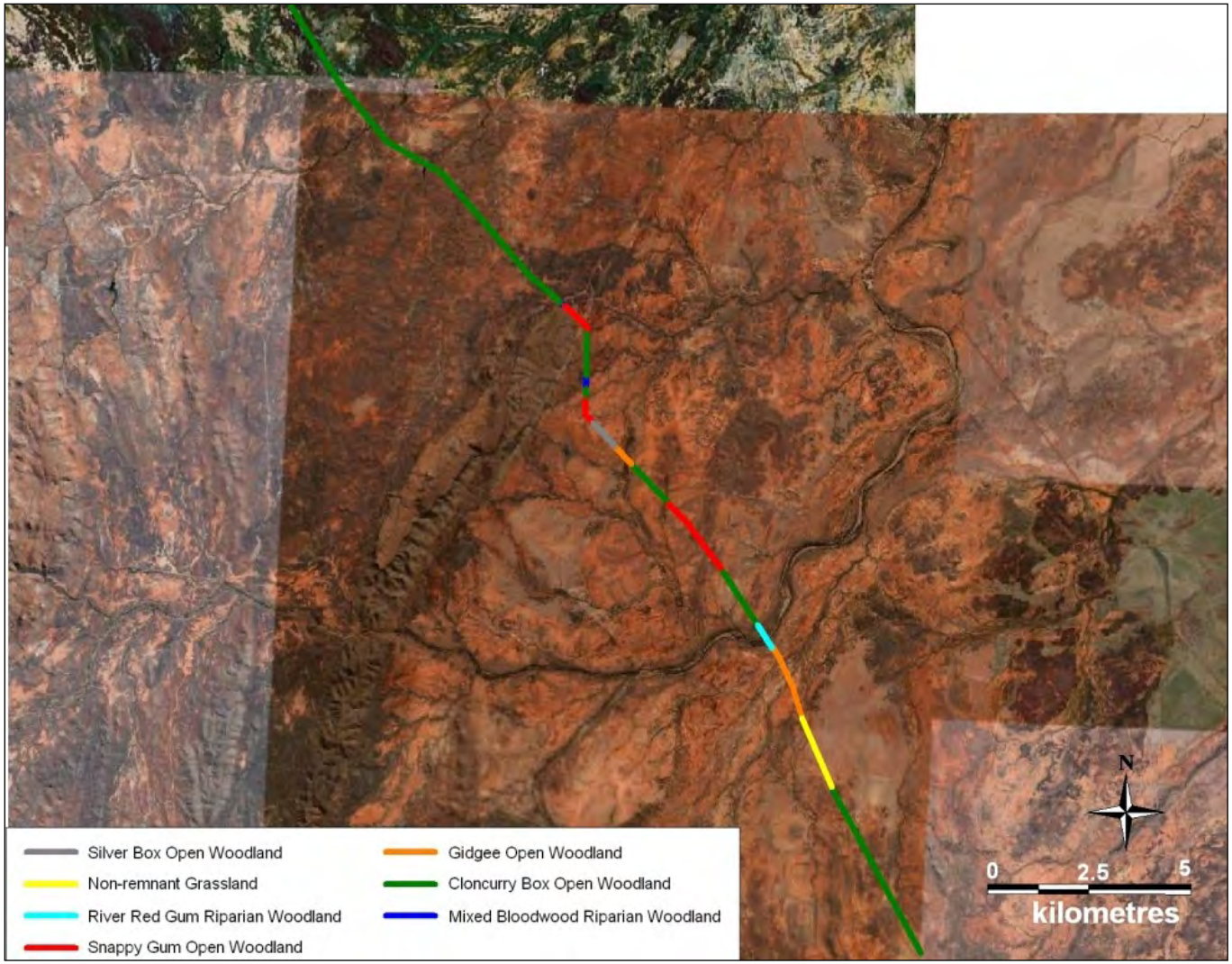

Figure 4.66 Vegetation Communities within the Central Section of the Power Line Corridor

Figure 4.67 Vegetation Communities within the Southern Section of the Power Line Corridor

Several features of conservational significance inhabit the power line corridor. These include:

- River Red Gum riparian community (RE 1.3.7); and
- Rocky outcrops containing Purple-neck Rock-wallaby (*Petrogale purpureicollis*) habitat.

Features of conservational significance are depicted in Figure 4.68, Figure 4.69 and Figure 4.70. Transect locations have been overlaid on aerial photographs and have been divided into three sections, northern, central and southern. The power line corridor maps were divided in this manner due to the length making it difficult to distinguish features on a single map.

The River Red Gum riparian woodland community is valuable to local fauna as it provides shelter around water holes and nesting holes within tree hollows. This community provides a shady and productive ecosystem for fauna in comparison to the arid, inhospitable communities surrounding the area. Floristically, it is the most diverse community within the local area of the Project site and helps maintain the environmental integrity of watercourses. The root system of the River Red Gum helps stabilize the banks of a watercourse and prevents erosion during flooding events.

A total of five rocky outcrop areas were found along the power line corridor. A summary of outcrops, GPS coordinates; estimated size and photo plate numbers can be found in 0.

Rocky outcrops provide suitable habitat for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*), listed as Vulnerable under Schedule 3 of the *Nature Conservation (Wildlife) Regulation 2006* but not listed under the *Environment Protection & Biodiversity Conservation Act 1999*.

Purple-neck Rock Wallabies are known to inhabit suitable rocky outcrops in North-west Queensland, particularly in the Cloncurry region, and are known to regularly travel short distances, with animals often required to travel to neighbouring mobs for reproductive purposes (Clancy and Close 1997).

Sightings of Purple-necked Rock-wallabies were made at two of the five rocky outcrops.

Table 4.61 Summary of Rocky Outcrops Found Within the Power Line Route

Survey Site	Geographic Coordinates*		Estimated Outcrop Length x Width (m)	Photo Plate Number	Comments
Rocky Outcrop 1	0429437 mE	7725139 mN	200 x 75	33,34	1 PNRW sighted, existing PNRW habitat
Rocky Outcrop 2	0425541 mE	7731717 mN	50 x 50	-	Minimal potential PNRW habitat
Rocky Outcrop 3	0423276 mE	7735328 mN	200 x 100	35,36	Potential PNRW habitat
Rocky Outcrop 4	0419128 mE	7739942 mN	100 x 50	37,38,39	1 PNRW sighted, existing PNRW habitat
Rocky Outcrop 5	0418906 mE	7739756 mN	30 x 50	40	Potential PNRW foraging habitat
Rocky Outcrop 6	0418151 mE	7740894 mN	Series of outcrops	41	Potential PNRW foraging habitat

All coordinates are in AGD 84 Zone 54 projection.

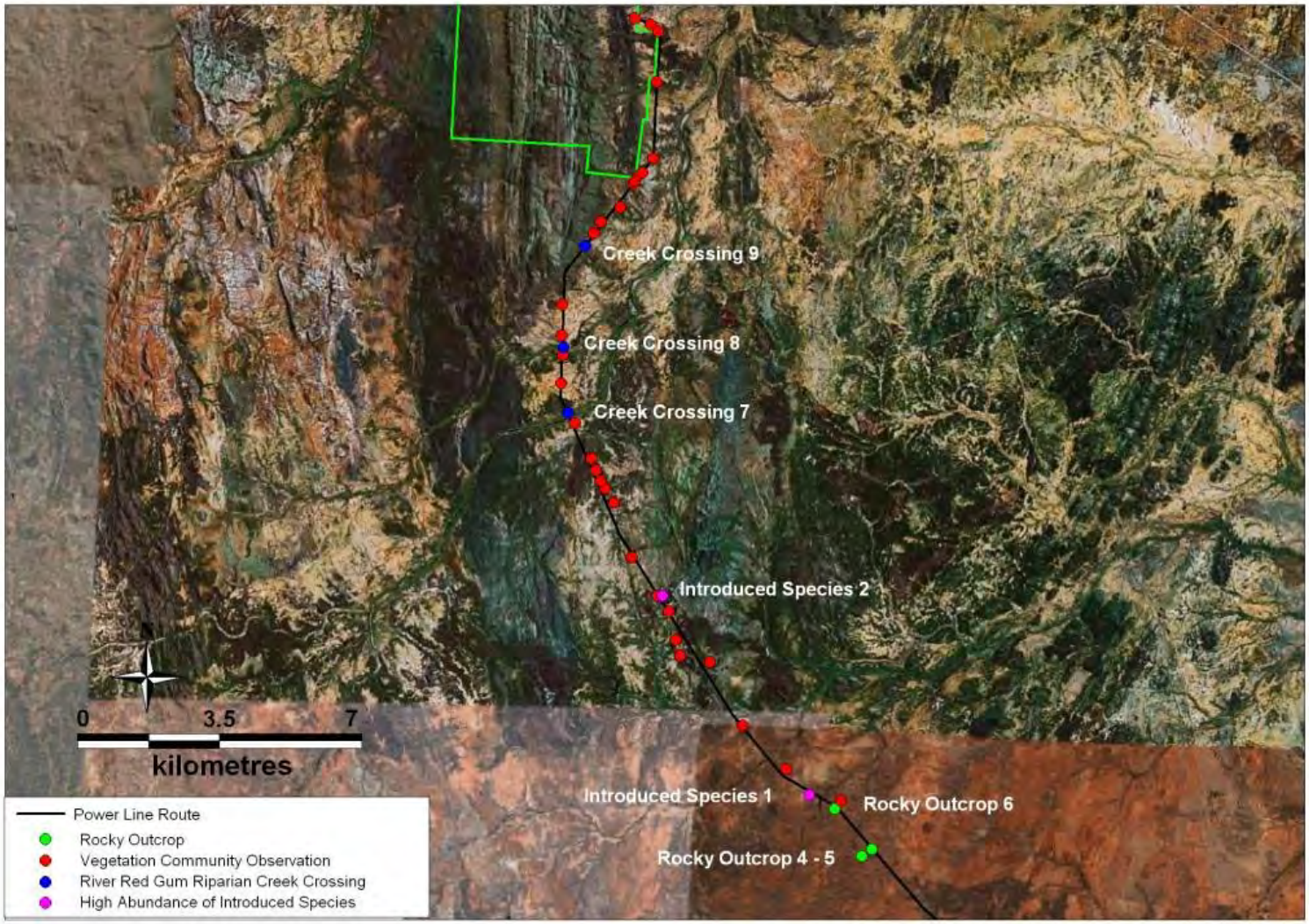

Figure 4.68 Northern Section of Power Line Corridor Transect Locations

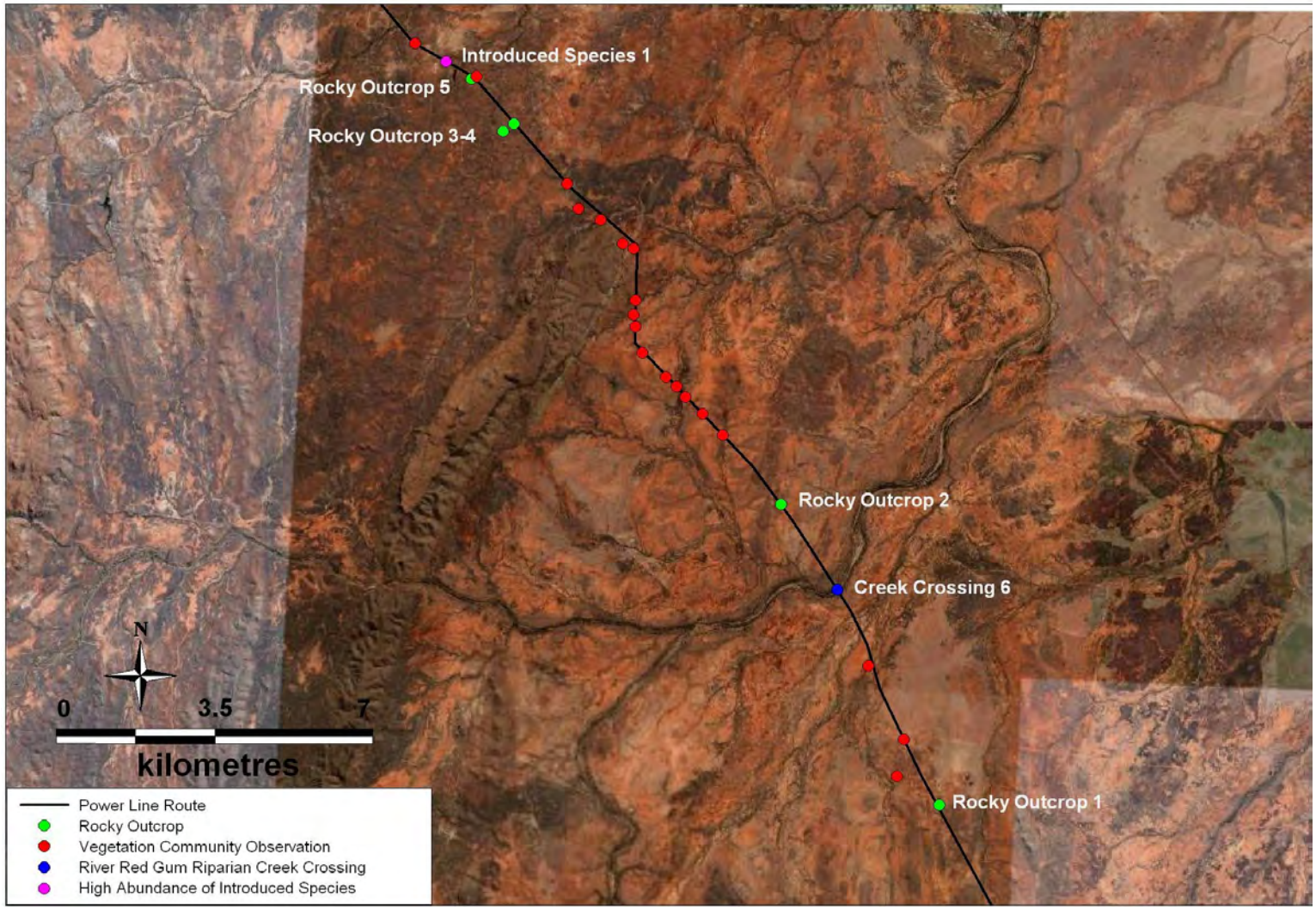

Figure 4.69 Central Section of Power Line Corridor Transect Locations

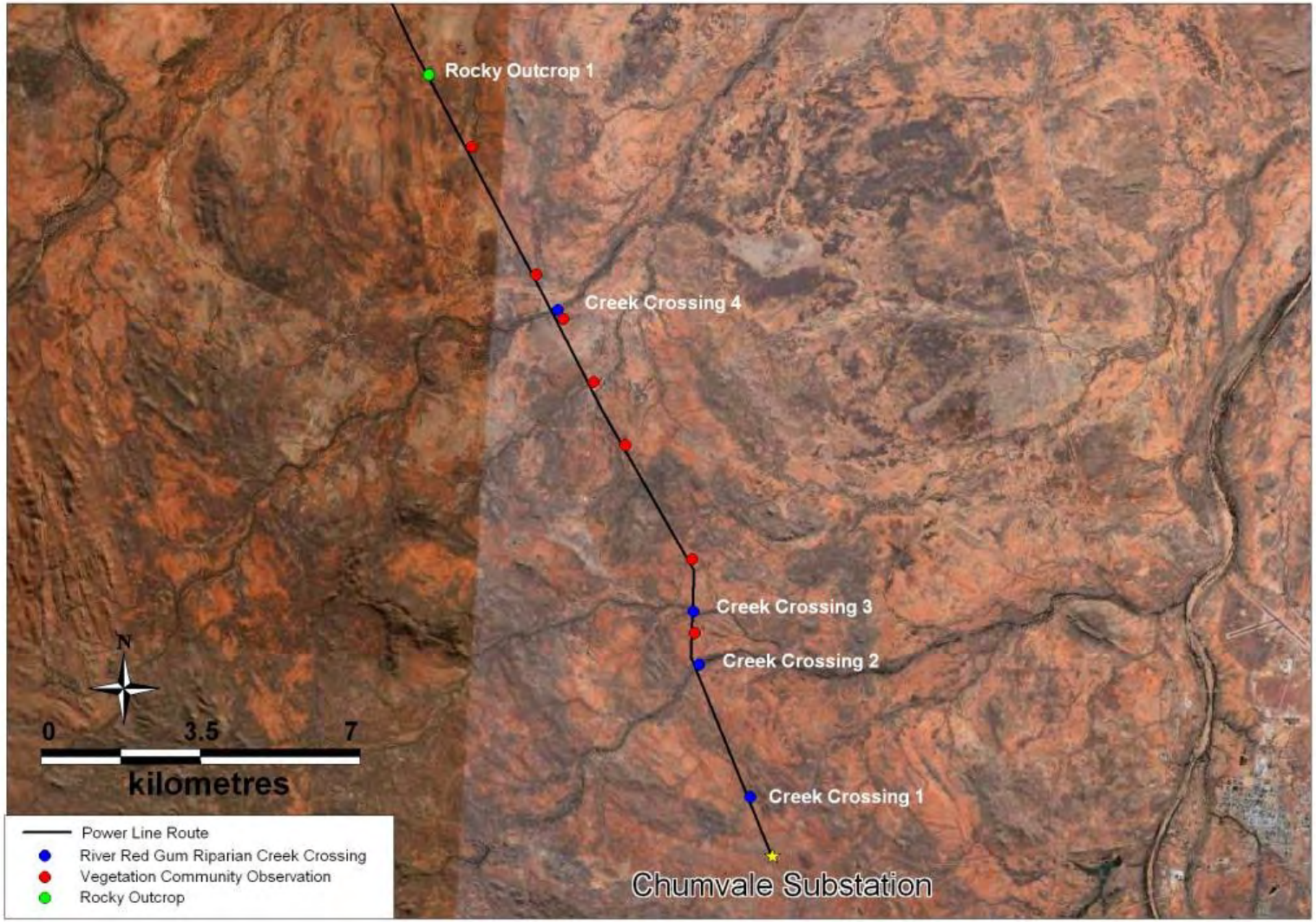

Figure 4.70 Southern Section of Power Line Corridor Transect Locations

Project Access Road

The primary access route corridor follows along an existing track for approximately 9 km from the Project Site. At the eastern end of the primary access route corridor, the primary access route diverts from the existing track for 1 km along a straight route across open terrain to join up with the Burke Developmental Road. An alternate access road route is being proposed and may be used in the foreseeable future. This route follows the primary access road route from the Project Site for 4 km, and then diverts directly east for 5 km, ultimately joining the Burke Developmental Road. It may also be necessary to use a temporary access road deviation (called the Longamundi Deviation), if mining activity occurs on adjacent tenures. The Longamundi Deviation will commence at the Project Site approximately 850 m north of the primary access route.

The following sections will discuss vegetation communities and creek crossings existing on the corridor. Although communities of conservational significance are present, no individual floral or faunal species of conservational significance are present. No weeds classified under the LP Act inhabit the access route corridor.

A total of four vegetation communities inhabit the access road corridor area. These communities are shown in Figure 4.71 and corresponding conservation status is listed in Table 4.62.

Table 4.62 Vegetation Communities on the Access Route Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VM Act	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.5.3	Low open-woodland of *Eucalyptus leucophloia* sometimes with a shrubby understory dominated by *Acacia spp.*and a *Triodia spp.* dominated ground cover. Occurs on lateric red earths and skeletal soils	Not Listed	Least Concern	Not of Concern
Cloncurry Box Open Woodland / 1.3.11x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *E. leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	Not of Concern

Vegetation Community / RE	Community Description	EPBC Status	Queensland VM Act	DERM Biodiversity Status
River Red Gum Riparian Woodland / 1.3.7a	Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *M. argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries.	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.3.4	Low open-woodland and low woodland of *Acacia cambagei* over annual grasses. Occasional *Atalaya hemiglauca, Hakea lorea subsp. lorea, Grevillea striata and Acacia excelsa*. Occurs on red or brown earths and clays.	Not Listed	Least Concern	Of Concern

The River Red Gum Riparian Woodland occurs in three separate areas along the access road corridor. One riparian site is a larger watercourse, while two are along relatively smaller creek lines. The creek line River Red Gum community is synonymous to the community found within the Project site, whilst the larger watercourse slightly differs in species. Two introduced species were noted within this community, the Calotrope (*Calotropis procera*) and Buffel Grass (*Pennisetum ciliare)*. River Red Gum Riparian Woodland (1.3.7a) is listed as 'Endangered' under DERM Biodiversity Status. Based on the proposed disturbance plans for the Project, additional clearing of the River Red Gum riparian woodland will be required. Assuming disturbance is minimised and mitigation strategies are implemented, it is unlikely the Project will significantly impact the regional occurrence of this community.

The Gidgee Open Woodland community occurs in two patches along the corridor. Gidgee Open Woodland community is listed as 'Of Concern' under DERM Biodiversity Status. The Gidgee Open Woodland is considered of little flora or fauna value. This is founded on the fact there is a non-existent shrub or canopy cover and very sparse layer of grass. Based on proposed disturbance plans for the Project, additional clearing of the Gidgee Open Woodland will be required. It is unlikely disturbance within the access road corridor will significantly impact on the regional occurrence of this community.

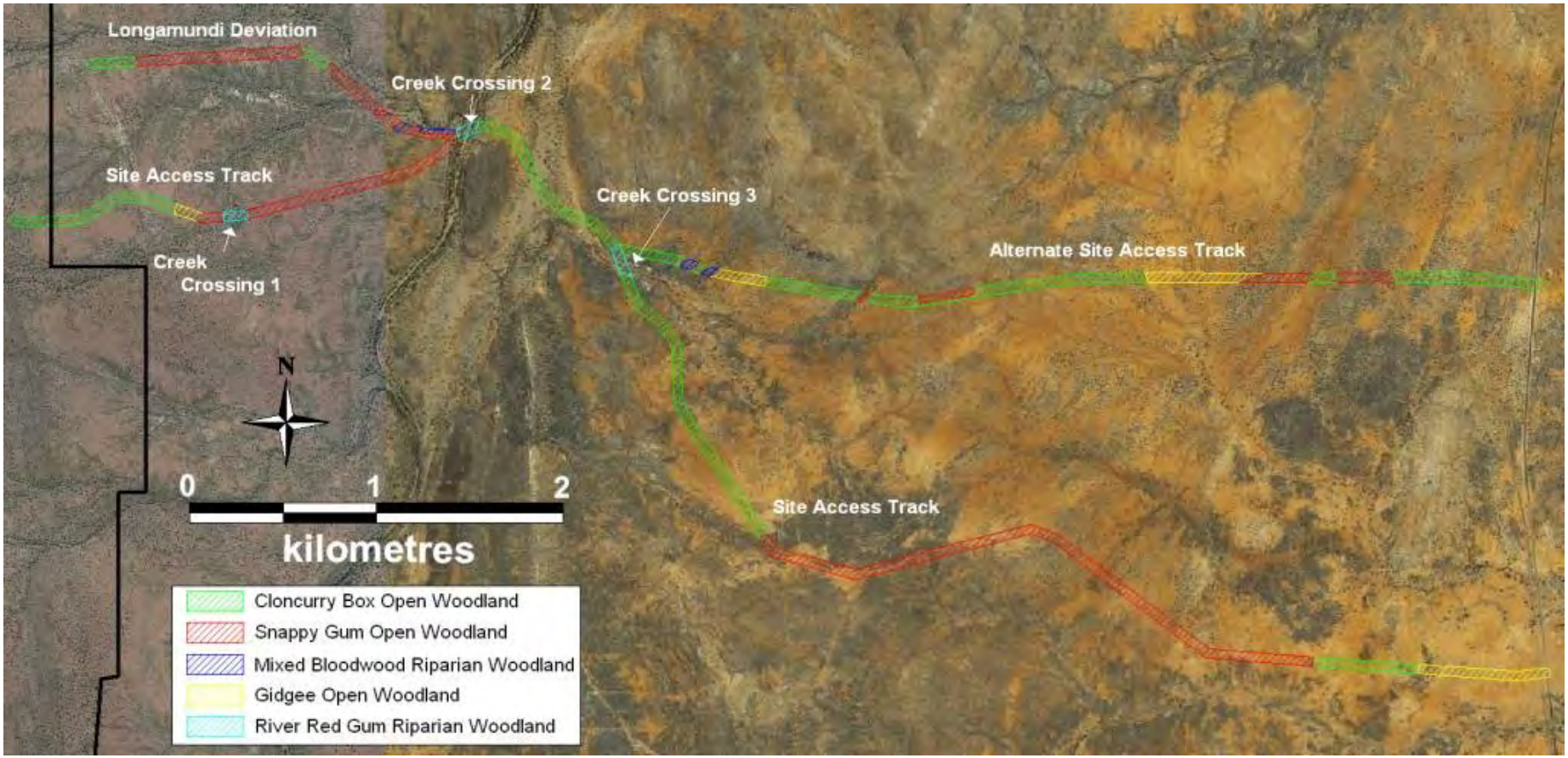

Figure 4.71 Access Route Corridor Vegetation Communities and Creek Crossing Locations

Three creek crossings exist along the access route corridor (refer to Figure 4.71). All crossings are the River Red Gum riparian woodland.

Creek Crossing 1 is Silver Mine Creek (Photo Plate 4.22). Silver Mine Creek spans approximately 30 m wide and is a mature creek. Although an existing track is present along the access route corridor, further disturbance is required to widen the track.

Creek Crossing 2 is the Dugald River (Photo Plate 4.23). The Dugald River is a mature, major watercourse. This crossing is approximately 150 m wide, including floodplains. Although an existing track is present along the Creek Crossing 2, further disturbance will be required to improve vehicle capacity.

Creek Crossing 3 is relatively small, approximately 8 – 10 m wide (Photo Plate 4.24). Surrounding vegetation density is moderate, and includes Turpentine. Based on development plans for the Project, additional clearing of this community will be required.

Photo Plate 4.22 Creek Crossing 1 – Silvermine Creek

Photo Plate 4.23 Creek Crossing 2 – Dugald River

Photo Plate 4.24 Creek Crossing 3

Water Pipeline

The proposed water pipeline commences in the Project site, runs through the Roseby Copper Project and connects up with the Lake Julius Ernest Henry Pipeline.

The water pipeline corridor included a 40 m wide assessment of the condition of the vegetation type with regard to quality and conservation value and the mapping of the REs. Since the water pipeline corridor travels close to the base of Mount Rose Bee, which potential Purple-necked Rock Wallaby habitat, scats were collected for analysis and outcrops were walked to determine extent of habitat.

Four vegetation communities are present along the water pipeline corridor; Cloncurry Box Open Woodland, Snappy Gum Open Woodland, Mixed Bloodwood Riparian Woodland and a co-dominant open woodland of Cloncurry Box and Snappy Gum Open Woodland (refer to Figure 4.72 and Figure 4.73). Each community is summarised with RE equivalents and corresponding conservational status in Table 4.63 below. There are no flora species of conservation significance along the proposed water pipeline corridor.

Table 4.63 Vegetation Communities on the Water Pipeline Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VM Act	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.5.3	Low open-woodland of *Eucalyptus leucophloia* sometimes with a shrubby understory dominated by *Acacia spp.*and a *Triodia spp.* dominated ground cover. Occurs on lateric red earths and skeletal soils	Not Listed	Least Concern	Not of Concern
Cloncurry Box Open Woodland / 1.3.11x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *E. leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	Not of Concern
Snappy Gum / Cloncurry Box Open Woodland 1.5.3 / 1.3.11x1	See above	See above	See above	See above

Mixed Bloodwood Riparian Woodland 1.3.6	Woodland and low woodland of *Corymbia aparrerinja* and *Corymbia terminalis*. *Acacia victoriae* may dominate heavier soils. Occurs on terraces and floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics	Not Listed	Least Concern	Of Concern

One rocky outcrop is located within the water pipeline corridor. Rocky Outcrop 1 is located along the northern section of the water pipeline corridor (refer to Figure 4.72 and Figure 4.73). The outcrop is 80 m in length, with a maximum relief of approximately 4 m. A few small crevices are present in this rock system. Marsupial scat samples have been collected and identified; however no Purple-necked Rock-wallaby scat was present. The absence of Rock-wallaby scats concludes this species does not reside at this small outcrop.

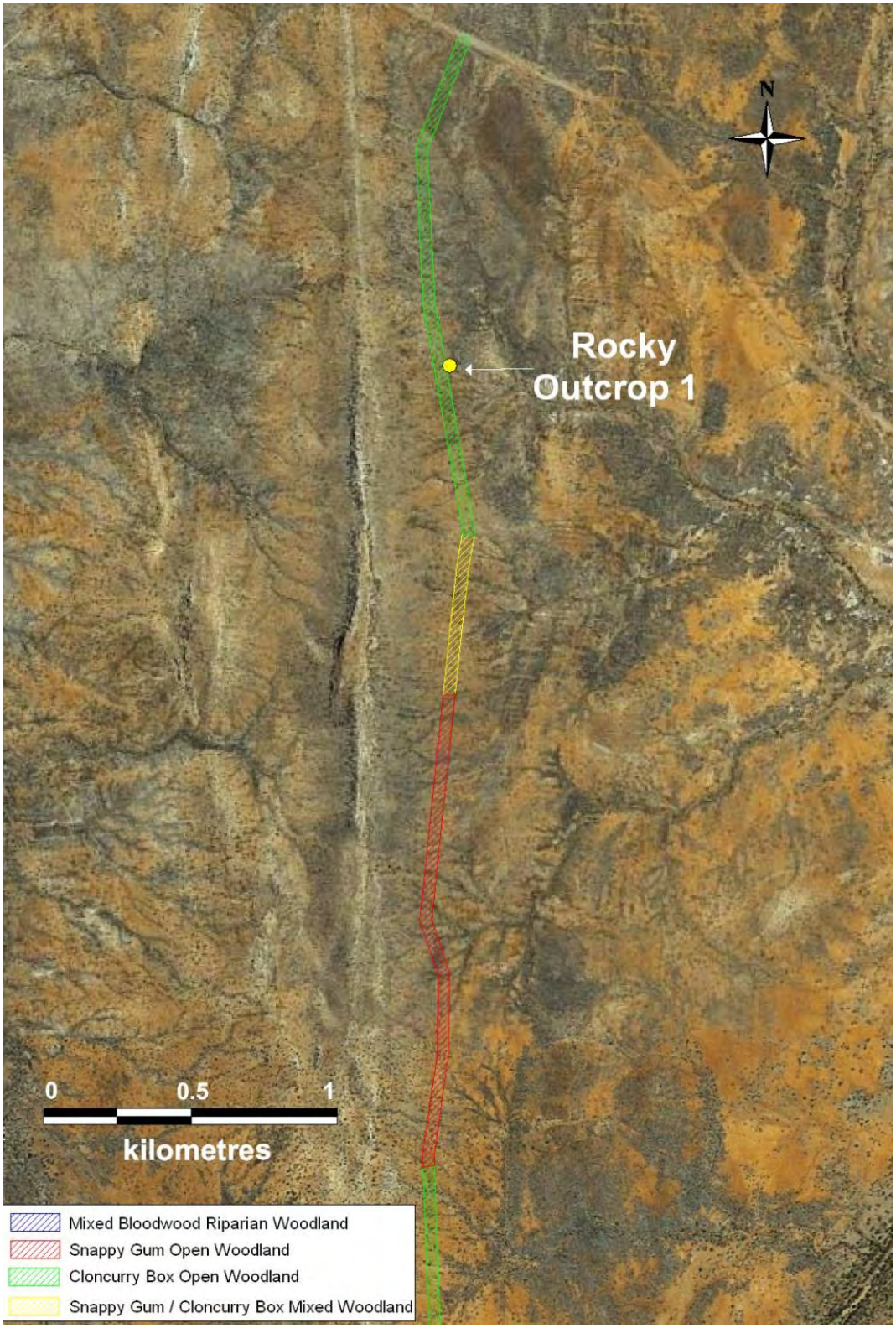

Figure 4.72 Northern Section Water Pipeline Corridor Vegetation Communities and Rocky Outcrop

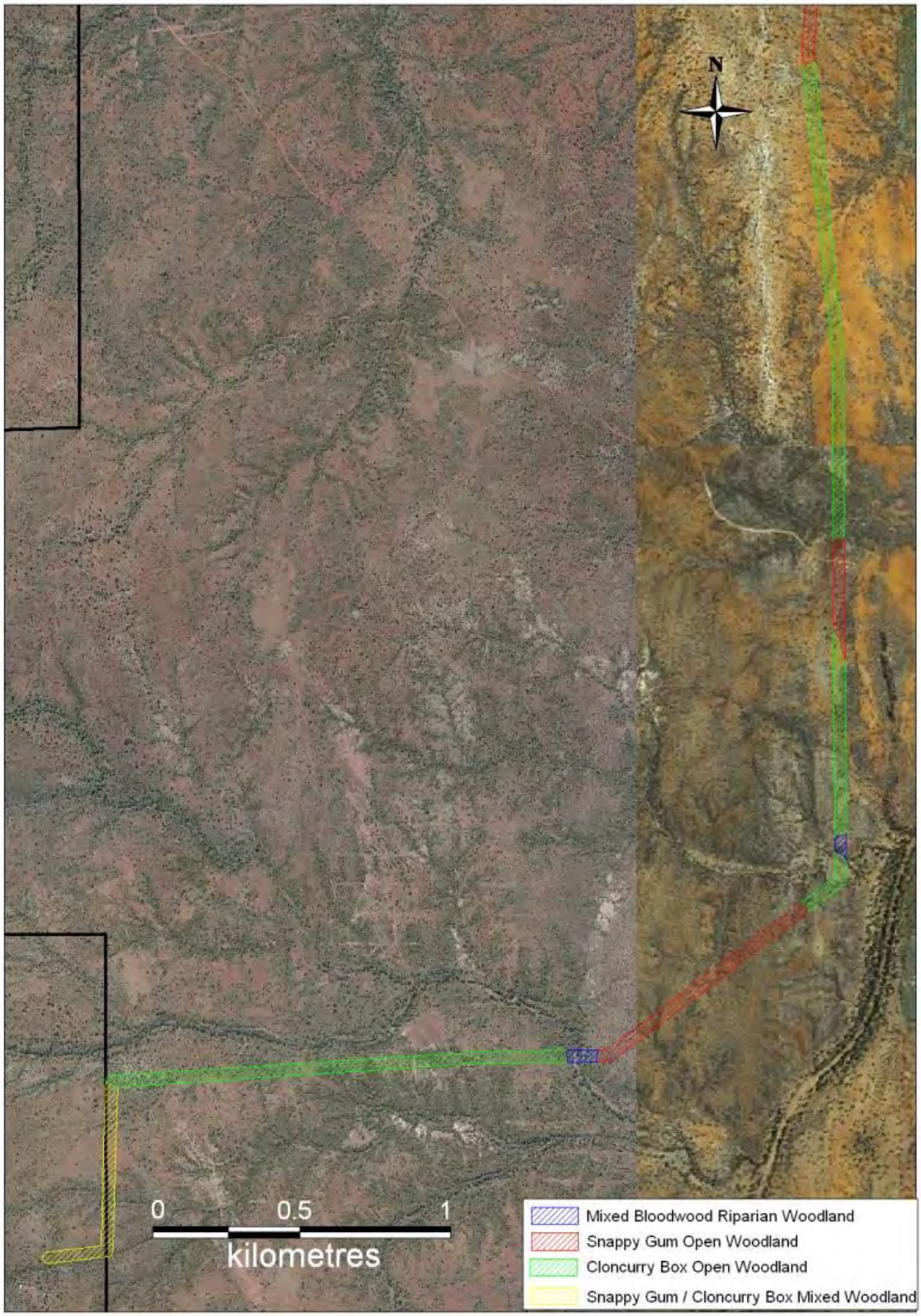

Figure 4.73 Southern Section of Water Pipeline Corridor Vegetation Communities

4.7.1.7 Aquatic Biology

Potential waterholes/sampling sites were visually assessed for their aquatic study site suitability. The following factors were considered for each site to assess the ecological value and study site suitability:

- Relative size;
- Accessibility;
- Abiotic aquatic habitat such as submerged logs, rocks, flow rate and substrate type (e.g. mud); and
- Biotic aquatic habitat such as aquatic flora species and abundance.

Descriptions of the aquatic study sites are discussed below and shown in Figure 4.74.

- **Aquatic Study Site 1** was located at the Longamundi Waterhole on the Dugald River; and
- **Aquatic Study Site 2** was located at the Dan Lynch Bridge (Dugald River) on the Burke Development Road.

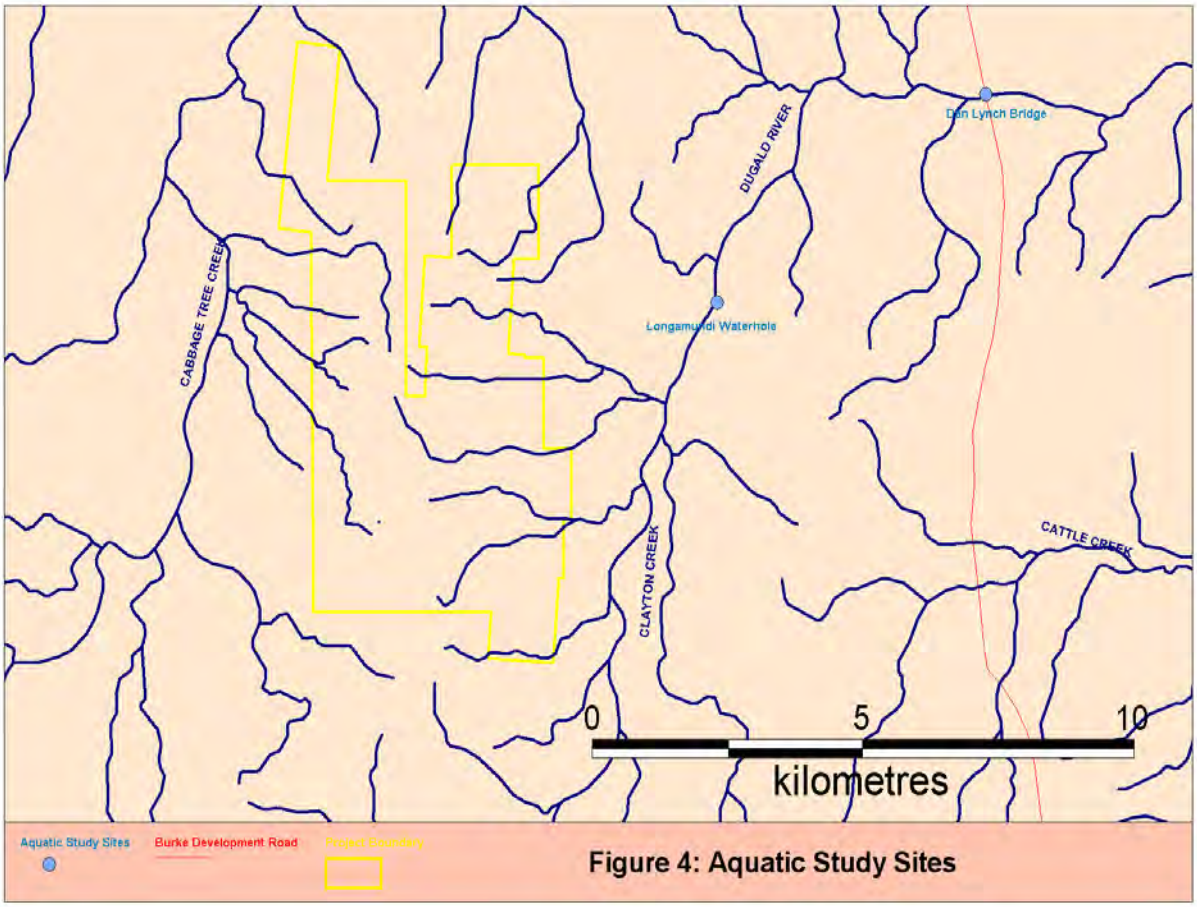

Figure 4.74 Aquatic Study Locations Downstream of the Project Site

Results

The ephemeral creeks and drainage lines present on the Project site are typical of ephemeral creek systems within the broader region, with no permanent water bodies and creeks flowing periodically during the wet season (November – April) after heavy rainfall events. Hence, due to the lack of water on the Project site during both the dry and wet season surveys, aquatic sampling was undertaken in downstream drainage areas off site where sufficient water was present.

Two aquatic study sites, known as the Dan Lynch Bridge, where the Bruke Developmental Road crosses the river, and Longamundi Waterhole, both located on the Dugald River were selected to assess aquatic habitat value and obtain a species list.

Four aquatic vertebrate species were detected downstream of the Project site during the 2008 survey. These species included the Eastern Rainbowfish (*Melanotaenia splendida*) (Photo Plate 4.25), Northwest Glassfish (*Ambassis Muelleri*), Spangled Perch (*Leiopotherapon unicolour*) and Hytrl's Tandan (*Nepsilurus hyrtlii*). A species of freshwater crab (*Holthuisana transversa*) was also noted commonly on the bank of the Dan Lynch Bridge billabong.

Surveys of aquatic vertebrates were undertaken in the vicinity of the Project site in 2004 and 2005, and incorporated both the Dan Lynch Bridge and Longamundi study sites, and an additional sampling site at Cockatoo Waterhole (also on the Dugald River). Results of these surveys returned similar species of aquatic vertebrates to the current survey, and also included the Bony Bream (*Nematalosa erebi*) (AARC, 2006).

All of these species are widespread within ephemeral waterways of north-west Queensland. It is possible that these species may be found within the Project site following flow events. No aquatic vertebrates of conservation significance were recorded on the Project site at the time of the surveys. Similarly no species of conservation significance were recorded at the study sites downstream of the Project site during the wet season survey.

Photo Plate 4.25 The Eastern Rainbowfish (Melanotaenia splendida)

Macro-invertebrates

Both the Dan Lynch Bridge and Longamundi waterhole were sampled for macro-invertebrate diversity during the 2004 and 2005 wet seasons with the objective of performing SIGNAL analysis as a stream health indicator (AARC, 2006). Seine nets were used to sweep the upper water column, vegetated banks, under submerged logs, across benthic substrate and in any other micro-environments likely to have macro-invertebrates present. Sweeping efforts resulted in nominal species. Survey results provide an indication of stream and site health during and soon after flow events, and are summarised below.

A total of 21 macro-invertebrate taxa were identified in the 2004 survey and 22 in the 2005 survey. A large number of cyclopoidean copepods and Daphnids (water flies) as well as ostracods were recorded. These were not included as they are omitted from SIGNAL calculations and are regarded as 'background noise' in most freshwater environments. A total of 23 macro-invertebrate taxa were identified at the sites during two surveys.

During the 2004 survey, the number of identified taxa varied little between sites, however the Dan Lynch Bridge was more diverse. Sensitivity scores for the identified families ranged between 1 and 4, although one Leptocerid with a sensitivity score of six was identified from the Dan Lynch Bridge. The occurrence of this high score at a site that seemingly had the highest level of disturbance (i.e. roads and associated run-off) is somewhat unexpected. Average sensitivity scores for each location are provided below in Table 4.64.

In contrast to 2004, the results from 2005 found considerable differences between the number of taxa collected at sample locations. Only six taxa were identified at Dan Lynch Bridge 1 with 11 taxa identified at Dan Lynch Bridge 1 and Longamundi south (Table 4.65).

In addition, the average SIGNAL scores were consistently higher during the 2005 survey (2.8 – 3.0 versus 3.3 – 3.4).

Table 4.64 Average Sensitivity Scores for Each Sample Location in 2004

Location	Total SIGNAL	No. of Taxa	Av. SIGNAL
Dan Lynch Bridge	21	7	3.0
Longamundi Waterhole	17	6	2.8

Table 4.65 Average Sensitivity Scores for Each Sample Location in 2005

Location	Total SIGNAL	No. of Taxa	Av. SIGNAL
Dan Lynch Bridge 1	39	11	3.4
Dan Lynch Bridge 2	20	6	3.3
Longamundi north	30	9	3.3
Longamundi south	36	11	3.3

SIGNAL scores in the low to mid 3 ranges are indicative of a highly disturbed system. It is, however, difficult to determine what a 'un-disturbed' system around Cloncurry would rate on the SIGNAL

system. This is largely due to the fact that no river systems in the region are in an 'undisturbed state' and therefore no suitable comparison systems exist. Rather, large areas are affected by grazing or upstream impacts. The levels of these impacts vary, but due to low stocking rates are unlikely to be as significant (compared to the east coast where clearing has facilitated heavy grazing).

This may also explain the difference in the SIGNAL scores between the two surveys. The 2004 survey was conducted within one month of substantial rainfall and the water bodies were relatively new. As recruitment by aquatic invertebrates can be slow, few species would have had a chance to build up sufficient numbers for detection. Consequently, the 2004 survey may have overlooked species that were less common at the time. However, the 2005 survey was conducted two months after substantial rainfall. This may have been sufficient time for less common species to become detectable.

4.7.2 Potential Impacts and Mitigation Measures

4.7.2.1 Potential Impacts

Flora

Maintaining stands of vegetation across the Project site is important for reasons such as maintaining high biodiversity levels, carbon sequestration, and aiding an ecosystems ability to maintain an assimilative capacity. Vegetation also assists with the management of anthropogenic activities by providing natural solutions to environmental problems such as soil and bank stabilisation, and reducing the risk of salinity and overland flow. Vegetation also provides important habitat for a range of fauna species.

Edge effects resulting from the proposed works can include the establishment of weeds, alteration to microclimatic conditions (such as greater light intensity, more wind penetration, lower humidity) and a reduction in plant health through loss of photosynthetic potential (as a result of plants being covered by dust generated from vehicle movement on unsealed tracks). In the absence of appropriate control measures, the Project has the potential to cause impacts in relation to edge effects, and particularly in relation to the introduction and / or spread of weed species throughout the Project site.

The following potential impacts on flora values may result from the proposed operations at the Project site:

- Land clearing and mining activities may reduce the available habitat for native flora species on the Project site. Disturbance footprint areas within the Project site and each corridor are assessed below;
- A loss of habitat connectivity across the mining/processing and infrastructure areas;
- Spread and introduction of weed seeds/propagules on footwear, machinery, vehicles and materials required for mine operation and construction;
- Potential weed invasion from earthworks activities in sensitive areas, particularly along watercourses; and
- Increased incidence of fire due to inappropriate fire regimes or accidental burning. Too frequent fires, or burning at the wrong time, may disrupt the life cycle of flora species leading to unpalatable grasses for cattle and increased incidents of woody and annual weeds such as Flannel Weed (*Sida cordifolia*) and Caltrope (*Calotropis procera*).

Estimated Footprints within each Community

Project Site

The estimated total disturbance of the Snappy Gum Open Woodland within the Project Site is approximately 117 ha, which includes the accommodation village, TSF, access tracks and process plant. This equates to 4.4% of the vegetation community's total area on the Project site. It is unlikely the regional extent of this vegetation community will be affected by the proposed Project.

The estimated area of disturbance within the Cloncurry Box Open Woodland from the proposed process plant and access tracks are 42.8 ha, or 8.2% of the total area within the Project site. It is unlikely the regional extent of this vegetation community will be affected by the proposed Project.

Proposed disturbance within the Mixed Bloodwood Riparian Woodland community includes tracks, roads and a TSF. The proposed disturbance will create an estimated 3.5 ha of disturbance, which equates to 5.4% of the Mixed Bloodwood Riparian Woodland's total area within the Project site. It is unlikely the regional extent of this vegetation community will be affected by the proposed Project.

The total area that River Red Gum Riparian Woodland community covers on the Project Site is 1.8 ha. Based on proposed disturbance plans for the Project and current infrastructure, less than 0.5 ha of Regional Ecosystem 1.3.7a will be required due to site access tracks. It is unlikely the regional extent of this vegetation community will be affected by the proposed Project.

No clearing within the Gidgee Open Woodland or Silver Box / Cloncurry Box Open Woodland will be necessary for the Project.

Powerline

The powerline easement is proposed to be 80 m in width; this width has been used to calculate the footprint disturbance within all communities. The following conclusions can be made:

- Based on proposed disturbance plans for the Project, additional clearing of the Snappy Gum Open Woodland will be required. Estimated vegetation disturbance from construction of the powerline is approximately 54 ha. This disturbance area is highly unlikely to affect the regional health and abundance of either RE which comprise this community;

- The estimated additional vegetation disturbance within the Cloncurry Box Open Woodland is approximately 328 ha. This disturbance footprint is unlikely to affect the regional occurrence or conservation status of either Cloncurry Box Open Woodland RE;

- Additional vegetation disturbance of the River Red Gum Riparian Woodland is estimated to be approximately 23 ha. Although this is a small area of the regional extent of this RE, due to the 'Endangered' listing under the *Queensland Biodiversity Status*, appropriate offsets will be established. Assuming sediment control methods are in place and rehabilitation strategies, such as establishment of artificial nest boxes and fallen timber, are undertaken, the overall health and diversity of this community will be maintained;

- The estimated total area of disturbance within the Gidgee Open Woodland community caused by the powerline construction is estimated to be approximately 75 ha. It is unlikely the disturbance footprint within this RE will degrade the regional diversity of this community;

- The estimated additional vegetation disturbance of the Mixed Bloodwood Riparian Woodland will be approximately 12 ha. Assuming mitigation strategies for sediment and weed control, it is unlikely this community will be affected on a regional scale; and

- The estimated area of Non-remnant Grassland within the corridor is 15 ha. Due to the abundance of this vegetation type within the region, little to no impacts on regional native flora diversity and fauna habitat can be expected from this disturbance footprint.

Access Route

The following conclusions can be made in regards to clearing of vegetation along this access route:

- The estimated disturbance footprint area within the Snappy Gum Open Woodland community is 7.2 ha. It is unlikely this area of disturbance will regionally impact either RE which are classed within this community;

- The disturbance footprint within the Cloncurry Box Open Woodland vegetation community is estimated to be 3.2 ha. It is highly unlikely the disturbance footprint within this vegetation community affect the regional health and occurrence of either RE;

- Based on proposed disturbance plans for the Project, current access track disturbance, and a proposed access road clearance width of 8 m, no additional clearing will be necessary within the River Red Gum Riparian Woodland.

- The estimated disturbance footprint area within the Gidgee Open Woodland from the access track will be 1.3 ha. It is unlikely this amount of clearing will regionally affect this RE; and

- The approximate amount of additional clearing of the Mixed Bloodwood Riparian Woodland will be 0.16 ha. It is highly unlikely the small disturbance footprint will affect the regional conservation status or health of this community.

Water Pipeline

Based on proposed disturbance plans for the Project, additional clearing of both the Snappy Gum Open Woodland and Cloncurry Box Open Woodland will be required. Proposed disturbance plans for the Project, show the estimated disturbance footprint within the Mixed Bloodwood Riparian Woodland is expected to be approximately 0.2 ha.

Fauna

The construction of mine infrastructure has the potential to affect fauna populations through habitat loss, population isolation, edge and barrier effects, and an increase in mortality from mine activities and increased traffic in road use. The development of mine infrastructure will involve landscape modification procedures through vegetation clearing, a recognised threatening process that can affect different taxa in differing ways.

Barrier effects on fauna occur when a species is unable or unwilling to move between suitable habitats. This is caused by increased habitat fragmentation due to roadways and other mine infrastructure. Species most vulnerable to barrier effects are habitat specific fauna and low mobility species (where even a small reduction in movements can reduce genetic continuity within a population, hence reducing the effective population size). Species least vulnerable to barrier effects tend to be those that are highly mobile, including birds and larger mammals, although even these species can vary in their response to barriers. Low mobility species utilising the Project site have the

potential to become genetically isolated. This occurs when individuals from a population within one fragment are unable to interbreed with individuals from populations in adjoining fragments.

The following potential impacts on fauna may result from the proposed works at the Project site:

- Land clearing and mining activities may reduce the available breeding and foraging habitat for fauna native species;
- Increased risk of fauna mortality resulting from vehicle strike and the destruction of tree hollows;
- Disruption of faunal species natural foraging behaviours;
- Increased habitat fragmentation and loss of connectivity across the mine/processing and infrastructure areas;
- An increase in noise, vibration and dust associated with the construction and operational phases of the Project may lead to the displacement of native species from their current home ranges;
- Changes in flow patters accompanied with an increased risk of sedimentation in riparian woodlands downstream of the proposed mine site may occur. Higher levels of erosion can lead to a loss of morphological diversity in streams adversely affecting habitat quality that may result in biodiversity loss in affected areas;
- An increase of introduced fauna species identified as utilising the Project Site may occur;
- Mine-related infrastructure, such as sediment dams, may be accessible to fauna and may be additional water sources;
- Assuming buffers are maintained for rocky outcrops along the proposed powerline route, it is unlikely that the Purple-necked Rock-wallaby species will be disrupted; and
- Vegetation clearing will result in a localised reduction in the amount of roost and nesting sites, microhabitats and potential foraging areas for many fauna species. This would add population pressure (such as competition for roost sites, mates and food resources) to resident bats in these adjacent areas and may potentially lead to decreased population viability.

Cumulative Impacts

The potential ecological impacts identified above are considered as a consequence of the construction and operation of the Project. The incremental effect of multiple sources of impact (past, present and future) is referred to as ‘cumulative impacts’ (Contant & Wiggins 1991; Council on Environmental Quality 1978). These impacts may become exacerbated over time. Consideration of cumulative impacts is necessary so impacts associated with the Project can be assessed with additional regional impacts from external sources.

Potential regional developments that may interact with the construction of the Project include:

- Other mines that may be opened in the future in the region, in particular the Roseby Copper Project;
- Low intensity stock graziers which may be affected by the Project.

All such developments are likely to contribute to a greater extent of ecological pressures on habitat and flora/fauna, such as vegetation clearing and a further fragmentation of habitat.

Irreversible / Residual Impacts

Residual impacts remain after a Project's environmental management strategies, mitigation measures and rehabilitation methods have been carried out. Residual impacts for the Project include removal of vegetation and associated faunal habitat, of [particular importance is the riverine vegetation communities River Red Gum Riparian Woodland (RE 1.3.7) and Mixed Bloodwood Riparian Habitat (RE 1.3.6). Where there is residual loss or degradation of vegetation, habitat or land use upon completion of mine decommissioning (or as residual impact is identified prior to decommissioning), compensation in the form of further habitat rehabilitation in areas adjacent to the Project site, land rehabilitation, contribution to research or vegetation offsets can be employed.

4.7.2.2 General Management Strategies

Suggested general strategies to minimise the impacts on native flora and fauna, and recommendations regarding rehabilitation of the Project site, are outlined below:

- Although the vegetation communities within the Project site are well-represented in the wider region, in recognition of the intrinsic value of native vegetation, every effort will be made to keep proposed disturbance areas to a minimum;

- To maintain the integrity of vegetated land that is not cleared, appropriate erosion and sediment controls are recommended to prevent sediment deposition in remaining habitat. Sediment ponds to contain stormwater run-off are discussed in Section 3.5.4;

- Maintenance of retained areas of native vegetation will also provide a source of seed for mine rehabilitation works;

- Native vegetation removal will be conducted only after:

    - the areas to be cleared have been clearly delineated and identified to equipment operators and supervisors (land clearing and management is discussed in section 4.2.2.2); and

    - appropriate erosion and sediment control structures are in place. Sediment ponds are discussed in Section 3.5.4;

- Methodologies for the rehabilitation/re-vegetation works for the Project will use the most appropriate species for the landscape elements of the site. Such methodologies should include habitat matching of species to ensure rehabilitation success. Areas such as the waste rock dumps should be assessed for species to ensure long-term stability and rehabilitation success rather than "quick fixes" that may not be successful in the long term. (see Section 3.7 for rehabilitation strategies);

- Landforms such as waste rock dumps will be designed with slopes that resemble the original local topography;

- Infrastructure planning will avoid the creation of permanent, shallow water areas, such as septic and other tank overflows that form a permanent seep. These areas attract Cane Toads that are lethal to most snakes and other fauna species when ingested;

- Measures should be taken to minimise harm to affected fauna communities by inspecting the vegetation to be disturbed prior to clearing to ascertain whether any fauna are present. If fauna is present, it should be given the opportunity to move on naturally before clearing occurs;

- A segment of the Staff Induction Program will be allocated to informing staff of the conservation values on the Project site to increase staff awareness of the species present. This could include photographs, brief descriptions and management requirements of native species;

- The rehabilitation strategy developed for the Project site will embody the concepts and recommendations presented above and include provision for monitoring of rehabilitation progress over the life of the operation;

- Mitigation strategies for the clearing of River Red Gum riparian, Silver Box Open Woodland and Mixed Bloodwood riparian woodland communities within the Project site and along the access road include:

    - Retention of large trees as close as possible to the clearance areas;

    - Presence of a wildlife carer or specialist to determine hollows used by fauna and to aid in fauna relocation when clearing. Hollows used by fauna that have been removed will be replaced by appropriate nesting boxes;

    - Avoiding disturbance of neighbouring creek banks and beds and utilise existing tracks whilst undertaking construction; and

    - Voluntary Offset strategies for the area of vegetation communities impacted (not legally required under the Policy for Vegetation Management Offsets (See Appendix S)) may include sponsoring a volunteer conservation group (i.e. – Landcare) to conduct weed eradication and wildlife habitat restoration in similar vegetation communities.

- ANRA recommended recovery actions for riverine habitats (RE 1.3.6 and RE 1.3.7) include habitat protection on state lands, reserves and private lands, weed control and research.

4.7.2.3 Power Line Construction Management Strategies

Strategies to minimise impacts on the River Red Gum riparian, Gidgee Open Woodland, Silver Box Open Woodland and Mixed Bloodwood riparian communities whilst constructing the power line corridor will include:

- Employing horticulturists and tree cutting specialists to trim trees, required to be cut due to the power line construction process;

- Only trimming up to one third of the Gum or Bloodwood tree height at any one time;

- Trimming should occur at the nearest growth point (tree stem or trunk offshoot) to protect trees from infections and disease. Trees should not be cut straight across to a standard clearance;

- Retention of large trees as close as feasible to power line;

- Presence of a wildlife carer or specialist to determine hollows used by fauna and to aid in fauna relocation when trimming trees. Hollows used by fauna that have been removed will be replaced by appropriate nesting boxes;

- Encourage natural regeneration of native shrubs by removing weeds, which will aid in keeping canopy at a lower height; and

- Voluntary Offset strategies for the area of vegetation communities impacted (not legally required under the Policy for Vegetation Management Offsets (see Appendix S)) may include sponsoring a volunteer conservation group (i.e. – Landcare) to conduct weed eradication and wildlife habitat restoration in similar vegetation communities.

- The power line corridor and power poles should be aligned to avoid any ground disturbance near rocky outcrops by at least 150 m, to protect the habitat of the Purple-necked Rock-wallaby.

4.7.2.4 Pest Flora and Fauna Management Strategies

A number of weed management strategies are recommended to minimise the potential of future weed infestations. These should be adopted for all stages of mine activity including construction, operation and rehabilitation:

- The present location of weeds should been highlighted and a comprehensive weed spraying program be implemented prior to the commencement of works. Declared weed species will be treated as per the relevant Department of Employment, Economic Development and Innovation (DEEDI) fact sheet for each particular species;

- Monitoring in the form of annual observations by site personnel for weeds of management concern should be undertaken. These should be conducted following significant rain events in the wet season particularly in disturbed areas, roadsides, riparian zones and wash down facilities;

- Wash down facilities should be constructed at access points for vehicles arriving and departing from the Project site. These facilities should be bunded and located away from drainage lines to minimise the risk of weed spread;

- All vehicles entering the Project site and leaving properties known to contain declared weeds should be thoroughly washed down before entering clean areas; ensuring wheels, wheel arches and the undercarriage are free of mud and plant material;

- Radiators, grills and vehicle interiors should be cleaned for accumulated seed and plant material;

- All materials should be certified as weed free prior to acceptance on-site;

- Soil and fill material from weed affected areas should not be transported to clean sites. Minimising soil disturbance will limit the ability of weeds to become established;

- If weeds of management concern are identified, they should be eradicated from the site in accordance with local best management practice from the Cloncurry Shire Pest Management Plan and/or the DEEDI Pest Fact sheets;

- Observations of treated areas to assess the success of declared weed eradication should be undertaken;

- To promote the awareness of weed management issues, it is recommended that weed management is included in the Site Induction Program for the Project; and

- Prepare a site specific weed management plan.

Most feral animals are either exotic, domestic animals that have gone wild or exotic animals that were introduced into the wild for pest control or for recreational use. Under the LP Act, land managers must take reasonable steps to ensure that lands are kept free of Class 2 pests. Given this legal requirement in addition to the potential for these species to impact the environmental values of the Project site, management strategies for each of the Class 2 pests identified on the Project Site are addressed below:

1. **Dingo/Wild Dog** (*Canis familiaris*) Different control methods including shooting, poisoning, trapping and fencing in combination with current land management practices are most effective to control Dingoes.

2. **Feral Cat** (*Felis catus*) Control methods for feral cats include shooting, poisoning, trapping and fencing in combination with current land management practices.

3. **Feral Pig** (*Sus scrofa*) Difficult to control, it is recommended that a combination of physical controls be employed, including shooting, poisoning, trapping and/or barrier construction.

Additional priority pest animals identified in the Cloncurry Shire Pest Management Plan (2004) include the European Rabbit (*Oryctoagus cuniculus*), Fox (*Vulpes vulpes*), Spur Throated Locust (*Austracris guttulosa*) and Wallaby (no species was identified in plan).

The *North West Management Plan* (DIP, 2010) aims to manage pest plants and animals to protect the present and future land use and the productive capacity of natural resources. The plan identified mining exploration and related activities may introduce a range of weeds and pests into previously unaffected areas by means of poor site management practices. Recommended management strategies within this plan include:

- Implementing pest management practices to protect the environment and the productive capacity of natural resources, communities, industries and business; and

- Encouraging further development of partnerships with the pastoral industry, local government and lessees, to build capacity to control and manage weeds.

4.7.2.5 Aquatic Biology Management Strategies

The following strategies will be employed to minimise impacts to aquatic species in the ephemeral waterways:

- The stormwater management system on the Project site will separate ‘clean’, ‘dirty’ and ‘contaminated’ run-off water around the mining, processing plant and the TSF. No contaminated water will be released off site excepting rare occasions where there is potential for extreme rainfall events (stormwater management and sediment ponds are discussed in Section 3.5.4);

- Sediments ponds will be constructed downstream of all other land disturbances to remove sediment from storm water flowing off these areas prior to release;

- Creek crossing will contain culverts of an appropriate design structure to allow fish movement to occur unimpeded;

- Bi-annual sampling of aquatic fauna species (both vertebrate and invertebrate), highlighting possible variation in species diversities and abundances associated with seasonal weather patterns;

- Bi-annual documentation of aquatic flora species;

- The inclusion of both downstream and upstream sampling locations. Waterholes at upper and lower Dugald River and Cabbage Tree Creek will be included. Results from these locations should be compared;

- Collection and analysis of water quality at pre-determined monitoring locations, including Longamundi waterhole and the Dan Lynch Bridge waterhole; and

- Identification of sensitive species/groups that could be used as indicators of stream health.

Project infrastructure will be covered under a mining lease for transport, as described in the EIS. Therefore, areas outside of this area, which include the powerline, access route and water pipeline corridors, are legislatively covered under the *Environmental Protection Act 1994*. Crossings within these corridors will maintain the self-assessable code; *Minor Waterway Barrier Works on Low Order Inland Waterways (Code Number WWBW01)* under the *Fisheries Act 1994*. The Project will maintain conditions of the code by:

- The barrier height will be such that it drowns continuously under high flow conditions for the duration of the flow, or for a minimum of 7 days;

- To the extent practicable, barrier sediment will be contained within the Project site;

- Banks and beds adjacent to the barrier will retain vegetation cover and natural substrate; and

- All material used in construction will be potentially acid sulfate soil free.

A notification sign will be placed by each creek crossing, as per conditions in the self assessable code *WWBW01*.

Ephemeral drainage lines and gullies, which predominantly collect localised runoff after heavy rainfall do not provide necessary available cover from predators, diversity in habitat or stability in bottom substrate. The Dugald River, which is crossed by the access route, does provide habitat which would support riverine vertebrates. The other, smaller ephemeral water courses do not provide substantial habitat for riverine vertebrates. Database searches and baseline field surveys show fish diversity to be relatively low, and include Eastern Rainbowfish (*Melanotaenia splendida*), Northwest Glassfish (*Ambassis Muelleri*), Spangled Perch (*Leiopotherapon unicolour*) and Hytrl's Tandan (*Nepsilurus hyrtlii*). None of these fish are classified as threatened or at the limit of their distributional range. The proposed Project's access road will have negligible, if any, impact on the regional migration and population of fish species within the area.

4.7.2.6 Rehabilitation Acceptance Criteria

The Project is in a semi-arid region where ecosystems are limited by water availability and can have extremely weathered soil profiles. There is limited nutrient cycling potential and limited natural topsoil. Rehabilitation of these areas, particularly after long periods of disturbance, can take an extended time frame and have limited initial success. The dynamics of the specific ecosystems and natural vegetation on site needs to be extensively studied over time, before any final rehabilitation success criteria can be determined. Therefore at this stage only preliminary rehabilitation success criteria have been proposed for the Project. Vegetation monitoring should be conducted twice per year and should commence during construction phases of the Project, to gain additional background data. This data will be used to assist in creating final rehabilitation criteria.

The preliminary rehabilitation success criteria for the Project have been developed with reference to *Guideline 18: Rehabilitation Requirements for Mining Projects* (DERM, 2008). The preliminary rehabilitation completion criteria are as follows:

- Slopes of all constructed landforms will be less than 15**º**;
- All constructed landforms will be safe and stable with no excessive erosion;
- Levels of metals in surface soils on rehabilitated landforms will be similar to that of relevant analogue sites;
- Land suitability will be consistent with the proposed disturbance type in the Environmental Authority;
- Surface water runoff quality of rehabilitated landforms will be consistent with water discharge criteria for Project as stated in the Environmental Authority or background/reference site levels;
- Groundwater quality surrounding rehabilitated landform will be consistent;
- Tree density (trees/ha), shrub density (shrubs/ha), herb/grass density (grasses/ha), groundcover (%) and species composition will be similar to relevant analogue sites;
- Artificial nesting boxes, with a similar density to the pre-mine landscape, should be established;
- Ground litter, including fallen timber, should be established within each vegetation community; and
- Sulphate, pH and EC surface water levels will be similar to the relevant analogue site.

4.7.2.7 Fauna Monitoring Programme

An ongoing fauna monitoring plan, based upon the information collected in existing field surveys, should be conducted to assess Project impacts. Monitoring events should take place twice per year, to capture the seasonal changes and fluctuations in the environment. The fauna monitoring programme should include assessment of avian species and pest mammalian species populations.

Avian fauna within the Mount Isa Inlier subregion has typical semi-arid avifauna, with a small number of introduced species inhabiting populated regional centres (ANRA, 2002). The avifauna within the

region have adapted well to fires, using hills as a refugia. Indicator species, as described in the ANRA database for the Mount Isa Inlier and which should be monitored on a biannual basis, include the Emu (*Dromaius novaehollandiae*), Australian Bustard (*Ardeotis australis*), Jacky Winter (*Microeca fascinans*) and Hooded Robin (*Melanodryas cucullata*). Trends have shown a lower rate for hollow-nesting birds and some ground-feeding granivores, and an increased rate of ground-feeding insectivores (ANRA, 2002).

Pest mammals species have the potential to benefit and proliferate from the Project infrastructure and disturbances, if populations are not kept under control through appropriate management strategies. Monitoring populations of existing pests on the Project site, which include the Feral Cat, Feral Pig and Dingo / Wild Dig, should be conducted twice per year to assess whether populations are being kept under control. Additionally, monitoring for potential populations of the priority pests in the Cloncurry Shire Pest Management Plan, including the European Rabbit, Fox and Spur Throated Locust, should be conducted by Environmental Staff for the Project to assess whether the introduction of additional pest species to the area has occurred.

4.8 CULTURAL HERITAGE

Both Indigenous and Non-Indigenous Cultural Heritage will be discussed in Section 4.8.1 below.

4.8.1 Description of Environmental Values

4.8.1.1 Non-Indigenous Cultural Heritage

An independent Non-Indigenous/Historic Cultural Heritage Assessment was undertaken, by Converge Heritage and Community, to evaluate the non-Indigenous cultural heritage within the proposed mining development (Appendix T), and associated infrastructure corridors (Appendix U). The assessment aimed to evaluate the potential impacts and required mitigation for the proposed Project. The assessment included:

- An historical background for the Study Area;
- The results of the cultural heritage field survey;
- The nature of cultural heritage significance within the Study Area and the potential impacts of the Project in relation to this significance;
- Specific management recommendations in relation to sites 1, 2, 6, 7, 16, 17, 18 and 19 on the Project site;
- Specific management recommendations in relation to sites 1, 7, 21 and 23 on the infrastructure corridors; and
- Recommendations for the protection of potential areas of cultural heritage significance.

Consultation with the following people was conducted as part of the research for this assessment:

- Gail Wipaki, Manager Mary Kathleen Museum and Cloncurry Historical Society;
- Wayne Tapp, President, Cloncurry Historical Society;
- Tim Lane, Camp Manager Dugald River, MMG;
- David Corbett, Manager Chumvale Station; and
- Mark McMillan, Manager Carsland Station.

Southern Gulf Catchments group declined the opportunity to comment on aspects of the Project as was discussed in the Draft Terms of Reference – Response to Comments report. Southern Gulf Catchments Group does not have a specialist in non-indigenous cultural heritage, and therefore their involvement is not required.

A summary of the two cultural heritage reports (Project site and corridors) is contained below or for further information see Appendices T and U.

Historical Background

Exploration, Mining and Pastoralism

The Project area has a long history of pastoralism, mining and prospecting. The Study Area does not appear to have been seen as prime country as it was not taken up as pastoral property until the beginning of the 1880s. The site was only used for grazing up until improvements were established by James Lynch in 1917, who installed a house, yards, fencing, 300 head of cattle and 50 head of horses. James Lynch consolidated several grazing land holdings and had them upgraded to a pastoral property in 1937. This pastoral property was called the Roseby Holding and was sold to the Coolullah Pastoral Company. The Coolullah Pastoral Company surrendered the lease in 1949 and in 1950 a large proportion of the property (84 square miles) was allotted to David George Christenson. A further 18 square miles was added to the property in 1953 and in 1959 Christenson swapped the property for grazing farm 2033. The new owners of the property were Charles and Bruce McMillan. The McMillans have successfully held the property ever since, and Harold Henry McMillan is the current station owner.

No serious prospecting occurred in the Project area until the 1880's when Ernest Henry travelled through the Dugald River area. In 1908 Lionel Ball visited the Longamundi group within the Dugald River Field. Ball recorded the most taken from 10 mines visited was 43 tonnes in 1905/06. In 1929 a rangers report details many small mineral leases being worked in the Karuba area with approximately 12 men working these areas. In 1938 an Aerial Geological and Geophysical Survey report recorded "Wallaroo Flats" as a small mine producing 61.49 tonne. Wallaroo Flats is located within the Project area. A search of the Department of Mines and Energy's interactive resource and tenure maps also provides a list of mines within the Study Area. It has assumed that the names of mines referred to in the interactive database refer to the later phases of workings in the Dugald River area, which is the 1930s – 1960s.

Chinese and Afghans in the Area

The gradual opening of North West Queensland to pastoral and mining activity led to an increasing demand for reliable transport across vast distances of semi arid Australia. The first camels (Photo Plate 4.26) had been introduced into Australia in 1840 (Stevens 1989:14). Their widespread use seems to have been delayed until twenty-four animals arrived in Melbourne in 1861 along with three 'Afghan' handlers. They were intended for use on the Burke and Wills expedition. Larger numbers followed. Many came in via South Australian ports to be used to establish a stud at Thomas Elder's Beltana property (Stevens 1989:20).

Over the years Cloncurry was to develop the largest 'Ghantown' in Queensland (Stevens 1989:73). Wool was carted for pastoralists and ore for the numerous mines that had sprung up around the Selwyn Ranges. The first known team to operate in the region appears to have been Duncan McIntyre of Dalgonally station's who camelteer, Mehemet Ali, led a team from Normanton back to the station in 1881 (Koch 1986:55).

Backloading of food and equipment ensured a steady, highly competitive business for many years despite their exclusion from the Carriers' Union (Koch 1986:56). They carted supplies some 400 kilometres to and from the port of Normanton (Stevens 1989:91) and west to Richmond and beyond (Koch 1986:56). They were frequent visitors to Mount Garnet and carried out a vital transport service for mines in the Cloncurry region, particularly in areas, such as mines in the Selwyn and Argylla Ranges which were virtually inaccessible to wheeled vehicles (Hardy 1983b:51).

Photo Plate 4.26 Camels Carting Ore in the Cloncurry Region (Platt Collection)

The slow progress of the railway west from Townsville ensured the cameleers profitable loadings of ore until 1908 when the railway eventually reached Cloncurry. But even then they were employed hauling ore shorter distances for several years thereafter.

No specific mention of Afghans operating in the Study Area has been located. There is mention of the hold-up of some Afghan drivers on the Quamby Road to Mt Cuthbert and Mt Oxide in 1911 (Koch:1986:58) and it is extremely likely that they used the Camooweal- Cloncurry Road. It is also known that they had camps at Rosebud, Duchess and Urquhart sidings (Cloncurry Centenary Celebrations Committee 1967:12).

First mention of Chinese in the Cloncurry area appears to have been the issuing gold licenses to five Chinese miners in 1870. These miners were the first in the Cloncurry field to 'deep sink'; that is pot hole along the line of ancient streams for alluvial gold. They were successful at several locations but each time were forced off their leases by Europeans. This conflict culminated in the "Cloncurry Clash", an armed fight, at Top Camp in November 1871. Although the Chinese miners held their own they were advised by the Gold Commissioner, Mr Morisset, that he could not protect them despite their legal rights and so they left the district. This and later legislative changes effectively blocked the Chinese from lucrative forms of mining. In the Cloncurry area many Chinese returned to China, a few may have turned to copper mining whilst others turned to other pursuits such as storekeeping, market gardening and cooking (Koch 1986:44-46).

Thus as in other parts of rural Queensland it was the Chinese migrants who sustained isolated towns with fresh fruit and vegetables, who ran bakeries and operated general stores. The majority, who were unable to strike it rich on the alluvial goldfields, were quick to seize other opportunities for employment.

As settlements evolved around the foot slopes of the Selwyn Ranges to service the numerous copper and reef gold mines so too did the need for fresh vegetables. It was in this regard that entrepreneurial Chinese migrants shone. Many eked out livelihoods in isolated gardens adjacent to large waterholes. They would regularly load their baskets and shuffle into towns like Cloncurry, Kuridala and Mount Cuthbert to sell fresh grown produce to mining families. Small outlying mines, like those within the study area may well have received visits from fruit and vegetable growers, although the physical evidence is harder to identify than the scant documentary accounts.

Somewhat uncharacteristically there is evidence that one Chinese miner worked a lease in the Dugald /Mt Roseby area. Ah Wing worked Lady Clare as a tributer in the 1950/60s (T. Lane pers. comm.). This mine lies to the south of the Study Area. It is not clear if any market gardens were associated with Longamundi waterhole which lies outside the Study Area to the north-east.

Register Searches

Online searches of the National and Commonwealth Heritage Register, Register of the National Estate and the Queensland Heritage Register identified no sites of heritage significance in the Study Area. Cultural Heritage is discussed in the Cloncurry Shire Planning Scheme, however a local heritage register is currently under construction. No sites of local heritage significance in the Study Area were identified through discussion with the local council.

Survey Methodology

The survey methodology adopted for this study incorporated a vehicle and pedestrian survey across the Study Area. Particular sites were targeted, for example mine sites identified by latitude and longitude on the DEEDI interactive tenure website. It is estimated that approximately 50% of the Project site and infrastructure corridors was surveyed. The *Queensland Heritage Act 1992* (QHA) was applied in the assessment of all sites.

All assessment data was recorded in field notebooks and locations of any items or places of historical cultural heritage significance were captured via a hand held global positioning system (GPS) receiver, accurate to ±5 meters using datum AGD 84. This information was then used to create maps outlining the location of sites and features noted during the assessment. Areas of interest were photographed using a digital camera (Canon PowerShot A650 IS) with 12.1 effective mega-pixels. Upon completion of the report, these photographs are stored on disk (CD) in the Converge Cairns office. Each site was considered in light of the QHA.

Survey Outcomes – Project Site

An estimated 50% of the Study Area was traversed by road and by pedestrian transects. No historical sites of cultural heritage significance sufficient to be of local significance or higher were noted within the Study Area, however a number of sites indicating various phases of mining activity in the Study Area were located. Nineteen historic sites were located within the Study Area (Table 4.66 and Figure 4.75). For more detailed descriptions of each of the 19 sites see Appendix T.

Table 4.66 Historical Cultural Heritage Sites Located on the Project site

Site No.	Name & Description of Site	GPS Co-ordinates		Cultural Heritage Significance Rating and Required Management Strategy
		Northing	Easting	
1	Wallaroo Flats – mine workings	411396	7759400	Low significance. Requires detailed recording and collection and analysis of diagnostic material
2	Godkin – mine workings	411815	7757070	Low significance. Requires detailed recording and collection and analysis of diagnostic material
3	CRA Core Shed footings	411288	7759280	No significance. No further recording required. No mitigation required
4	CRA test trench 1	411188	7758899	No significance. No further recording required. No mitigation required
5	Unnamed 118571 – mine workings	411864	7757238	No significance. No further recording required. No mitigation required

Site No.	Name & Description of Site	GPS Co-ordinates		Cultural Heritage Significance Rating and Required Management Strategy
		Northing	Easting	
6	Godkin Camp	411890	7757198	Low significance. Requires detailed recording and collection and analysis of diagnostic material
7	Stone structure	411833	7757086	Low significance. Requires detailed recording and collection and analysis of diagnostic material
8	CRA drill pad footings	411373	7758665	No significance. No further recording required. No mitigation required
9	CRA test trench 2	411550	7760647	No significance. No further recording required. No mitigation required
10	Mining Lease peg	411565	7763110	No significance. No further recording required. No mitigation required
11	Shaft	411707	7759964	No significance. No further recording required. No mitigation required
12	Unnamed 112617 - mine workings	411230	7761664	No significance. No further recording required. No mitigation required
13	Linus – mine workings	411540	7763929	No significance. No further recording required. No mitigation required
14	Unnamed 116593/Patti's – mine workings	411582	7759319	No significance. No further recording required. No mitigation required
15	Unnamed 119564 – mine workings	411865	7756409	No significance. No further recording required. No mitigation required
16	Mount Co – mine workings	409089	7757159	Low significance. Requires detailed recording and collection and analysis of diagnostic material
17	Cowsara campsite	409085	7757439	Low significance. Requires detailed recording and collection and analysis of diagnostic material
18	Cowsara - mine workings	409134	7757463	Low significance. Requires detailed recording and collection and analysis of diagnostic material
19	Wallaroo Flats & Pattis camp	411616	7759555	Low significance. Requires detailed recording and collection and analysis of diagnostic material
1. UTM/UPS Grid Zone 54K. Geodetic Datum – AGD 84.				

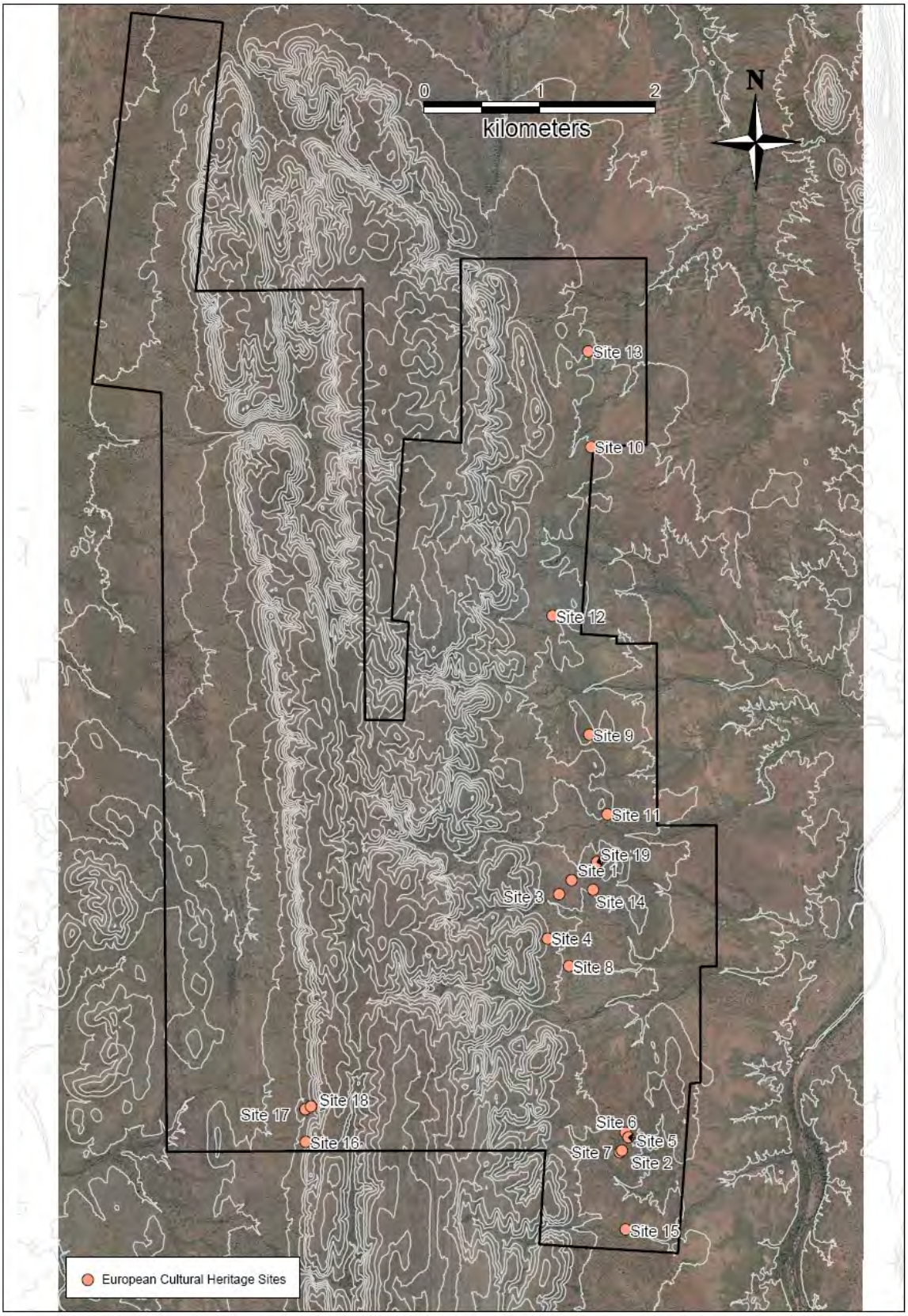

Figure 4.75 Location of Identified Historical Cultural Heritage Sites

Survey Outcomes – Infrastructure Corridors

Twenty five historic sites were located within the power, access and water pipeline corridors (Figure 4.76 and Figure 4.77). The significance rating and proposed management strategy associated with each of these sites was assessed as summarised in Table 4.67.

Table 4.67 Historic Cultural Heritage Sites Located Within the Infrastructure Corridors

Site No.	Name & Description of Site	GPS Co-ordinates (AGD84 zone 54)		Cultural Heritage Significance Rating and Required Management Strategy
		Northing	Easting	
1	Mt Cuthbert Railway located south of access point	420124	7757714	Low significance. Avoid if possible. Will require detailed recording should it be necessary to disturb.
2	Water Bore	419583	7757775	Low to no significance. Multi-phase. Avoid if possible. No further recording required.
3	Cattle Holding Pen	419244	7757706	Low to no significance. Multi-phase. Avoid if possible. No further recording required.
4	Mining lease posts	412251	7760848	Low to no significance. No further recording required. No mitigation required.
5	Mine workings	414240	7763612	Low to no significance. No further recording required. No mitigation required.
6	Fence	414510	7765215	Low to no significance. No further recording required. No mitigation required.
7	Chum Mine	436458	7711816	Low significance. Avoid if possible. Requires detailed recording should it be necessary to disturb.
8	Exploration grid peg 1	435645	7713375	Low to no significance. No further recording required. No mitigation required.
9	Exploration grid peg 2	435027	7714645	Low to no significance. No further recording required. No mitigation required.
10	Five Girls Mine	433185	7717447	Low to no significance. No further recording required. No mitigation required.
11	Answer Mine	431537	7721211	Low to no significance. No further recording required. No mitigation required.
12	Unnamed 307230 Mine	430667	7723023	Low to no significance. No further recording required. No mitigation required.
13	Unnamed 307231 Mine	430654	7723139	Low to no significance. No further recording required. No mitigation required.
14	Unnamed 306234 Mine	430580	7723396	Low to no significance. No further recording required. No mitigation required.
15	Fence (2)	421896	7735093	Low to no significance. No further recording required. No mitigation required.
16	Water Bore (2)	410909	7749565	Low to no significance. Multi-phase. Avoid if possible. No further recording required.
17	Mine lease post	411326	7753893	Low to no significance. No further recording required. No mitigation required.
18	Caroline	411183	7753870	Low to no significance. No further recording required. No mitigation required.

Site No.	Name & Description of Site	GPS Co-ordinates (AGD84 zone 54)		Cultural Heritage Significance Rating and Required Management Strategy
		Northing	Easting	
19	Scanlan	411235	7754321	Low to no significance. No further recording required. No mitigation required.
20	Mining lease posts (2)	412318	7756211	Low to no significance. No further recording required. No mitigation required.
21	Camp	412370	7756229	Low significance. Avoid if possible. Requires detailed recording and collection and analysis of diagnostic material should it be necessary to disturb.
22	Unnamed 138606	413810	7760593	Low to no significance. No further recording required. No mitigation required.
23	Mt Cuthbert Railway embankment	419767	7759847	Low significance. Build access road over embankment if possible. Requires detailed recording if disturbance is required.
24	Cattle Holding Pen (2)	414765	7760494	Low to no significance. Multi-phase. No further recording required. Avoid if possible.
25	Water Bore (3)	414618	7760770	Low to no significance. Multi-phase. No further recording required. Avoid if possible.

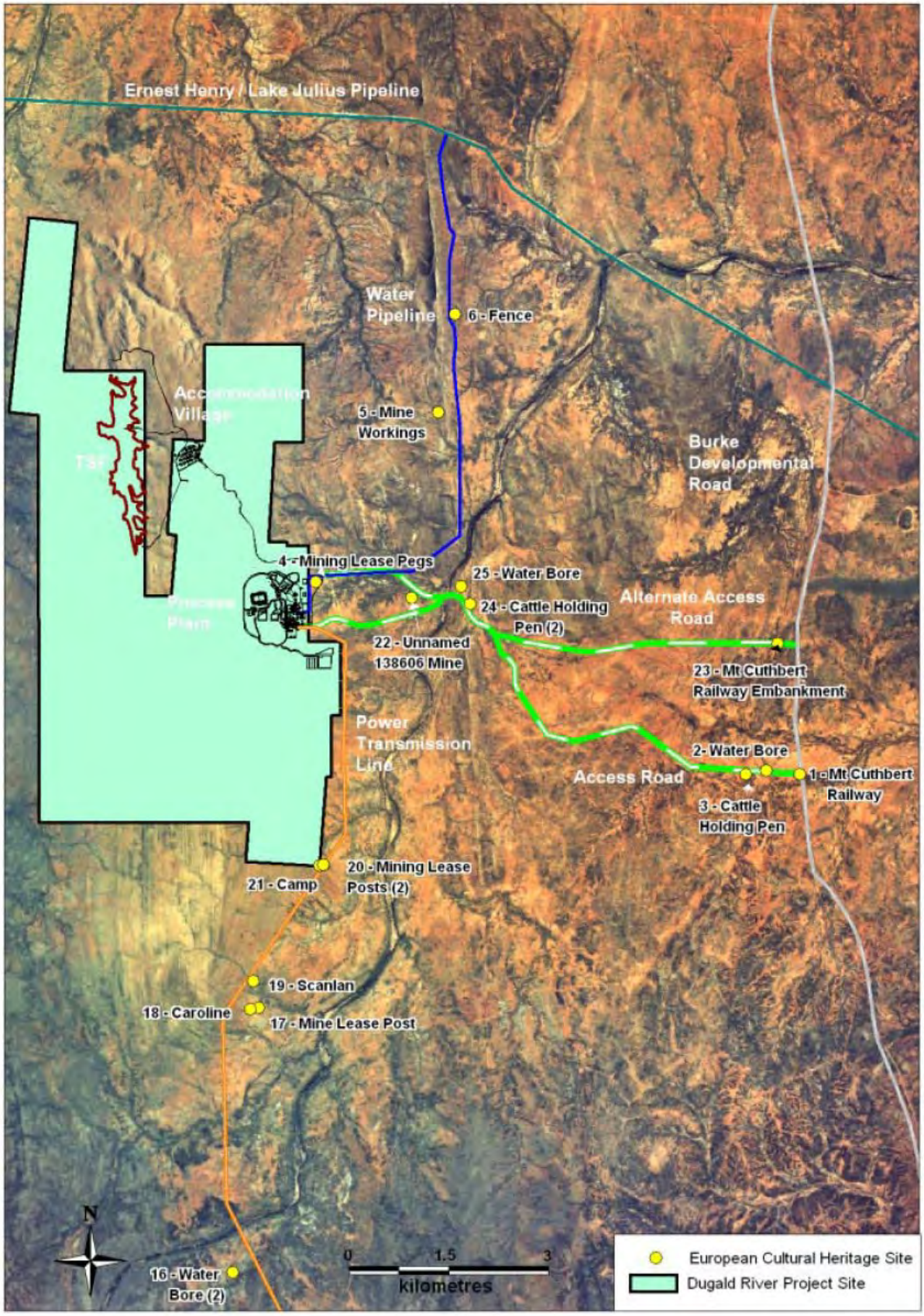

Figure 4.76 Historical Cultural Heritage Site – Infrastructure Corridor (Northern Section)

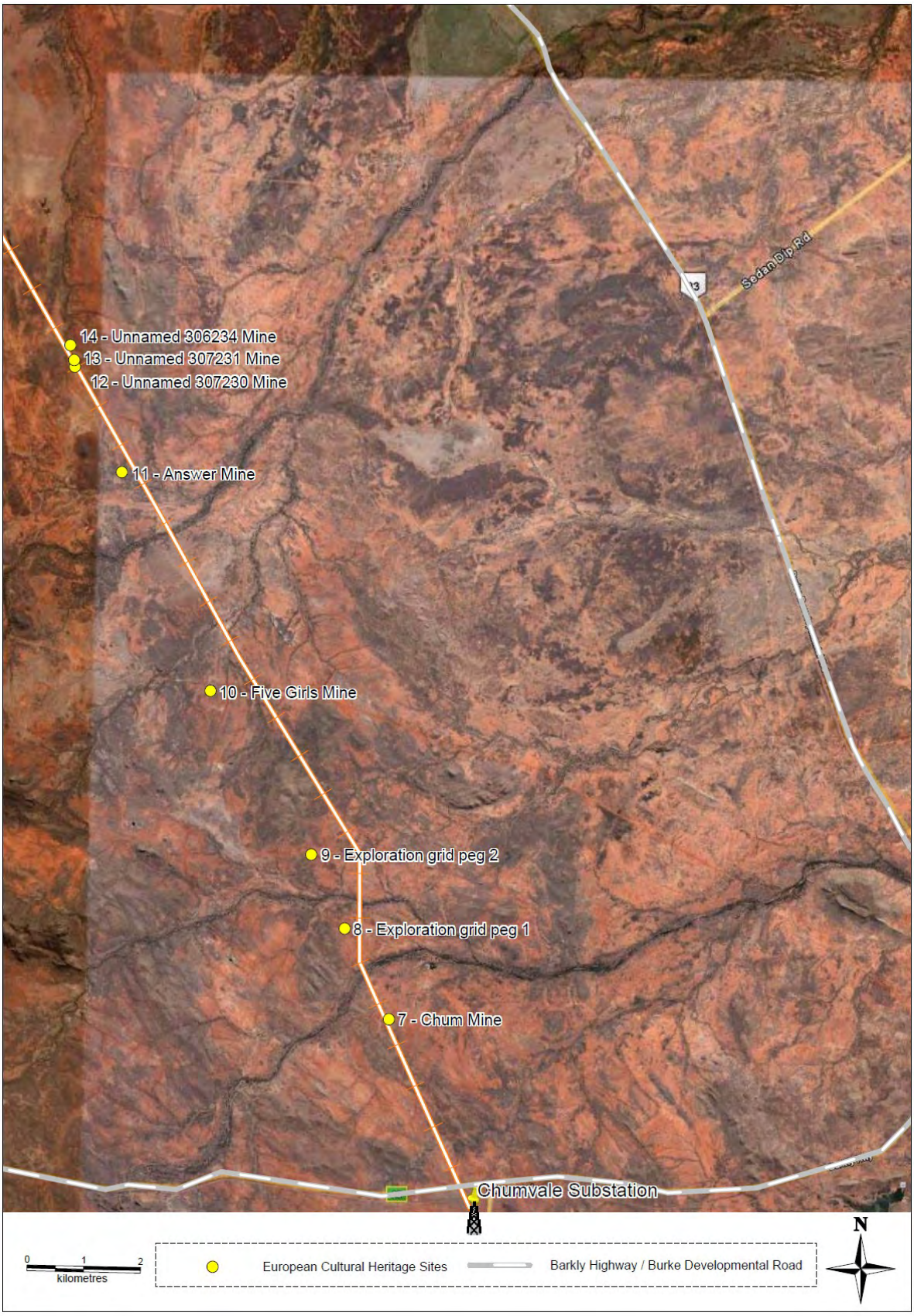

Figure 4.77 Historical Cultural Heritage Sites - Infrastructure Corridor (Southern Section)

4.8.1.2 Indigenous Cultural Heritage

Requirements for management of indigenous cultural heritage are prescribed in the provisions of the *Queensland Aboriginal Cultural Heritage Act 2003* (ACHA), which recognises that Aboriginal people own and are the primary guardians of their cultural heritage and that those conducting activities in areas of significance have a duty of care in respect of Aboriginal cultural heritage. The ACHA applies whether or not Native Title exists.

The Act also provides for preparation of a CHMP for certain high-level impact activities including activities related to the exploration, development and operation of the Dugald River project. A registered Aboriginal cultural heritage body as defined by the ACHA, which may be a registered Native Title holder or claimant, must approve the CHMP developed for such activities. Such approval effectively becomes a registered binding agreement between the developer and the Aboriginal cultural heritage body.

Two Native Title claimants groups have been recognised as owners of indigenous cultural heritage over the Project area and proposed power line corridor shown, each of which has approved its respective CHMP:

- The Kalkadoon People (approved 28 June 2008); and
- The Mitakoodi and Mayi People (approved 28 May 2008).

Several cultural clearance surveys were undertaken in the Project area by Pasminco and the Kalkadoon people in the past. More recently, MMG and the Kalkadoon people conducted surveys in the Project area to provide cultural clearance for exploration activities and the construction of the exploration camp. The surveys covered an area of 4.22 km^2 and were conducted in May 2007, August 2007, March 2008 and October 2008. Results of these surveys are confidential and therefore can not be presented in this EIS.

MMG intends to engage the Kalkadoon people to conduct cultural heritage surveys to clear all areas required for the mining activities of the Dugald River Project. The surveys will be conducted in accordance with the Cultural Heritage Management Plan ahead of any disturbance in the Project area.

4.8.2 Potential Impacts and Mitigation measures

4.8.2.1 Non-Indigenous Cultural Heritage

The potential impacts on non-indigenous cultural heritage sites on the Project site are as follows:

- The current infrastructure layout for the mine indicates that sites 9, 11 and 12 will be directly impacted by the proposed Project (Figure 4.78). The assessment report considered these sites to be of no significance and therefore no mitigation strategy will be required in relation to their disturbance and/or destruction; and
- However it is likely that all sites and places identified within the Project will be either directly or indirectly impacted by the proposed Project over the life of the mine. In addition it is possible that further historic sites may be located during future mining activities.

The potential impacts on non-indigenous cultural heritage sites on the infrastructure corridors are as follows:

- All sites and places lying directly within the service corridors may be either directly or indirectly impacted by their construction or operation. Direct impacts will generally be in the nature of surface and sub-surface disturbance and vegetation clearance related to the construction of the powerline and placement of the power poles, water pipeline or access road;

- Indirect impacts may occur from the construction of roads and infrastructure associated with mining activities including the day to day operation of vehicles across the broader areas; and

- It is also possible that there is potential for further historic places/items to existing within the infrastructure corridors. In particular, it is noted that Scanlan's Grave may be located within the powerline corridor however, it was not located during the survey.

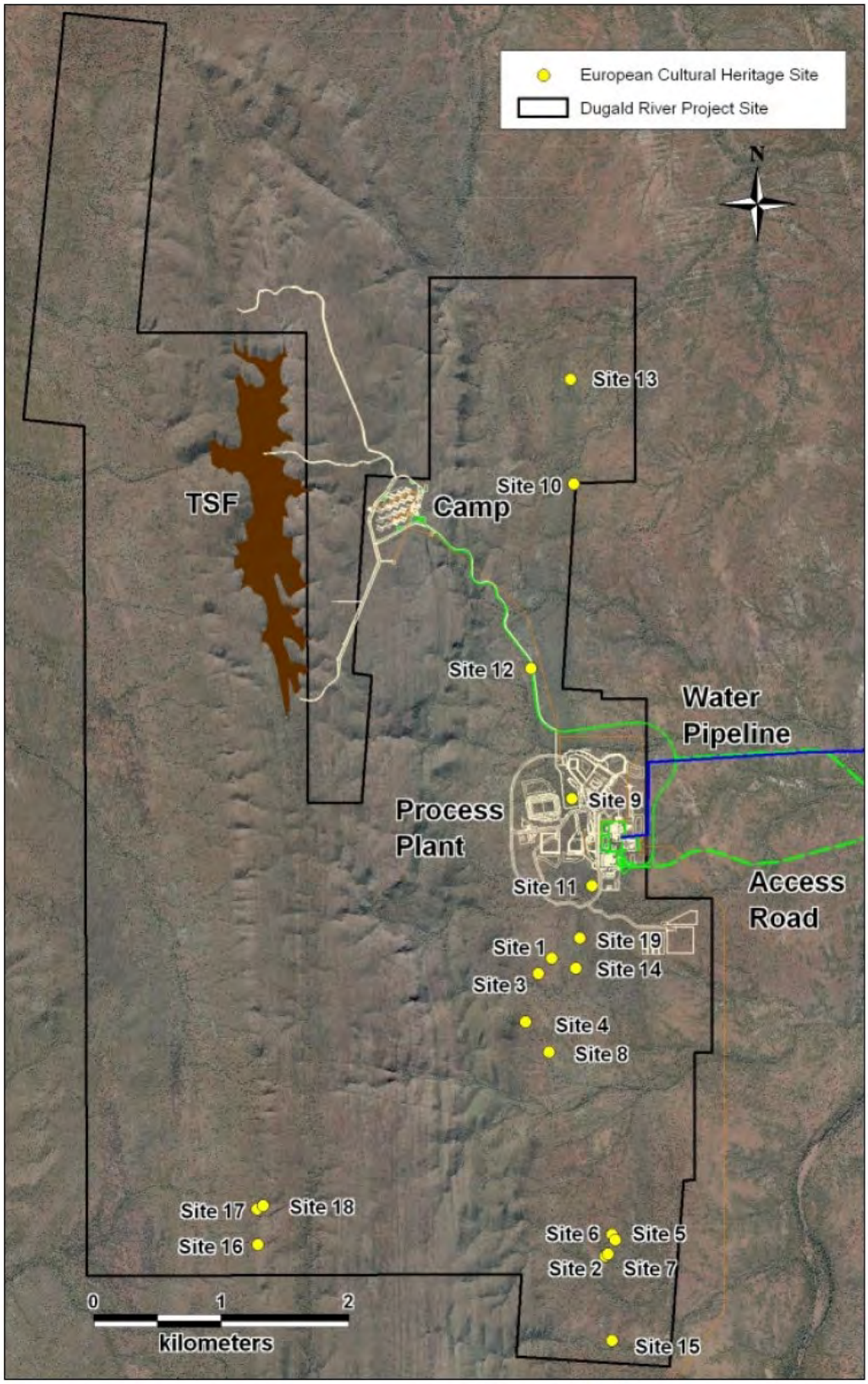

Figure 4.78 Non-Indigenous Cultural Heritage Sites and Proposed Infrastructure

Significance Assessment for the Study Area

The cultural heritage significance of the Project area and corridors was evaluated using recognised benchmarks such as The Burra Charter and *Queensland Heritage Act 1992*. These findings are summarised in Table 4.68:

Table 4.68 Summary of Cultural Heritage Significance for Project Site and Corridors

Value	Rating	Justification
Category A – Historical	Low	Represents historical activities such copper mining and the pastoral industry.
Category B - Rarity	N/A	There are no sites or places within the Study Area which could be considered rare or unusual.
Category C – Yield further Information	Low	14 sites within the Study Area are considered to have some potential to yield information within the meaning defined by section 35(1) and section 60 the QHA.
Category D – Particular Class of Place	Thought to be N/A	Detailed analysis was not possible within the constraints of this survey.
Category E - Aesthetic	Low	The historic heritage sites sit within a typical local pastoral landscape and are not considered to be outstanding.
Category F – Technical Achievement	Thought to be N/A	Detailed analysis was not possible within the constraints of this survey. No physical evidence was noted to suggest exemplary technical achievements.
Category G – Special Association	N/A	There are no special associations within the Study Area
Category H – Association with particular Person	Potentially low	There is one historic place (Scanlan's Grave) which has an association with a particular person. This site was not located during the surveys.

Sites for Nomination onto the Queensland Heritage Register

No sites located within the Project site or infrastructure corridors (Study Area) contain levels of cultural heritage of significance important to Queensland under Section 31 (1) of the QHA.

No sites within the Study Area contain levels of cultural heritage of sufficient significance to warrant nomination for the local register.

No sites within the Study Area contain levels of archaeological material sufficient to warrant nomination under Section 60 of the QHA.

No sites or places are therefore recommended at this point for nomination to the Queensland Heritage Register as a result of the Cultural Heritage Assessments.

Conclusions and Recommendations

From a heritage perspective, the Study Area contains, at best, low levels of local cultural heritage significance. Management strategies will be implemented to minimise the impact to sites of non-indigenous cultural significance. These strategies will include:

- Avoiding impact on sites and places of significance where possible;
- Practicing diligence during works conducted within the Study Area, particularly during any clearing or construction phases associated with initial preparation of the Project area. This includes:
    - Instructing crews specifically of their obligations to look for and avoid cultural heritage material;
    - Conducting familiarisation training for work crews so that they are aware of what constitutes a cultural heritage feature; and
    - Providing educational materials to personnel informing them what archaeological material may look like, and provide clear instructions on what to do should any such material be found.
- Conducting mitigation of Sites 1, 2, 6, 7, 16, 17, 18 and 19 on the Project site by carrying out the following processes prior to any development or ground disturbance at these sites:
    - The sites will be recorded in detail by a qualified cultural heritage person;
    - Diagnostic material will be collected from these sites;
    - Analysis and contextual research will be conducted on this material (such as bottles, match boxes, identifiable bottles, cans and containers), in order to add to the information available regarding small mines and miners in Queensland, such as dates for workings and dietary habits;
    - The diagnostic material will be lodged with a suitable organization, such as the Mary Kathleen Park Museum, at completion of analysis; and
    - A written report will be provided on the results of this analysis to the organization with whom the material is lodged, and the John Oxley library.
- Conducting mitigation of Sites 1 and 7 on the infrastructure corridors by carrying out the following processes prior to any development or ground disturbance at these sites:
    - The sites will be recorded in detail by a qualified cultural heritage person; and
    - A written report will be provided on the results of this detailed recording to MMG.
- Conducting mitigation of Site 21 on the infrastructure corridor by carrying out the following processes prior to the installation of the powerline:
    - The site will be recorded in detail by a qualified cultural heritage professional;
    - Diagnostic material will be collected from this site;

- Analysis and contextual research will be conducted on this material (such as bottles, match boxes, identifiable bottles, cans and containers), in order to add to the information available regarding small mines and miners or their associates in Queensland, such as dates for workings and dietary habits;
- The diagnostic material will be lodged as an appropriately accessioned collection with a suitable organization, such as the Mary Kathleen Park Museum, at completion of analysis; and
- A written report will be provided on the results of this analysis to MMG, the organization with whom the material is lodged, and the John Oxley library.

- Conducting mitigation of Site 23 on the infrastructure corridor by carrying out the following processes prior to the construction of the alternate access road:
  - The alternate access road will be designed in such a way as to incorporate the railway embankment rather than cut throught it;
  - The site will be recorded in detail by a qualified cultural heritage professional, should disturbance of the site be required; and
  - A written report will be provided on the results of the detailed recording to MMG.

4.8.2.2 Indigenous Cultural Heritage

The potential impacts on indigenous cultural heritage sites on the Project are yet to be identified in detail. MMG intends to engage the Kalkadoon people to conduct cultural heritage surveys to clear all areas required for the mining activities of the Dugald River Project. The surveys will be conducted in accordance with the CHMP ahead of any disturbance in the Project area. Any potential impact to indigenous cultural heritage will be managed in accordance with the CHMP.

MMG have entered into CHMPs with the two recognised Native Title Claimant groups. The details of the groups are as follows:

- The Kalkadoon Number 4 People (approved 28 June 2008); and
- The Mitakoodi and Mayi People (approved 28 May 2008).

CHMPs are State approved agreements between the sponsor of the plan (MMG) and the Aboriginal parties (Kalkadoon Number 4 and the Mitakoodi and Mayi Peoples). The CHMP clearly defines how the Project will be managed to avoid harm to Aboriginal cultural heritage and if harm cannot be reasonably avoided, to minimise harm to Aboriginal cultural heritage.

The CHMPs developed by MMG and the relevant Aboriginal parties comply with the statutory processes contained in Part 7 of the ACHA 2003. Each party has agreed to management actions in relation to land use activities to be undertaken on the Project site and along the powerline corridor.

4.9 SOCIAL

AARC undertook a Social and Economic Impact Assessment (SEIA) of the Project which is summarised in the following sections. The full report is provided in Appendix V.

4.9.1 Description of Environmental Values

The Project lies within the Cloncurry Local Government Area (LGA), and the boundary of the LGA was used define the Study Area of the SEIA. The Cloncurry LGA covers an area of approximately 48,000 km^2 and encompasses the regional centre of Cloncurry as well as the smaller rural communities of Dajarra, Duchess, Kajabbi and Quamby.

Cloncurry is located on the Cloncurry River and Flinders Highway approximately 770 km west of Townsville and 100 km east of the major northwest regional centre of Mount Isa. At the 2006 census Cloncurry town had a population of approximately 2,300 people and the entire LGA had a population of almost 4,000 people.

Information was gathered for the SEIA from primary and secondary sources including comments from advisory bodies during the draft TOR comment period, meetings with various government departments, meetings between MMG and the community, the Australian Bureau of Statistics (ABS), tenure and valuation databases, the Cloncurry Shire Council, journal articles and published books, and websites.

4.9.1.1 Local Communities and Lifestyle

Community recreation and lifestyle information for the Project area was gathered through a range of methods. The Cloncurry Shire Council provided the bulk of information, whilst community value and lifestyle information was collated through other means.

Cloncurry is located on the banks of the Cloncurry River in northwest Queensland. It has a young and transient population that has fluctuated throughout the past three census surveys. The business centre supports a number of Government departments and provides local business opportunities. According to the Cloncurry Community Research Report (RWAC 2001), there is a strong sense of community within the town and this is strengthened by local history and the regional location. Cloncurry is known as the 'friendly heart of the great north west' due to the thriving community spirit and support (RWAC 2001).

Burke and Wills were the first known Europeans to visit in the area in 1861. Cloncurry was founded six years later as a frontier mining town and quickly became one of the most prosperous towns in the region thanks to the discovery of copper and the town's importance as a transport centre for western Queensland (Cloncurry Shire Council 2008).

Cloncurry was involved in the early days of QANTAS and the original QANTAS hangar is still in use today. The Royal Flying Doctor Service was also founded in Cloncurry in 1928 (RFDSA 2008).

Cloncurry has a number of 'special places' listed on the Register of the National Estate and the Queensland Heritage Register that afford the townspeople a strong sense of history. Records held by the Australian Heritage Commission (2008) indicate that there are 22 sites in the Cloncurry region listed on the Register of the National Estate including:

- Cloncurry Court House, a registered historic place;

- Fountain Range near Mary Kathleen, a registered natural place;
- 15 registered Indigenous places[1]; and
- 5 indicative Indigenous places[1].

There are five sites in the Cloncurry region listed on the Queensland Heritage Register including:

- Mount Cuthbert Township and Smelter, northwest of Kajabbi;
- Mount Elliot Company Metallurgical Plant and Mill, near Cloncurry;
- Cloncurry Court House;
- Cloncurry Post Office; and
- Bower Bird Battery, near Cloncurry.

There are two museums in Cloncurry; one that serves as a memorial to the air service that began in Cloncurry in 1922 and Mary Kathleen Memorial Park, which preserves historic buildings from the abandoned mining town in a park setting.

In 2004, the Cloncurry Heritage Project was the winner of the Regional Development category of the Queensland Project Management Achievement Awards. The Cloncurry Heritage Project is testimony to the people's pride in the town's history. It involved refurbishment and conservation of the heritage-listed Cloncurry courthouse, together with the construction of a visitor discovery and orientation centre, and associated visitor interpretative multi-media including a 'Cloncurry - Friendly Heart of the Great North West' website.

Cloncurry's sense of community is highlighted in the array of community groups active in the area. Rotary and Lions groups both have regular meetings, as do the local rodeo, and show committees. Several religious congregations also exist, including the Catholic, Anglican and Uniting branches of the church.

4.9.1.2 Recreation, Culture and Leisure

An array of sporting teams and leisure facilities are in operation in the Cloncurry region. Existing facilities include indoor sport and fitness centres, municipal swimming pool, and multi-purpose sports ground. Sporting activities in the region include indoor soccer, indoor netball, basketball, rugby union, volleyball, netball, tennis, rugby league, soccer, boxing, judo, aerobics and bowls.

As previously mentioned, the township is host to a Rotary Club and Lions Club. As well as this, the community supports the Girl Guides, Police Citizens Youth Club, RSL Club, Cloncurry Arts Council, plus a variety of specialty clubs and groups. Performing arts in the region is further fostered with dance and ballet classes.

Cloncurry's Chinaman Creek Dam is commonly used for water activities, picnicking, walking, hiking and fishing. On top of this regular campdraft and rodeo events are held in the area.

[1] Detailed name and location information for Indigenous sites listed on the Register of the National Estate is not publicly accessible.

Community access to these facilities is limited only by the proximity of rural residents to the centre of town.

4.9.1.3 Community Services and Infrastructure

Cloncurry is located on the junction of the Flinders/Barkly and Matilda Highways in the North West of Queensland. Given its prominent standing as a rural centre, Cloncurry has a range of services and infrastructure to support residents in the immediate and surrounding areas. The township has many facilities, in addition to those previously mentioned in Section 4.9.1.2; these are outlined in the following subsections.

Cloncurry has a kindergarten, two primary schools and a high school. These schools consist of a Catholic Primary and Cloncurry State School which services grades prep to 12 in a coeducational environment. In 2007 the Cloncurry State School had an enrolment base of 404, with a staff base of 32. The school has indicated that they're expecting a significant increase in enrolment numbers over the next 7 years and can satisfactorily cope with such an increase.

Local Technical and Further Education (TAFE) studies are available through the Mount Isa TAFE Campus in Cloncurry. The town also has established Childcare facilities available for children of all ages.

Queensland Health services the Cloncurry Hospital, which in 2005/06 treated 11,113 patients. The hospital has experienced a steady decline in admittance numbers over the last 13 years, whilst experiencing a steady increase in non-admitted activity. Overall, the total number of patients treated annually has steadily increased from 8,071 in 1993/94, to the most recently published figure.

Further hospital facilities are available in nearby Mount Isa but the city of Cloncurry provides an array of health services satisfactorily meeting community needs such as the Flinders Medical Centre, Community Health, Blue Care, Senior Citizens and the Home and community Care Program.

Located within Cloncurry are a Police Station, Ambulance Service and Fire Brigade. Coupled with these services the town is also a base for the State Emergency Service.

Cloncurry Shire Council has several community development projects in the pipeline for the near future. Improvements planned for the transport system are projected to bring about further employment and tourism opportunities. There are plans for the upgrade of community recreational facilities, a library expansion, as well as continued upgrade and beautifying of Main Street. Cloncurry Shire is also working on strategies to encourage more retail business to the area.

In 2007, the Queensland government announced that Cloncurry will become the first town in the state to be run entirely on solar power. A solar thermal power station is to be built and will have a capacity of 10-megawatt and will deliver about 30 million kilowatt hours of electricity a year, enough to power the whole town. The total cost of the project is $31 million including a $7 million gift from the government. It is expected a pilot plant will be completed during the third quarter of 2010.

4.9.1.4 Whole Community Demographic Profile

Demographic profile information was taken from the ABS time series spreadsheet and the community profile for the Cloncurry Local Government Area. The 1996, 2001 and 2006 census results are compared where possible to show any trends over time. Date is taken from 'place of usual residence' statistics unless otherwise stated.

The 2006 population (by place of enumeration) of Cloncurry is recorded as 4,015 persons. Table 4.69 shows the population increases between 1996 and 2001, and then decreases between 2001 and 2006. The number of males appears to fluctuate more than the number of females.

The ratio of females to males in Cloncurry is approximately 1:1.5 or 40/60%. This is different from the State ratio which is 1:1 or 50/50%. This indicates that there is a gender disparity in Cloncurry, with more males than females.

Table 4.69 Population by Gender in Cloncurry Versus Queensland

	Cloncurry 1996		Cloncurry 2001		Cloncurry 2006		QLD 2006	Cloncurry 1996-2001		Cloncurry 2001-2006	
Male	2,366	61%	3,097	64%	2,366	59%	50%	+ 731	30.1%	- 731	-23.6%
Female	1,532	39%	1,731	36%	1,649	41%	50%	+ 199	13%	- 82	- 4.7%
Total Persons	**3,898**		**4,828**		**4,015**		**100%**	**+ 930**	**23.9%**	**- 813**	**- 16.8%**

The population of Cloncurry is projected to reach between 2,880 and 3,852 persons by 2031 based on three growth scenarios (see Figure 4.79). Two of the scenarios actually predict a decline in the overall population of Cloncurry.

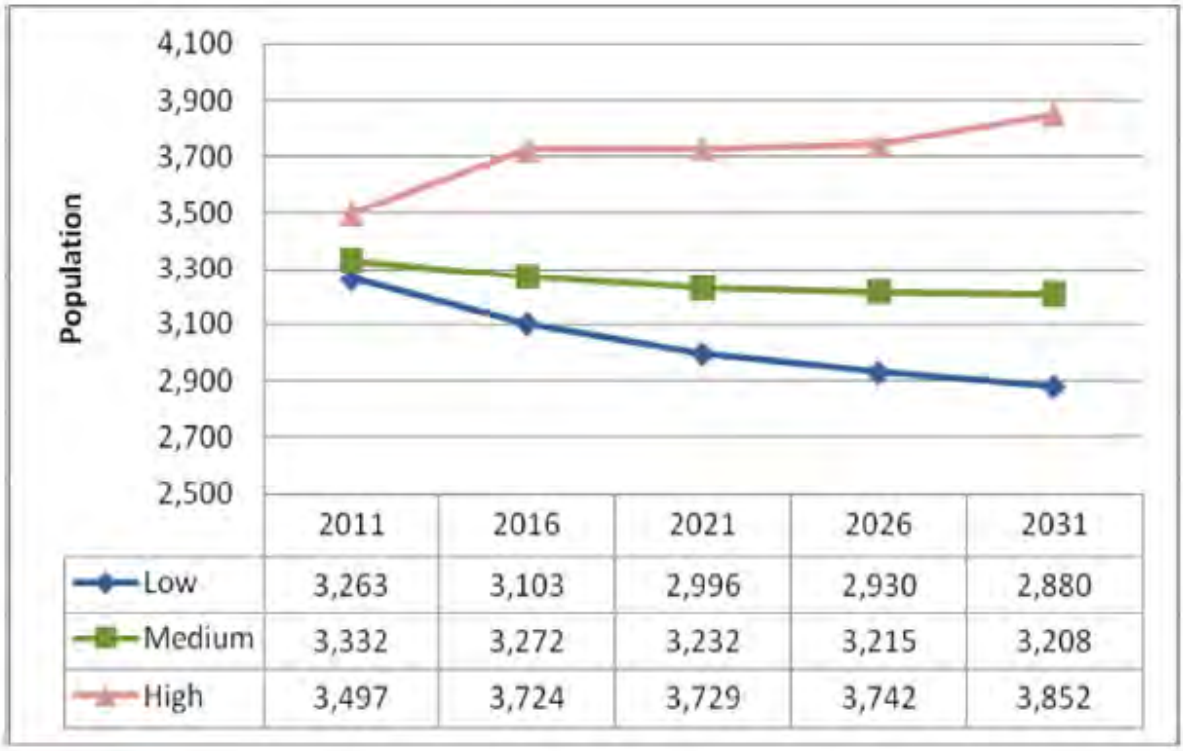

Figure 4.79 Population Projection Scenarios for Cloncurry

Age Structure

The age structure in Cloncurry (by place of enumeration) is shown in comparison to Queensland in Table 4.70. The 25-34 age range is the largest percentage of the population followed by 35-44 age group. The 85 years + age group is the smallest percentage of the population.

Table 4.70 Population by Age Cloncurry Versus Queensland

Age group	2006 - Cloncurry		2006 - Queensland	
	Number	% of Population	Number	% of Population
0-4 years	278	6.9%	260,704	6.4%
5-14 years	510	12.7%	557,947	13.8%
15-24 years	553	13.8%	560,572	13.9%
25-34 years	711	17.7%	540,647	13.4%
35-44 years	612	15.2%	588,246	14.5%
45-54 years	589	14.7%	553,383	13.7%
55-64 years	454	11.3%	461,325	11.4%
65-74 years	210	5.2%	285,611	7.1%
75-84 years	73	1.8%	180,042	4.4%
85 years +	25	0.6%	58,404	1.4%
Total	**4,015**	**100**	**4,046,880**	**100**

From comparison with Queensland percentages there are three noteworthy points:

- The 25-34 year old age group in Cloncurry is approximately 4.3% above the State percentage;
- The 65-74 and 75-84 age groups are both lower than the state percentages, the 75-84 noticeably so; and
- The 85 years + age group is approximately half of the State percentage.

All other age groups appear to be consistent with the State percentages.

These noteworthy points indicate that there are a lower percentage of older generations living in Cloncurry compared to the rest of the State, and that there is higher percentage of younger to middle-aged generations living in Cloncurry.

Mobility

At the 2006 census, approximately half of the population of the Study Area were residing at the same address or at an address within the same LGA, as they had been 5 years prior (Figure 4.80). Interestingly, over one third of the population were residing in a different State or Territory 5 years prior to the 2006 census, potentially indicating internal migration to the Cloncurry region.

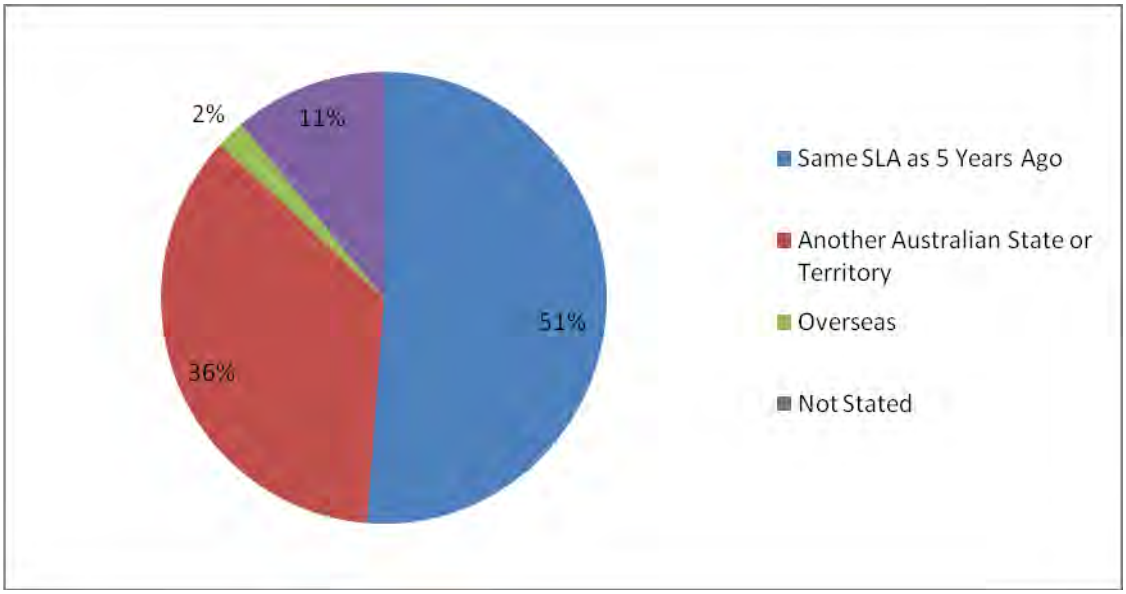

Figure 4.80 Place of Usual Residence 5 Years Ago

Marital Status

Almost half the population of Cloncurry has never been married (see Table 4.71). Separated, divorced and widowed are all fairly small percentages of the population.

In comparison to Queensland State percentages:

- The amount of people in Cloncurry never married is over 10% higher that the State average; and
- The amount of people married is almost 10% lower than the State average.

Table 4.71 Marital Status by Place of Usual Residence

Marital Status	Number	Cloncurry % (Over 15 years)	Queensland % (Over 15 years)
Married	951	40.6%	49.1%
Separated	74	3.2%	3.3%
Divorced	179	7.6%	9%
Widowed	92	3.9%	5.4%
Never married	1045	44.6%	33.2%
Total	**2341**		

Employment Levels

The labour force, which consists of employed people and unemployed people seeking work, is almost three quarters of the Cloncurry population (based on place of enumeration) (Table 4.72). This is higher than the previous two census reports (65.2% and 68.3% respectively), although people recorded as 'not in labour force' in the 2006 census is slightly higher than the 2001 census.

The percentage of people in the labour force is higher in Cloncurry than the State average (69.6% versus 58.2%). Accordingly the percentage of people not in the labour force is lower in Cloncurry than the State percentage.

Table 4.72 Labour Force Characteristics in Cloncurry and Queensland

Status	Cloncurry 2006		Cloncurry - 2001		Cloncurry - 1996		Qld - 2006
	Number	%	Number	%	Number	%	%
Employed	2212	69.6%	2465	63.6%	1958	65.6%	58.2%
Not Employed - Seeking	59	1.9%	92	2.4%	125	4.2%	2.9%
In Labour Force	2271	71.5%	2527	65.2%	2038	68.3%	61.1%
Not in Labour Force	628	19.7%	717	18.5%	780	26.1%	32.0%
Not Stated	277	8.7%	630	16.3%	122	4.1%	6.9%
Total	**3176**	**100**	**3874**	**100**	**2985**	**100**	**100**

Labour Force → "Employed" + "Unemployed but Seeking"

Employment by Industry

The major industries of employment for males and females in the Cloncurry region are mining and agriculture, forestry and fishing. Retail and transport, postal and warehousing follow as the next largest employment sectors (Figure 4.81)

In comparison to the largest industries of employment in Queensland, it is clear that the mining industry in Cloncurry is a significantly higher employer than the State percentage (Figure 4.81). Agriculture, forestry and fisheries, transport, postal and warehousing are also higher employers in Cloncurry compared to Queensland.

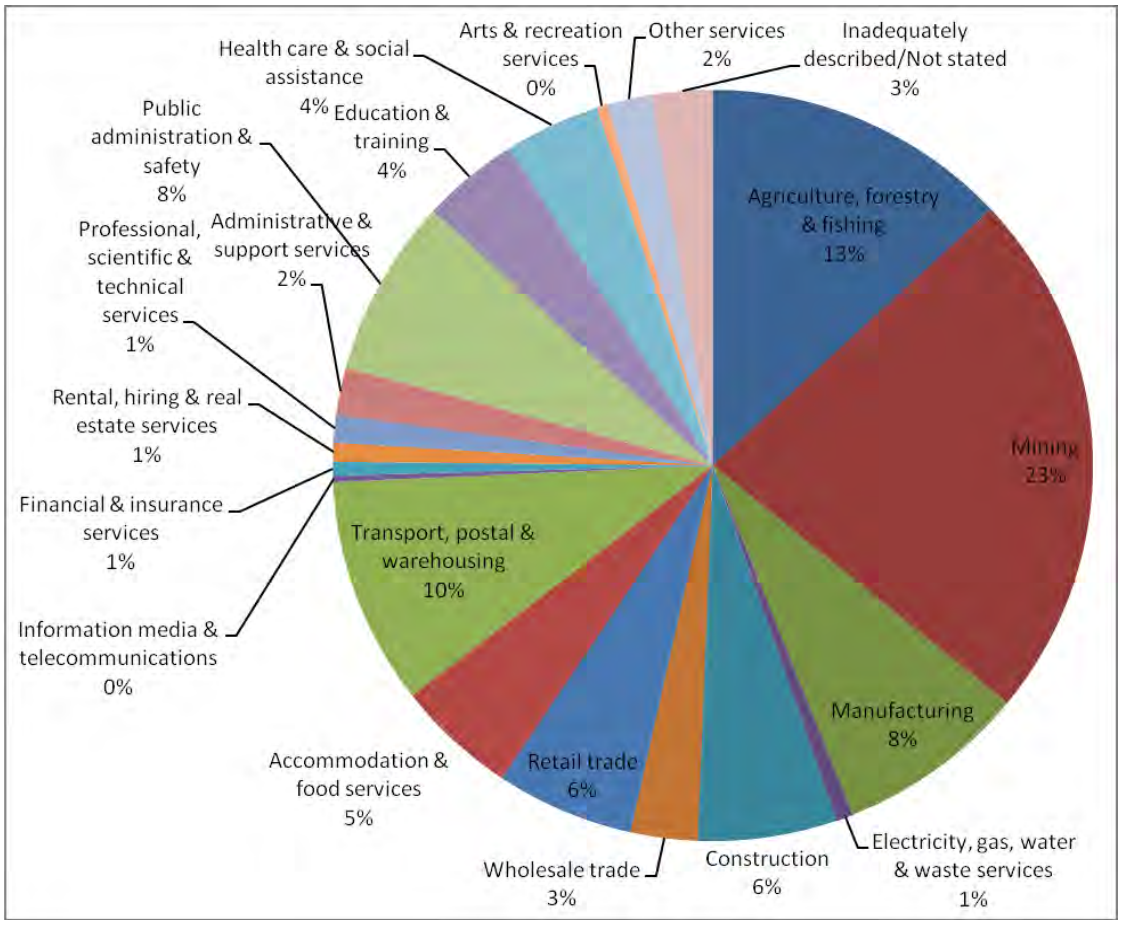

Figure 4.81 Employment by Industry in Cloncurry – 2006

Employment by Occupation

The principal occupations in Cloncurry are technicians and tradeworkers, and machinery operators and drivers (Figure 4.82). These occupations have higher percentages in Cloncurry in comparison to the rest of the State (technicians and tradeworkers: 26.2% versus 20.5% respectively; machinery operators and drivers: 27.9% versus 21.0% respectively). The occupations are mostly male orientated, and reflect the dominant industry; mining. There is a lower percentage of professionals in Cloncurry compared to the rest of the State.

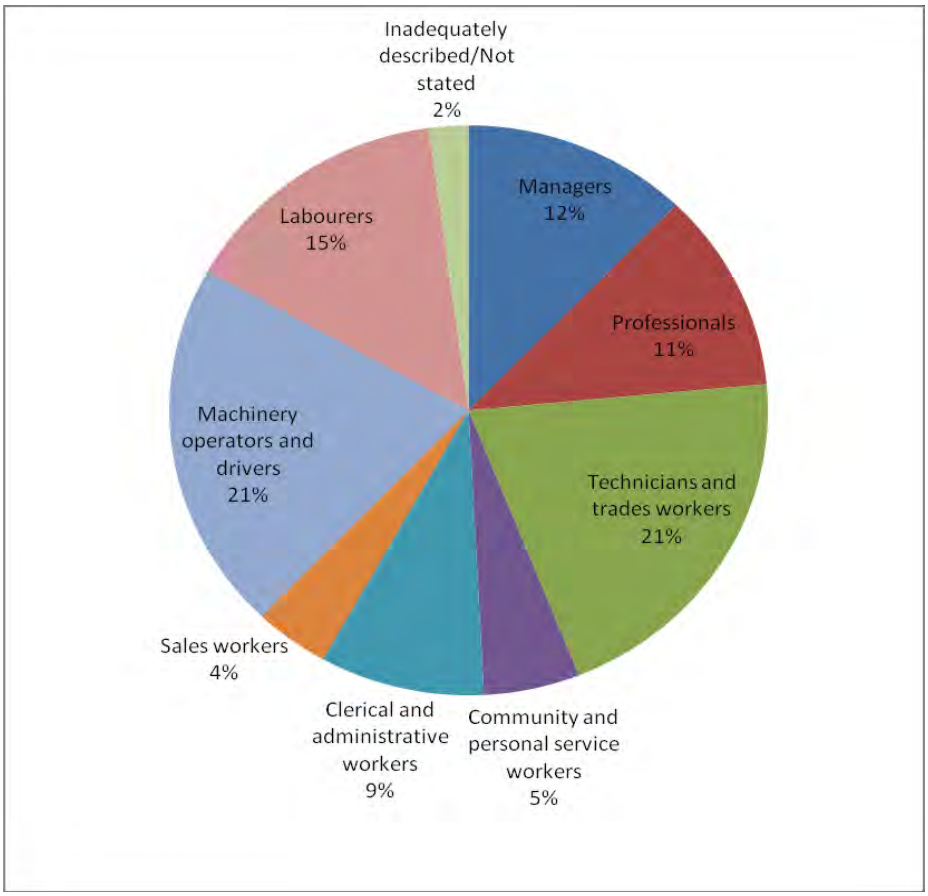

Figure 4.82 Employment by Occupation in Cloncurry – 2006

Income Levels

The two most common income groups in Cloncurry are the $400-599 per week bracket followed by the $1,000-1,299 bracket (Table 4.73). A noteworthy point is that the percentage of people in the Cloncurry community earning $1,000-1,299 per week is higher than the State percentage (11.5% versus 7.8%). In addition persons earning $1,300-1,599 is also higher than the State average (7.4% versus 3.9%). This is probably due to the prevalent industry being mining, which is a well paid industry, particularly in regional areas.

The higher income bracket earners in Cloncurry are most commonly the 25-34 year old age group.

Table 4.73 Weekly Income Totals

Income Category	Persons	Cloncurry %	Queensland %
Negative/Nil income	120	5.1%	6.4%
$1-$149	100	4.3%	6.6%
$150-$249	223	9.5%	13.4%
$250-$399	245	10.5%	13.3%
$400-$599	328	14.0%	14.9%
$600-$799	247	10.6%	11.4%
$800-$999	194	8.3%	8.0%
$1,000-$1,299	269	11.5%	7.8%
$1,300-$1,599	174	7.4%	3.9%
$1,600-$1,999	84	3.6%	2.2%
$2,000 +	73	3.1%	2.9%
Not stated	285	12.2%	9.1%
Total	**2,342**	**100**	**100**

Low Income Households

Low income households are defined by being below the poverty line. Poverty lines are income levels designated for various types of income units. If the income of an income unit is less that the poverty line applicable to it, then the unit is considered to be in poverty. An income unit is the family group normally supported by the income of the unit (Melbourne Institute of Applied Economic and Social Research 2008). The details of the poverty lines (PL) for Cloncurry are provided in Appendix V. The amount of people below the poverty line in Cloncurry is displayed in Figure 4.83. This Figure displays the tabulated data in a flowchart. From this figure it is clear that:

- There are family units below the poverty line in all groups except the un-employed couples with children;
- Unemployed single parents contain the largest number of family units below the poverty line;
- There are 24, 25 and 21 family units in close range of the poverty line across the three groups respectively; and

- There is a much higher percentage of people above the poverty line in the groups 'employed couples with no children' and 'employed couples with children'.

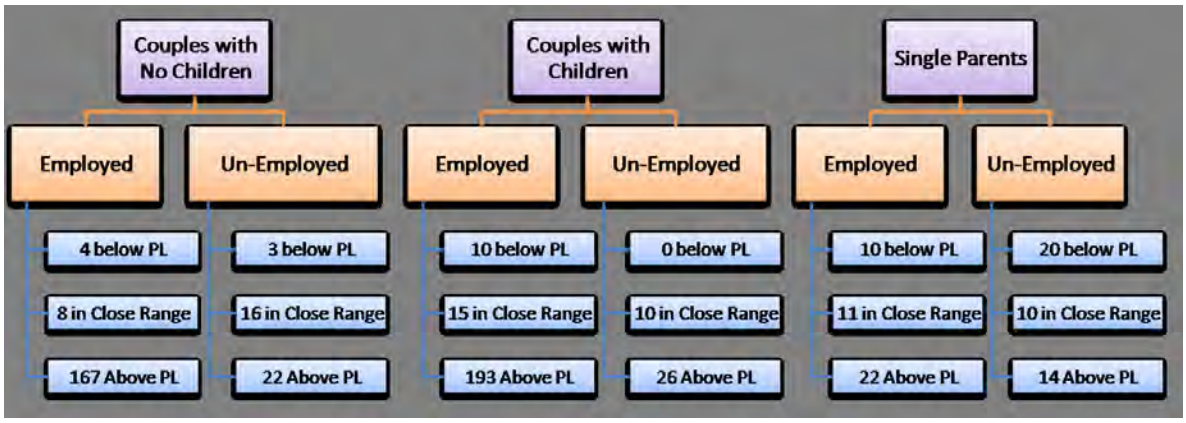

Figure 4.83 Low Income Households in Cloncurry

Education Level

The most commonly obtained post secondary school education level for Cloncurry is TAFE certificates or equivalent (Table 4.74). The percentage of the population with certificates is higher than the State average (42.8% versus 35.5%). University education such as Postgraduate degree, Graduate diploma, Bachelor degree and Advanced diploma are all lower in Cloncurry than the State averages. This reflects a trade based community.

Table 4.74 Level of Education Attained Cloncurry and Queensland - 2006

Education Level	Persons	Cloncurry %	Queensland %
Postgraduate Degree	14	1.4%	3.9%
Graduate Diploma and Certificate	3	0.3%	2.3%
Bachelor Degree	144	14.1%	19.8%
Advanced Diploma and Diploma	91	8.9%	13.1%
TAFE Certificates or equiv.	436	42.8%	35.5%
Not Stated	331	32.5%	25.4%
Total	**1,019**	**100**	**100**

The two most common levels of secondary school obtained are year 12 or equivalent and year 10 or equivalent (32.6% and 29.2%). These are societal norms, however in Cloncurry the percentages of people leaving school in year 12 is lower than the State average and the percentage of people leaving school in year 10 is higher that the State average (Table 4.75). Cloncurry has a slightly higher percentage of people leaving school in years 8 and 9.

Table 4.75 Age left School Cloncurry and Queensland – 2006

Education Level	Persons	Cloncurry %	Queensland %
Year 12 or equivalent	762	32.6%	41.3%
Year 11 or equivalent	183	7.8%	8.2%
Year 10 or equivalent	683	29.2%	26.9%
Year 9 or equivalent	169	7.2%	5.8%
Year 8 or below	237	10.1%	7.4%
Did not go to school	22	0.9%	0.5%
Highest year of school not stated	285	12.2%	9.9%
Total	**2341**	**100**	**100**

Culture and Language

85% of residents in the Study Area originated from Australia, with the next most common countries of origin being New Zealand (2%) and the United Kingdom (1.2%) (see Table 4.76).

The vast majority of Indigenous people in Cloncurry reported they spoke only English (see Table 4.77). Only seven people reported they spoke Indigenous Australia language and 21 people reported they spoke other languages.

Table 4.76 Country of Origin

Country (a)	Population
Australia	2,642
Canada	3
Germany	9
India	6
Malaysia	3
Malta	5
Netherlands	7
New Zealand	62
Papua New Guinea	13
Philippines	11
South Africa	9
United Kingdom (b)	39
United States of America	4
Born elsewhere (c)	31
Country of birth not stated	294
Total	**3,138**

NOTES: (a) This list of countries consists of the most common 35 Country of Birth responses reported in the 2001 Census.
(b) Comprises 'United Kingdom, nfd', 'Channel Islands', 'England', 'Isle of Man', 'Northern Ireland', 'Scotland' and 'Wales'.
(c) Includes countries not identified individually, 'Australian External Territories', 'Inadequately described', 'At sea' and 'Not elsewhere classified'.

Table 4.77 Primary Language Spoken at Home

Language Spoken	Population
Speaks English only	2,788
Speaks other language:	
Australian Indigenous Languages	7
Dutch	3
Filipino (excludes Tagalog)(a)	4
German	8
Greek	7
Hungarian	3
Sinhalese	3
Spanish	20
Tamil	3
Other(b)	21
Language spoken at home not stated	271
Total	**3,138**

(a) In 2006 'Tagalog' and 'Filipino' have been identified individually, in 2001 they were classed as one language.
(b) Comprises languages not identified individually, 'Inadequately described' and 'Non-verbal, so described'.

Religion

The population of Cloncurry is very religious with approximately 73% being affiliated to a religious group, 98% of those affiliated to a religion belong to Christianity (see Table 4.78). Approximately 13% of the population of Cloncurry have no religious affiliation.

Table 4.78 Religious Affiliation by Gender

Religion	Gender		
	Males	Females	Persons
Buddhism	5	0	5
Christianity	*1,182*	*1,075*	*2,257*
Hinduism	5	0	5
Islam	4	0	4
Judaism	0	0	0
Other Religious Groups	5	3	8
No Religion(c)	263	168	431
Other religious affiliation(d)	11	4	15
Religious affiliation not stated	227	187	414
Total	**1,702**	**1,437**	**3,139**

(c) Comprises 'No Religion, nfd', 'Agnosticism', 'Atheism', 'Humanism' and 'Rationalism'.
(d) Comprises 'Religious belief, nfd', 'Not defined', 'New Age, so described' and 'Theism'.

4.9.1.5 Housing and Accommodation

Household Structure

The prevalent family structure in Cloncurry is couples without children (38.1%) followed by two parent families with dependent offspring (36.1%). This is the same as for Queensland State. The percentages of family types in Cloncurry are comparable with State averages and show no significant differences (Table 4.79).

Table 4.79 Family Structure of Cloncurry and Queensland (By Usual Residence)

Household Structure	Families	Cloncurry %	Queensland %
One Parent Families:			
With dependent offspring only	59	9%	9.9%
With non-dependent offspring only	21	3.2%	4.7%
With dependent and non-dependent offspring	12	1.8%	1.4%
Two parent families:			
With dependent offspring only	238	36.1%	31.6%
With non-dependent offspring only	36	5.5%	7.3%
With dependent and independent offspring	28	4.3%	4.3%
Couples without children	251	38.1%	39.1%
Other	14	2.1%	1.7%
Total	**659**		

Household Size

The average household size in Cloncurry is 2.7 people, a figure which is slightly higher than the Queensland State average of 2.6.

Compared to Queensland, Cloncurry has a higher percentage of single occupant households, as well as 5, and 6 occupant households (Figure 4.84). This is contrasted by the Queensland State having a higher percentage of 2, 3 and 4 occupant households.

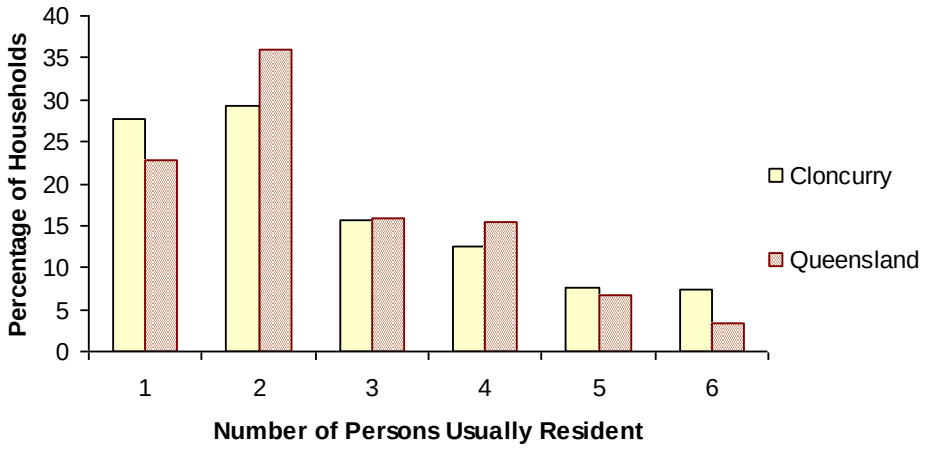

Figure 4.84 Number of People Usually Resident for Cloncurry vs. Queensland

Dwelling Structure and Tenure

The most common form of dwelling type and tenure are 'separate houses that are rented'. Two other common forms of dwelling and tenure are 'separate houses fully owned' and 'separate houses being purchased'. Within the total rented group the most common type of dwelling is 'other landlord types', which covers things like caravan parks, defence force housing or mining camps, as shown in Table 4.80.

Table 4.80 Dwelling Type by Tenure in Cloncurry

	Separate house	Semi-detached, row or terrace house, townhouse	Flat, unit or apartment	Other dwelling	Total
Fully owned	200	0	3	28	**231**
Being purchased	167	0	5	5	**177**
Rented:					
Real estate agent	20	0	3	0	**23**
State or territory housing authority	57	7	22	0	**86**
Person not in same household – eg family	91	0	12	0	**103**
Housing co-operative/community/church group	39	0	25	0	**64**
Other landlord type – caravan, defence, camps	154	3	16	14	**187**
Landlord type not stated	34	0	0	0	**34**
Total Rented	**395**	**10**	**78**	**14**	**497**
Other tenure type	15	3	0	3	**21**
Tenure type not stated	24	0	4	9	**37**
Total	**801**	**13**	**90**	**59**	**963**

Typical Rent for the Area

Typical rent in Cloncurry is significantly lower than the Queensland State average in 2006 (Table 4.81). As a whole, Census data reveals that the median weekly rent for the Cloncurry area is $75 per week, lower than the equivalent Queensland State figure of $200 per week.

Approximately 70% of renters in Cloncurry pay less then $140 per week in rent. Conversely, approximately 76% of renters in Queensland pay more than $139 per week.

Table 4.81 Rental range for Cloncurry housing for 2006

	Cloncurry		Queensland
Rent Range	**Number of Properties**	**%**	**%**
$0-$49	137	27.5	5.4
$50-$99	149	29.9	8.3
$100-$139	71	14.3	10.1
$140-$179	30	6.0	13.9
$180-$224	41	8.2	18.3
$225-$274	21	4.2	19.1
$275-$349	13	2.6	14.2
$350-$449	7	1.4	5.2
$450-$549	0	0.0	1.3
$550 and over	3	0.6	1.3
Rent not stated	26	5.2	2.9
Total	498		

Existing Housing Market Conditions

The median house sale price for houses sold in Cloncurry is lower than for the region (see Table 4.82). There is a lot of statistically unreliable data, particularly for unit sales, due to the small numbers of house sales during the twelve month period. The annual growth of house and unit prices is presented in Figure 4.85 and Figure 4.86 respectively.

Table 4.82 Property Prices for Houses and Units in Cloncurry

12 months to June 2010				
	Houses		Units	
	Cloncurry	Region	Cloncurry	Region
Median Prices	$203,000	$320,000	SNR	$280,000
Long Term Trend	9.5%	13.0%	SNR	11.1%
Auction clearance rates	SNR	27%	SNR	20%
Days on Market	SNR	144	SNR	139
Discounting	SNR	8%	SNR	7%
SNR = Statistically Not Reliable. *Based on sales reported to Australian Property Monitors				

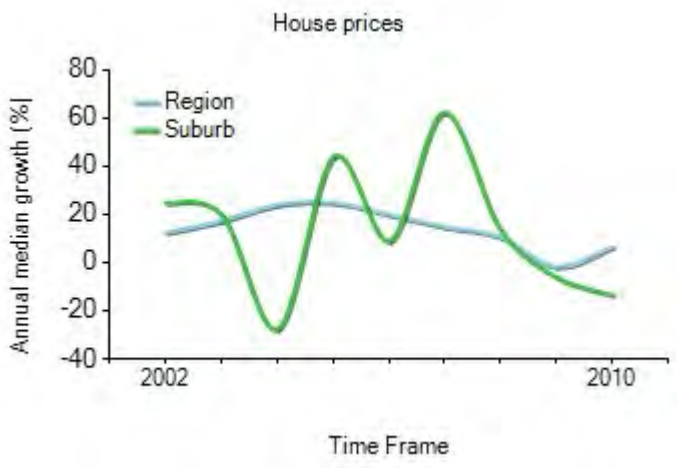

Figure 4.85 Median Annual House Price Growth for Cloncurry (%)

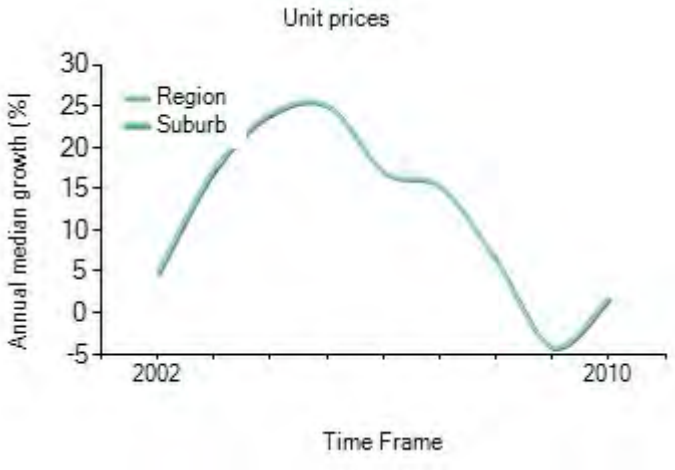

Figure 4.86 Median Annual Growth of Unit Prices for Cloncurry (%)

The majority of the population (approximately 42%) in Cloncurry rent their house as opposed to purchasing or fully owned (see Figure 4.87).

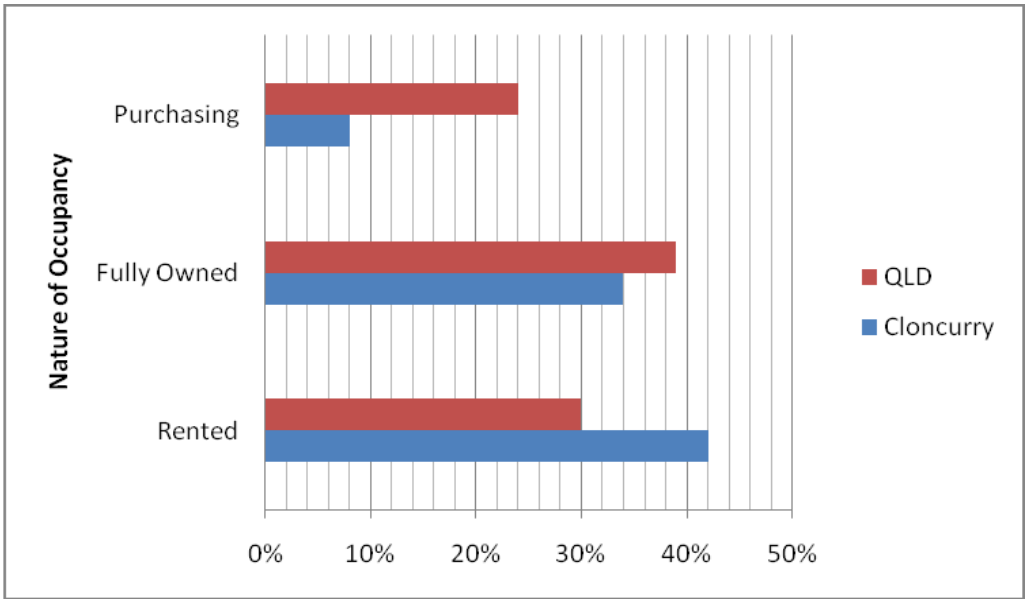

Figure 4.87 Nature of Occupancy for Cloncurry and Queensland

An assessment of housing prices, housing / rental availability, housing stress / affordability and land development potential in Cloncurry, indicates that the region is not suffering housing stress or extreme accommodation pressure.

Property values and property sales data are not currently available from ABS for Cloncurry; however the median house price in 2008 for Cloncurry town, as determined by Australian Property Monitors (2009) was $274,000, which has increased from $203,000 in 2006. In contrast, the median house price for Northwest Queensland region is $306,000.

Cloncurry regional real estate agents report limited vacancies for rental accommodation in the area. This trend has been constant for some time. There are generally 5 – 10 properties vacant at any one time, with each real estate agent reporting less than 2 vacant properties on their books. All real estate agents reported limited seasonal fluctuations, with most properties being tenanted immediately after the previous residents vacate the property.

Housing stress and affordability are measured by comparing the percentage of weekly household income that is spent on rent or housing loan repayments. Table 4.83 shows housing stress and affordability for Cloncurry as well as other regional and city centres and Queensland. Cloncurry residents have low percentages of income going to loan repayments or rent, indicating good current the mining industry has not decreased housing affordability in the area.

Discussions with Cloncurry Shire Council indicated that the Cloncurry town boundaries are already zoned and as such, the boundaries cannot be extended, however the Council indicated the presence of vacant land within the town boundaries. Cloncurry Shire Council indicated that there are 5 builders in Cloncurry. The nearest housing development company is based in Townsville.

Table 4.83 Housing Stress and Affordability in Cloncurry versus Queensland.

Local Government Area	Median Monthly Loan Repayments		Median Weekly Rent	
	$	% of income	$	% of income
Cloncurry	982	21.1	75	6.4
Mt Isa	1083	18.1	150	10.0
Brisbane	1450	31.3	240	20.7
Cairns	1265	30.0	200	19.0
Townsville	1200	28.2	180	16.9
Queensland	1300	31.5	200	19.4

Data Source: ABS 2006.

Household Internet Connection

The majority of households in the Study Area do not have an internet connection available (see Figure 4.88). For households that do have a connection to the internet the majority have a broadband connection.

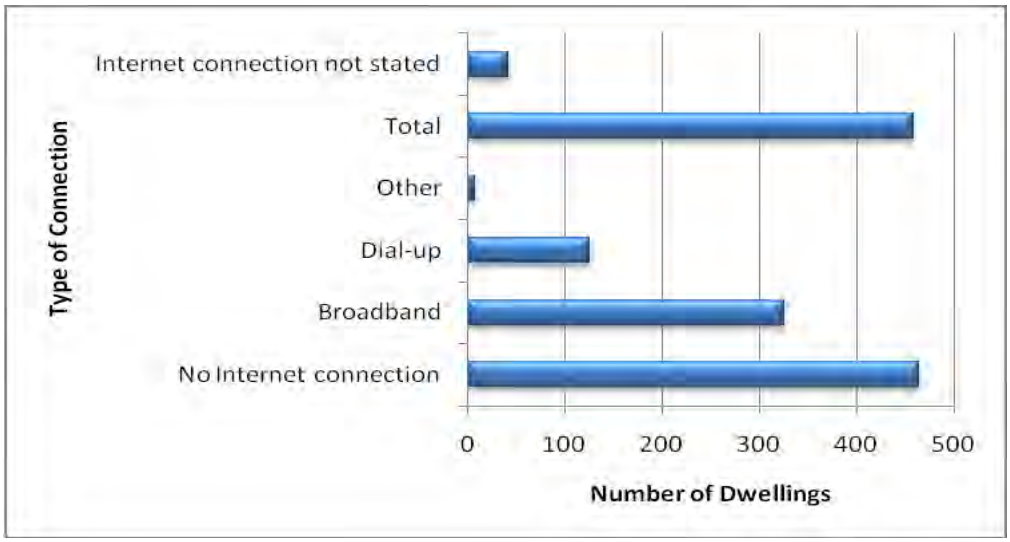

Figure 4.88 Type of Internet Connection in Households

4.9.1.6 Indigenous Community Demographic Profile

Demographic profile information was taken from the Australian Bureau of Statistics time series spreadsheet and the Indigenous community profile for the Cloncurry Local Government Area.

The Indigenous population of Cloncurry as of 2006 was 705 persons (Table 4.84). This consisted of 347 males and 358 females. The Indigenous population appears to have declined since 1996 by 126 persons however the majority of this decrease occurred between 2001 and 2006. There has been a larger decrease in males than females.

Table 4.84 Indigenous Population in Cloncurry

	1996	**2001**	**2006**	**1996-2001** Increase/decrease		**2001-2006** Increase/decrease	
Male	439	417	347	- 22	- 5%	- 70	16.79%
Female	392	392	358	0	0%	- 34	8.67%
Total Persons	**831**	**809**	**705**	**- 22**	**2.65%**	**- 104**	**14.75%**

Age Structure

The most common age group within the Indigenous population is 5-14 year olds. The younger generations 0-4, 5-14, and 15-24 years olds are a higher percentage of the community than other age groups (Table 4.85).

Table 4.85 Indigenous Population by Age in Cloncurry

Age group	2006 - Cloncurry			
	Males	Females	Persons	%
0-4 years	37	58	95	13.5%
5-14 years	99	89	188	26.6%
15-24 years	60	56	116	16.4%
25-34 years	40	44	84	11.9%
35-44 years	36	41	77	10.9%
45-54 years	38	31	69	9.8%
55-64 years	26	21	47	6.7%
65 years +	12	18	30	4.2%
Total	**348**	**358**	**706**	**100**

Household Structure

The most common family structure in Indigenous communities in Cloncurry is couples with children. Within this group it is most common to have 6 or more persons present within the household. The second most common family structure is one parent families, where it is most common to have 3 persons present within the household (Table 4.86).

Table 4.86 Indigenous Family Structure in Cloncurry

Household Structure	Number of Persons Usually Present							
	1	2	3	4	5	6+	Total	%
One family households:								
Couple family with no children	..	23	3	0	0	3	29	13.24%
Couple family with children	..	..	20	23	13	25	81	37.00%
One parent family	..	7	15	8	10	9	49	22.37%
Other family	..	0	3	0	0	0	3	1.37%
Total	***..***	***30***	***41***	***31***	***23***	***37***	***162***	
Multiple family households	..	..	..	3	0	3	6	2.74%
Total family households	***..***	***30***	***41***	***34***	***23***	***40***	***168***	
Lone person households	44	..	..	..	..	..	44	20.09%
Group household	..	4	0	3	0	0	7	3.20%
Total	**44**	**34**	**41**	**37**	**23**	**40**	**219**	**100**

Dwelling Structure and Tenure

The most common form of tenure in Indigenous communities in Cloncurry is rented State housing (Table 4.87). Within the State housing category the most common dwelling structure is separate houses. The second most common form of tenure in Indigenous communities is rented housing cooperative, community or church group provided housing. Within this category separate houses are the most common.

Table 4.87 Dwelling Type by Tenure in Cloncurry

	Separate house	Semi-detached, row or terrace house, townhouse	Flat, unit or apartment	Caravan or Cabin	Total
Fully owned	27	0	0	0	27
Being purchased	25	0	0	0	25
Rented:					
Real estate agent	5	0	0	0	5
State or territory housing authority	43	7	13	0	63
Person not in same household – e.g. family	13	0	0	0	13
Housing co-operative/community/church group	38	0	9	0	47
Other landlord type – caravan, defence, camps	22	0	0	4	26
Landlord type not stated	4	0	0	0	4
Total Rented	***125***	***7***	***22***	***4***	***158***
Other tenure type	3	0	0	0	3
Tenure type not stated	5	0	0	0	5
Total	**185**	**7**	**22**	**4**	**218**

Employment

The Indigenous Labour force in Cloncurry is approximately 58.39%. Accordingly, the level of people not in the labour force is 36.17%, with 5.23% of people not stating. Employment levels in the Indigenous community in Cloncurry are similar to the State percentages for Indigenous people in Queensland (Table 4.88). There are no significant differences.

Table 4.88 Indigenous Labour Force Characteristics – Cloncurry 2006

Status	Indigenous Cloncurry		Indigenous Queensland
	Number	%	%
Employed	211	49.88%	48.85%
Not Employed - Seeking	36	8.51%	7.39%
In Labour Force	***247***	***58.39%***	***56.24%***
Not in Labour Force	153	36.17%	38.53%
Not Stated	23	5.44%	5.23%
Total	**423**	**100**	**100**

Labour Force → "Employed" + "Unemployed but Seeking"

Employment by Industry

The largest industry sector for Indigenous male employment in Cloncurry is Transport, postal and warehouse with 27.42% of males employed (Table 4.89) The second largest industry for males is Public administration and safety with 12.10% and the third largest is Construction with 11.29%.

The largest industry sector for Indigenous female employment in Cloncurry is a tie between Public Administration and Safety, and Education both at 14.12%. The second largest industry for females is Retail followed by Healthcare and societal assistance in third.

For the whole Indigenous community the largest sectors of employment were Transport, postal and warehouse, followed by Public administration and safety and then Construction (Table 4.89).

Table 4.89 Indigenous Employment by Industry in Cloncurry

Industry	Males		Females		Persons	
	No.	%	No.	%	No.	%
Agriculture, forestry & fishing	11	8.87%	5	5.88%	16	7.66%
Mining	10	8.06%	4	4.71%	14	6.70%
Manufacturing	6	4.84%	0	0.00%	6	2.87%
Construction	14	11.29%	6	7.06%	20	9.57%
Retail trade	4	3.23%	11	12.94%	15	7.18%
Accommodation & food services	3	2.42%	5	5.88%	8	3.83%
Transport, postal & warehousing	34	27.42%	3	3.53%	37	17.70%
Financial & insurance services	0	0.00%	3	3.53%	3	1.44%

Industry	Males		Females		Persons	
	No.	%	No.	%	No.	%
Rental, hiring & real estate services	0	0.00%	3	3.53%	3	1.44%
Administrative & support services	3	2.42%	5	5.88%	8	3.83%
Public administration & safety	15	12.10%	12	14.12%	27	12.92%
Education & training	4	3.23%	12	14.12%	16	7.66%
Health care & social assistance	4	3.23%	10	11.76%	14	6.70%
Other services	4	3.23%	0	0.00%	4	1.91%
Inadequately described/Not stated	12	9.68%	6	7.06%	18	8.61%
Total	**124**	**100**	**85**	**100**	**209**	**100**

Employment by Occupation

The most common occupation for Indigenous males is Labourers at 35.77%, followed by machinery operators and drivers at 24.39% and finally Technicians and tradesworkers at 17.07% (Table 4.90). The most common occupation for Indigenous females is a tie between Community personnel and service workers, and labourers, both at 20.93%. Overall the most common occupation in the Indigenous community in Cloncurry is Labourers, followed by machinery operators and drivers and finally Technicians and tradesworkers.

Table 4.90 Indigenous Occupation by Sex in Cloncurry - 2006

Occupation	Males		Females		Persons	
	No.	%	No.	%	No.	%
Managers	4	3.25%	3	3.49%	7	3.35%
Professionals	3	2.44%	6	6.98%	9	4.31%
Technicians and trades workers	21	17.07%	8	9.30%	29	13.88%
Community and personal service workers	8	6.50%	18	20.93%	26	12.44%
Clerical and administrative workers	6	4.88%	15	17.44%	21	10.05%
Sales workers	0	0.00%	7	8.14%	7	3.35%
Machinery operators and drivers	30	24.39%	6	6.98%	36	17.22%
Labourers	44	35.77%	18	20.93%	62	29.67%
Inadequately described/Not stated	7	5.69%	5	5.81%	12	5.74%
Total	**123**	**100**	**86**	**100**	**209**	**100**

Income Levels

The most common weekly income bracket for Indigenous people in Cloncurry is $150-$249 (refer to Table 4.91). The second most common weekly income bracket is $250-$399. This is fairly consistent with State percentages for Indigenous weekly income. One noteworthy point is that in Cloncurry, there is a slightly higher percentage of Indigenous people in the higher weekly income bracket, compared to the rest of the State (10.59% versus 7.01%).

Table 4.91 Indigenous Weekly Income Totals

Income Category	Indigenous Persons	Indigenous Cloncurry %	Indigenous Queensland %
Negative/Nil income	26	6.12%	8.43%
$1-$149	24	5.65%	7.64%
$150-$249	95	22.35%	21.48%
$250-$399	82	19.29%	15.62%
$400-$599	59	13.88%	15.37%
$600-$799	37	8.70%	8.76%
$800-$999	21	4.94%	4.99%
$1,000 or more	45	10.59%	7.01%
Not Stated	36	8.47%	10.70%
Total	**425**	**100**	**100**

Education Level

Of the Indigenous people that stated the level of education they attained, the most common level is the TAFE certificate of equivalent (Table 4.92). This is the same for Indigenous people in Queensland State.

The most common year to leave school for Indigenous people in Cloncurry is year 10 followed by year 12 (24.94% and 19.53%) (Table 4.93). This is comparable to the State percentages, however there is a lower percentage of people leaving in year 12 compared to Queensland (19.53% versus 25.54%) and a higher percentage of people leaving in year 8 compared to Queensland State (18.82% versus 11.99%).

Table 4.92 Level of Education Attained Cloncurry - 2006

Education Level	Indigenous Persons	Indigenous Cloncurry %	Indigenous Queensland %
Postgraduate Degree	0	0	0.85
Graduate Diploma and Certificate	0	0	0.64
Bachelor Degree	0	0	5.25
Advanced Diploma and Diploma	3	5.08	6.64
TAFE Certificates or equiv.	19	32.20	43.21
Not Stated	37	62.71	43.41
Total	**59**	**100**	**100**

Table 4.93 Age left School Cloncurry and Queensland – 2006

Education Level	Indigenous Persons	Indigenous Cloncurry %	Indigenous Queensland %
Year 12 or equivalent	83	19.53	25.54
Year 11 or equivalent	44	10.35	11.13
Year 10 or equivalent	106	24.94	28.62
Year 9 or equivalent	46	10.82	10.63
Year 8 or below	80	18.82	11.99
Did not go to school	6	1.41	1.24
Highest year of school not stated	60	14.12	10.85
Total	**425**	**100**	**100**

Culture and Language

The vast majority of Indigenous people in Cloncurry reported they spoke only English (Table 4.94). Only 3 people reported they spoke Indigenous Australia language and 3 people reported they spoke other languages.

Table 4.94 Indigenous Language Spoken

		Speaks other language and speaks English				Language and proficiency in English not stated	Total
	Speaks English only	Very well or well	Not well or not at all	Proficiency in English not stated	Total		
Speaks English only	682	..	..	..	..	..	682
Speaks Australian Indigenous languages:							
Arandic	..	3	0	0	3	..	3
Total	..	3	0	0	3	..	3
Speaks other language	..	3	0	0	3	..	3
Language spoken at home not stated	..	3	3	0	6	9	15
Total	**682**	**9**	**3**	**0**	**12**	**9**	**703**

4.9.1.7 Land Prices and On-Farm Activities

Table 4.95 describes the properties in the Project vicinity, along with their current land use, size and last valuation.

Table 4.95 Details of Properties Under and Surrounding the Project

Holding Name	Owner(s)	Real Property Description	Primary Land Use	Area (ha)	Property Value
Dipvale	Anita Maree and Grant James Telford	L4025 PH173:PH Dipvale Holding	Cattle Grazing and Breeding	4,918.3	$225,000 (27/02/2006)
Urquhart, Patricia Vale, Quamby, Yambani, Carsland, and Non-specifc Reserves	Harold Henry McMillan	L2-4 BD56 Urquhart Holding L18 GR28: (Non-specific) reserve 4 L6 GR33: (Non-specific) reserve 1 L2 GR41 Patricia Vale Holding L1 GR42 Quamby Holding L1 PER4881 L2577 PH139 Yambani Holding L3692 PH2168 Carsland Holding	Cattle Grazing and Breeding	61,413.5	$1,250,000 (16/10/2007)
Cameron Creek	Cameron Creek Pastoral Co Pty Ltd	L3635 PH2175 Cameron Creek	Cattle Breeding and Fattening	32,115.9	$480,000 (27/02/2006)
Boomarra and Coolullah	North Australian Pastoral Co Pty Ltd	L3 LS18 Boomarra Holding L59 TG40 Coolullah Holding	Cattle Grazing and Breeding	322,000	$6,300,000 (27/02/2006)

Holding Name	Owner(s)	Real Property Description	Primary Land Use	Area (ha)	Property Value
Corella Park, Timberu, Ginburra, Mount Maggie and Non-specific Reserves	McMillan Pastoral Company	L12 BD121: (Non-specific) reserve 2 L50 CP857736: (Non-specific) reserve 50 L1 PER6671 & L1 PER882 L4126 PH1069 Ginburra Holding L5214 PH1272 Mount Maggie Holding L220 SP177588 Timberu Holding L3942 PH2162 Corella Park Holding	Cattle Grazing and Breeding	142,491	$1,700,000 (1/10/2005)
Chumvale Aggregation	Jersey Plains Pastoral Company	L1 BD102 Tommy Creek Holding L417 CP855213 L521 CP905413 Chumvale Holding L4144 PH2265 Jersey Plains Holding	Cattle Grazing and Breeding	61255	$1,600,000 (01/10/2005)
Flat Top	Chris William and Merrill Anne Phillips	LA AP11726 LA AP13704 Non Specific Reserve 106 L4676 PH331 Flat Top Holding	Cattle Grazing and Breeding	2394.9	$122,000 (01/10/2005)
Jessivale	Catherine Patricia and Harold Henry McMillan	L10 BD182 L3487 PH2127 Venus Holding	Cattle Fattening	31881.2	$1,950,000 (01/10/2005)

The Project area is surrounded by pastoral properties. The closest homestead to the Project is the Roseby Homestead which lies 2.5 km to the southeast of the Project boundary (Figure 4.89). This pastoral property is the central operation of a number of family farms linked to homestead. Roseby pastoral property contains the homestead itself, several additional buildings including a smaller homestead alongside the Roseby Homestead, an air strip, aeroplane and helicopter hangers, engine sheds, horse yards, stockyards, stables, truck, car and machinery sheds, and several groundwater bores and windmills.

The activities undertaken on this pastoral properly include:

- General housing of several families;
- Cattle mustering (on ground and aerial);
- Other associated stock maintenance (drenching, tagging, branding etc); and
- Farm maintenance.

The operations at Roseby are family owned and operated.

Other pastoral properties exist in the vicinity of the Project as shown in Figure 4.89 (some owned/partially owned/operated by the owners of Roseby Homestead).

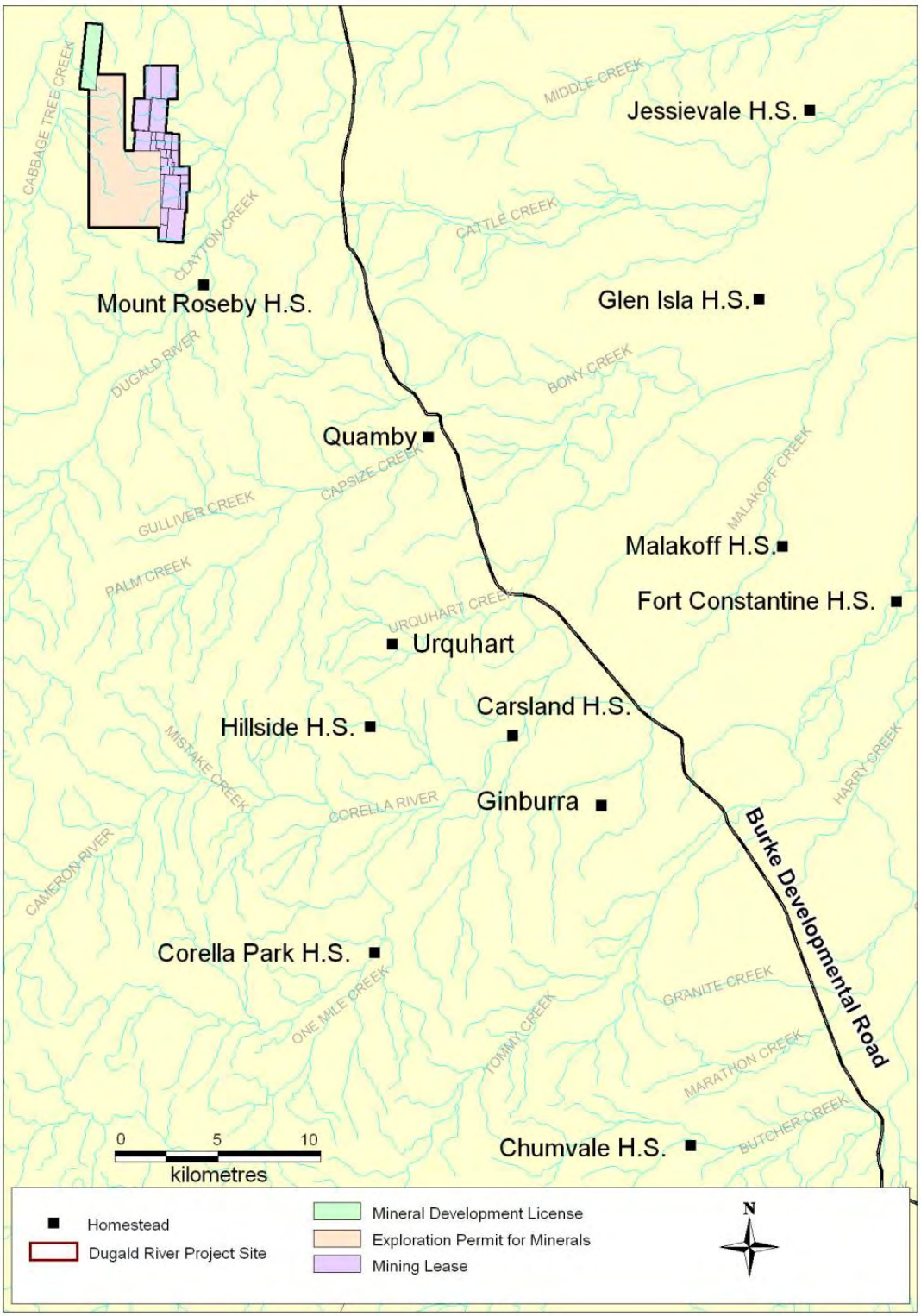

Figure 4.89 Residences in Relation to the Project Site

4.9.1.8 Community Consultation Program

During preparation of the EIS for the Project a community consultation process was undertaken to allow the local community the opportunity to:

- Become fully informed of the Project status and the likely impacts of any development on the local community prior to approval;
- Express any concerns regarding current or planned Project activities and their environmental impacts; and
- Discuss, review, and contribute to the formulation of the strategies proposed for the Project for mitigation of any potential adverse impacts that may arise.

The community consultation program adopted to date, has included the following consultation methods:

- Advertising the draft TOR in local and state media for the duration of the draft TOR comment period;
- Facilitating a public comment period for the draft TOR;
- Inviting comments and providing responses from the proponent;
- Mailing information direct to residents;
- Organising meetings and surveys with interested and affected persons;
- Presentations to gatherings of stakeholders and other interested groups; and
- Landholder Agreements.

In addition the following community consultation activities will be conducted once the EIS has been submitted:

- Submission and advertising of the draft EIS;
- Facilitating a public comment period for the draft EIS; and
- Managing responses to comments on the draft EIS and incorporation of these comments into the final EIS.

4.9.2 Potential Impacts and Mitigation Measures

As mentioned previously, AARC undertook a SEIA for the Project, the impacts and mitigation strategies from which are summarised in the following sections. The full report is provided in Appendix V. AARC has also produced a Draft Social Impact Management Plan (SIMP) from the Project which is provided in Appendix W.

The purpose of the SIMP is to define the roles of MMG, government and the community in mitigating and managing social impacts throughout the life of the Dugald River Project. The SIMP reflects the findings and recommendation of the SEIA and presents implementation actions for the mitigation and management strategies proposed for the Project.

4.9.2.1 Direct Impacts

Direct social and economic impacts on the local township of Cloncurry and wider economy and community could be construed as adverse or beneficial depending on context. Potential impacts on the Cloncurry community and wider economy and community from the Project that are seen as beneficial could include:

- Economic benefit for the Project workforce through the employment of a maximum 795 personnel both on site and off site;
- Training, graduate studies, vacation work and scholarship programs provided to employees and students;
- Indigenous employment and training opportunities will be negotiated under Native Title agreements with Traditional Owners;
- The Project's construction will result in a positive input into the local, Queensland and Australian economy of more than $700 million through the purchase of equipment, goods and services;
- During the operating phase of the Project, which is estimated to be approximately 23 years, industries associated with mining will be positively impacted through the provision of services, equipment and supply of consumables to the Project. The annual economic contribution is estimated to be $160 M in operating expenditure, and $35 M in taxes, subject to metal prices and production at the time;
- The payment of Royalties to the State of Queensland an average of $14M per year, depending on metal prices and production at the time;
- Economic benefits to the local economy from the use of the certain services in Cloncurry and Mount Isa to support the Project as described in Section 4.11.2;
- As the Project workforce will mostly be accommodated in an on site accommodation camp housing markets and prices in Cloncurry are unlikely to be significantly affected by the Project;
- When at home FIFO employees will have an extended time to devote to leisure activities and family, i.e. 6 days instead of one weekend. For other potential benefits of the FIFO roster see Section 4.9.2.3 and

- The owners of Mount Roseby Homestead will be compensated for any impacts on their pastoral operation through land compensation agreements.

Potential impacts on the Cloncurry community and wider economy and community from the Project that are seen as adverse could include:

- Local businesses and the local economy in Cloncurry will not directly benefit from the Project workforce in the supply of accommodation and meals etc, as the workforce will be accommodated on site;

- The Project workforce will not contribute to population growth in Cloncurry which may have added numbers and diversity to schools, recreational groups and community groups;

- The majority of the negatives associated with FIFO arrangements are as a result of extended absences from families followed by insufficient rest for mine workers. For other potential adverse impacts of the FIFO roster see Section 4.9.2.2;

- The land area that can be used for grazing cattle on the Project site, will be decreased due to the footprint of Project infrastructure; and

- The liveability and quality of lifestyle of the residents of the Mount Roseby Homestead may be affected by the impacts of noise, dust and vibrations from the operating mine and the transport of personnel on and off the site.

Demographic Impacts

Cloncurry Shire's population statistics are largely influenced by the predominant mining industry which already exists in the region. In general, the population has a higher ratio of males to females, and has a higher proportion of the population in the 25-34 year age bracket when compared to the state average. The Project proposes to employ approximately 590 operational personnel with a maximum of 795 personnel at peak of construction, approximately 96% of which will be Fly-In-Fly-Out (FIFO) and are unlikely to spend significant time in Cloncurry, since a range of facilities will be available in the accommodation camp. The remaining ~4% of personnel will be sourced from the surrounding community where possible. The Project should have minimal impact on the current population size and structure of Cloncurry.

The Project is expected to be primarily FIFO and FIFO employees will be accommodated at the Project's mine camp. A small portion of the workforce will be sourced from the local community. If personnel are not currently residing in Cloncurry then they will be required to reside within the accommodation camp.

Impacts of Fly-In-Fly-Out

Research suggests that FIFO arrangements can have both positive and detrimental implications for mine workers, their families, and the source communities from which miners are travelling (Beach 1999; Graham 2000). As such, it is recognized that careful consideration should be given to the FIFO schedule to be implemented at Dugald River.

Employees will be engaged on one of three potential rosters, depending on the requirements of their role:

- 8 days on, 6 days off, working day and night shift

- 8 days on, 6 days off, working day shift only
- 5 days on, 2 days off, working day shift only

The rosters shift work cycles have been developed to balance work and home life, as well as manage fatigue for shift workers. These roster cycles are similar to those employed at other underground mines in the region and are generally accepted by the target workforce.

Studies by Graham (2000) looked favourably on the 8:6 schedule as allowing more regular family and community contact whilst still retaining the financial benefits FIFO workers are enticed by. Longer rotations, with workers experiencing stints greater than 8 consecutive days on, are recognised as the primary contributing factor to occupational fatigue, and diminished well being (Muller *et. al.* 2008). To statistically highlight the 8:6 roster as being the most 'worker friendly', Beach *et. al.* (2003) found that at the same mine site workers on a 8:6 roster had a turnover rate of 12%, whereas workers on a 14:7 roster had a turnover rate of 30%.

As a whole the FIFO arrangement facilitates a range of positive, as well as negative aspects to everyday life for those involved (Table 4.96). The majority of the negatives associated with FIFO arrangements are as a result of extended absences from families followed by insufficient rest for mine workers (Muller *et. al.* 2008). An 8:6 roster coupled with some practical measures can reduce the negative impacts and improve outcomes.

Table 4.96 Aspects of FIFO Lifestyle (Graham, 2000)

Beneficial	Adverse
More time for hobbies	Inability to sustain friendships
More time for recreation	Adverse affect on community involvement
Quality family time	Problems participating in sporting teams
Quality leisure time	Emotional isolation
More freedom	Partners feeling unsupported
Enhanced family relationship	Long absences
Financial incentive	Stress on family unit

FIFO and commute rosters are now accepted across the Australian resources industry and, in recent times been used in locations which have traditionally been residential. The key benefit of commute rosters to the industry, is that it provides labour to remote communities where there is no available workforce and there are not sufficient people willing to relocate.

Working on a commute roster is a lifestyle choice and often, people will change their roster status at different stages in their life. Young singles may elect to commute in order to maintain social ties in the coastal centres, whilst young families might choose a remote residential role in order to increase time spent together, then families with older children could opt for a commute roster to improve educational opportunities.

Ultimately, commute rosters are a personal choice and Dugald River will provide employment that is attractive to some, but not all people in the targeted labour markets.

Whilst, it is a personal choice to work on a commute roster, as an employer who already engages people at three existing commute sites (Century, Golden Grove and Sepon), MMG understands the importance of support for employees and their dependants at home. To provide this support and peace of mind for employees, MMG offer the following range of services to their employees:

- A fully subsidised counselling service (Employee Assistance Programme – EAP);
- Subsidised private health fund for employees and dependants;
- Allocated compassionate leave (bereavement, special and carers); and
- Health and Lifestyle programme.

The EAP exists to support employees with personal or work issues. This service will be provided at the Dugald River Project to all employees and their immediate family who will have access to fully qualified psychologists and social workers via phone. It is provided independently of MMG by the OSA Group, an international EAP provider that services all of Australia.

The accommodation camp will also contain a number of recreational activities including a gym, a swimming pool, tennis courts and a mess hall. Access to these facilities by personnel may help to alleviate stress and promote a sense of community.

The main source community for employees for the Project will be Townsville, with some personnel potentially sourced from Brisbane and locally from Cloncurry or Mount Isa, depending on the capacity of these local labour markets. It is anticipated there will be some technical roles, which will be difficult to fill and suitable candidates for these positions will be sought from across Australia and if necessary overseas. Opportunity to promote and transfer suitable staff from other MMG's operations will also be taken.

Impacts on Fly-In-Fly-Out Source Settlements

Townsville and Brisbane are large coastal regional centres. Table 4.97 below shows the percentage of people from these centres that currently work in the mining industry.

Table 4.97 Mining Industry in Brisbane and Townsville Source Communities (ABS, 2006)

	Brisbane		Townsville	
	Persons	***%***	***Total***	***%***
Mining Industry	3,203	0.66	1,091	2.30
All Industries	488,614		47,399	

Brisbane and Townsville are well provisioned with community services and it is not anticipated that the employees and their families will be left unsupported if they require community services due to the absence of family members.

Mount Isa is one of the original mining towns in the region with the famous Mount Isa Mine in the centre of town. Mount Isa is another possible employee source community for the Project, although it is anticipated that employees sourced from this community will probably be low. This community has a significantly higher percentage of people working in the mining industry (Table 4.98) and coupled with its smaller population size, may make it difficult to find available employees. Existing industry in

Mount Isa currently brings labour into town on commute rosters from coastal centres. Any personnel employed from Mount Isa would be accommodated on site in the same manner as other employees on the FIFO roster system.

Table 4.98 Mining Industry in Mount Isa Source Community (ABS, 2006)

	Mount Isa	
	Total	***%***
Mining Industry	2459	26.67
All Industries	9221	

Impacts on Accommodation and Housing

Accommodation in Cloncurry is generally in short supply, however, turnaround is quick with numerous mining and exploration companies utilising existing housing and accommodation facilities on a temporary basis. Local real estate agencies indicated that although there are generally only a limited number of rental properties available, turnaround is quick and availability has remained constant.

The Project is expected to be primarily FIFO and FIFO employees will be accommodated at the Project's mine camp. A small portion of the workforce will be sourced from the local community. As indicated in Section 4.9.1.4 Cloncurry is not suffering from housing stress and Council have identified vacant land within town boundaries that could be utilised for building development if necessary, although this is unlikely. Overall, the Project is expected to have limited to no impact on accommodation facilities or existing housing stock in Cloncurry.

No significant impact is predicted on housing or rental prices in Cloncurry.

Ability of Community to Live According to their Values

Pastoralism and mining have existed alongside one another for over 100 years in the Cloncurry region and it is an accepted historical and cultural background to the lifestyle and township of Cloncurry. Pastoralists that are affected by the Project will be duly compensated for any financial losses they may incur but their ability to live according to their values should be unaffected by the Dugald River Project.

MMG will continue ongoing consultation with the community through their community consultation group. This will allow MMG to identify any potential negative impacts and mitigate them accordingly. It will also allow MMG to identify potentially positive aspects of the Project and utilise or improve processes to pursue these. This will help to allow the local community to live according to their existing values and in some circumstances may help to improve values. MMG plan to utilise mutually beneficial relationships over the long term to achieve positive outcomes in the community.

The ability of Traditional Owners of the land on which the Project is located to live in accordance with their values and the protection of cultural heritage will be managed under a Cultural Heritage Management Plan agreed to by both the Traditional Owners and MMG. This process, the findings and the agreements reached are of a sensitive nature and will not be described in this report.

Technical and Professional Development Programmes

MMG are active in the development of technical and professional personnel through graduate and vacation employment schemes which are already active at existing operations, including the Century Mine in North West Queensland. These corporate programmes will continue during the operation of Dugald River.

Under the terms of the existing programme, students in relevant fields are eligible to apply for paid vacation positions at MMG site over the university summer vacation period. Graduates are able to apply to join the graduate employment scheme which is a two year programme for recent graduates involving workplace integration and mentoring services.

MMG also have scholarships available to selected students who have completed their first year of tertiary study in a field relevant to MMG operations. Relevant fields include Engineering (Mining, Electrical, Mechanical or Process), Earth Sciences, Metallurgy and Surveying.

Under the existing schemes, it is common that students and graduates from communities in which MMG operate are preferred candidates.

MMG supports post-graduate education and training for existing employees who wish to improve their qualifications. Where it will benefit the business, approved tertiary study is financially supported by the company, as an investment is training and skills of employees

Vocational Training Programmes

Whilst the Dugald River project will draw on existing skilled labour pools, it is intended that the project will play an active role in contributing to the development of the labour force with skills relevant to the operation and the resources industry as a whole. In addition to the normal operating needs of the site, the following roles are included in the proposed operations plan:

- 12 x Apprentices: mechanical and electrical trades in the mine and process plant;
- 12 x Trainees: additional operations roles for trainees in the mine and process plant; and
- 31 x Administrative, Technician and Services roles, of which a portion could be used for development and training.

It is anticipated that these roles could form the basis of potential development programmes which may be negotiated with the community and/or Traditional Owners. It is anticipated that such programme may be negotiated as part of the Native Title Agreements but, due to the confidential nature of these agreements, details will not be published in this report.

4.9.2.2 Cumulative Impacts

The impact of the Dugald River Project on the local community needs to be considered alongside the impacts of existing mines, and other proposed mines in the region, as many seemingly insignificant impacts created by individual mines, may accumulate into unforseen larger issues.

Cloncurry is a small town which is somewhat dependent on the mining industry, with 22.8% of the Cloncurry population are directly employed in the mining industry, and other industries such as transport, manufacturing and construction which provide services to the local mining industry.

The cumulative impacts of the Dugald River Project and other similar mining project on Cloncurry could include:

- The peripheral mining populations may draw some services from Cloncurry without contributing socially to the town;
- If many new mines open in the region it might encourage a non-local transient population to move to Cloncurry to work on the mines. This may result in an increasing the price of local housing/renting and strain on local services to the community; and
- The peripheral and transient population may increase crime, vandalism, violence and alcoholism in the community as Cloncurry will be treated as a 'stop over' rather than a 'home'.

MMG can minimise the impacts from the Dugald River Project on the Cloncurry community and ensure that the Project does not unnecessarily add to these potential cumulative impacts. MMG will maintain a community complaints database, investigate all community complaints, and implement mitigation strategies where needed.

No cumulative impact is predicted on crime rates or social dysfunction due to the limited reliance of the Project workforce on the existing community. This is due to the majority of the workforce being accommodated onsite and any personnel from Cloncurry will be existing residents. Onsite accommodation has sufficient facilities to sustain the workforce without relying on existing community infrastructure. There is also no predicted impact on vulnerable members of the community, due to the reasons stated above.

The Project may recruit a portion of the workforce locally, which will contribute further positive benefits to the community through wages and salaries.

4.9.2.3 Mitigation Strategies

The key mitigation strategies identified by the SEIA and SIMP are presented in Table 4.99. Each strategy has been allocated performance indicators and timeframes to facilitate the implementation process.

Table 4.99 SIMP Implementation Summary

Actions	Performance indicators	Timeframes *
Sustainable regional planning framework		
Work with government, industry and community stakeholders, through community consultative group (CCG) to develop regional plan to take advantage of synergies associated with close proximity of similar major projects	Community satisfaction with management of cumulative impacts	1 year Ongoing
Work with nearby resources projects to mitigate cumulative impacts on infrastructure, towns and businesses in the region	Community satisfaction with management of cumulative impacts	1 year Ongoing
In conjunction with the CCG, develop strategy, including community legacy program, to manage long-term impact of mine closure	Mine-closure impact management strategy in place	2 years

Actions	Performance indicators	Timeframes *
Local education, training and employment training strategy		
Implement local skills audit to establish baseline	Audit completion	6 months
Provide ongoing local training and employment opportunities (including apprenticeships and traineeships, as well as administrative, technical and services roles)	3-5% of employment for life of Project sourced locally	1 year
Local content plan/local business participation strategy		
Implement local business capacity audit to establish baseline	Audit completion	3 months
Develop and communicate fair and equitable prequalification guidelines to local businesses (i.e. minimum safety, environment and quality standards)	Minimum 5% local procurement for life of Project	6 months Ongoing
Work with business support entities such as DEEDI and ICN to maximise local business capacity for Project participation	Minimum 5% local procurement for life of Project	1 year Ongoing
Indigenous participation strategy		
Implement CHMPs in conjunction with Kalkadoon and Mitakoodi and Mayi groups	Industry-standard CHMPs in place All cultural heritage impacts mitigated in line with Kalkadoon and Mitakoodi and Mayi requirements, and government legislation	Before Project start-up Ongoing
Identify and implement ongoing Indigenous training and employment opportunities (including apprenticeships and traineeships, as well as administrative, technical and services roles)	5 indigenous traineeships per year Appropriate mentoring program in place to support Indigenous trainees/ employees	1 year Ongoing
Support development of Indigenous businesses through mentoring and/or procurement (also see “local content plan” above)	2% annual Project procurement from Indigenous businesses	1 year Ongoing
Allocate a share of MMG’s community investment program initiatives to Indigenous community organisations. (Focus on addressing poor socio-economic conditions outlined in SEIFA indexes)	20% of fund directed to Indigenous community service providers	1 year Ongoing
Land access/land use management strategy		
Implement regular communication process, including monthly landholder consultative group (LCG) meetings	Monthly LCG meetings	1 month Ongoing
In conjunction with local landholders, agree and implement land-access protocols and include these protocols in employee induction program	Landholder satisfaction with access procedures and how they are adhered to by Project employees 100% employees inducted in landholder-related protocols	Before Project start-up
Regularly and transparently monitor groundwater impact throughout the life of the Project	Number/nature of stakeholder enquiries/complaints Results reported to CCG and relevant	Before Project start-up Ongoing

Actions	Performance indicators	Timeframes *
	government authorities	
Implement progressive mine rehabilitation program	Rehabilitation targets set and achieved	Before Project start-up Ongoing
Extend access to employee assistance program (EAP) counselling to landholders	Landholder uptake of telephone counselling service (confidentiality maintained)	Project start-up
Community integration strategy		
Gain increased understanding of community values and lifestyle ideals through CCG	Community satisfaction with level of Project integration and contribution	6 months
Feed increased understanding into other SIMP initiatives, such as regional planning and community investment	Community satisfaction with level of Project integration and contribution	1 year
Facilitate Project integration into the community through participation in community and sporting organisations	Community satisfaction with level of Project integration and contribution 80% Project management participation in community organisations	6 months
Community investment program		
In conjunction with CCG, develop community investment program charter and processes	Community satisfaction with level of program transparency	6 months
Implement community investment opportunities through 'identification, evaluation and selection' process. (Focus on addressing poor socio-economic conditions outlined in SEIFA indexes)	Community satisfaction with level and type of investment	1 year
Ensure transparency of the program through annual reporting to CCG	Community investment report to at least one CCG per year	9 months Ongoing
Community health and safety strategy		
Implement comprehensive traffic management plan and accompanying community notification system	Zero traffic incidents Community satisfaction with notification times and information Community satisfaction with level of disruption	Before Project start-up Ongoing
Implement employee safety education and awareness programs	Zero traffic-related incidents	6 months
Establish self-sufficient onsite health service so as to ensure minimal impact on regional hospitals and health service providers	Limited use of local health services Community satisfaction with impact on local health services	2 months
Short-term accommodation strategy		
Within the CCG, work with surrounding proponents, CSC and local businesses to assess and identify solutions for Cloncurry's ongoing short-term accommodation needs	Availability of short-term accommodation (i.e. motels, caravans, etc)	1 year

Actions	Performance indicators	Timeframes *
Workforce accommodation strategy		
Reduce likelihood of occupational fatigue and diminished wellbeing associated with FIFO (Graham, 2000) by implementing family/community-friendly roster	Eight-days-on-six-days-off roster system implemented	Project start-up
Provide employees with high-quality 'home away from home' accommodation, including en-suited, air-conditioned rooms; structured wet mess; gymnasium, pool and tennis courts	Employee satisfaction with accommodation	Project start-up
Implement camp rules to maintain a cohesive and supportive 'home away from home'	Camp rules implemented Camp rules adhered to	Before Project start-up Ongoing
Employee relations strategy		
Provide fully subsidised employee assistance program (EAP) to support employees in their personal or work-related issues (includes phone access to qualified psychologists and social workers)	EAP communicated and made available to all employees	Project start-up
Employee induction program		
Develop comprehensive induction program to educate employees on local community standards and values; Indigenous history and traditions, community safety, land access and general behaviour	Number/nature of stakeholder enquiries/complaints	Before Project start-up
Implement and enforce employee code of conduct, both on the Project and within the community	Number/nature of stakeholder enquiries/complaints Community satisfaction with employee behaviour	Before Project start-up

Monitoring and Evaluation

MMG has developed a draft framework to provide structure and integrity in its monitoring and evaluation processes. The framework will measure performance indicators (see Table 4.99) against baseline SEIA data and progressive data. The latter will be sourced with support from the Queensland Government and Cloncurry Shire Council, as well as via ongoing Project evaluation tools, including:

- Stakeholder satisfaction surveys (distributed after milestones, meetings and events)
- Reference/committee/working group meeting minutes
- Enquiries/complaints reports (see Section 9), including close-out performance.

A sample framework is detailed below; however, the Project is committed to working with its stakeholders to finalise a mutually agreeable monitoring and evaluation process. In consultation with stakeholders, the framework will be in place within six months of Project start up and will be reviewed quarterly.

Table 4.100 Sample Monitoring Framework

Mitigation strategy	Performance indicator	Responsible	Monitoring tools
In conjunction with local landholders, agree and implement land-access protocols	Landholder satisfaction with access procedures and how they are adhered to by Project employees	CLO	Baseline SEIA data LCG meeting minutes Enquiries/complaints reports

MMG will implement annual reviews of this SIMP, in consultation with Project stakeholders, to assess:

- Delivery of actions within the specified timeframes;
- Effectiveness of those actions; and
- Improvement strategies to address any performance gaps.

Outcomes of these reviews, along with a compilation of quarterly social monitoring results, will be detailed in a report for the DIP Social Impact Assessment unit.

Dispute Resolution

Enquiries and complaints management will be handled using a variety of tools including the following:

- Community Liaison Officer – The Dugald River Project team will include the role of Community Liaison Officer (CLO) to oversee all stakeholder integration and communication processes. The part-time role, which is expected to be recruited for locally, will be responsible for implementing, monitoring, evaluating and reporting on the SIMP.

- Frequently Asked Questions – From SEIA research and ongoing liaison with Project stakeholders, frequently asked questions (FAQs) and responses will be developed to support the community enquiries/complaints process.

- Enquiries/complaints register – all stakeholder enquiries and complaints will be entered onto a register from which weekly reports will be generated for the Project Manager.

MMG's enquiries and complaints management process is outlined in Figure 4.90. If the enquiries/complaints process is unable to resolve a conflict between the Project and a key stakeholder, MMG will seek to take a collaborative conflict resolution approach to achieving a joint solution. This will include implementing a small working group comprising of complainant and Project management representatives, as well as the Community Liaison Officer, who will have training in the areas of conflict resolution and negotiation.

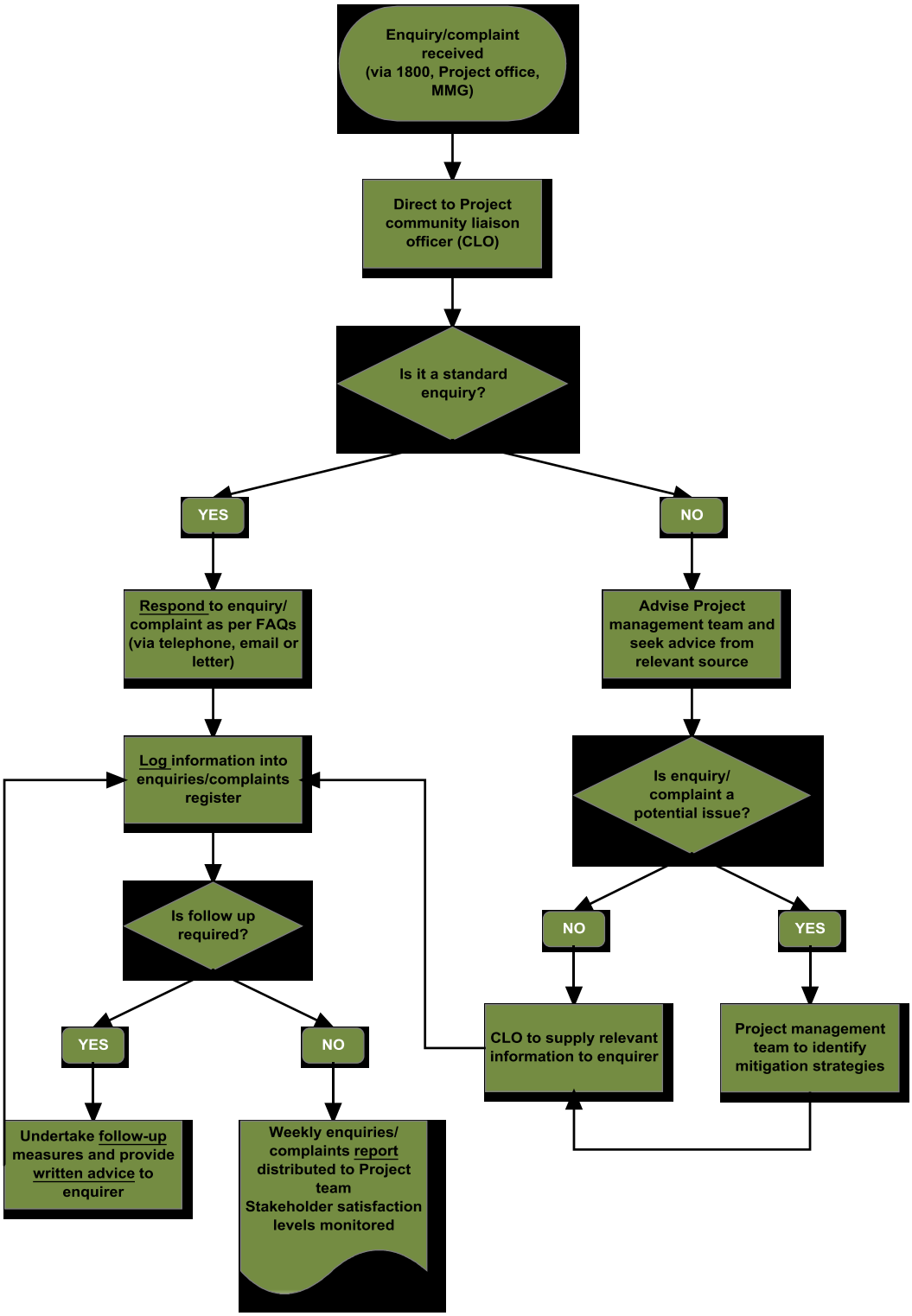

Figure 4.90 Enquiries/Complaints Management Process

4.10 HEALTH AND SAFETY

4.10.1 Description of Environmental Values

The establishment of a mine involves risks to the health and the safety of its employees and in some instances to those in the surrounding communities. It is therefore important that the risks involved in such an operation are minimised and managed through the application of standard procedures in combination with a legislative framework.

The existing community values for public health and safety include that the Project be managed in a manner to prevent impacts on public health and prevent accidents both on the Project site and in the surrounding community.

The closest sensitive receiver (the Roseby Homestead) lies 6 km south east of the processing area of the Project. The Roseby Homestead comprises several houses, sheds, cattle yards, an airstrip, and several groundwater bores. The Roseby Copper Project mining camp is proposed to be constructed 11 km to the north east of the processing area of the Project and will be the second closest sensitive receiver. Five other homesteads are located between 28-32 km from the Project. Other residences are located within the towns of Kajabbi and Quamby, more than 30 km from the boundary of the proposed Dugald River Project. The Project site lies approximately 65 km from central Cloncurry. Sensitive receivers are shown in Figure 4.91.

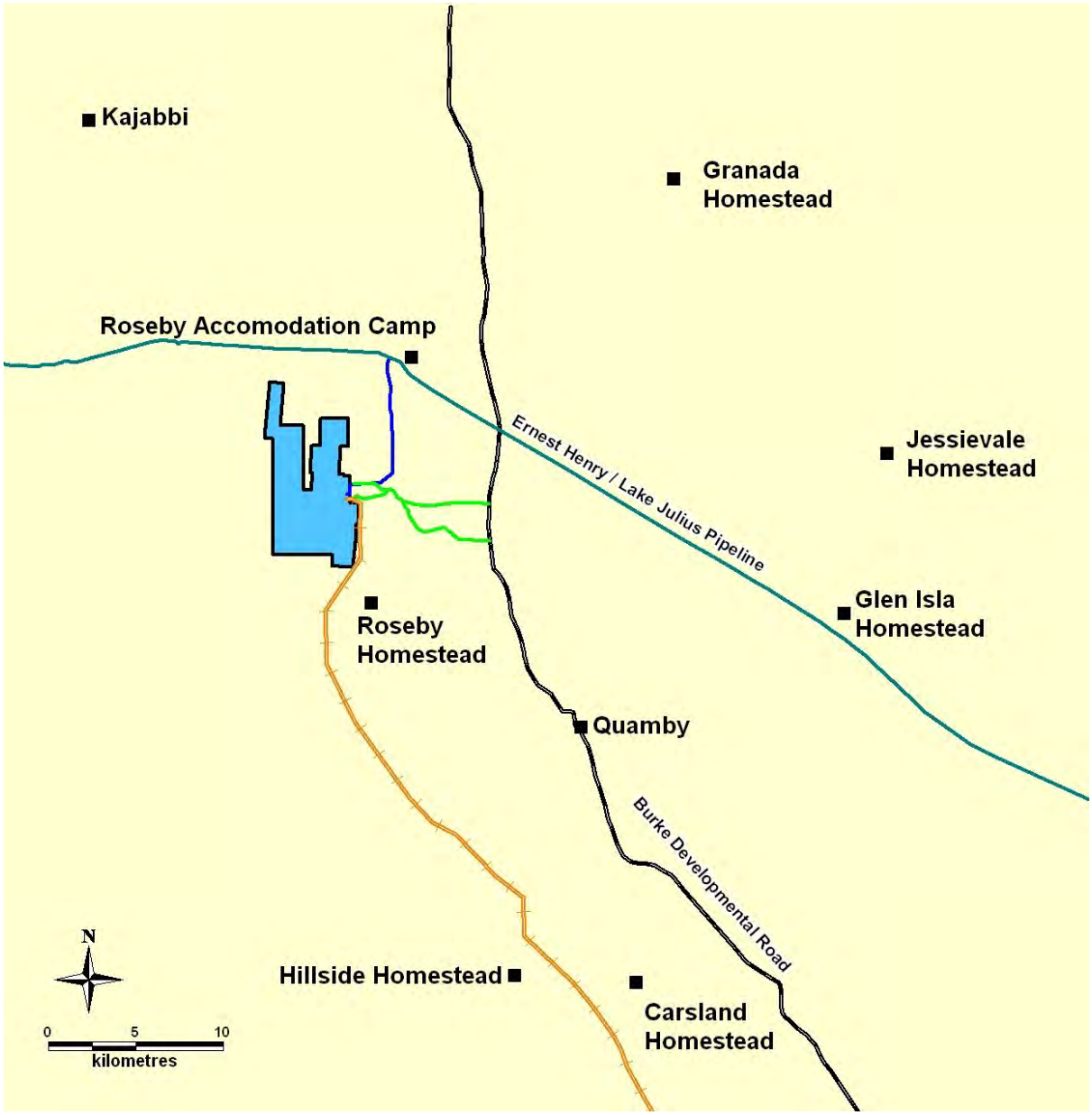

Figure 4.91 Location of Sensitive Receivers

4.10.2 Potential Impacts and Mitigation Measures

4.10.2.1 Potential Impacts

Existing community values and expectations of public safety and health that may be affected by the Project include:

- Road safety on public roads to and from the Project;
- The health and safety of employees due to the operation of the Project;

- Air quality impacts from the operations including from TSP dust, PM_{10}, dust, arsenic, cadmium and lead;
- Noise impacts from the Project;
- Spills of chemicals used on site (diesel fuel, oil and cyanide) causing land or waterway contamination off site;
- The release of contaminants in water discharges or stormwater from the Project;
- Food safety and hygiene in the accommodation camp on the Project;
- Providing appropriate health care and emergency care to employees on site; and
- Standing water storages on the Project may provide an environment for mosquito or biting midge populations.

Traffic will be increased along the Burke Developmental Road and on the heavy vehicle bypass of Cloncurry along Hensley Drive. Quad road trains carrying 105t load will be making 14 round trips from the mine site to Yurbi per day. A shuttle bus will travel between the Project site and the Cloncurry airport twice per day to transport staff members, and there will be an additional 6 traffic movements per day to transport materials and consumables to site. Overall the vehicle movements along the Burke Developmental Road for the Project constitute an increase of 15.96%. This may impact on road safety or the perception of road safety in Cloncurry.

With processing lead/zinc ore there is potential for lead particles (and other metals) to become airborne from the processing plant. There is also potential for lead or other metals to concentrate in the soil around the processing plant from these dust emissions. The results of the air quality assessment (Section 4.5) determined the levels of PM_{10}, $PM_{2.5}$, TSP, dust, cadmium, arsenic, manganese, nickel and lead at the Roseby Homestead (closest sensitive receiver) for three scenarios. These scenarios catered for background levels, operation of the Dugald River Project and combined operation of the Dugald River and Roseby Copper Projects. Combined levels, taking into account the background levels and Dugald River and Roseby Copper Projects, can be summarised as follows:

- 24-hour $PM_{2.5}$ concentration of 17.8 µg/m^3 and annual $PM_{2.5}$ concentration of 7.3 µg/m^3;
- 24-hour PM_{10} concentration of 63.2 µg/m^3
- TSP annual concentration of 62.6 µg/m^3;
- Annual concentrations of Lead 0.004 µg/m^3, Arsenic 0.054 ng/m^3, Cadmium 0.054 ng/m^3, Manganes 0.0014, Nickel 0.006 ng/m^3; and
- Annual concentration of dust 0.8 mg/m^2/day.

The levels were all well below suggested DERM goals and guidelines and do not pose a threat to human health at the closest sensitive receiver. The EPP(Air) objective for 24-hour average ground-level concentrations of PM_{10} is predicted to be exceeded at the Roseby Homestead in the later years of the Roseby Copper Project when the Roseby Copper Project operations are closer to the location of the homestead.

Noise modelling was also undertaken to predict noise levels at the Roseby Homestead (see Section 4.6). The noise levels at the Roseby homestead when the Dugald River Project is operational are expected to average 31 dB(A) which is well below the DERM suggested site specific noise criteria. As the predicted noise levels are well below the DERM proposed noise limits, it is considered likely that the cumulative impact of the Dugald River and the adjoining Roseby Copper Project will also comply with the criteria. DERM EcoAccess Design Noise Guideline levels are predicted to be met in the day, but exceedences are predicted to occur in the evening and night under particular meteorological conditions.

4.10.2.2 On Site Mitigation

As part of their Project planning, MMG will develop and implement a Health and Safety Policy, management plan and procedures prior to site establishment. This documentation will outline appropriate measures for all stages of the Project to ensure the health and safety of site personnel, contractors and members of the public. The Policy will ensure conformance with relevant legislation and standards including, but not limited to:

- *Mining and Quarrying Safety and Health Regulation 2001*;
- *Explosives Act 1999*;
- *Dangerous Goods Act 1985*;
- AS/NZ 4804:1997 Occupational Health and Safety Management Systems; and
- AS/NZS4360:2004 Risk Management.

The health and safety system on the Project will include:

- Comprehensive training programs ensuring that all employees, contractors and visitors understand individual responsibilities in order to maintain a safe workplace environment. Such training programs will include information on risk assessment, fire prevention and safe work practices. Personnel will also be trained in collective responsibilities across certain departments;
- Comprehensive on-site lead management strategies, including procedures for working safely with lead, prevention of lead contamination and safe disposal of lead contaminated products;
- Develop specific Health and Safety policies, procedures and practices to deliver appropriate health care and emergency care to employees on site;
- Protective clothing/devices that will be provided for use as required by standard procedures for site safety;
- Requirements for all equipment to be regularly serviced and deemed operationally safe before use;
- The requirement for all accidents and incidents, independent of their severity, to be reported and investigated by relevant authorities in order to prevent recurrence;

- Risks will be identified, assessed and reduced wherever possible through the risk assessment process; and

- Regular audits of health and safety procedures to ensure procedures are being followed by employees and to implement changes/improvements when required.

Safety procedures put place will include, but not limited to:

- Detailed instructions of responsibilities of all employees, contractors and visitors in order to maintain a safe workplace;

- Appropriate hygiene standards will be employed for all food preparation activities that are conducted on site, in order to ensure that food-borne ailments do not arise;

- Procedures for the use of personal protective equipment, including clothing and devices, which will be provided for employees;

- Special procedures will be developed for tasks where potential risks may occur;

- Procedures will be implemented to ensure adequate monitoring of workplace conditions including but not limited to, noise, inspirable and respirable dust, silica, lead and other chemicals used within the site;

- Clean in, clean out procedures for all mine and process plant employees to reduce the transfer of lead and other chemicals from the mining and processing area to the outside environment;

- Procedures to minimise standing water that is not part of the Project water management system to reduce the risk of midge/mosquito breeding on the Project site;

- Management Strategies and Safety Procedures, including the use and maintenance of bunds in chemical and hydrocarbon storage areas, to reduce the risk of contamination of soil, surface water or groundwater from hydrocarbon or chemical spills;

- Spillage Management Plan and an Emergency Plan for all hazardous materials stored on-site, together with a description of suitable equipment and training, must be updated and included with each Plan of Operations;

- Land contamination risks will be reduced by ensuring that all chemical and hydrocarbon storage facilities are appropriately bunded and spills cleaned up immediately;

- Procedures to ensure that all personnel will have relevant certificates, licences and authorisations for the tasks included in their work duties;

- Procedures and plans for the Implementation of emergency response; and

- Clearly stated safety rules which will include site specific road and traffic rules.

4.10.2.3 Off Site Mitigation

To limit the off site noise, air and water impacts of the Project on the health and safety of the surrounding community the following mitigation strategies will be implemented:

- Stormwater dams constructed downstream of mining and processing area will capture all spills and stormwater except for in extreme rainfall events and are discussed in Section 3.5.4;

- Air quality monitoring as required to confirm or evaluate the findings of the air quality assessment. The air quality assessment for the Project has determined that all legislative Air Goals can be met at the closest sensitive receivers for all pollutants, including PM_{10}, $PM_{2.5}$, TSP, dust, arsenic, cadmium, manganes, nickel and lead. For a full description of air quality modelling see Section 4.5 and Appendix N; and

- Noise monitoring as required to confirm or evaluate the findings of the noise and vibration assessment. Noise modelling for the Project has determined that the Dugald River Project will meet specific legislative noise criteria at the Roseby Homestead. During the evening and night under particular climatic conditions there is a risk of exceeding the noise guideline levels. Noise impacts and mitigation measures are discussed in Section 4.6 and Appendix P.

Road safety will be maintained in Cloncurry and surrounding the Project through the following:

- Use of the heavy vehicle bypass by the quad road trains to avoid congestion and large vehicle traffic in the Cloncurry town centre;

- Enforced speed limits set by DTMR and Cloncurry Shire Council to maintain road safety;

- Signage that the chosen route is a road train area;

- Department of Main Roads and Cloncurry Shire Council will be presented with the intended haulage route, volumes and changes in traffic movements for response on the adequacy of the roads to deal with the additional movements; and

- Traffic impacts and mitigation are discussed in Sections 3.5.1, 4.2.2.8 and Appendix F.

4.11 ECONOMY

4.11.1 Description of Economic Values

The existing local and regional economic environment of Cloncurry can be summarised as follows:

- Economic base and activity – the main economic activities in Cloncurry Shire include agriculture, forestry and fishing, mining, transport, postal, warehousing, public administration, construction and retail trade.

- The total value of regional agricultural production in 2005 – 2006 was $86.5 million, with agriculture, forestry and fishing industries employing about 17 percent of the regions labour force.

- The mining industry is also a major employer in the region, engaging about 13 percent of the labour force. Tourism also represents a significant economic activity in the region.

- Of the 330 businesses registered in the Cloncurry Shire Local Government Area in 2006 – 2007, 303 were small businesses, 24 were medium and three were large enterprises. This figure represents 0.1 percent of all businesses in Queensland. In terms of productivity, 54 of these businesses recorded turnovers in excess of $1 million.

- The unemployment rate for Cloncurry Shire is approximately four percent (Queensland Regional Profiles – Cloncurry Shire, 2006);

- Future economic opportunities – the following business sectors have been identified by Local Government as areas of economic opportunity for Cloncurry Shire; beef industry, mineral deposit exploration and alternative energy sources;

- Economic trends – Although pastoral activities have historically made a significant contribution to the local economy, the regional drought which has persisted over the last ten years (Cloncurry has experienced minimal rainfall for about six months of the year), has caused a significant decline in this industry. Improved weather conditions could lead to a rival of this industry;

- The local and regional decline in pastoral activities has been off-set by the productivity of the local mining industry, which is less susceptible to unpredictable rainfall events.

The potential impacts that the Project may have upon the local and regional economic viability are discussed in section 4.11.2.

Over the last 100 years, mining has provided significant economic benefits for the greater Mt Isa / Cloncurry region. The following large-scale mining operations (some of them the largest mines of their type in the world) have been operated over this period:

- Century Mine – owned by MMG, producing zinc;

- Cannington Mine – owned by BHP Billiton Minerals Pty Ltd, producing silver and lead

- Mount Isa Mines - owned by Xstrata PLC, producing copper, lead, zinc and gold;

- Phosphate Hill - owned by Incitec Pivot Limited, producing phosphate;

- Ernest Henry Mine - owned by Xstrata PLC, producing copper and gold;
- Osbourne Mine – owned by Barrick Limited, producing copper and gold;
- Mount Cuthbert Mine – owned by Cape Lambert, producing copper;
- Eloise Mine – owned by Barminco Pty Ltd, producing copper and gold; and
- White Range Mine – owned by Queensland Mining Corporation Limited, producing copper and cobalt.

These mines have made a significant contribution to the health of both local and regional businesses, as well as generating taxes and royalties for the State of Queensland.

4.11.2 Potential Impacts and Mitigation Measures

The Project's construction will result in a positive input into the local, Queensland and Australian economy of more than $700 million through the purchase of equipment, goods and services. During the operating phase of the Project, which is estimated to be approximately 23 years, industries associated with mining will be positively impacted through the provision of services, equipment and supply of consumables to the Project. The annual economic contribution is estimated to be $160 million in operating expenditure, and $35 million in taxes, subject to metal prices and production at the time.

The Project will produce zinc/lead/silver and copper concentrate suitable for export to overseas markets. In accordance with Queensland legislation the Proponent will pay mineral royalties to the Queensland Government for the right to mine the State's resources. These royalties are paid on an *ad valorum* (or value) basis, they are calculated as a percentage of the value of the mineral or petroleum as determined by the Minister. It is estimated that the Project will pay the State of Queensland an average of $14 million per year in royalties, depending on metal prices and production at the time.

The Project will not require the construction of any additional infrastructure by any level of government. MMG will engage the Queensland DTMR regarding maintenance costs of road infrastructure utilised by the Project. Further discussion of the Federal, State and local government infrastructure proposed to be used by the Project is provided in Section 3.5.1. A discussion of the impacts of the Project on regional infrastructure is discussed in Section 4.2.2.8 including road capacity and road maintenance.

Five landholders will be directly affected by construction of the Project and its associated infrastructure corridors on their land. MMG will negotiate compensation agreements with these directly affected parties.

The local economy of Cloncurry and Mount Isa is expected to benefit from the economic flow on effects of the Project through the provision of the following goods and services:

- Vehicle hire;
- Aviation services;
- Bus services;
- Concentrate transport;

- Light engineering;
- Road transport services;
- Fuel supply and transport;
- Training and personnel management services;
- Plant maintenance and fabrication services;
- Electricity supply from Mount Isa; and
- Water supply from Lake Julius.

The Project is also likely to have a positive impact on the establishment of additional new small businesses in Cloncurry and Mount Isa over time, to service the Project's needs.

Opportunities for direct or indirect equity investment in the Project are not available as MMG is an unlisted privately held company.

Economic impacts on the local township of Cloncurry and wider economy and community could be construed as adverse or beneficial depending on context. Potential impacts on the Cloncurry community and wider economy and community from the Project that are seen as beneficial could include:

- Economic benefit for the Project workforce through the employment of a maximum 795 personnel (lead/zinc and copper operations) both on site and off site;
- Training, graduate studies, vacation work and scholarship programs provided to employees and students;
- Indigenous employment and training opportunities will be negotiated under Native Title agreements with Traditional Owners;
- The Project's construction will result in a positive input into the local, Queensland and Australian economy of more than $700 million through the purchase of equipment, goods and services;
- During the operating phase of the Project, which is estimated to be approximately 23 years, industries associated with mining will be positively impacted through the provision of services, equipment and supply of consumables to the Project. The annual economic contribution is estimated to be $160 million in operating expenditure, $14 million in royalties and $35 million in taxes, subject to metal prices and production at the time;
- The contribution to the State of Queensland and average of $14 million per year in royalties, depending on metal prices and production at the time; and
- Economic benefits to the local economy from the use of the certain services in Cloncurry and Mount Isa to support the Project.

Potential impacts on the Cloncurry and wider economy from the Project that are seen as adverse could include:

- Local businesses and the local economy in Cloncurry will not directly benefit from the Project workforce in the supply of accommodation and meals etc, as the workforce will be accommodated on site;

- The owners of Mount Roseby Homestead will be impacted by the Project by reducing the area that can be used for grazing cattle on their property, due to the footprint of Project infrastructure; and

- Nearby residents may be impacted by nuisance caused by dust, noise, landscape alteration and changes to water flows or quality.

Mitigations strategies for the above potential adverse economic impacts would include:

- Consultation with local business on what services they may be able to provide to the Project and actively seek opportunities for local business to supply services that the Project requires;

- Regular consultation with landholders to identify nuisance issues and address concerns;

- Negotiation with, and compensation to landholders for the loss of land use;

4.12 HAZARD AND RISK

4.12.1 Description of Environmental Values

AARC conducted an Environmental and Social Risk Assessment of the Dugald River Project which is contained in Appendix X. The risk assessment was a preliminary review of risks based on the level of detail available for the Project at Feasibility stage. The risk assessment was based on the methodology provided in *AS/NZS ISO 31000:2009 Risk Management – Principles and Guidelines* and *HB203:2006 Environmental Risk Management Principles and Processes*.

A brainstorming session was conducted to conceptualise all the activities on the Project that may have potential to cause an environmental or social impact using a series of flow diagrams for construction, operational and decommissioning related activities. Process inputs, chemical storages and wastes were also included in these flow diagrams.

The environmental values likely to be affected that were assessed in this risk assessment can be broadly summarised as follows:

- Soil erosion/land values;
- Sedimentation of waterways;
- Vegetation communities;
- Fauna species;
- Habitat values;
- Biodiversity;
- Fauna movement;
- Noise and vibration levels;
- Air quality;
- Cultural Heritage;
- Grazing value for the landholder;
- Greenhouse gas emissions;
- Water quality;
- Waterway health;
- Groundwater quality;
- Liveability and visual amenity; and
- Social and lifestyle values of local community and of employees.

For a full description of impacts see Appendix X.

4.12.2 Potential Impacts and Mitigation Measures

The Risk Matrix used to define the level of risk for each environmental impact is shown in Table 4.101. The consequence values included an assessment of the likely impacts of the event on harm to the environment or the community, legal action, public/media attention and financial loss. Control strategies applied were based on current industry best practice for the region in which the Project occurs.

Table 4.101 Qualitative Risk Analysis Matrix – Level of Risk

Likelihood	Consequences				
	1 Catastrophic	2 Major	3 Moderate	4 Minor	5 Insignificant
A - Almost certain	E	E	E	H	H
B - Likely	E	E	H	H	M
C - Possible	E	E	H	M	L
D - Unlikely	E	H	M	L	L
E - Rare	H	H	M	L	L

Source: Environmental Risk Management – Principles and Process. HB 203:2006. (Standards Australia/Standards New Zealand, 2006).

In summary, 104 environmental and social risks where identified for the Project. Prior to applying management strategies, the following was the breakdown of the risks by risk ranking:

- 1 Extreme Risk;
- 26 High Risks;
- 24 Medium Risks; and
- 53 Low Risks.

Once mitigation strategies where applied the following was the breakdown of the risks by risk ranking:

- 1 High Risk;
- 6 Medium Risks; and
- 97 Low Risks.

The one extreme risk identified prior to applying management strategies was associated with surface water or groundwater contamination from waste rock dumps due to AMD and/or Neutral Mine Drainage during the operating phase of the Project. Management strategies identified to manage this potential environmental risk included:

- PAF waste rock that will be permanently stored on the surface will be encapsulated and compacted in NAF waste rock cells. Intermediate layers of NAF waste rock will be compacted over PAF materials to prevent exposure to oxidating conditions, especially prior to the wet season;
- No PAF waste rock will be disposed off under the outer waste rock dump slopes;
- The PAF waste rock dump will have a stormwater pond downstream to capture all stormwater runoff and will be designed for a 1:100 Year ARI, 2 month wet season;
- A compacted layer of NAF waste rock will form the base of the waste rock dump where PAF waste rock will be disposed;
- PAF waste rock that will be store temporarily on the surface will be stored on NAF waste rock pads, prior to being disposed of back underground. This area will have a stormwater pond downstream to capture all stormwater runoff and will be designed for a 1:100 Year ARI, 2,month wet season; Once underground mine development allows, the temporarily stored PAF waste rock will be disposed of underground on a regular basis; and
- Priority will be given to returning as much PAF waste rock underground as possible.

Once these management strategies had been applied the risk was re-ranked as low.

Once management strategies were applied to the 26 high risks, one risk remained as a high risk. This risk was associated with a wall failure of the TSF. Although the likelihood of this risk occurring is very low, should it happen the consequences would be major. The application of further mitigation strategies is unlikely to reduce the risk ranking further.

Once mitigation strategies were applied to the remaining high risks, four risks were re-ranked as medium and 22 risks were re-ranked as low. The four risks that were re-ranked as medium following mitigation strategies are as follows:

- Tailings stored in TSF causing:
    - Groundwater seepage and AMD leading to groundwater contamination; and
    - On overflow from the TSF leading to land and waterway contamination;
- Concentrate transport off site to Yurbi by truck causing a concentrate spill leading to land and/or waterway contamination; and

- Flooding of site in extreme event (cyclone) leading to overtopping the TSF and/or stormwater dams on site causing land and waterway contamination.

Mitigation strategies that were applied to the above risks during re-ranking included the following:

- Geotechnical investigation of the TSF base to ensure adequate impermeability to seepage.
- Reclaim TSF decant water for reuse in process plant.
- Capping and rehabilitation strategy for TSF on closure to prevent further oxidation of PAF tailings, seepage and capillary rise of salts;
- The TSF and major contaminated stormwater dams have been designed with a 1:100 Year ARI, 2 month wet season design storage capacity to prevent overtopping except in an extreme rainfall event; and
- Emergency response plan for cleaning up concentrate spills.

Of the 24 risks ranked as medium before mitigation strategies were applied, two remained as medium risks after mitigation strategies were applied. These aspects of the Project and associated risks were as follows:

- Ore feed to Primary Crusher and Stockpile causing noise nuisance at Roseby Homestead leading to complaints; and
- Ore feed to SAG mill and Ball Mill causing noise nuisance at Roseby Homestead leading to complaints.

The noise study has shown that noise limits at Roseby Homestead can be met during most meteorological conditions. Continuous noise monitoring at the homestead will be undertaken during construction and operations to determine actual levels of impact.

Mitigation strategies identified in the environmental and social risk assessment have been incorporated into the relevant sections of Section 4.0 (Environmental Values and Management of Impacts) and 5.0 (Environmental Management Plan) of this EIS and will become the basis for which Environmental Authority conditions are set for the Project. In this way nominated quantitative standards and indicators will be applied to meet the mitigation strategies identified and a system of monitoring and auditing will be implemented for the Project.

Once detailed design of the Project is complete and before construction commences, a review of the environmental and social risk assessment should be conducted and communicated to all relevant stakeholders. Should Project design changes occur during operations, then this risk assessment process should be repeated. A regular review of this risk assessment should also be conducted during the operating phase of the Project to ensure that it is still appropriate.

4.12.2.1 Chemical Inventory

Table 4.102 details the chemicals to be used in on-site and their associated dangerous goods information and permitting requirements.

Table 4.102 Dangerous Goods Inventory

Chemical Name	Concentration in Raw Material Chemicals	Concentration in Operation Storage Tank	U.N. Number	Packaging Group	Correct Shipping Name	Hazchem Code	Classification	Maximum Inventory of Each Substance	Rate of Usage
Lime	100%	15-20% w/w solids	1910	III	Calcium Oxide	-	8	200t	0.72 kg/t
Collector SIBX	100%	20% w/v solution	3342	II or III	Xanthates	1Y	4.2	72 hour solution tank	0.26 kg/t
NaCN	100%	20%w/w solution	1689	I	Sodium Cyanide	2X	6.1		0.25 kg/t
Frother – (MIBC)	100%	100%	2053	III	Methyl Isobutyl Carbinol	3Y	3	$29m^3$ Solution tank	0.50 kg/t
ANFO	-	-	0082	-	Explosives, Blasting, Type B	-	-	-	0.37 -0.53 kg/ stope t
Copper Sulphate	100%	15% w/v solution	3077	III	Environmentally Hazardous Substances, N.O.S.	2X	9	40 hour solution tank	0.93 kg/t
Ammonium Nitrate prills	98-100%	-	1942	II	Ammonium Nitrate	-	5.1	-	-

Under Section 238 of the Queensland *Health (Drugs and Poisons) Regulation 1998* it is an offence to obtain, possess or use cyanide without endorsement under the act, or a cyanide licence. MMG will apply to the chief executive to use sodium cyanide in processing.

The transport, storage, use, handling and on-site movement of the materials listed above will be conducted according to MMG's internal occupational health and safety standard for hazardous materials to ensure that employee and public risk associated with hazardous materials is managed to the lowest practicable level. Hazardous materials will be transported and stored in compliance with all relevant statutory requirements. The Dugald River Project will conform to the following mininmum requirements:

- Risk assessments will be conducted to determine the level of risk to public safety and environmental impacts resulting from the transportation and storage of hazardous materials
- Hazardous material transport equipment will be regularly inspected and maintained
- Transport service providers will need to demonstrate the competencies required to transport hazardous materials based on statutoty and organisational requirements
- Implement hazardous materials practices which address storage, bunding, containment, leak detection and compatibility of chemicals; and
- Utilise signs and labels for transport, storage and handling

Bunds around storage tanks will be built and sized in accordance with applicable legislative requirements and Australian Standards.

All explosives will be stored safely in explosive magazines and transported in authorised vehicles.

4.12.2.2 Spillage and Emergency Management

A Spillage and Emergency Management Plan will be included in site induction and training programs for staff and contractors. The Spillage and Emergency Management Plan will include the use of best practice techniques to control, clean up and remediate any spills that may occur on the Project site.

All requests to purchase and/or bring chemicals or hazardous materials onto the Project will be reviewed and approved by the MMG site management. MMG site management will be responsible for obtaining MSDSs for all chemicals prior to them being transported onto the site. Responsibility extends to the co-ordination of transport and storage of all hazardous materials and other chemicals according to the procedures detailed on the relevant MSDSs. Site management will also be responsible for keeping the MSDS database up to date and ensuring all copies of the relevant MSDSs are kept near all chemical storage areas.

All spills of hazardous materials will be cleaned up appropriately and disposed of in a manner as determined by the relevant MSDSs. Professional advice on spillage management, clean up and disposal will be sought where necessary from the emergency services, the Mount Isa DERM or environmental specialists. Should the spill pose a fire threat or a threat to human life, then the relevant emergency services will be contacted without delay by calling 000.

The internal and external reporting of a spill of hazardous materials is based on the following criteria:

- The amount of substance spilt; and
- If the spill has caused or may cause an environmental impact.

The following provides guidance on reporting spills as formulated to comply with Environmental Duties under the EP Act:

- All spills in excess of 20 L, or kilograms, shall be internally reported;
- All spills of hazardous materials that have impacted the environment outside of the Project leases will be reported internally and externally to DTMR and DERM within 24 hours; and
- If a spill on the Project has occurred and it has caused environmental harm or has the potential to cause environmental harm, or the spill is of a quantity greater than either 1,000 L or 1 t, the spill will be reported internally and externally to the administering authority within 24 hours.

Advice will be requested from DTMR, DERM and/or specialist consultants regarding any remediation or rehabilitation of any areas impacted by a spill.

Table 4.103 details the procedure to be followed in the case of a spill of a hazardous substance.

Table 4.103 Procedure for Spill of Hazardous Substance

Emergency Situation	Equipment	Procedure
Diesel, oil, or other chemical spill causing or potentially causing environmental harm on or off the Project site.	• Adequate quantities of inert absorbent material, e.g. sand, fuller's earth or suitable proprietary substances; • Calcium hydroxide (hydrated lime), for use on acidic spills; • Sodium bisulfate, for use with alkaline spills; • Crushed calcium carbonate (limestone); • A sufficient number of resealable waste-recovery containers, e.g. drums, made of materials compatible with the substances being handled and appropriately marked as being for emergency use only; • Portable pumps and decanting equipment; • A front end loader, bob cat or shovels may be used to bund or absorb large spills with soil or sand from the Project; and • Should a large amount of free spilt liquid need to be recovered from a bund then a suction truck or similar will be used to recover this liquid.	• Stop leak or spill at source, contain spilled materials and protect the area (if possible to do without risking contact or exposure to chemical or otherwise risking personal safety); • Should the spill pose a fire threat or a threat to human life contact emergency services without delay on 000; • Report spill to MMG site management; • Review MSDSs for the spilled chemical, and advise of any precautions for safe handling of the spilled material or disposal of the material (e.g. protective clothing); • Absorb spill using absorbent pads, inert absorbent material, or for large spills use soil or sand. Dispose of the contaminated material as per MSDSs requirements. For large spills consult environmental specialist or the Mount Isa DERM; • Report spill to Mount Isa DERM and DTMR within 24 hours if necessary; and • Remediation and rehabilitation to be carried out in consultation with DTMR, DERM and/or specialist consultants for any areas affected by spills.

4.13 CROSS-REFERENCE WITH THE TERMS OF REFERENCE

Table 4.104 Cross Reference with Terms of Reference

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
	Executive Summary	The function of the executive summary is to convey the most important aspects and options relating to the project to the reader in a concise and readable form. It should use plain English and avoid the use of jargon and esoteric terms. The structure of the executive summary should follow that of the EIS, and focus strongly on the key issues and conclusions.		
	Glossary of Terms	A glossary of technical terms, acronyms and abbreviations should be provided.		
1.0	**Introduction**	The function of the introduction is to explain why the EIS has been prepared and what it sets out to achieve. In particular, the introduction should address the level of detail of information required to meet the level of approval being sought (for example, whether the proponent is seeking only a preliminary approval or a full approval with all permits). It should also define the audience to whom it is directed, and contain an overview of the structure of the document. Throughout the EIS, factual information contained in the document should be referenced.	1.0	
1.1	**Project Proponent**	Provide details of the project proponents, including details of any Joint Venture partners.	1.1	
1.2	**Project Description**	A brief description of the key elements of the project should be provided and illustrated. Any major associated infrastructure requirements should also be summarised and mapped. Detailed descriptions of the project should follow in Section 3. A brief description should be provided of studies or surveys that have been undertaken for the purposes of developing the project and preparing the EIS. This should include reference to relevant baseline studies or investigations undertaken previously.	1.2	Figures 1.1, 1.2, 1.3, 1.4
1.3	**Project Objectives and Scope**	Provide a statement of the objectives which have led to the development of the project and a brief outline of the events leading up to the project's formulation, including alternatives, envisaged time scale for implementation and project life, anticipated	1.3	Table 1.1, 1.2

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		establishment costs and actions already undertaken within the project area. Describe the current status of the project and outline the relationship of the project to other developments or actions that may relate whether or not they have been approved. The consequences of not proceeding with the project should also be discussed.		
1.4	**The EIS Process**	The purpose of this section is to make clear the methodology and objectives of the Environmental Impact Statement (EIS) under the relevant legislation.	1.4	
1.4.1	**Methodology of the EIS**	This section should provide a description of the EIS process steps, timing and decisions to be made for relevant stages of the project. This section should also indicate how the consultation process (which will be described in detail in section 1.5) would integrate with the other components of the impact assessment, including the stages, timing and mechanisms for public input and participation. The information in this section is required to ensure: • relevant legislation is addressed; • readers are informed of the process to be followed; and • stakeholders are aware of any opportunities for input and participation.	1.4.1	Figure 1.5
1.4.2	**Objectives of the EIS**	Having described the methodology of the EIS, a succinct statement should be made of the EIS objectives. The structure of the EIS can then be outlined as an explanation of how the EIS will meet its objectives. The reader should be able to distinguish the EIS as the key environmental document providing advice to decision makers considering approvals for the project. In addition, it is essential that the main text of the EIS should address all relevant matters concerning environmental values, impacts on those values and proposed mitigation measures. When considering whether an impact is or is not significant, the proponent should take account of both the intensity of the impact and the context in which it would occur. In brief, the EIS objectives should be to provide public information on the need for and likely effects of the project, to set out acceptable standards and levels of impacts (both	1.4.2	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		beneficial and adverse) on environmental values, and demonstrate how environmental impacts can be managed through the protection and enhancement of the environmental values. Discussion of options and alternatives and their likely relative environmental management outcomes is a key aspect of the EIS. The cumulative impacts of the proposal must be considered over time or in combination with other (all) impacts in the dimensions of scale, intensity, duration or frequency of the impacts. This assessment may include air and water sheds affected by the proposal and other proposals competing for use of the local air and water sheds.		
1.4.3	**Submissions**	The reader should be informed as to how and when public submissions on the draft EIS will be addressed and taken into account in the decision-making process. Interested and Affected Persons should be made aware of how submissions on the EIS will be addressed and taken into account in the decision making process. The EIS should inform the reader about how to make submissions, provide contact details and what form the submissions should take; and when submissions must be made to gain standing for any appeal process.	1.4.3	
1.5	**Public Consultation Process**	This section should outline the methodology that will be adopted to identify and mitigate socio-economic impacts of the project. Information about the consultation that has already taken place and the results of such consultation should be provided. The submission of a list of affected persons and interested persons as well as a statement of how the proponent proposes to consult with those persons is a statutory requirement of the EIS process in the Environmental Protection Act 1994 (See section 7).	1.5	Table 1.3, 1.4
1.6.1	**Project Approvals**	This section should explain the legislation and policies controlling the approvals process. Reference should be made to the Queensland Environmental Protection Act 1994, Integrated Planning Act 1997 and other relevant Queensland laws. Any requirements of the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC) should also be included. Local Government planning controls, local laws and policies applying to the development should be described, and a list provided of the approvals required for the	1.5.1	Table 1.5, 1.6

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		project and the expected program for approval of applications. This information is required to assess how the legislation applies to the proposal, which agencies have jurisdiction, and whether the proposed impact assessment process is appropriate.		
1.6.2	**Planning Processes and Standards**	This section should discuss the project's consistency with existing land uses or long-term policy framework for the area (e.g. as reflected in local and regional plans), and with legislation, standards, codes or guidelines available to monitor and control operations on site. This section should refer to all relevant State and regional planning policies. This information is required to demonstrate how the proposal conforms to State, regional and local plans for the area.	1.5.2	
1.7	**Accredited Process for Controlled Actions**	It is not considered likely that this Project will impact on matters of National Environmental Significance, however if at a later stage, an impact on NES is anticipated the Commonwealth assessment process will be employed.	1.6	
2.1	**Project Justification**	The justification for the project should be described, with particular reference made to the economic and social benefits, including employment and spin-off business development, which the project may provide. The status of the project should be discussed in a regional, State and national context. The justification needs to be balanced with potential for negative environmental and social impacts.	2.1	
2.2	**Alternatives to the Project**	Describe feasible alternatives, including conceptual, technological and locality alternatives to the project, and discussion of the consequences of not proceeding with the project. Alternatives should be discussed in sufficient detail to enable an understanding of the reasons for preferring certain options and courses of action and rejecting others. Comparative environmental impacts of each alternative should be summarised. The interdependencies of the proposal components should be explained, particularly in regard to how each of any industrial developments, or various combinations of industrial developments, and any infrastructure requirements relate to the viability of the proposal.	2.2	Figure 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7. Table 2.1

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		Should water supply, power, transport and/or storage infrastructure be included as an element of the proposal, this section should include a description of and rationale for such infrastructure. Reasons for selecting the preferred options should include technical, commercial, social and natural environment aspects. In particular, the principals of Ecologically Sustainable Development (ESD), best practice environmental management and sustainable development should be included. The relationship of options chosen for waste management and any emissions produced should be detailed.		
3.0	**Description of the Project**	The objective of this section is to describe the project through its lifetime of construction and operation and decommissioning. This information is required to allow assessment of all aspects of a proposal including all phases of the proposal from planning, construction and operation through to decommissioning and post closure. It also allows further assessment of which approvals may be required and how they may be managed through the life of the proposal. The location of the study area for the EIS should be clearly defined and described in maps at suitable scales. This area should include the location of all on site works and activities, areas of proposed buffers and areas where off-site impacts or influences from the proposed project may occur and will be investigated.	3.0	
3.1.1	**Regional Context**	The regional context of the proposal should be described and illustrated on maps at suitable scales.	3.1.1	Figure 3.1
3.1.2	**Local Context**	The local context of the proposal should be described and illustrated on maps at suitable scales. Real property descriptions of the Project site should be provided. Local context information to be provided will include: • Land tenures; • Present land uses and Planning Scheme zonings; • Surrounding industries and other land uses; • Features of State and National environmental Significance;	3.1.2	Figure 3.2, 3.3, 3.4, 3.5, 3.6, 3.7, 3.8, 3.9

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		• Photo images at appropriate scales; and • The location of any transport corridors such as roads, power lines and pipelines.		
3.2	**Construction**	The extent and nature of the project's construction phase should be described. The description should include the type and methods of construction, the construction equipment to be used and the items of plant to be transported onto the construction site. Any staging of the proposal should be described and illustrated showing site boundaries, development sequencing and timeframes.	3.2	Figure 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21, 3.22 Table 3.1, 3.2,
3.3	**Operations**	The location and nature of the processes to be used should be described in the text and illustrated with maps, diagrams and artist's impressions as required. Operational issues to be addressed should include, but may not be limited to: • a description of plant and equipment to be employed; • the capacity of plant and equipment, and • chemicals to be used. Concept and layout plans should be provided highlighting proposed buildings, structures, plant and equipment associated with the processing operation. The nature, sources, location and quantities of all materials to be handled, including the storage and stockpiling of raw materials, should be described. Indicative process flow-sheets should be provided showing material balances for the processing plant, and the anticipated rates of inputs, along with similar data on products, wastes and recycle streams.	3.3	
3.3.1	**Location and Tenure**	Maps at suitable scales should be provided showing the precise location of the project area, and in particular: • the location and boundaries of land tenures, in place or proposed, to which the project area is or will be subject;	3.3.1	Figure 3.23, 3.24, Table 3.3, 3.4,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		• the location and boundaries of the project footprint showing all key aspects including excavations, stockpiles, areas of fill, watercourses, plant locations, water storages, buildings, bridges, culverts, hardstands, car parks, etc; and • the location of any proposed buffers surrounding the working areas. Consideration should be given to providing a rectified air photo enlargement to illustrate components of the project in relation to the land and mining tenures and natural and built features of the area. A recent (<2 years old) rectified photo enlargement must be included.		
3.3.2	**Mine Life and Resource Base**	Specific details should be provided of the following: • the proposed mine life and an outline of the mineral resource base (further detail should be provided in section 4.2.1.2, Geology); and • the quantity of mineral to be mined annually including any proposed ramping of production or staging of development.	3.3.2	Figure 3.25 Table 3.5
3.3.3	**Mining Methods and Equipment**	Specific details should be provided of the following: • the mining type and methods to be used, including the major equipment to be used in the various components of the operation; • the use of different techniques in areas of different topographic or geo-technical character; and • chemicals to be used. The description should refer to, and be complemented by, the figures previously presented in section 3.3.1 showing the locations of key aspects of the project. Additional figures should be provided if required.	3.3.3	Figure 3.26, 3.27 Table 3.6, 3.7, 3.8
3.3.4	**Mine Sequencing**	Specific details should be provided of the following: • the proposed sequence and timing of mining of each ore body within the mining lease;	3.3.4	Figure 3.28 Table 3.9

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		• The physical extent of excavations, location and detailed design of stockpiles and or dumps of waste rock and/or mineral reject to be handled during the project's operation or left after mining ceases. The description should include the rate of throughput of stockpiles of product, reject and waste rock; • The proposed progressive backfilling of excavations; and • The area proposed to be disturbed at each major stage of the project; and • Information should also be provided on the sequencing of post closure and rehabilitation. Information should also be provided on the workforce numbers to be employed in the facility's operations during its various phases (construction, commissioning, operation and decommissioning) and stages with a brief description of where those people may be accommodated and/or how they will be transported to the site. Comment should be made on the anticipated basis of employment (permanent, contract, etc).		
3.3.5	**Processing and Products**	This section should describe the quantities and characteristics of the products produced on an annual basis. Indicative process flow-sheets should be provided showing material balances for the processing plant, and the anticipated rates of inputs, along with similar data on products, wastes and recycle streams.	3.3.5	Figure 3.29, 3.30, 3.31, 3.32, 3.33 Table 3.10, 3.11
3.3.6	**Ongoing Evaluation and Exploration Activities**	This section should describe the extent and nature of any proposed ongoing exploration or geological/geo-technical evaluation within the project area that may be required over the life of the project.	3.3.6	
3.4	**Product Handling**	Describe and show on plans at an appropriate scale, the proposed methods and facilities to be used for product storage and for transferring product from the processing plant to the storage facilities and from the storage facilities to the transport facilities. Include discussion of any environmental design features of these facilities including bunding of storage facilities.	3.4	Figure 3.34, 3.35
3.5	**Infrastructure Requirements**	This section should provide descriptions, with concept and layout plans, of requirements for constructing, upgrading or relocating all infrastructure in the vicinity of the project	3.5	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		area. The matters to be considered include such infrastructure as roads, rail, bridges, tracks and pathways, dams and weirs, bore fields, power lines and other cables, wireless technology (e.g. microwave telecommunications), and pipelines for any services (whether underground or above).		
3.5.1	**Transport**	Describe arrangements for the transport of plant, equipment, products, wastes and personnel during both the construction phase and operational phases of the project. The description should address the use of existing facilities and all requirements for the construction, upgrading or relocation of any transport related infrastructure. Provide details of proposed use of rail for transport of materials, products or wastes to or from the Project site. In relation to shipping of products, details of the number of ships and their size should be documented. Provide drawings of proposed new accesses onto any State-Controlled Road. Any required road works are to be in accordance with Main Roads "Road Planning and Design Manual. Information should be provided on road, rail, sea and air transportation requirements for both construction and operations phases.	3.5.1	Figure 3.36, 3.37, 3.38, Table 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 3.20, 3.21
3.5.2	**Energy**	The EIS should describe all energy requirements, including electricity, natural gas, and/or solid and liquid fuel requirements for the construction and operation of the proposal. The locations of any proposed easements or mining lease corridors should be shown on the infrastructure plan. Energy conservation should be briefly described in the context of any Commonwealth, State and local government policies.	3.5.2	Figure 3.39, 3.40 Table 3.22
3.5.3	**Water Supply and Storage**	The EIS should provide information on water usage by the project, including the quality and quantity of all water supplied to the site. In particular, the proposed and optional sources of water supply should be described (e.g. bores, any surface storages such as dams and weirs, municipal water supply pipelines). Estimated rates of supply from each source (average and maximum rates) should be given. Any proposed water conservation and management measures should be	3.5.3	Figure 3.41, 3.42

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		described. Determination of potable water demand should be made for the project, including the temporary demands during the construction period. Details should be provided of any existing town water supply to meet such requirements. If water storage and treatment is proposed on site, for use by the site workforce, then this should be described. A description of the testing and treatment regime for potable water should be documented. Reference to Australian Drinking Water Guidelines is recommended.		
3.5.4	**Stormwater Drainage**	A description should be provided of the proposed stormwater drainage system and the proposed disposal arrangements, including any off-site services. Provide a description and map of the proposed mine and processing plant stormwater drainage system and the proposed disposal arrangements, including any off-site discharge points. This should include the consideration of placement of waste rock dumps and tailing storage and/or disposal site(s) with relation to natural drainage lines. The need for and design of sediment control structures downstream of disturbance areas and strategies for diverting clean water away from disturbed or contaminated areas should be described. If roads, pipelines or other infrastructure are proposed to cross-waterways on the project then this infrastructure and its design should be discussed in this section. Provide a description of the contaminants of concern on the project.	3.5.4	Figure 3.43, 3.44, 3.45, 3.46 Table 3.23, 3.24, 3.25, 3.26
3.5.5	**Sewerage**	This section should describe, in general terms, the sewerage infrastructure required by the project. If it is intended that industrial effluent or relatively large amounts of domestic effluent are to be discharged into an existing sewerage system, an assessment of the capacity of the existing system to accept the effluent should be provided in Section 4.3 'Waste'. For industrial effluent, this should include detail of the physical and chemical characteristics of the effluent(s). Provide an assessment of impacts from the selected disposal option (i.e. irrigation / discharge) on the receiving environment. The daily quality and quantity must be identified and QLD recycling guidelines taken into consideration.	3.5.5	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
3.5.6	**Telecommunications**	The EIS should describe any impacts on existing telecommunications infrastructure (such as optical cables, microwave towers, etc.) and identify the owners of that infrastructure.	3.5.6	
3.5.7	**Accommodation and other Infrastructure**	A description should be provided of any other developments directly related to the project not described in other sections, such as: • Accommodation options and locations under consideration (on site and off site); • Processing options under consideration if not mentioned elsewhere; • Fuel storage areas; • Equipment hardstands and maintenance area; and • Technical workshops and laboratories.	3.5.7	Figure 3.47, 3.48 Photo Plate 3.1
3.6.1	**Character and Quantities of Waste Materials**	Provide an inventory of all wastes to be generated by the proposal during the construction, operational and decommissioning phases of the project. In addition to the expected total volumes of each waste produced, include an inventory of the following per unit volume of product produced: • the tonnage of raw materials processed; • the amount of resulting process wastes; and • the volume and tonnage of any re-usable by-products. Having regard for best practice waste management strategies and the Environmental Protection (Waste) Policy, the proposals for waste avoidance, reuse, recycling, treatment and disposal should be described in the appropriate sub-section below. Information should also be provided on the variability, composition and generation rates of all waste produced at the site and processing plant. Cleaner production waste management planning should be detailed especially as to how these concepts have been applied to preventing or minimising environmental impacts at each stage of the proposal. Details on natural resource use efficiency (e.g. energy and water), integrated processing design, co-generation of power and by-	3.6.1	Figure 3.49 Table 3.27, 3.28,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		product reuse as shown in a material/energy flow analysis should be presented.		
3.6.1.1	**Air Emissions**	Describe in detail the quantity and quality of all air emissions (including particulates, fumes and odours) from the project during construction and operation. Particulate emissions include those that would be produced by any industrial process, or disturbed by wind action on stockpiles and conveyors, or by transportation equipment (e.g. trucks, either by entrainment from the load or by passage on unsealed roads). Emissions should include point source emissions and fugitive emissions for the Project area. The methods to be employed in the mitigation of impacts from air emissions should be described in section 4.6.	3.6.2	Table 3.29, 3.30, 3.31
3.6.1.2	**Excavated Waste**	This section should describe and show the location, design rationale (e.g. why is it being constructed in this way) and methods for constructing dumps for waste rock. The location of the dumps should be shown on a map relative to topography and other natural features of the area including geology, geological structures (e.g. faults, springs / wetlands). The following should be detailed and discussed: • an estimated tonnage and/or volume of waste rock to be produced annually and during the life of the project; • Details of methodology and results of waste rock characterisation that includes the potential quantity, variability and net acid producing potential of the mined waste rock material through static testing (metals analysis, sulphides, pH, conductivity, net acid generation (NAG) and acid neutralising capacity (ANC), etc), and tests that show likely outcomes under field conditions for example, kinetic testing where waste rocks are likely to generate acid. Sampling should be representative with profiles of all geological units included and based on accepted statistical procedures. The sample regime and testing methodology to be used should take into account recognised guidelines such as those issued by Environment Australia (1997) and the US EPA (1992) and DME Technical Guidelines (1995) to demonstrate confidence in characterisation data for each geological unit; Characterisation should also specify the PAF / NAF tonnage	3.6.3	Figure 3.50, 3.51, 3.52, 3.53 Table 3.32, 3.33, 3.34, 3.35, 3.36, 3.37, 3.38, 3.39

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		and any associated mineralisation; • the timing of the generation of different waste types and their placement; • evaluation of various methods of waste rock disposal including the design details for those methods such as treatment, materials blending (or mixing or co-disposal with tailings) capping, lining, encapsulation, and configuration and justification for chosen method(s); • Provide details of any contingency planning for failure of management systems. Describe how back up systems will be implemented (e.g. catchment of WRD reports to pit void); • measures to ensure geotechnical stability of the waste dumps, particularly the management of drainage; and • Provide a description of how acid mine drainage or neutral mine drainage will be addressed.		
3.6.1.3	**Tailings Disposal**	This section should describe the tailings waste produced by preparation and/or processing plants and the proposed methods for its disposal. Describe alternative options for tailings disposal including the proposed location, site suitability and volume of any tailings storage and/or disposal site(s), including the method of construction. Describe the approximate quantity of tailings to be produced by the project and its processing plant annually for the life of the mine. Tailings characterisation information should also be presented in this section Describe the timing and staging for development of each tailings storage and/or disposal site to accommodate the life-of-mine tailings production. Describe the strategies to monitor and manage seepage into ground and surface waters taking into account inferred hydraulic conductivity and fractured rock in the location. The location of the storage and/or disposal site with regard to adjacent creeks and rivers should be described. Describe the proposed capping design and rehabilitation strategy of the tailings disposal facility.	3.6.4	Figure 3.54, 3.55, 3.56, 3.57, Table 3.40, 3.41, 3.42, Photo Plate 3.2
3.6.1.4	**Solid Waste**	Describe the quantity and quality of solid wastes other than waste rock and tailings, and	3.6.5	Figure 3.58,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
	Disposal	the proposed methods of their disposal. The proposed landfill location options, site suitability, dimensions and volume of any landfill and how it will be managed and monitored, including its method of construction, should be shown.		
3.6.1.5	**Liquid Waste**	A description should be presented of the origin, quality and quantity of wastewater and any immiscible liquid waste originating from the project. Particular attention should be given to the capacity of wastes to generate toxic, acid, and saline or sodic wastewater. A water balance for the project and processing plant is required to account for the estimated usage of water. Detail how wastewater discharges are avoided, minimised, recycled and treated as much as practicable as required under Section 15 of the Environmental Protection (Water) Policy 1997.	3.6.6	
3.7	**Rehabilitation and Decommissioning**	This section should describe the options, strategies and methods for progressive and final rehabilitation of the environment disturbed by the proposal. The strategies and methods presented for progressive and final rehabilitation of disturbed areas should demonstrate compliance with relevant government guidelines. Land suitability assessment should follow the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland, 1995, considering Best Practice environmental management. Provide a description of infrastructure that is proposed to be left for landholder post mine land use. Provide a description of the process that will be used for reaching agreement on which infrastructure will remain post mine life. The means of decommissioning the project, in terms of the removal of plant, equipment, structures and buildings should be described, and the methods proposed for the stabilisation of the affected areas should be given. A description of selective overburden/waste rock material handling requirements necessary to ensure construction of rehabilitated landform soil profiles with desirable physical and chemical properties should be presented. A description of topsoil management should consider transport, storage and replacement of topsoil to disturbed areas.	3.7	Figure 3.59, Table 3.43, 3.44, 3.45,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		Where dams are to be constructed, proposals for the management of these structures after the completion of the project should be given. A description should be given of the removal of any waterway barriers that will not be required after the cessation of mining operations.		
4.0	**Environmental Values and Management of Impacts**	The functions of this section are: • to describe the existing environmental values of the area which may be affected by the proposal; • to describe the potential adverse and beneficial impacts of the proposal on the identified environmental values. Any likely environmental harm on the environmental values should be described; • to describe any cumulative impacts on environmental values caused by the proposal, either in isolation or by combination with other known existing or planned sources of contamination; • to present environmental protection objectives and the standards and measurable indicators to be achieved; • to examine viable alternative strategies for managing impacts; and • This section should detail the environmental protection measures incorporated in the planning, construction, operations, decommissioning, rehabilitation and associated works for the proposal. Measures should prevent, or where prevention is not possible, minimise environmental harm and maximise socio-economic and environmental benefits of the proposal. Preferred measures should be identified and described in more detail than other alternatives.	4.0	
4.1	**Climate**	This section should describe the rainfall patterns (including magnitude and seasonal variability of rainfall), air temperatures, humidity, wind (direction and speed) and any other special factors (e.g. temperature inversions) that may affect management of the proposal including air quality within the region of the proposal. Extremes of climate (droughts, floods, cyclones, etc) should also be discussed with particular reference to water management at the proposal site.	4.1	Figure 4.1, 4.2, 4.3, 4.4, 4.5

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		The potential impacts due to climatic factors should be addressed in the relevant sections of the EIS. The impacts of rainfall on soil erosion should be addressed in Section 4.2. The impacts of storm events on the capacity of waste containment systems (e.g. site bunding/stormwater management and tailings storage facilities) should be addressed in Section 4.4 with regard to contamination of waterways, and in Section 4.3 with regard to the design of the waste containment systems. The impacts of winds, rain, and humidity and temperature inversions on air quality should be addressed in Section 4.5. Climatic data from the Project site must be incorporated into any environmental modelling for the site (e.g. air dispersion modelling).		
4.2.1	**Land – Description of Environmental Values**	This section describes the existing environment values of the land area that may be affected by the proposal. It should also define and describe the objectives and practical measures for protecting or enhancing land-based environmental values, describe how nominated quantitative standards and indicators may be achieved, and how the achievement of the objectives will be monitored, audited and managed.	4.2.1	
4.2.1.1	**Topography/Geo morphology**	Maps should be provided locating the project in both regional and local contexts. The topography of the proposal site should be detailed with contours at suitable increments, shown with respect to Australian Height Datum (AHD). Significant features of the locality should be included on the maps. Such features would include any locations subsequently referred to in the EIS (e.g. the nearest noise sensitive locations) that are not included on other maps in Section 4.2. Commentary on the maps should be provided highlighting the significant topographical features.	4.2.1.1	Figure 4.6
4.2.1.2	**Geology**	The EIS should provide a description, map and a series of cross-sections of the geology of the proposal area, with particular reference to the physical and chemical properties of surface and sub-surface materials and geological structures within the proposed areas of disturbance. Geological properties that may influence ground stability (including seismic activity, if relevant), occupational health and safety, rehabilitation programs, or the quality of wastewater leaving any area disturbed by the proposal should be described. In locations where the age and type of geology is such that significant fossil specimens (such as of dinosaurs or their tracks) may be uncovered during construction/operations, the EIS should address the potential for significant finds. A structural geology map with proposed infrastructure locations superimposed is	4.2.1.2	Figure 4.7, 4.8, 4.9 Table 4.1

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		required to assess suitability (e.g. TSF located above a major fault).		
4.2.1.3	**Mineral Resources**	The EIS should provide a summary of the results of studies and surveys undertaken to identify and delineate the mineral resources within the project area (including any areas underlying related infrastructure). The location, tonnage and quality of the mineral resources within the project area should be described in detail as indicated below. The mineral resources should be estimated and reported in accordance with the Australasian Code for Reporting of Mineral Resources and Ore Reserves (the JORC Code - available at www.jorc.org/main.php).	4.2.1.3	Figure 4.10
4.2.1.4	**Resource Utilisation**	The EIS should analyse the effectiveness of the mining proposal in achieving the optimum utilisation of the mineral resources within the project area and consider its impacts on other resources. It should demonstrate that the mining proposal will 'best develop' the mineral resources within the project area, minimise resource wastage and avoid any unnecessary sterilisation of these or any other of the State's coal, mineral, and petroleum (including gas and coal seam methane) resources that may be impacted upon or sterilised by the mining activities or related infrastructure.	4.2.1.4	
4.2.1.5	**Soils**	A soil survey of the sites affected by the proposal should be conducted at a suitable scale, with particular reference to the physical and chemical properties of the materials that will influence erosion potential, storm water run-off quality, rehabilitation and agricultural productivity of the land. Information should also be provided on soil stability and suitability for construction of proposal facilities. Soil profiles should be mapped at a suitable scale and described according to the Australian Soil and Land Survey Field Handbook (McDonald et al, 1990) and Australian Soil Classification (Isbell, 1996). An appraisal of the depth and quality of useable soil should be undertaken. Information should be presented according to the standards required in the Planning Guidelines: the Identification of Good Quality Agricultural Land (DPI, DHLGP, 1993), and the State Planning Policy 1/92: Development and the Conservation of Agricultural Land.	4.2.1.5	Figure 4.11 Table 4.2
4.2.1.6	**Land Use**	The EIS should provide a description of current land tenures and land uses, including	4.2.1.6	Figure 4.12, 4.13,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		native title issues, in the proposal area, with particular mention of land with special purposes. The location and owner/custodians of native title in the area and details of native title claims should be shown. Describe the land use suitabilities of the affected area in terms of the physical and economic attributes. The assessment should set out soil and landform subclasses assigned to soil mapping units in order to derive land suitability classes. The limitations and land suitability classification system to use is that in Attachment 2 of Land Suitability Assessment Techniques in the Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland (1995). Provide a land suitability map of the proposed and adjacent area, and setting out land suitability and current land uses, e.g. for grazing of native and improved pastures and horticulture. Land classified as Good Quality Agricultural Land in the Department of Natural Resources' land classification system is to be shown in accordance with the planning guideline, The Identification of Good Quality Agricultural Land, which supports State Planning Policy 1/92.		4.14, 4.15, 4.16, 4.17 Table 4.3, 4.4, 4.5, 4.6, 4.7
4.2.1.7	**Infrastructure**	The location and owner/custodians of all tenures, reserves, roads and road reserves, railways and rail reserves, stock routes and the like, covering the affected land should be shown on maps of a suitable scale. Indicate locations of gas and water pipelines, power lines and any other easements. Describe the environmental values affected by this infrastructure.	4.2.1.8	Figure 4.18
4.2.1.8	**Sensitive Environmental Areas**	The proximity of the proposal to any environmentally sensitive areas should be shown on a map of suitable scale. This section of the EIS should then identify whether any of those environmentally sensitive areas could be affected, directly and indirectly, by the proposal. Consideration should be given to national parks, conservation parks, declared fish habitat areas, wilderness areas, aquatic reserves, heritage/historic areas or items, national estates, world heritage listings and sites covered by international treaties or agreements (e.g. Ramsar, JAMBA, CAMBA), areas of cultural significance and scientific reserves (see section 4.8 for further guidance on sensitive areas).	4.2.1.9	Figure 4.19, 4.20
4.2.1.9	**Landscape Character**	This section should describe in general terms the existing character of the landscape that will be affected by the proposal. It should comment on any changes that have	4.2.1.10	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		already been made to the natural landscape since European settlement. It should 'set the scene' for the description of particular scenic values in the following section on visual amenity. The difference being that this section describes the general impression of the landscape that would be obtained while travelling through and around it, while the visual amenity section addresses particular panoramas and views (e.g. from constructed lookouts, designated scenic routes, etc.) that have amenity value.		
4.2.1.10	**Visual Amenity**	This section should describe existing landscape features, panoramas and views that have, or could be expected to have, value to the community whether of local, regional, State-wide, national or international significance.	4.2.1.11	Photo Plate 4.1, 4.2, 4.3, 4.4, 4.5, 4.6, 4.7, 4.8
4.2.2	**Land – Potential Impacts and Mitigation Measures**	This section defines and describes the objectives and practical measures for protecting or enhancing the land-based environmental values identified through the studies outlined in the previous section. It should describe how nominated quantitative standards and indicators may be achieved, and how the achievement of the objectives will be monitored, audited and managed.	4.2.2	
4.2.2.1	**Land Use Suitability**	The potential for the construction and operation of the proposal to change existing and potential land uses of the proposal site and adjacent areas should be detailed. Post operations, land use options should be detailed including suitability of the area to be used for agriculture, industry, or nature conservation. The factors favouring or limiting the establishment of those options should be given in the context of land use suitability prior to the proposal and minimising potential liabilities for long-term management. The potential environmental harm caused by the proposal on the adjacent areas currently used for agriculture, urban development, recreation, tourism, other business and the implications of the proposal for future developments in the impact area including constraints on surrounding land uses should be described.	4.2.2.1	Figure 4.21 Table 4.8
4.2.2.2	**Land Disturbance**	A strategy should be developed with a view to minimising the amount of land disturbed at any one time. The strategic approach to progressive and final decommissioning should be described. The different disturbance types on the project, the final land uses proposed for each, and analogue sites or other completion criteria proposed should be described using a table. The methods to be used for the proposal, including backfilling,	4.2.2.2	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		covering, re-contouring, topsoil handling and revegetation, should be described. Proposals should be provided to divert creeks during construction or operations, and, if applicable, for the reinstatement of the creeks. A contour map of the area should be provided (if relevant). Also, the final drainage and seepage control systems and any long-term monitoring plans should be described. Proposed decommissioning should be described in detail, including consolidation, revegetation, fencing, and monitoring. Information should be provided regarding decommissioning of any plant site, removal of processing plant, rehabilitation of concrete footings and foundations, hard stand areas, and storage tanks (including any potential for reuse of these facilities).		
4.2.2.3	**Land Contamination**	The EIS should describe the possible contamination of land from aspects of the proposals including waste, reject product, acid generation from exposed sulfidic material (WRD's, plant site, contaminated ponds and TSF) and spills at chemical and fuel storage areas. The means of preventing land contamination (within the meaning of the Queensland Environmental Protection Act 1994) should be addressed. Methods proposed for preventing, recording, containing and remediating any contaminated land should be outlined. The EIS should address management of any existing or potentially contaminated land in addition to preventing and managing land contamination resulting from project activities. The Draft Guidelines for the Assessment and Management of Contaminated Land in Queensland can be downloaded from the EPA website at: www.epa.qld.gov.au/environment/business/contaminated). Proponents should refer study proposals to the EPA for review prior to commencement (Consult with the Contaminated Land Section in the Queensland EPA).	4.2.2.3	
4.2.2.4	**Soil Erosion**	For all permanent and temporary landforms, erosion management techniques should be described. For each soil type identified, erosion potential (wind and water) and erosion management techniques should be outlined. An erosion-monitoring program, including rehabilitation measures for erosion problems identified during monitoring, should also be outlined. Mitigation strategies should be developed to achieve acceptable soil loss rates, levels of sediment in rainfall runoff and wind-generated dust concentrations.	4.2.2.4	
4.2.2.5	**Landscape**	Describe the potential impacts of the project landscape character of the site and the	4.2.2.5	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
	Character	surrounding area. Particular mention should be made of any changes to the broad-scale topography and vegetation character of the area, such as due to waste rock dumps, excavated voids and broad-scale clearing. Details should be provided of measures to be undertaken to mitigate or avoid the identified impacts.		
4.2.2.6	**Visual Amenity**	This section should analyse and discuss the visual impact of the proposal on particular panoramas and outlooks. It should be written in terms of the extent and significance of the changed skyline as viewed from places of residence, work, and recreation, from road, cycle and walkways, from the air and other known vantage points day and night, during all stages of the project as it relates to the surrounding landscape. Detail should be provided of all management options to be implemented and how these will mitigate or avoid the identified impacts.	4.2.2.6	
4.2.2.7	**Lighting**	Management of the lighting of the project, during all stages, is to be provided, with particular reference to objectives to be achieved and management methods to be implemented to mitigate or avoid: • the visual impact at night; • night operations/maintenance and effects of lighting on fauna and residents; • the potential impact of increased vehicular traffic; and • changed habitat conditions for nocturnal fauna and associated impacts.	4.2.2.7	
4.2.2.8	**Transport**	The EIS should provide sufficient information to make an independent assessment of how the State-controlled and local government road networks, rail network, aviation facilities and air and sea ports will be affected. Sufficient information should also be provided to enable an independent assessment of how the rail network (including infrastructure) will be affected. Details should be provided of the impacts on environmental values of any new roads or road realignments. The EIS should include detailed analysis of probable impact of identified construction and operational traffic generated by the project with particular reference to impacts on road infrastructure, road users and road safety. An assessment of wet and dry season access should be	4.2.2.8	Figure 4.22

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		provided. The EIS should provide details of the usage of any current or proposed rail infrastructure. Provide information on product spill contingency plans and the adequacy of equipment and facilities to deal with possible spills for the transport nodes of the proposal. Indicate whether there is a need to update the plans based on increase in frequency of traffic and volumes to be transported.		
4.3.1	**Waste – Description of Values**	This section should introduce and briefly describe the existing environment values that may be affected by the project's wastes. Refer to each of the waste streams described in section 3.7 and provide references to more detailed descriptions of the relevant environmental values in other sections of part 4 of the EIS.	4.3.1	Table 4.9
4.3.2	**Waste – Potential Impacts and Mitigation Measures**	This section should complement other sections of part 4 of the EIS by providing technical details of waste treatment and minimisation, with proposed emission, discharge and disposal criteria, while other sections describe how those emissions, discharges and disposals would impact on the relevant environmental values. The purpose of this format is to concentrate the technical information on waste management into one section in order to facilitate its transfer into the EM Plan. The purpose of this section is to bring together a description of the preferred methods (and discuss any alternatives) to be used to deal with waste streams and outline their impacts.	4.3.2	Table 4.10
4.4.1	**Water Resources – Description of Environmental Values**	This section describes the existing environment for water resources that may be affected by the proposal in the context of environmental values as defined in such documents as the Environmental Protection Act 1994, Environmental Protection (Water) Policy 1997 (EPP (Water)), ANZECC 2000, Queensland Water Quality Guidelines, 2006, and the South East Queensland Water Quality Management Strategy. The definition of waters in the EPP (Water) includes the bed and banks of waters, so this section should address impacts on benthic sediments as well as the water column. Where a licence or permit will be required under the Water Act 2000 to take or interfere with the flow of water, this section of the EIS should provide sufficient information for a decision to be made on the application. Similarly, waterway barrier works may need	4.4.1	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		approval under the Fisheries Act 1994, and if so should be addressed in the EIS.		
4.4.1.1	**Surface Waterways**	A description should be given of the surface watercourses and their quality and quantity in the study area. This includes the on-site and off-site areas affected by the proposal with an outline of the significance of these waters to the river catchment system in which they occur. The description should include characterisation of the in-stream sediments as a baseline reference.	4.4.1.1	Figure 4.23, 4.24, 4.25, 4.26, 4.27, 4.28, 4.29, 4.30, 4.31 4.32, 4.33, 4.34, 4.35 Table 4.11,4.12, 4.13, 4.14, 4.15 Photo Plate 4.9, 4.10, 4.11, 4.12
4.4.1.2	**Groundwater**	The EIS should review the quality, quantity and significance of groundwater in the proposal area, together with groundwater use in neighbouring areas. (i.e. other groundwater users are to be identified and assessed). Information on local and regional groundwater resources is to be provided. Any groundwater protection zones are also to be identified.	4.4.1.2	Figure 4.36, 4.37, 4.38 Table 4.16, 4.17, 4.18, 4.19, 4.20
4.4.2	**Water Resources – Potential impacts and mitigations measures**	This section is to assess potential impacts on water resource ecological and environmental values identified in the previous section. It will also define and describe the objectives and practical measures for protecting or enhancing water resource ecological and environmental values, to describe how nominated quantitative standards and indicators may be achieved, and how the achievement of the objectives will be monitored, audited and managed. The EIS should describe the possible environmental harm caused by the proposed proposal to environmental values for water as expressed in the EPP (Water).	4.4.2	
4.4.2.1	**Surface Water and Water Courses**	The potential environmental harm to the flow, stream sediment quality and the quality of surface waters from all phases of the proposal should be discussed, with particular reference to their suitability for the current and potential downstream uses, including the requirements of any affected riparian area or wetland and in-stream biological uses. The impacts of surface water flow on existing infrastructure should be considered.	4.4.2.1	Figure 4.39, 4.40, 4.41 Table 4.21, 4.22, 4.23, 4.24, 4.25, 4.26, 4.27

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		Refer to the Environmental Protection (Water) Policy 1997 and Water Act 2000. The hydrological impacts of the proposal should be assessed, particularly with regard to stream diversions, scouring and erosion, and changes to flooding levels and frequencies both upstream and downstream of the project. When flooding levels will be affected, modelling of afflux should be provided and illustrated with maps. In relation to water supply and usage, and wastewater disposal, the EIS should discuss anticipated flows of water to and from the proposal area. The need or otherwise for licensing of any dams (including referable dams) or creek diversions, under the Water Act 2000 should be discussed. The EIS should describe all disturbances to surface waterways, with particular attention to construction of waterway barriers including causeway crossings, infrastructure crossings, dams, weirs, and stream diversions that may have the potential to impact on fish passage across the barrier. Furthermore, the EIS should describe the monitoring that will be undertaken after decommissioning, and who will have responsibility for management measures and corrective action, to ensure that rehabilitated creeks do not degrade. Sufficient data should be collected in order to determine local trigger values for surface waterways. Reference is also to be made to the Queensland Water Quality Guidelines (2006) and relevant DERM Operational Policies, such as 'Waste Water discharge to Queensland Waters". In setting local trigger values, efforts must be made to consider the cumulative inputs from nearby inputs (e.g. Roseby Copper project).		
4.4.2.2	**Groundwater**	The EIS should include an assessment of the potential environmental harm caused by the proposal to local groundwater resources. The impact assessment should define the extent of the area within which groundwater resources are likely to be affected by the proposed operations and the significance of the proposal to groundwater depletion or recharge, and propose management options available to monitor and mitigate these effects. The response of the groundwater resource to the progression and finally cessation of the proposal should be described. An assessment should be undertaken of the impact of the proposal on the local ground water regime caused by the altered porosity and permeability of any land disturbance or from the construction of surface landforms such as tailings disposal facilities, open pits	4.4.2.3	Figure 4.42 Table 4.28, 4.29,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		and waste rock dumps. An assessment of the potential to contaminate groundwater resources and measures to prevent, mitigate and remediate such contamination should be discussed.		
4.4.2.3	**Dam Design**	In relation to water supply and usage, and wastewater disposal, the EIS should discuss anticipated flows of water to and from the proposal area. Where dams, weirs or ponds are proposed, the EIS should investigate the effects of predictable climatic extremes (storm events, floods and droughts) on: the capacity of the dams to retain contaminants; the structural integrity of the containing walls; and the quality of water contained, and flows and quality of water discharged. The design of all water storage facilities should follow the technical guidelines on site water management. The need or otherwise for licensing of any dams (including referable dams) under the Water Act 2000 should be discussed. Water allocation and water sources should be established in consultation with Department of Natural Resources and Water.	4.4.2	
4.5.1	**Air – Description of Environmental Values**	This section describes the existing air environment that may be affected by the proposal. A description of the existing air shed environment should be provided having regard for particulates. The background levels and sources of suspended particulates, including metal particulates such as lead, arsenic, cadmium and gases such as SOx, NOx, and any other major constituent of the air environment that may be affected by the proposal should be discussed. Sufficient data on local meteorology and ambient levels of pollutants should be gathered to provide a baseline for later studies or for the modelling of air quality environmental harms within the air shed. Parameters should include air temperature, wind speed and direction, atmospheric stability, mixing depth and other parameters necessary for input to the models.	4.5.1	Figure 4.43, 4.44, 4.45 Table 4.30
4.5.1.1	**Greenhouse Gas Emissions**	This section of the EIS should: • provide an inventory of projected annual emissions for each relevant greenhouse gas, with total emissions expressed in 'CO2 equivalent' terms; • estimate emissions from upstream activities associated with the proposed project, including fossil fuel based electricity consumed; and	4.5.1.1	Table 4.31, 4.32

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		• briefly describe method(s) by which estimates were made. The Australian Greenhouse Office Factors and Methods Workbook (available via the internet) can be used as a reference source for emission estimates and supplemented by other sources where practicable and appropriate.		
4.5.2	**Air – Potential Impacts and Mitigation Measures**	This section defines and describes the objectives and practical measures for protecting or enhancing environmental values for air, to describe how nominated quantitative standards and indicators may be achieved, and how the achievement of the objectives will be monitored, audited and managed. Where appropriate, the predicted average ground level concentrations in nearby areas should be provided. These predictions should be made for both normal and expected maximum emission conditions and the worst case meteorological conditions should be identified and modelled where necessary. Ground level predictions should be made at any residential, industrial and agricultural developments believed to be sensitive to the effects of predicted emissions. Evaluate the impacts of gaseous and particulate emissions from construction and operational power generation at the Project area on air quality and the surrounding environment. Where appropriate, address both acute and cumulative impacts by considering the project in conjunction with existing emission sources within the region.	4.5.2	Figure 4.46, 4.47, 4.48, 4.49, 4.50, 4.51, 4.52, 4.53, 4.54, 4.55, 4.56, 4.57 Table 4.33, 4.34, 4.35, 4.36, 4.37, 4.38, 4.39. 4.40, 4.41
4.5.2.1	**Greenhouse Gas Abatement**	This section of the EIS should propose and assess greenhouse gas abatement measures. It should include: • a description of the proposed measures (alternatives and preferred) to avoid and/or minimise greenhouse gas emissions directly resulting from activities of the project, including such activities as transportation of products and consumables, and energy use by the project; • an assessment of how the preferred measures minimise emissions and achieve energy efficiency; • an indication of how the preferred measures for emission controls and energy consumption compare with practice in the relevant sector of industry with a view to achieving best practice environmental management; and • a description of any opportunities for further offsetting greenhouse gas	4.5.2.3	Table 4.42, 4.43

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		emissions through indirect means.		
4.5.2.2	**Climate Change Adaptation**	The EIS should provide an assessment of the Project's vulnerabilities to climate change throughout the construction, operation and decommissioning phases. The EIS should describe possible adaptation strategies for the activity including: • a risk assessment of how changing patterns of rainfall and hydrology, temperature and extreme weather may affect the viability and environmental management of the project; • the preferred and alternative adaptation strategies to be implemented; and • commitments to undertaking, where practicable, a cooperative approach with government, other industry and other sectors to address adaptation to climate change. The proponent should use their best efforts to incorporate adaptation to climate change in their EIS and project design.	4.5.2.4	
4.6.1	**Noise and Vibration – Description of Environmental Values**	This section describes the existing environment values that may be affected by noise and vibration from the proposal. The locations of sensitive sites should be identified on a map at a suitable scale. The results of any baseline monitoring of noise and vibration in the proposed vicinity of the proposal should be described. The daily variation of background noise levels at nearby sensitive sites should be monitored and reported in the EIS, with particular regard given to detailing variations at different periods of the night.	4.6.1	Figure 4.58, 4.59, 4.60 Table 4.44, 4.45, 4.46
4.6.2	**Noise and Vibration – Potential Impacts and Mitigation Measures**	This section defines and describes the objectives and practical measures for protecting or enhancing environmental values from impacts by noise and vibration, describes how nominated quantitative standards and indicators may be achieved for noise and vibration management, and how the achievement of the objectives will be monitored, audited and managed. Proposed measures for the minimisation or elimination of impacts should be provided, including details and illustrations of any screening, lining, enclosing or bunding. A discussion should be provided of timing schedules for construction and operations with respect to minimising environmental nuisance and harm from noise.	4.6.2	Figure 4.61, 4.62 Table 4.47, 4.48, 4.49, 4.50, 4.51, 4.52

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
4.7.1	**Nature Conservation – Description of Environmental Values**	This section should describe the existing nature conservation of the proposal area and how these values may be affected by the proposed activity. Describe the nature conservation values of nature conservation for the study area in terms of: • species listed under the Nature Conservation Act 1992 or Environment Protection and Biodiversity Conservation Act 1999 which occur or potentially occur in the proposal area; • how the proposed activity will likely impact listed species; • the distribution of habitat for listed species; • how this habitat will likely be impacted by the proposed activity; • the distribution of 'of concern' or endangered regional ecosystems as listed under the Vegetation Management Act 1999 and the DERM's Biodiversity Status in the proposal area; • how these 'of concern' or endangered regional ecosystems will likely be impacted by the proposed activity; • how the proposed activity will likely impact water quality in riverine and other wetlands within, adjoining and adjacent to the project area; and • how these impacts will be mitigated. Reference should be made to both State and Commonwealth endangered species legislation and the proximity of the area to any World Heritage property. The Queensland Vegetation Management Act 1999 and DERM Biodiversity Status listing of regional ecosystem status and the findings of any regional vegetation management plan should also be referenced. The occurrence of pest plants and animals in the project area should be described.	4.7.1	
4.7.1.1	**Listed Species and Species of**	Describe the nature/biodiversity conservation values of the affected area.	4.7.1.2	Table 4.53, 4.54,

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
	Special and Ecological Note	This description should include, but not be limited to: • A list of flora and vertebrate fauna listed under either the Nature Conservation Act 1992 (NCA) or Environment Protection and Biodiversity Conservation Act 1999 (EPBC), known to or which potentially occur in the subject area. This list should advise the likelihood of potential taxa occurring within the subject area; • A discussion stating the habitat requirements of all taxa in this list, and the distribution and quality of this potential habitat within the subject area; • A discussion of the likely impacts of the proposed operation on potential habitat for listed taxa known to or potentially occurring in the subject area; • A discussion of the significance of these likely impacts on listed species habitat values which addresses potential impacts on listed species populations in the local area and south west Gulf Plains and eastern North West Highlands bioregions (Queensland Bioregions). Where these impacts are determined to be significant, appropriate mitigation measures should be advised; • A discussion of near threatened or bio-regionally significant species or essential, viable habitat for near threatened or bio-regionally significant species which may occur in the subject area; • A discussion of populations of common or listed species which represent a distributional limit for that species; and • A description of sites of palaeontologic significance such as fossil sites.		
4.7.1.2	**Terrestrial Flora**	A map of vegetation at a scale of 1:25 000 should be provided for the subject area. This map should: • use the DERM's regional ecosystem type descriptions in accordance with the Regional Ecosystem Description Database [REDD] available at the DERM's website; • indicate the location of vegetation types which correspond to regional ecosystems listed as 'of concern' or endangered under the Vegetation	4.7.1.4	Figure 4.63 Table 4.55, 4.56, 4.57, 4.58, 4.59, 4.60, 4.61 Photo Plate 4.13, 4.14, 4.15, 4.16, 4.17, 4.18

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		Management Act 1999 (VMA) or the DERM 'Biodiversity Status' listing; • detail the location of ecosystems which provide important ecological functions such as wetlands and associated riparian vegetation; • A discussion should be presented describing likely and potential impacts upon vegetation determined to be consistent with types listed as 'of concern' or endangered under the VMA or the DERM's Biodiversity Status. This discussion should address the significance of these potential impacts in a bioregional context. Where these impacts are likely to be significant, mitigation measures should be advised; and • The location and abundance of exotic or weed species should be described. When mapping vegetation: • All species listed as common which are recorded during the survey/mapping of vegetation should be presented in an appendix to the main report.		
4.7.1.3	**Terrestrial Fauna**	A comprehensive vertebrate fauna survey should be conducted for the subject area. This survey effort should include a wet season survey and a dry season survey. Data on listed species collected during these surveys should be represented as described in section 4.7.1.1. Data for common species should be represented as a general species list in an appendix to the main report.	4.7.1.5	Figure 4.64, 4.65, 4.66, 4.67, 4.68, 4.69, 4.70 Table 4.62, 4.63, 4.64 Photo Plate 4.19, 4.20, 4.21, 4.22, 4.23, 4.24
4.7.1.4	**Aquatic Biology**	If no biota surveys/studies have previously been conducted in and downstream of the project area, the aquatic flora and fauna occurring in the areas affected by the proposal should be described, noting the patterns and distribution in the waterways and/or associated lacustrine and marine environments. The patterns and distribution in the waterways and/or associated lacustrine and marine environments should be described and mapped at an appropriate scale and representative sampling locations determined for baseline and on-going monitoring programs. The EIS studies should establish a	4.7.1.7	Figure 4.71, 4.72, 4.73 Table 4.65, 4.66, 4.67 Photo Plate 4.25

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		detailed baseline to be used for future monitoring programs as part of an on-going environmental management plan (EMP) for the proposed development The EIS should include a list of all known and potential rare, endangered, threatened or otherwise noteworthy species or assemblages present, or likely to be present and dependent on the aquatic environments of the project area, including species important for recreation and commercial fisheries.		
4.7.2	**Nature Conservation – Potential Impacts and mitigation measures**	This section defines and describes the objectives and practical measures for protecting or enhancing nature conservation values, describes how nominated quantitative standards and indicators may be achieved for nature conservation management, and how the achievement of the objectives will be monitored, audited and managed. The EIS should address any actions of the project or likely impacts that require an authority under the Nature Conservation Act 1992, and/or would be assessable development for the purposes of the Vegetation Management Act 1999. Strategies for collecting and preserving any significant fossils should be described. Mitigation measures and/or offsets should be proposed for adverse impacts. Any departure from no net loss of ecological values should be described. The potential environmental harm on flora and fauna due to any alterations to the local surface and ground water environment should be discussed with specific reference to environmental impacts on riparian vegetation or other sensitive vegetation communities. Measures to mitigate the environmental harm to habitat or the inhibition of normal movement, propagation or feeding patterns, and change to food chains should be described. The provision of buffer zones and movement corridors, and strategies to minimise environmental harm on migratory, nomadic and aquatic animals should be discussed. Weed management strategies are required for containing existing declared weed species and ensuring no new declared plants are introduced to the area. Feral animal management strategies and practices should also be addressed. The study should develop strategies to ensure that the project does not contribute to increased encroachment of a feral animal species. A detailed monitoring program should be outlined for each Nature Conservation component described in 4.7 as part of an on-going environmental management plan (EM Plan). Monitoring programs should be	4.72	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		designed and built from baseline information collected during the EIS studies. The EIS should develop a broad range of rehabilitation acceptance criteria including criteria defining floristic characteristics, such as composition, cover and species diversity.		
4.8.1	**Cultural Heritage – Description of Environmental Values**	This section describes the existing cultural heritage values that may be affected by the proposal. Describe the environmental values of the cultural landscapes of the affected area in terms of the physical and cultural integrity of the landforms.	4.8.1	
4.8.1.1	**Indigenous Cultural Heritage**	A cultural heritage study may be required that will describe indigenous cultural heritage sites and places, and their values. Any such study must be conducted by an appropriately qualified cultural heritage practitioner. Cultural heritage surveys and reporting of any results will be conducted in accordance with the Traditional Owners wishes. This may include or exclude a cultural heritage practitioner being involved in the surveys. Results of cultural heritage surveys may also need to be kept confidential.	4.8.1.2	
4.8.1.2	**Non-Indigenous Cultural Heritage**	An Historic Assessment should be conducted as part of EIS process specific to Non-indigenous cultural heritage sites. This includes a thorough investigation of known or potential sites of historical significance for the range of non-indigenous activities (pastoral, mining and market gardening history) which may have occurred in the area. The Historic Assessment is to address potential impact of all aspects of the range of activities such as exploration through to construction and mining methods and provide mitigation measures which could be adopted to address emerging issues. Within this document realistic timeframes need to be identified and incorporated to gain appropriate approvals from the relevant authorities.	4.8.1.1	Figure 4.74, 4.75, 4.76 Table 4.68, 4.69 Photo Plate 4.26
4.8.2	**Cultural Heritage – Potential Impacts and Mitigation Measures**	This section defines and describes the objectives and practical measures for protecting or enhancing cultural heritage environmental values, describes how nominated quantitative standards and indicators may be achieved for cultural heritage management, and how the achievement of the objectives will be monitored, audited and managed.	4.8.2	Figure 4.77 Table 4.70
4.9	**Social**	The description of social and cultural values potentially impacted by the Project, and the	4.9	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		assessment of the impacts on those values, will be conducted in consultation, through the EIS Coordinator, with the Social Imapct Assessment Unit of the DIP. The proponent will engage at the earliest practical stage with stakeholders and potentially affected parties to discuss and explain the Project, and to identify and respond to issues and concerns regarding social impacts. The stakeholder engagement processes will continue throughout the EIS and contribute to the identification of social and cultural values and to the assessment of impacts.		
4.9.1	**Social – Description of Environmental Values**	Define the social and cultural values within the project's area of influence, including the local, district, regional and state level as appropriate, taking into account the: • potential for social and cultural impacts to occur • location of other relevant proposals or projects • location and types of physical and social infrastructure, settlement and land use patterns • social values that might be affected by the project, including integrity of social conditions, liveability, social harmony and wellbeing, and sense of community • Indigenous social and cultural characteristics, such as areas under native title rights or application. Undertake a targeted baseline study of the people in the project's social and cultural area to identify social values that may be impacted by the project. The social baseline study will be based on qualitative, quantitative, and participatory methods supported by stakeholder engagement processes. It will reference relevant data contained in local and state government publications, reports, plans, guidelines and documentation, including regional plans and any available community plans. The social baseline study should describe and analyse a range of demographic and social statistics determined relevant to the project's social and cultural area including: • total enumerated population and the full time equivalent transient population • existing or anticipated major population trends and changes irrespective of the	4.9.1	Figure 4.78, 4.79, 4.80, 4.81, 4.82, 4.83, 4.84, 4.85, 4.86, 4.87, 4.88 Table 4.71, 4.72, 4.73, 4.74, 4.75,4.76 4.77, 4.78, 4.79, 4.80, 4.81, 4.82, 4.83, 4.84, 4.85, 4.86, 4.87, 4.88, 4.89, 4.90, 4.91, 4.92, 4.93, 4.94, 4.95, 4.96, 4.97

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables

		project
		• family structures
		• age and gender distributions
		• education, including schooling levels
		• measures of community safety, health and wellbeing
		• cultural and ethnic characteristics
		• Indigenous population including age and gender
		• personal and household income
		• labour force by occupation and industry
		• housing tenure type and landlord type for rental properties
		• housing availability:
		  ○ private ownership: number and percentage of houses for sale
		  ○ rental market: size, vacancy rate and seasonal variations
		  ○ availability of social housing
		• housing costs:
		  ○ private ownership: typical costs of houses for sale in project area and monthly housing repayments with percent of dwellings in each category published by the Australian Bureau of Statistics (ABS)
		  ○ rental: weekly rent with percent dwellings in each category published by the ABS
		• housing affordability separately for private ownership and rent
		• household and family type
		• disability prevalence		

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		• the social and economic index for areas, index of disadvantage—score and relative ranking • types and prevalence of crime, including domestic violence • any other indicators determined through the community engagement process as relevant. The social baseline study should also take account of and address issues such as: • the social infrastructure including community and civic facilities, services and networks (for definition see South East Queensland Plan 2005-2026 Implementation Guideline No.5, <www.dip.q1d.gov.au/resources/guideline/Implennentationguidelineapdf>) • settlement patterns including the names, locations, size, history and cultural aspects of settlement in the social and cultural area • identity, values, lifestyles, vitality, characteristics and aspirations of communities in the social and cultural area, including Indigenous communities • land use and land ownership patterns including: o the number of properties potentially directly or indirectly affected by the project o rural properties, farms, croplands and grazing areas including on-farm activities near the proposed activities o properties used for other primary, secondary or tertiary industries o residential acreage properties o townships or other relatively small block residential areas • the number of families potentially directly or indirectly affected by the project including Indigenous traditional owners and their families, property owners, and families of workers either living on the property or workers		

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		where the property is their primary employment • use of the social and cultural area for forestry, fishing, recreation or tourism • Indigenous cultural use of plants and animals.		
4.9.2	**Social – Potential Impacts and Mitigation Measures**	Describe the stakeholder engagement processes and summarise their outcomes, including the response of Indigenous and non-indigenous communities to the project. Assess and describe the type, level and significance of the project's beneficial and adverse impacts on social and cultural values identified in the social baseline study and address issues raised in the stakeholder engagement processes. Assess the cumulative potential beneficial and adverse impacts of the project in relation to other major projects or known proposals in the social and cultural area. Discuss whether impacts would be felt at a local, regional or national level. Assess the impacts in sufficient detail for local and state authorities to make informed decisions about the project's potential effect on their business and social infrastructure. If the project is likely to result in a significant increase in the population of the area, then the proponent should consult the relevant state authorities and summarise the results of the consultations in the EIS. Provide separate profiles of the expected workforce for the construction, operational and decommissioning phases of the project that describe the: • numbers and variations of personnel to be employed • skills base of the required workforce • likely sources of personnel, such as local, regional, national or overseas. Provide an outline of the proponent's and contractors' recruitment schedules and their policies for recruitment of workers; describe initiatives for local employment business opportunities; and address the recruitment of Indigenous workers, people from culturally and linguistically diverse backgrounds and people with a disability. Outline training that would be provided to increase the skills levels of workers. Assess the social and cultural impacts of recruiting and training the construction or	4.9.2	Figure 4.89 Table 4.98, 4.99, 4.100, 4.101, 4.102

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		operational workforces from within the host community and of bringing in workers from outside. Estimate the population growth due to the proposal, directly, indirectly (such as due to service industry growth) and cumulatively with other projects, providing detail on gender, age and any other relevant cohorts. Assess the potential impacts on: • demographic patterns • local, regional and state labour markets for separate occupational groupings of the workforce, particularly highlighting any potential skill shortages • disruptions to existing lifestyles • health and social wellbeing of families and communities • social dysfunction, including use of alcohol and drugs • crime and violence. Assess the potential impacts of the project on vulnerable groups including women, children and young people, the aged and people with a disability. Describe the social impacts of changes in land use, the alienation of property and loss of connection with the land, including the impacts and stresses associated with relocations. Assess the impacts of construction and operational workforces, their families, and associated contractors on land, housing and accommodation availability and affordability. Assess the capability of existing housing and rental accommodation, including public housing, to meet any additional demands created by the project including direct impacts on disadvantaged groups and Indigenous people. Estimate how much service revenue and wages from the project would be likely to flow to the project's social and cultural area, and assess the beneficial and adverse impacts of that financial inflow. Describe the transport operations that would be used to move staff between their residences, dormitory camps and work sites. Modes of transport should be described in		

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		section 4.3, but this description should address the mix of privately-owned, public or chartered transport operators. Assess the potential social impacts of transport operations on the local and regional communities, including any road safety issues. Propose measures, developed in consultation with relevant local authorities, state government agencies and stakeholders that would avoid, mitigate or offset any short, medium or long-term adverse impacts, particularly those on: • housing affordability and availability, including the rental market, in the social and cultural area • demographic changes in the profile of the region • the capacity of social infrastructure to meet community needs, particularly in the areas of health, welfare, early childhood education and care, other education and training, policing and emergency services • provision of education, training and employment opportunities for women, people with a disability, and Indigenous peoples. Describe consultation with local and state authorities and stakeholders about their acceptance of proposed mitigation strategies and how practical management and monitoring regimes are proposed to be implemented. Provide a draft social impact management plan that promotes an active and ongoing role for impacted communities and local authorities through the project life cycle. The draft plan should cover: • an overview of the project • all proposed mitigation measures and benefit strategies • action plans to implement mitigation measures and benefit strategies • assignment of accountability and resources for mitigation measures and project benefits • practical mechanisms to monitor and adjust mitigation measures and action		

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		plans • ongoing updates to stakeholders on activities and commitments • mechanisms to respond to public enquiries and complaints • mechanisms to resolve disputes with stakeholders • stakeholder engagement processes including periodic review mechanisms.		
4.10.1	**Health and Safety – Description of Environmental Values**	This section describes the existing community values for public health and safety that may be affected by the proposal. For projects proposing air emissions, and/or those with the potential to emit odours, nearby and other potentially affected populations should be identified and described. Particular attention should be paid to those sections of the population, such as children and the elderly that are especially sensitive to environmental health factors.	4.10.1	Figure 4.90
4.10.2	**Health and Safety – Potential Impacts and mitigation measures**	This section defines and describes the objectives and practical measures for protecting or enhancing health and safety community values, describes how nominated quantitative standards and indicators may be achieved for social impacts management, and how the achievement of the objectives will be monitored, audited and managed. The EIS should assess the effects on the project workforce of occupational health and safety risks and the impacts on the community in terms of health, safety, and quality of life from project operations and emissions. Any impacts on the health and safety of the community, workforce, suppliers and other stakeholders should be detailed in terms of health, safety, quality of life from factors such as air emissions, odour, dust and noise. Map(s) should be provided showing the locations of sensitive receptors, such as, but not necessarily limited to residential areas, and centres of work (e.g. office buildings, factories and workshops).	4.10.2	
4.11.1	**Economy – Description of Environmental Values**	This section describes the existing economic environment that may be affected by the proposal. The character and basis of the local and regional economies should be described including: • economic viability (including economic base and economic activity, future	4.11.1	

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		economic opportunities, current local and regional economic trends, in particular drought and rural downturn etc); and • historical descriptions of large-scale resource developments and their effects in the region.		
4.11.2	**Economy – Potential Impacts and mitigation measures**	The function of this section is to define and describe the objectives and practical measures for protecting or enhancing economic values, to describe how nominated quantitative standards and indicators may be achieved for economic management, and how the achievement of the objectives will be monitored, audited and managed. An economic analysis, including from national, state, regional and local perspectives as appropriate to the scale of the project. The general economic benefits from the project should be described. Attention should be directed to the long and short-term effects of the project on the land-use of the surrounding area and existing industries, regional income and employment and the state economy. For identified impacts to economic values, suggest mitigatory and enhancement strategies and facilitate initial negotiations towards acceptance of these strategies. Practical monitoring regimes should also be recommended.	4.11.2	
4.12.1	**Hazard and Risk – Description of Environmental Values**	This section describes the potential environmental hazards and risk that may be associated with the proposal. Detail the environmental values likely to be affected by any hazardous materials and actions incorporated in the proposal. The degree and sensitivity of risk should be detailed.	4.12.1	
4.12.2	**Hazard and Risk – Potential Impacts and mitigation measures**	This section defines and describes the objectives and practical measures for protecting the environment from hazards and risk, describes how nominated quantitative standards and indicators may be achieved for hazard and risk management, and how the achievement of the objectives will be monitored, audited and managed. The EIS should provide an inventory for each class of substances listed in the Australian Dangerous Goods Codes to be held on site, and permitting required from	4.12.2	Table 4.103, 4.104, 4.105

TOR Section Number	TOR Section Name	Requirement	EIS Section	EIS Figures & Tables
		Queensland Health, prior to operational use. A preliminary environmental hazard analysis should be conducted to assess both natural and induced hazards associated with the construction, operation and decommissioning of the Project in accordance with AS/NZS Risk Management Standard 4360:2004 for the Project and will incorporate: • all relevant majors hazards both technological and natural; • the possible frequency of potential hazards, accidents, spillages and abnormal events occurring; • indication of cumulative risk levels to surrounding land uses; • life of any identified hazards; and • State Planning Policy 1/03 – Mitigating the Adverse Impacts of Flood, Bushfire and Landslide, where necessary.		

APPENDIX J: Air Quality Impact Assessment (SEGroup, 2025)

Document title:

Dugald River Mine Tailings Dam Lift & PAF Pad Expansion

Document Type:

Air Quality Assessment

Prepared for:

MMG Dugald River Pty Ltd

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Authorised and signed

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Mark A Simpson *(Principal) BE RPEQ 6224*

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Table of Contents

LIST OF TABLES **2**

LIST OF FIGURES **2**

GLOSSARY OF TERMS **1**

1 INTRODUCTION **2**
- 1.1 PROJECT DESCRIPTION 2
- 1.2 LOCALITY DESCRIPTION 4

2 DESCRIPTION OF EXISTING ENVIRONMENT **6**
- 2.1 CLIMATE 6
- 2.2 MONITORING LOCATIONS AND SENSITIVE RECEPTORS 6
- 2.3 BACKGROUND AIR QUALITY 7
  - *2.3.1 Monitoring Location Adopted Background Levels* *9*

3 AIR QUALITY CRITERIA **10**
- 3.1 EXISTING ENVIRONMENTAL AUTHORITY 10
- 3.2 GUIDELINE ESR/2015/1840 ERA 10
- 3.3 ENVIRONMENTAL PROTECTION (AIR) POLICY 11
- 3.4 NEPM 12
- 3.5 PROJECT SPECIFIC AIR QUALITY CRITERIA 12

4 AIR QUALITY MODELLING **13**
- 4.1 MODELLING METHODOLOGY 13
  - *4.1.1 Preparation of Meteorological Data* *13*
  - *4.1.2 Development of the Emissions database* *14*
  - *4.1.3 Dispersion Model* *16*
- 4.2 AIR QUALITY RESULTS 18
- 4.3 AIR QUALITY ASSESSMENT 19

5 GREENHOUSE GAS EMISSIONS **20**

6 CONCLUSIONS **22**

REFERENCES **23**

APPENDIX A: WINDROSE FOR SITE **24**

APPENDIX B: DUST EMISSION FACTORS **27**

APPENDIX C: CONTOURS **29**

List of Tables

Table 1: Sensitive Receptors Surrounding the Mine 6
Table 2: Adopted Dust Deposition Background Levels 8
Table 3: PM10 and TSP Adopted Backgrounds 8
Table 4: Adopted Background levels for each Monitoring Location 9
Table 5: EA Air Quality Limits (Source: EPML00731213) 10
Table 6: Excerpt from Environmental Protection (Air) Policy 2019 Schedule 1 11
Table 7: Excerpt from NEPM Schedule 2 Table 1: Standards and Goal for Pollutants other than Particles as $PM_{2.5}$ 12
Table 8: Frequency of Stability Classes at Site 14
Table 9: Emission Factors for Dam Raise Construction 15
Table 10: Emission Factors for PAF Construction 16
Table 11: Predicted Air Quality at Sensitive Receptors – Dam Raise Construction 18
Table 12:Predicted Air Quality at Sensitive Receptors - PAF Construction 18
Table 13:Predicted Air Quality at Sensitive Receptors – Both Construction 19
Table 14: Direct (scope 1) and indirect (scope 3) emission factors for the consumption of transport fuels in different transport equipment 20
Table 15: GHG Emissions per 1000 l of diesel fuel consumption 21
Table 16: TSF Emission Factors 27
Table 17: PAF Emission Factors 28

List of Figures

Figure 1: Stage 2 Raise Concept Design 3
Figure 2: PAF Pad Location (Source ATC Williams Dugald River Mine PAF Pad Expansion Conceptual Options Study) 4
Figure 3: Regional View Showing the Project Area 5
Figure 4: Monitoring Locations 7
Figure 5: Source Locations for Model 17
Figure 6: Windrose All Hours – from Model 24
Figure 7: Windrose 9am - from Model 25
Figure 8: Windrose - 3PM from model 26

Glossary of Terms

PM_{10}	particles in the air environment with an equivalent aerodynamic diameter of not more than 10microns.
$PM_{2.5}$	particles in the air environment with an equivalent aerodynamic diameter of not more than 2.5 microns
TSP	total suspended particles are particles in the air environment with an equivalent aerodynamic diameter of not more than 50 microns.
Air Emission	a substance released into the air.
CALMET	a diagnostic 3-dimensional meteorological model
CALPUFF	an air quality dispersion model
CALPOST	a postprocessing package
TAPM	A model that predicts three-dimensional meteorology and air pollution concentrations
Dust	An air suspension of particles of any solid material

1 Introduction

Wulguru Technical Services (WTS) on behalf of MMG Dugald River Pty Ltd, engaged Simpson Engineering Group (SEG) to assess potential air quality impacts associated with two construction projects at MMG Dugald River. The works comprises the construction phase of:

- Proposed tailings dam lift; and,
- Potentially Acid Forming (PAF) Pad Expansion

The objective of this assessment is to inform the relevant aspects of Department of Environment and Science Guideline ESR/2015/1840 – Application requirements for activities with impacts to air.

This report addresses the following issues:

- Existing environment;
- Air quality goals;
- Air emissions inventory;
- Likely change in air quality during the construction phase; and,
- Recommendations for mitigation measures.

1.1 Project Description

Dugald River Mine (the mine) is located in the Cloncurry Shire Council (CSC) Local Government Area (LGA) within the semi-arid north-west Queensland minerals province, approximately 65 km north-west of Cloncurry.

The mine is located on several Mining Leases (MLs) and is authorised by Environmental Authority (EA) EPML00731213, dated 7 November 2024.

The mine consists of an underground zinc mine. Mine production and mineral processing activities include underground mining for ore, processing and operation of key surface infrastructure to support its operations. Processing.

The concepts for works associated with the Tailings Storage Lift is shown in Figure 1 and for the PAF lift in Figure 2.

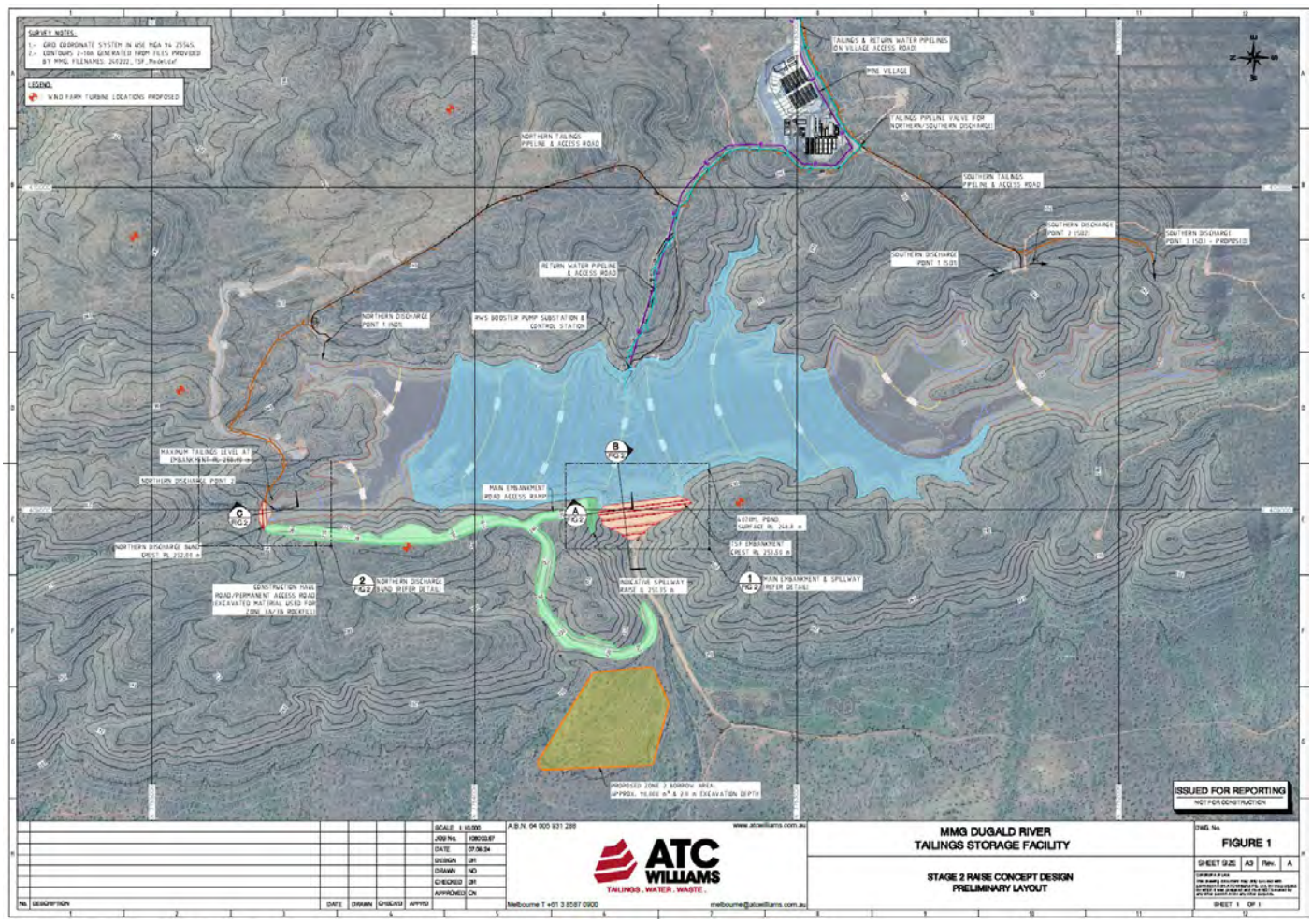

Figure 1: Stage 2 Raise Concept Design

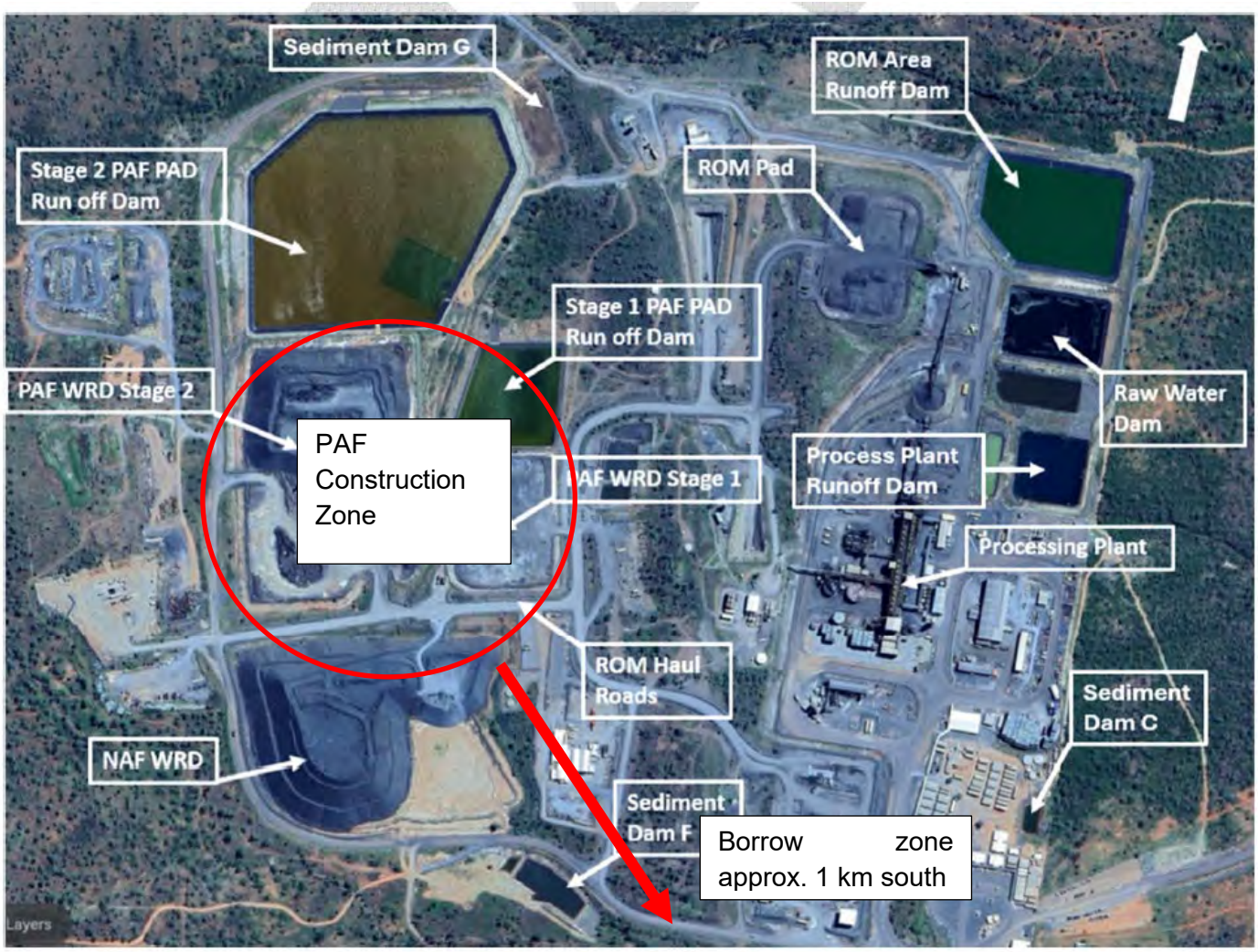

Figure 2: PAF Pad Location (Source ATC Williams Dugald River Mine PAF Pad Expansion Conceptual Options Study)

1.2 Locality Description

The project is situated in a well-established grazing and mining region. Knapdale Range is located to the west of the project. The TSF is located within this range. Elsewhere the region is relatively flat, generally comprising open broad acre grazing and native scrublands. The location of the Project is shown on Figure 1. The closest residential community is Cloncurry, situated 65km to the SE of the site. Cloncurry is the service centre for the farming, mining and tourist industry.

The closest homestead is Mount Roseby homestead and is located 6km to the south of the processing plant. Two other sites were identified as part of the model and included in charting and reporting, Dipvale homestead and Quamby Pub. These two sites do not form part of the EA requirements for the site.

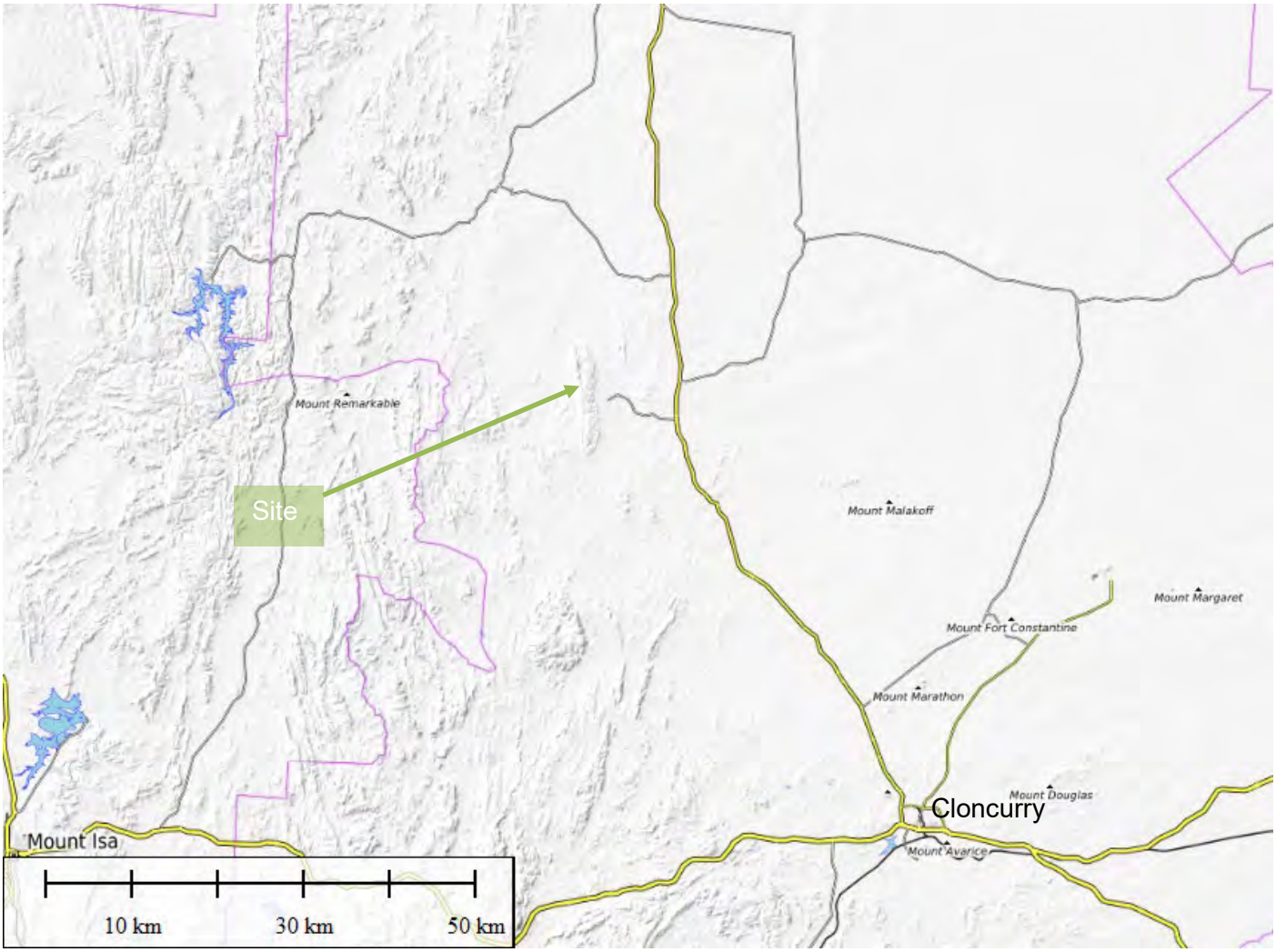

Figure 3: Regional View Showing the Project Area

2 Description of Existing Environment

2.1 Climate

The Project is situated in an inland tropical area. The region has a warm to hot climate with two distinct seasons, a dry winter season and a wet summer season. Based on the nearest BoM automatic weather station at Cloncurry Airport[1], winter temperatures average from 10 ºC to 26 °C, while summer temperatures range from around 25°C to 38°C. The region averages approximately 495 mm of rainfall each year, falling mostly between November and March.

During the wet summer season, the soil moisture content increases and there is increased grass ground cover. This results in lower dust emissions from most activities, including local roads. During the dry winter season, the soil moisture content reduces (particularly at the surface) and grass cover reduces. The dust emissions are more prevalent from most activities during this period. This is also the period when grass fires (including permit fire) are likely to occur. These types of fire release significant quantities of smoke into the lower atmosphere.

2.2 Monitoring Locations and Sensitive Receptors

The locations and separation distances to the three closest sensitive receptors are contained in Table 1. Roseby homestead is the compliance monitoring location for the project. An image showing the Monitoring Locations and receptors is included in Figure 4.

Table 1: Sensitive Receptors Surrounding the Mine

Receptors (Homesteads)	Distance [km] From Lease Boundary	Bearing (degrees)
Roseby	1	158
Dipvale	19	136
Quamby	19	136
Eva Mine Camp	1.5	190

[1] *Climate Statistics for Australian Locations – Cloncurry Airport, http://www.bom.gov.au/climate/averages/tables/cw_029141.shtml*

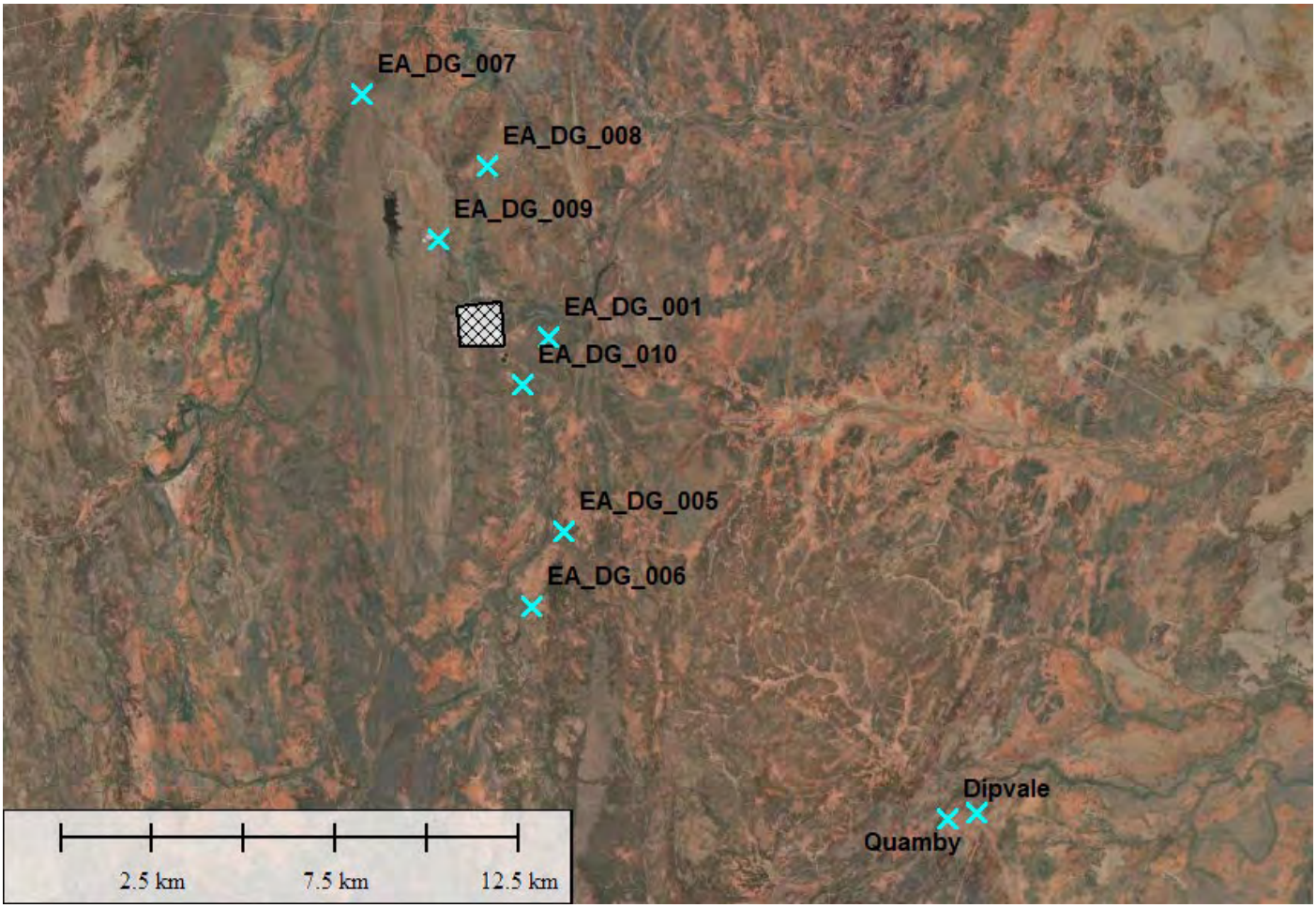

Figure 4: Monitoring Locations

2.3 Background Air Quality

Potential sources of particulate emissions from the surrounding environment primarily comprise:

- farming and grazing activities;
- existing mining operations;
- unsealed roads; and
- smoke from grass/bush fires (permitted or otherwise).

Due to the lack of other industries in the area, the majority of emissions from the surrounding areas would be crustal matter that is released from farming activities, mining activities and unsealed roads. The characteristic of these emissions are particulates and dusts made up of crustal matter rather than other material that has specific limits.

MMG has undertaken extensive air quality monitoring in accordance with the requirements of the EA. The monitoring has been conducted at several reference locations. Location EA_DG_005 is located approximately 700m north of Roseby Homestead and is the Compliance monitoring location. Where the data exists the monitoring data at the Compliance and Reference Sites has been adopted as the background level for each of the monitoring locations. Since the measured site-specific exposure levels are representative of the cumulative effect of existing background exposure and emissions from the current mining operations, it is not necessary to model the existing operations.

Dust Deposition monitoring has been conducted at the various Compliance and Reference Monitoring locations. The results from the monitoring program conducted between January 2020 and July 2024 have been averaged for each monitoring site and tabulated in Table 2.

Table 2: Adopted Dust Deposition Background Levels

Monitoring Location	Assumed Deposition Background ($mg/m^2/day$) (including existing mining)
EA_DG_005 (Roseby Homestead)	17
EA_DG_001	16
EA_DG_006	20
EA_DG_007	17
EA_DG_008	15
EA_DG_009	18
EA_DG_010	17

TSP and PM_{10} monitoring was conducted at EA_AQ_005 and EA_AQ_006. The results for each of the monitoring sites has been averaged for the monitoring conducted between May 2020 and July 2024. The tabulated average for each of the monitoring locations is included in Table 3.

Table 3: PM10 and TSP Adopted Backgrounds

Monitoring Location	PM_{10} 24-hour average (mg/m^3)	TSP 24-hour average (mg/m^3)
EA_DG_005 (Roseby Homestead)	19.5	22.0
EA_DG_006	16.0	19.2

In the absence of site-specific background levels (without existing mining), a background level has been determined from the most recent published DES Queensland National Environment Protection (Ambient Air Quality) Measure monitoring of dust deposition and average PM_{10}, $PM_{2.5}$ monitoring for Mt Isa[2]. Mt Isa was chosen due to the proximity to the site, but will likely be biased high due to the proximity of heavy industry to the DES monitoring location in Mt Isa. The background levels from Mt Isa are:

- Dust deposition of 5 $mg/m^2/day$ for all locations
- Particulate concentration of:
  - $PM_{2.5}$(24 hour) = 6 $\mu g/m^3$
  - $PM_{2.5}$(annual average) = 5 $\mu g/m^3$
  - PM_{10}(24 hour) = 17 $\mu g/m^3$
  - $PM_{10(annual\ average)}$ = 15 $\mu g/m^3$

[2] *Particulate Concentrations, Key Findings, https://www.stateoftheenvironment.des.qld.gov.au/pollution/air-quality/particulate-concentrations*

2.3.1 Monitoring Location Adopted Background Levels

Monitoring location specific background levels have been adopted for each monitoring location. For locations specified in Schedule B where data does not exist, the maximum of the sites in Schedule B or DES value has been adopted. For sites that are not specified in Schedule B, the DES value has been adopted. A summary of the assumed background levels for each of the monitoring locations is included in Table 4.

Table 4: Adopted Background levels for each Monitoring Location

Indicator	**PM2.5**		**PM10**		**TSP**	**Deposition**
Averaging Period	24-hour	Annual	24-hour	Annual	Annual	30-day
Units	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^3	mg/m^2/day
Location						
Roseby Homestead (EA_DG_005) & Eva camp	6	5	20	20	22	17
EA_DG_001	6	5	20	20	22	16
EA_DG_006	6	5	17	17	19	20
EA_DG_007	6	5	20	20	22	17
EA_DG_008	6	5	20	20	22	15
EA_DG_009	6	5	20	20	22	18
EA_DG_010	6	5	20	20	22	17
Dipvale	6	5	17	17	22	15
Quamby	6	5	17	17	22	15
Eva accommodation camp	6	5	20	20	22	17

Note: This analysis excludes impacts from operations on the Eva lease.

3 Air Quality Criteria

3.1 Existing Environmental Authority

The existing Environmental Authority EPML00731213 was issued 7 November 2024. Schedule B indicates the release of any airborne contaminant resulting from mining activities must not cause environmental harm at any sensitive place or commercial place. The dust and particulate matter limits in the EA are described in Table 5.

Table 5: EA Air Quality Limits (Source: EPML00731213)

EA Condition	Indicator	Metalloid	Limit	Averaging Period
B3 (a)	PM_{10}	All dust	50 µg/m^3	24 Hour
B3 (b)	TSP	All dust	90 µg/m^3	1Year
B3 (c)	PM_{10}	Arsenic	0.006 µg/m^3	24 Hour
B3 (d)	PM_{10}	Cadmium	0.005 µg/m^3	24 Hour
B3 (e)	TSP	Lead	0.5 µg/m^3	24 Hour
B4	Dust Deposition	All dusts	120 mg/m^2/day or 4g/m^2/month	Monthly
	Dust Deposition	Arsenic	4 µg/m^2/day	Annual Average
	Dust Deposition	Cadmium	2 µg/m^2/day	Annual Average
	Dust Deposition – trigger level	Lead	100 µg/m^2/day	Annual Average
	Dust Deposition – limit	Lead	250 µg/m^2/day	Annual Average

3.2 Guideline ESR/2015/1840 ERA

The Guideline ESR/2015/1840 ERA describes types of impacts that environmentally relevant activities can have in relation to air and outlines the information to be provided to the department as part of the ERA application process.

There are three key areas to be identified and addressed through the ERA application process:

- Identify the environmental values of the receiving air environment including the identification of any nearby sensitive places.
- Identify the possible impacts due to the proposed activity and all associated risks to environmental values.
- Identify the strategies to mitigate the identified risks to the environmental values

It is necessary to identify the environmental values of the site, this is assisted by the following:

1. Describe the surrounding land
2. Use of a scaled map with site and sensitive receptors
3. Describe site topography
4. Analyse and describe the prevailing site wind direction and speed.

5. Provide a description of the localised ambient air quality.

The department seeks to determine possible impacts to identified environmental values. To assist with this the following information is sought:

1. Identify and provide an overview of emissions and processes.
2. Describe the characteristics of the emissions
3. Identify if an odour impact assessment is required
4. Describe how air emissions will be avoided, minimised or otherwise managed in accordance with the EPP (Air).

Once the value and risk of each impact to the environmental value is known, mitigation strategies can be devised to address the risk. When selecting a mitigation strategy, the following will be provided:

1. Describe the control measure including equipment and techniques used.
2. Identify contingency plans in case of failure in a control measure

3.3 Environmental Protection (Air) Policy

The Queensland Environmental Protection (Air) Policy 2019 (EPP(Air) 2019) commenced in 2019. The EPP (Air) 2019 (Part 2 Section 5) aims to achieve the object of the *Environmental Protection Act 1994* (the Act) in relation to Queensland's air environment. The object of the Act is ".. to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)."

Specifically, the EPP (Air) 2019 addresses the environmental values to be enhanced or protected namely—

(a) the qualities of the air environment that are conducive to protecting the health and biodiversity of ecosystems; and

(b) the qualities of the air environment that are conducive to human health and wellbeing; and

(c) the qualities of the air environment that are conducive to protecting the aesthetics of the environment, including the appearance of buildings, structures and other property; and

(d) the qualities of the air environment that are conducive to protecting agricultural use of the environment .

To meet the environmental values, Schedule 1 of the EPP (Air) nominates relevant air quality indicators and goals. Relevant air quality indicators from Schedule 1 dealing with particulates are included in Table 6.

Table 6: Excerpt from Environmental Protection (Air) Policy 2019 Schedule 1

Indicator	Environmental value	Air quality objectives (µg/m^3)	Period
$PM_{2.5}$	health and wellbeing	25	24 hours
		8	1 year
PM_{10}	health and wellbeing	50	24 hours
		25	1 year
Total Suspended Particles	health and wellbeing	90	1 year

All these indicators are qualities of the air environment that are conducive to human health and wellbeing. The indicators apply at any sensitive or commercial place, such as residences, National Parks schools etc.

3.4 NEPM

The current National Environment Protection (Ambient Air Quality) Measure has been included in Table 7.

Table 7: Excerpt from NEPM Schedule 2 Table 1: Standards and Goal for Pollutants other than Particles as $PM_{2.5}$

Pollutant	Averaging period	Maximum concentration
Particles as PM_{10}	1 day 1 year	50 µg/m^3 25 µg/m^3
Particles as $PM_{2.5}$	1 day 1 year	25 µg/m^3 8 µg/m^3

3.5 Project Specific Air Quality Criteria

Particulates are often described as respirable and inhalable. Respirable particulates are those small enough to penetrate the nose and deep into the lung. Respirable particulates that penetrate past the nose and upper respiratory system are likely to be retained in the body. This involves particulates having an aerodynamic diameter of up to 10 µm. Inhalable particulates are particulates which enter the body but are collected in the nose and upper respiratory system and rejected. Inhalable particulates are those having an aerodynamic diameter of nominally 10 µm and larger. The proposed works is not a mining/extraction nor processes of ore. These are earthworks and are associated with movement and placement of crustal matter. Consequently, the EA limits for metalloids are not relevant for the type of dusts released by the construction activity.

As a general guide particulates having diameters of 7 to 10 µm are mostly large enough to be caught by nose and throat. Particles in the range 0.5 to 7 µm are small enough to reach the lung yet large enough to be retained. Since these particulates remain in the lung they may be hazardous to health and well-being.

In summary, the applicable air quality criteria (from EPP Air and the EA conditions) are:

- Particulate concentration of $PM_{2.5}$ 25 µg/m^3 averaged over 24 hours;
- Particulate concentration of $PM_{2.5}$ 8 µg/m^3 averaged over one year;
- Particulate concentration of PM_{10} of 50 µg/m^3 over a 24-hour averaging time;
- Particulate concentration of PM_{10} of 25 µg/m^3 over one year;
- Total suspended particulate 90 µg/m^3 averaged over a year; and,
- Dust deposition of 120 mg/m^2/day averaged over one month;

All these indicators (except deposition) are qualities of the air environment that are important to human health and wellbeing. The deposition (or dust fallout) is for assessing dust nuisance. The indicators apply at any sensitive or commercial place, such as residences, National Parks, schools, etc.

4 Air Quality Modelling

4.1 Modelling Methodology

Typically, particulate matter is characterised by its size. The particulate size ranges specified in ambient air criteria are total suspended particulate (TSP), particulate matter below 10 microns (PM_{10}) and particulate matter below 2.5 microns ($PM_{2.5}$). TSP includes both the PM_{10} and $PM_{2.5}$ fractions, and PM_{10} includes the 2.5 fraction.

Under normal conditions, particles with aerodynamic diameters of more than PM_{10} will typically fall out and be deposited onto the ground within several minutes of release.

The PM_{10} and $PM_{2.5}$ particulates do not have a significant settling velocity and will behave in a gaseous fashion, that is, the fall out time is significantly longer than a few minutes. The settling velocity for PM_{10} particles is nominally 5 mm/s while for $PM_{2.5}$ it is 0.5 mm/s. This may be compared with PM_{20} where the settling velocity is approximately 20 mm/s (Baumeister et al, 1982).

The air quality modelling methodology comprised three phases namely:

1) preparation of meteorological data The Air Pollution Model (TAPM) and Calmet;
2) development of an emissions database using
   a) Australian National Pollution Inventory “Emission Estimation Technique Manual for Mining Version 3.1”;
   b) National Pollution Inventory Reported Individual Facility Details
3) modelling of the likely downwind ground level concentrations using Calpuff.

4.1.1 Preparation of Meteorological Data

TAPM predicts meteorology and pollutant concentration for a range of pollutants important for air pollution applications. The model consists of coupled prognostic meteorological and air pollution concentration components, eliminating the need to have site-specific meteorological observations. Instead, the model predicts the flows important to local-scale air pollution, such as sea breezes and terrain induced flows, against a background of larger-scale meteorology provided by synoptic analyses.

Some limitations of TAPM include:

- it is not suitable for horizontal domain sizes above approximately 1,000 km by 1000 km.
- it cannot be used to accurately represent deep atmospheric circulations or extreme weather events (cyclones).
- it cannot be used for very steep terrain because of the use of a terrain following coordinate system in the model. Thus, the model cannot represent discontinuities in terrain height (for example, cliffs or bluffs).
- it assumes that cloud processes are resolved by the typical inner grid spacings used in the model (i.e. 3km or less). Therefore, no large-scale cloud convection parameterisation is included.

These limitations are of minor significance to the modelling of pollution for this study. The area of interest is much smaller than the maximum horizontal domain size. Extreme weather events (such as cyclones) are not of interest from an air pollution perspective. The terrain does not have significant cliffs or bluff bodies within the region and it is expected that the inclusion of large-scale cloud convection would only slightly change the radiation and moisture balances.

TAPM is highly regarded in the scientific community as a suitable tool to develop meteorological data sets for sites without site-specific meteorological observations. However, the meteorological dataset can be improved by incorporating local meteorology.

The TAPM meteorological file developed for the site covered the seven-year period 2018 to 2024. TAPM was configured with 4 nested grids with grid spacing of 30000m, 10000m, 3000m and 1000m. Additionally 40 grid points were used with 30 vertical grids. The model was centred on -20°15' and 140°9'. All other settings were as per default.

The general features of winds affecting plume dispersion are illustrated in the wind rose diagrams for the years 2023 to 2024 (Appendix A: Windrose for Site). The wind roses summarise the wind statistics at a 10m height on site, as calculated by the TAPM meteorological model. The wind roses show the frequency of occurrence of winds by direction and strength. The bars correspond to the 16 compass points – N, NNE, NE, ENE ,E etc. The length of the bar represents the frequency of occurrence of winds from that direction, and the colour of the bar sections correspond to wind speed categories. It is noted that the predominant wind direction during the year is from the north-east through to the south-east. The representative frequency of Pasquil stability classes for the region is based on data from TAPM. Pasquil stability classes represent the stability of the atmosphere. The stability Class F conditions (stable conditions), which result in poor dispersion of pollutants does not occur during the day. Table 8: Frequency of Stability Classes at Site shows the frequency of stability classes for the site.

Table 8: Frequency of Stability Classes at Site

Stability Class	Description	Frequency of Occurrence (%)
A	Very unstable	4
B	Moderately unstable	14
C	Slightly unstable	18
D	Neutral	26
E	Slightly stable	12
F	Stable	26

4.1.2 Development of the Emissions database

The development of an accurate and representative particulates emissions database has been primarily based on National Pollution Inventory Emission Estimation Technique Manual for Mining Version 3.1 (NPI 2012). The main mining activities and processes that produce, or could produce, particulate emissions were identified for the operations.

All emission factor equations and default emission factors in NPI are for uncontrolled emissions. However, this database has included the control effects from water trucks as is typically used at mines. In the model of the operations the emissions were calculated as an average and applied for all relevant hours. Calculating emissions is a four-step process:

1. Identify sources of emissions.
2. Obtain information on the scale of the activity.
3. Apply the relevant emission factor equation or default emission factor from NPI to the activity data;
4. Where applicable, apply control efficiency reduction factors-based water truck use or built-in controls.

The sources of dust emissions are from the following operations:

1. D11 dozer
2. 50T Excavator
3. 30T Excavator
4. Grader

5. Moxy Dump Truck
6. Moxy Water Truck
7. Body Truck Heavy Rigid
8. Water Truck Heavy Rigid
9. Wind Erosion

Two modelling cases are considered:

1. Tailings Dam Raise; and
2. PAF redevelopment.

The duration of the construction works (for the purpose of annual averages) are assumed to be at least 12 months. This ensures a conservatively high estimations of future dust exposure of the annual average. Additionally, since the model is based on the intensity of use of the equipment, rather than based on the quantity of material moved. This approach also accurately models the maximum likely 24 hour and monthly averages.

The contour results from each modelling case are presented separately. However, if the construction works occur at the same time, these results have been tabulated.

Finally, the dust exposure measurements obtained by MMG include the background and the emissions from the mine. Thus, it is not necessary to model dust exposure from the existing mining operations since the 'background' measurements include mining dusts.

The calculated annual emissions for the equipment operating at near maximum intensity is contained in Table 9 and

Table 10 for the tailings dam raise and PAF expansion respectively. A breakdown of the individual plant emissions is included in Appendix B: Dust Emission Factors. The emission factors are based upon a similar vehicle fleet being used for both operations.

Table 9: Emission Factors for Dam Raise Construction

Activity	**Includes Control Factor**	**Emissions [t/a] for Particulate Fraction (Operations scaled to full year)**		
		TSP	**PM_{10}**	**$PM_{2.5}$**
D11 dozer		74.5	18.0	2.2
50tonne excavator		136.9	65.7	8.2
30tonne excavator		16.4	7.9	1.0
16m Grader		8.3	3.7	0.5
Moxy dump truck	Level 2 Watering	69.5	20.5	2.6
Moxy dump truck - Dumping		65.7	23.5	2.9
Moxy water truck	Level 2 Watering	23.2	6.8	0.9
Body truck heavy rigid	Level 2 Watering	69.5	20.5	2.6
Body truck heavy rigid - Dumping		7.9	2.8	0.4
Water Truck heavy rigid	Level 2 Watering	23.2	6.8	0.9
Wind Erosion		17.5	8.8	1.1
Total for Dam Raise Construction		**512.5**	**185.1**	**23.2**

Table 10: Emission Factors for PAF Construction

Activity	Includes Control Factor	Emissions [t/a] for Particulate Fraction (Operations scaled to full year)		
		TSP	PM_{10}	$PM_{2.5}$
D11 dozer		74.5	18.0	2.2
50tonne excavator		126.3	60.6	7.6
30tonne excavator		16.4	7.9	1.0
16m Grader		8.3	3.7	0.5
Moxy dump truck	Level 2 Watering	69.5	20.5	2.6
Moxy dump truck - Dumping		60.6	21.7	2.7
Moxy water truck	Level 2 Watering	23.2	6.8	0.9
Body truck heavy rigid	Level 2 Watering	69.5	20.5	2.6
Body truck heavy rigid - Dumping		7.9	2.8	0.4
Water Truck heavy rigid	Level 2 Watering	23.2	6.8	0.9
Wind Erosion		17.5	17.5	2.2
Total for PAF Construction		**496.9**	**187.0**	**23.4**

4.1.3 Dispersion Model

Calmet was used to process the exported 3D wind data from TAPM. The metrological grid was set for 76 by 76 cells with a cell dimension of 500m by 500m. Terrain was imported from SRTM 30m DEM[3]. CALPUFF was configured to use TAPM 3D wind data as an initial guess field for the model. All other settings were kept at the recommended default.

Calpuff v7 was used to determine the downwind ground level particulate concentrations and dust depositions. It is designed to predict ground-level concentrations or deposition of pollutants emitted from one or more sources, which may be stacks, area sources, volume sources, line sources or any combination of these.

The construction sources have been separated into three sources in Calpuff model for each construction operation; borrow pit, road and emplacement. The area source is modelled as having dimensions similar to the extent of the source and an elevation of 5m above local terrain for area sources and 3m for road sources. A map showing the location of the sources is included in Figure 5: Source Locations for Model A sampling/calculation grid of 76 by 76 grid with 500m spacing and a receptor at each of the sensitive receptors was used to develop the contours.

[3] *Digital Elevation Data, Geosciences Australia, ga.gov.au/scientific-topics/national-location-information/digital-elevation-data*

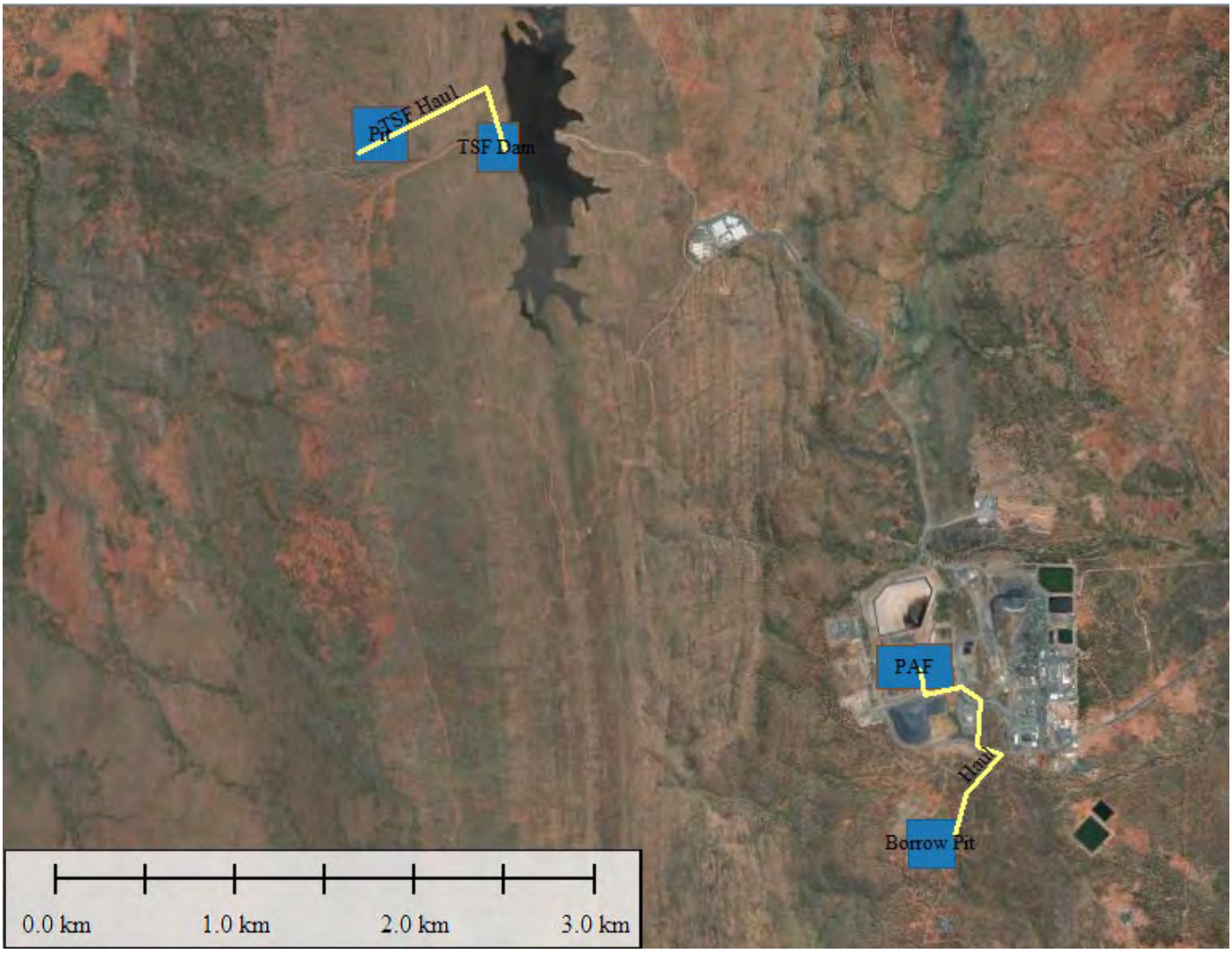

Figure 5: Source Locations for Model

4.2 Air Quality Results

The calculated particulate emissions described in Section 4.1.2 were included in the Calpuff model at the appropriate locations. The likely particulate levels due to the construction of the Dam Raise are shown in Table 11. The likely particulate levels due to the construction of the PAF Raise are shown in Table 12. If both construction operations occur at the same time; the likely particulate levels due to construction are included in Table 13.

The calculated air pollution contours (including background) are contained in Appendix C: Contours.

Table 11: Predicted Air Quality at Sensitive Receptors – Dam Raise Construction

Receptor	Calculated Particulate and Dust Levels at Nearby Sensitive Receptors					
	$PM_{2.5}$ (24-hour) Maximum (µg/m³)	$PM_{2.5}$ (Annual Average) (µg/m³)	PM_{10} (24-hour) Maximum (µg/m³)	PM_{10} (Annual Average) (µg/m³)	TSP (Annual Average) (µg/m³)	Dust Deposition (Max month) (mg/m²/day)
Limit	**25**	**8**	**50**	**25**	**90**	**120**
Roseby Homestead	6.3	5.0	20.9	19.5	22.0	16.9
EA_DG_001	6.8	5.0	24.4	19.6	22.1	16.4
EA_DG_006	6.1	5.0	17.6	16.0	19.2	19.8
EA_DG_007	7.8	5.1	32.3	20.3	23.4	22.1
EA_DG_008	8.0	5.0	29.6	19.6	22.1	14.9
EA_DG_009	9.7	5.1	45.2	19.9	22.6	20.9
EA_DG_010	6.7	5.0	23.6	19.6	22.1	17.4
Dipvale	6.1	5.0	17.5	15.0	22.0	15.0
Quamby	6.1	5.0	17.3	15.0	22.0	15.0
Eva accommodation camp	6.3	5.0	20.9	19.5	22.0	16.9

Table 12:Predicted Air Quality at Sensitive Receptors - PAF Construction

Receptor	Calculated Particulate and Dust Levels at Nearby Sensitive Receptors					
	$PM_{2.5}$ (24-hour) Maximum (µg/m³)	$PM_{2.5}$ (Annual Average) (µg/m³)	PM_{10} (24-hour) Maximum (µg/m³)	PM_{10} (Annual Average) (µg/m³)	TSP (Annual Average) (µg/m³)	Dust Deposition (Max month) (mg/m²/day)
Limit	**25**	**8**	**50**	**25**	**90**	**120**
Roseby Homestead	6.7	5.0	22.9	19.6	22.1	17.2
EA_DG_001	8.5	5.0	34.4	19.7	22.3	17.8
EA_DG_006	6.4	5.0	18.7	16.0	19.2	20.1
EA_DG_007	6.6	5.1	23.5	19.9	22.5	19.5
EA_DG_008	7.2	5.1	27.1	20.0	22.7	17.3
EA_DG_009	8.5	5.3	37.1	21.8	26.0	38.5
EA_DG_010	9.2	5.1	42.6	20.1	23.1	21.8
Dipvale	6.1	5.0	17.5	15.0	22.0	15.1
Quamby	6.1	5.0	17.4	15.0	22.0	15.1
Eva accommodation camp	6.7	5.0	22.9	19.6	22.1	17.2

Table 13:Predicted Air Quality at Sensitive Receptors – Both Construction

Receptor	Calculated Particulate and Dust Levels at Nearby Sensitive Receptors					
	$PM_{2.5}$ (24-hour) Maximum (µg/m³)	$PM_{2.5}$ (Annual Average) (µg/m³)	PM_{10} (24-hour) Maximum (µg/m³)	PM_{10} (Annual Average) (µg/m³)	TSP (Annual Average) (µg/m³)	Dust Deposition (Max month) (mg/m²/day)
Limit	**25**	**8**	**50**	**25**	**90**	**120**
Roseby Homestead	6.9	5.0	23.7	19.6	22.1	17.4
EA_DG_001	8.5	5.0	34.5	19.8	22.4	18.1
EA_DG_006	6.5	5.0	19.1	16.0	19.3	20.2
EA_DG_007	7.8	5.2	32.3	20.7	23.9	24.6
EA_DG_008	8.1	5.1	29.6	20.0	22.8	17.3
EA_DG_009	9.7	5.4	45.2	22.2	26.6	38.5
EA_DG_010	9.4	5.1	43.9	20.2	23.2	22.0
Dipvale	6.1	5.0	17.8	15.0	22.0	15.1
Quamby	6.1	5.0	17.7	15.0	22.0	15.1
Eva accommodation camp	6.9	5.0	23.7	19.6	22.1	17.4

4.3 Air Quality Assessment

The predicted average ground level concentrations at all nearby sensitive areas have been modelled and Section 4.1.2 contains a full description of the modelling methods. The methodology includes both the expected maximum emission conditions and the worst-case meteorological conditions.

The proposed construction of the Dam raise and the PAF raise are expected to readily comply with air quality goals at all sensitive receptors.

The construction phase will lead to a small increase in the PM_{10} and $PM_{2.5}$ (24 hour) average, but the overall levels are likely to remain within acceptable goals for air quality at all sensitive receptors.

5 Greenhouse Gas Emissions

The greenhouse gas emission for the construction fleet is based on National Greenhouse Accounts (NGA) Factors for 2024.

Scope 1

Direct (or scope 1) emissions are produced from sources within the boundary of an organisation and as a result of that organisation's activities. They are calculated at the point of emission release. The relevant emissions comprise

- Operation of heavy vehicles (either owned and operated by MMG or contractors)

The Emission factors are contained in Table 14.

Table 14: Direct (scope 1) and indirect (scope 3) emission factors for the consumption of transport fuels in different transport equipment

Transport type	**Fuel combusted**	*Energy Content factor (GJ per unit of fuel)*	**Scope 1 Emission Factor (kg CO_2-e/GJ) CO_2**	**Scope 1 Emission Factor (kg CO_2-e/GJ) CH_4**	**Scope 1 Emission Factor (kg CO_2-e/GJ) N_2O**	**Scope 1 Emission Factor (kg CO_2-e/GJ) Combined gases**	**Scope 3 Emission Factor (kg CO_2-e /GJ)**
Heavy duty vehicles	Diesel oil - Euro iv or higher	***38.6***	69.9	0.07	0.4	70.37	17.3
Heavy duty vehicles	Diesel oil - Euro iii	***38.6***	69.9	0.1	0.4	70.4	17.3
Heavy duty vehicles	Diesel oil - Euro i	***38.6***	69.9	0.2	0.4	70.5	17.3

The energy content of diesel is 38.6 GJ/kL. Thus, for each 1000l of diesel consumed the greenhouse gas emissions are contained in Table 15.

Table 15: GHG Emissions per 1000 l of diesel fuel consumption

$$t\ CO_2\text{-}e = \frac{Q\ \times\ EC\ \times (EF1 + EF3)}{1{,}000}$$
Where: Q = 1 kL EC = 38.6 GJ/kL EF1 is the Scope 1 emission factor for each individual gas as per Table 14 , which can be combined into a single emission factor. carbon dioxide CO_2 = 69.90 kg CO_2-e/GJ methane CH_4 = 0.1 kg CO_2-e/GJ nitrous oxide N_2O = 0.4 kg CO_2-e/GJ EF3 from Table 14 = 17.3 kg CO_2-e/GJ
Solution 1: Calculation of Total Greenhouse Gas Emissions (t CO_2-e)
Combined emission factor $= 69.9\ +\ 0.1\ +\ 0.4\ + 17.3$ = 87.7 kg CO_2-e/GJ
Combined scopes 1 and 3 total greenhouse gas emissions (t CO_2-e) $= \frac{1 \times 38.6 \times 87.5}{1{,}000}$ = 3.38 t CO_2-e per 1000litre of diesel fuel

It is anticipated that the construction fleet would use on average 1.5 kL per day of diesel and the construction period would require approximately 6 months of intensive construction per work site. Thus, the estimated total GHG emissions (t CO2-e) is (1.5*3.38*175*2) = 1777 t CO_2-e. It is recommended the greenhouse emissions be reviewed once the construction fleet and works program is complete.

6 Conclusions

It was determined that the key issues to be addressed in the assessment is dust from all operations. Other types of air emissions have minor and impacts localised to the lease area. In relation to particulates (dusts), EPP(Air) provides environmental objectives associated with health and wellbeing and from the DERM Licensing and Permits, a single nuisance objective was obtained. The NEPM also provides environmental objectives.

The modelling was carried out using TAPM and Calmet to develop the meteorology data set used in the modelling. The particulate dispersion modelling simulation was carried out over 2 years 2022 to 2023 using Calpuff.

Two modelling cases were considered. One for the PAF lift and the other for the tailings dam lift.

The main construction activities and processes that produce, or could produce, particulate emissions were identified for the operations. An emission factor (from NPI Emissions databases) was attributed to these operations.

The predicted average ground level concentrations at nearby sensitive receptors and reference locations were modelled and Section 4.1.2 contains a full description of the modelling methods. The methodology includes both expected maximum emission conditions and the worst case meteorological conditions.

It was found that both cases readily comply with the air quality goals at all sensitive receptors.

Based on this analysis the Dugald River Mine may readily continue operating at full capacity and undertake concurrent construction works associated with the Dam Raise and PAF raise and continue to comply with environmental obligations with respect to air quality.

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Appendix A: Windrose for Site

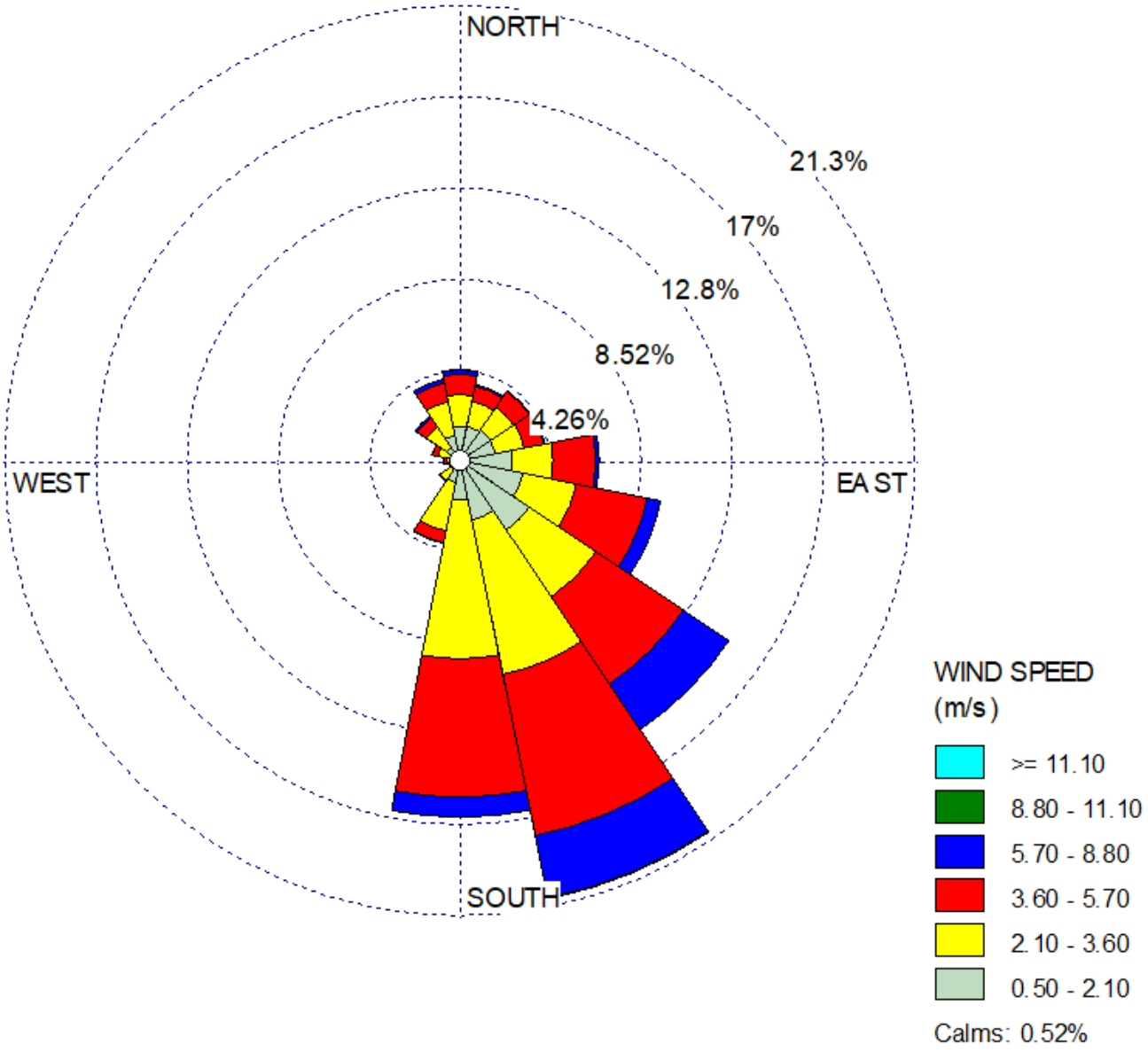


Figure 6: Windrose All Hours – from Model

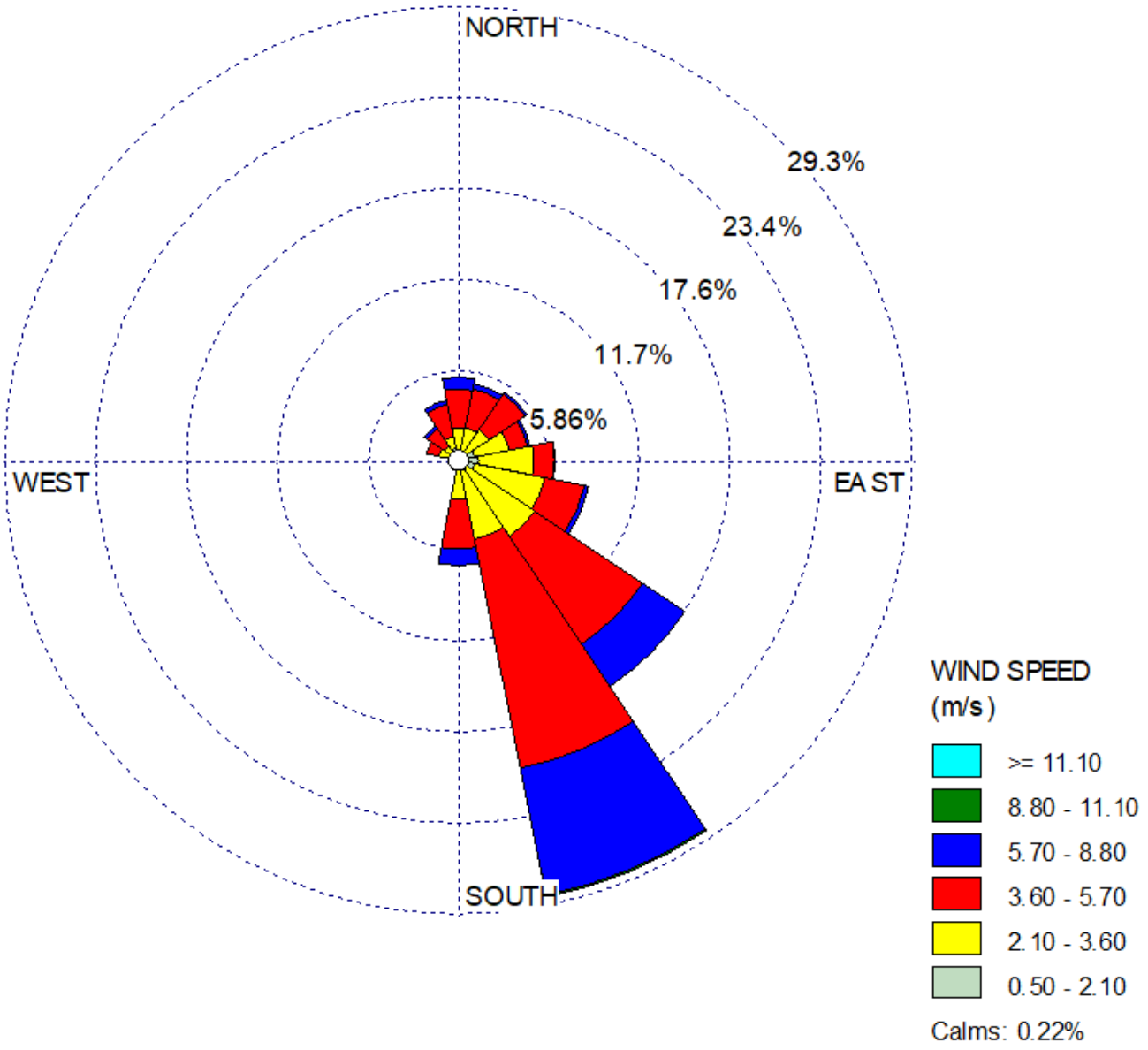


Figure 7: Windrose 9am - from Model

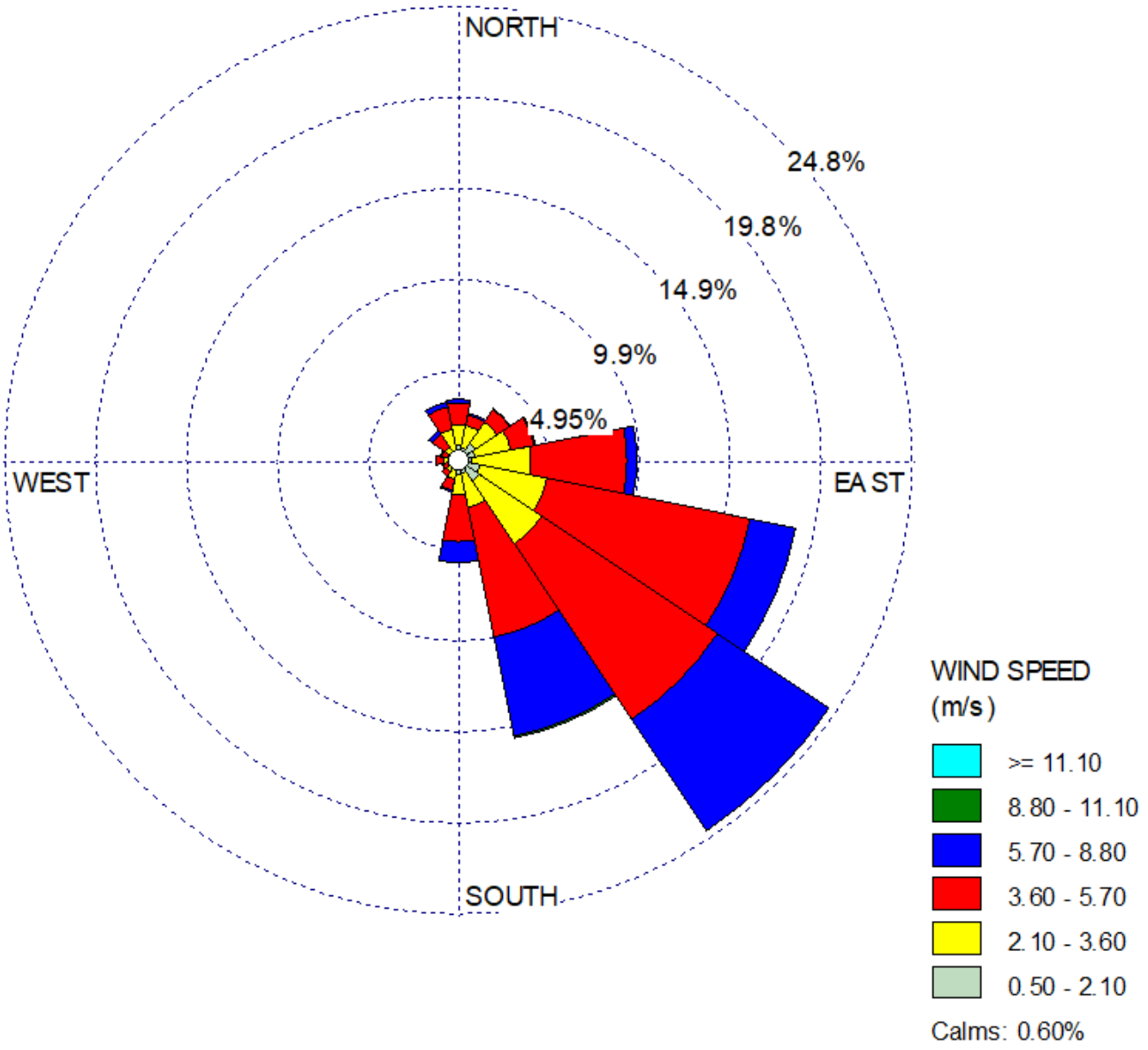


Figure 8: Windrose - 3PM from model

Appendix B: Dust Emission Factors

Table 16: TSF Emission Factors

Plant	Operation								Emission Factors								Control	Emissions (Total)		Emissions (Controlled)		Emissions By Source						Tonnes/Annum (controlled)		
									TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}						Road		Borrow Pit		Dam				
	Quantity	Duration	Running Time	Speed (km/hr)	Distance (per	Cycles/hr	T/hr	Area	kg/T	kg/T	kg/VKT	kg/VKT	kg/h/vehicle		kg/ha/hr	kg/ha/hr	%	TSP	PM10	TSP	PM10	TSP	PM10	TSP	PM10	TSP	PM10			
D11 dozer	1	3	10	3									17	4.1				17	4.1	17.0	4.1					17.0	4.1	74.5	18.0	2.2
50tonne excavator	3	6	10				1250		0.025	0.012								31.25	15	31.3	15.0			31.3	15.0			136.9	65.7	8.2
30tonne excavator	1	7	10				150		0.025	0.012								3.75	1.8	3.8	1.8			3.8	1.8			16.4	7.9	1.0
16m Grader	1	4	10	10							0.19	0.085						1.9	0.85	1.9	0.9	0.19	0.085			1.71	0.765	8.3	3.7	0.5
Moxy dump truck	5	6	10	15	2.4	31.3					4.23	1.25					75%	63.45	18.75	15.9	4.7	15.9	4.7					69.5	20.5	2.6
Moxy dump truck (Dumping)	5						1250		0.012	0.0043								15	5.375	15.0	5.4					15.0	5.4	65.7	23.5	2.9
Moxy water truck	1	7	10	5	2.4	2.1					4.23	1.25					75%	21.15	6.25	5.3	1.6	3.1725	0.9375	1.0575	0.3125	1.0575	0.3125	23.2	6.8	0.9
Body truck heavy rigid	1	3	10	15	2.4	6.3					4.23	1.25					75%	63.45	18.75	15.9	4.7	15.9	4.7					69.5	20.5	2.6
Body truck heavy rigid (Dumping)	1						150		0.012	0.0043								1.8	0.645	1.8	0.6					1.8	0.6	7.9	2.8	0.4
Water Truck heavy rigid	1	8	10	5	2.4	2.1					4.23	1.25					75%	21.15	6.25	5.3	1.6	3.1725	0.9375	1.0575	0.3125	1.0575	0.3125	23.2	6.8	0.9
Wind Erosion								10							0.4	0.2		4	2	4.0	2.0			2	1	2	1	17.5	8.8	1.1
Total																		**243.9**	**79.8**	**117.0**	**42.3**	**38.3**	**11.3**	**39.1**	**18.4**	**39.6**	**12.5**	512.5	185.1	23.1

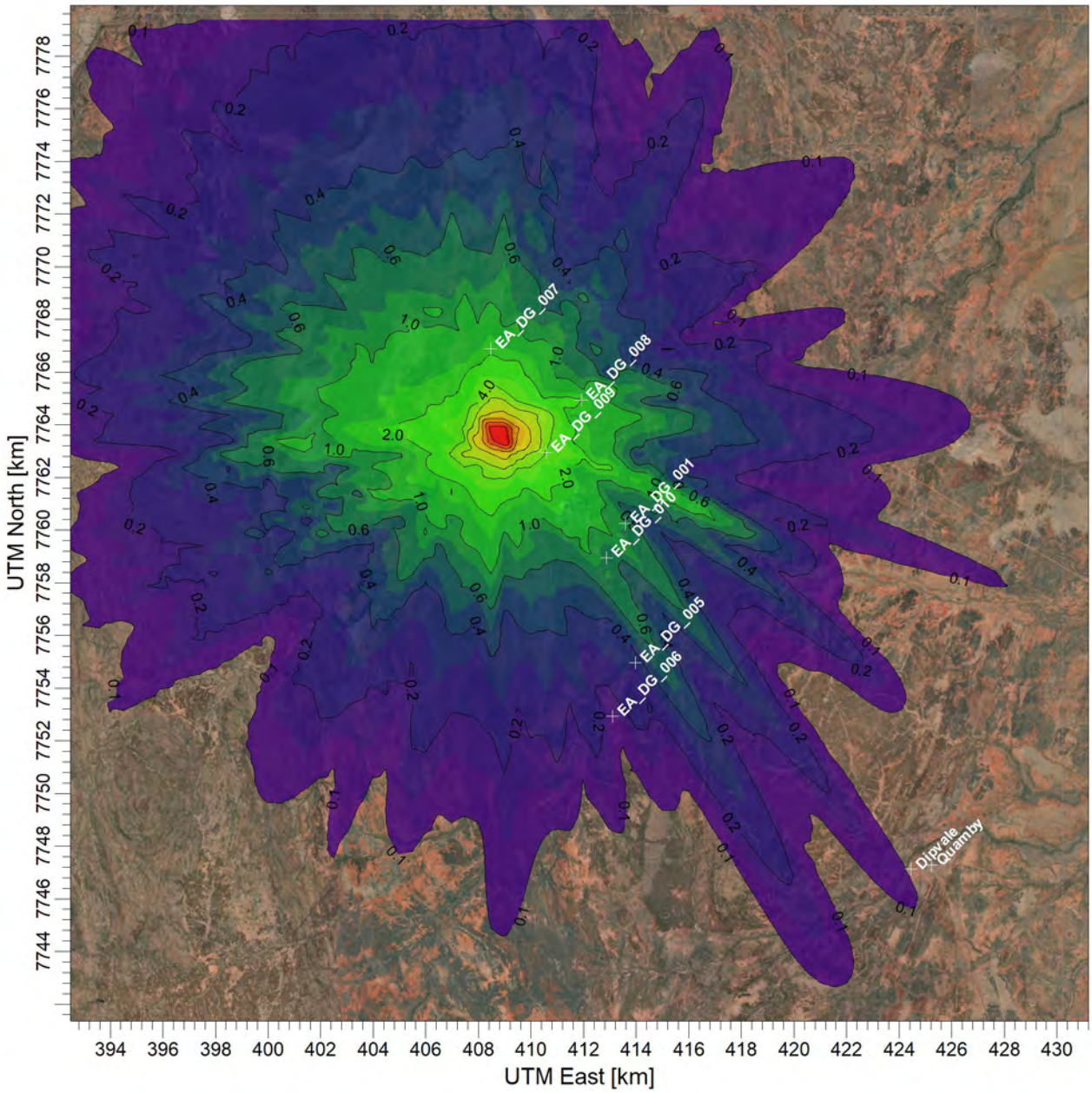
Table 17: PAF Emission Factors

Plant	Operation								Emission Factors								Control	Emissions (Total)		Emissions (Controlled)		Emissions By Source						Tonnes/Annum (controlled)		
									TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}	TSP	PM_{10}						Road		Borrow Pit		Dam				
	Quantity	Duration	Running Time	Speed (km/hr)	Distance (per	Cycles/hr	T/hr	Area	kg/T	kg/T	kg/VKT	kg/VKT	kg/h/vehicle		kg/ha/hr	kg/ha/hr	%	TSP	PM10	TSP	PM10	TSP	PM10	TSP	PM10	TSP	PM10			
D11 dozer	1	3	10	3									17	4.1				17	4.1	17.0	4.1					17.0	4.1	74.5	18.0	2.2
50tonne excavator	3	6	10				1154		0.025	0.012								28.84615385	13.8	28.8	13.8			28.8	13.8			126.3	60.6	7.6
30tonne excavator	1	7	10				150		0.025	0.012								3.75	1.8	3.8	1.8			3.8	1.8			16.4	7.9	1.0
16m Grader	1	4	10	10							0.19	0.085						1.9	0.85	1.9	0.9	0.19	0.085			1.71	0.765	8.3	3.7	0.5
Moxy dump truck	5	6	10	15	2.6	28.8					4.23	1.25					75%	63.45	18.75	15.9	4.7	15.9	4.7					69.5	20.5	2.6
Moxy dump truck (Dumping)							1154		0.012	0.0043								13.84615385	4.961538462	13.8	5.0					13.8	5.0	60.6	21.7	2.7
Moxy water truck	1	7	10	5	2.6	1.9					4.23	1.25					75%	21.15	6.25	5.3	1.6	3.1725	0.9375	1.0575	0.3125	1.0575	0.3125	23.2	6.8	0.9
Body truck heavy rigid	1	3	10	15	2.6	5.8					4.23	1.25					75%	63.45	18.75	15.9	4.7	15.9	4.7					69.5	20.5	2.6
Body truck heavy rigid (Dumping)							150		0.012	0.0043								1.8	0.645	1.8	0.6					1.8	0.6	7.9	2.8	0.4
Water Truck heavy rigid	1	8	10	5	2.6	1.9					4.23	1.25					75%	21.15	6.25	5.3	1.6	3.1725	0.9375	1.0575	0.3125	1.0575	0.3125	23.2	6.8	0.9
Wind Erosion								10							0.4	0.2		4	2	4.0	4.0			2	2	2	2	17.5	17.5	2.2
Total																		74.5	18.0	2.2	74.5	18.0	2.2	74.5	18.0	2.2	74.5	18.0	2.2	74.5

Appendix C: Contours

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - PM2.5 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM2.5) ug/m**3

Max = 54.1 [ug/m**3] at (X = 408974.00, Y = 7763376.00)

0.1 0.2 0.4 0.6 1.0 2.0 4.0 6.0 10.0 20.0 30.0 40.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

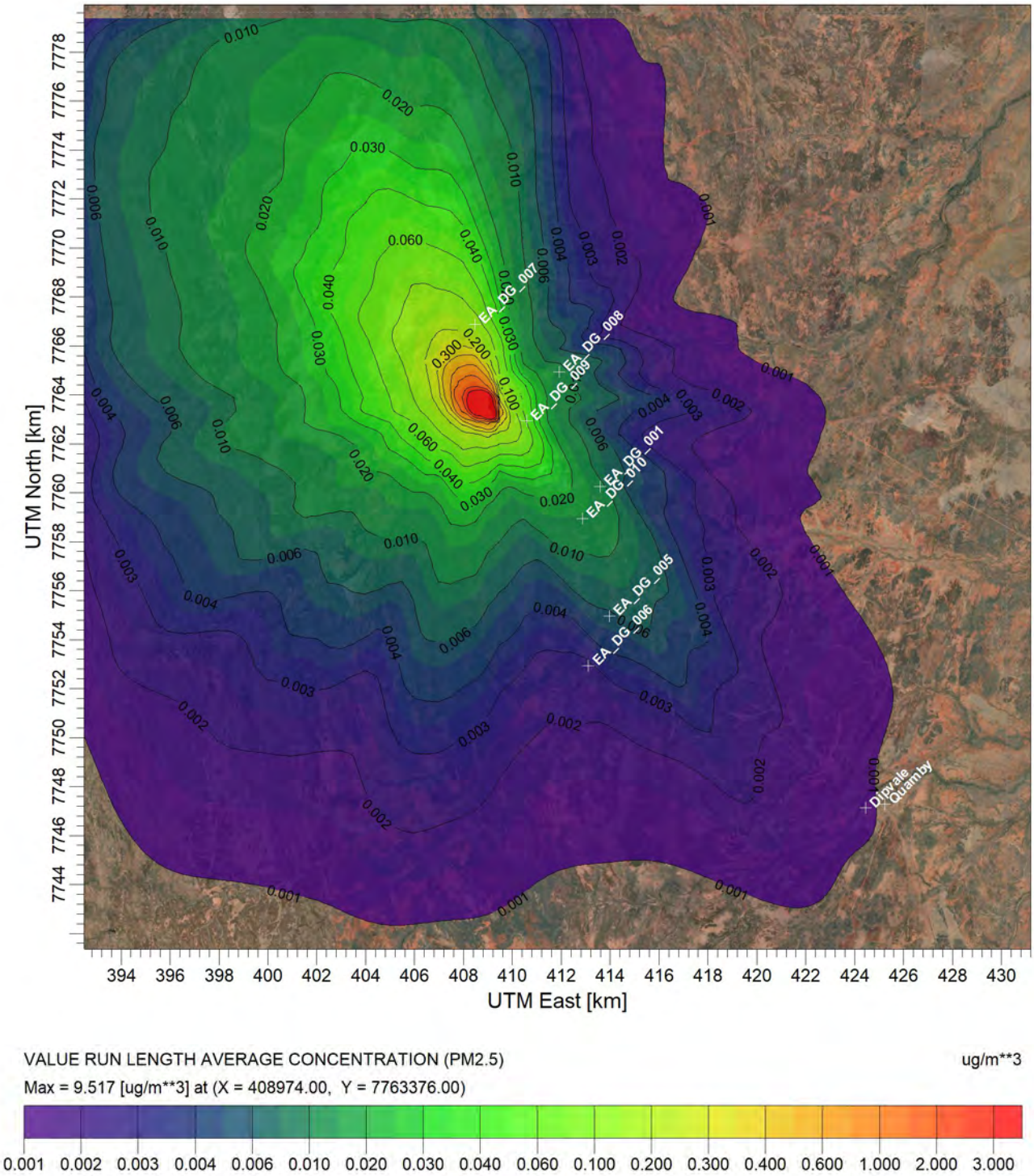
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - PM2.5 Annual Average



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

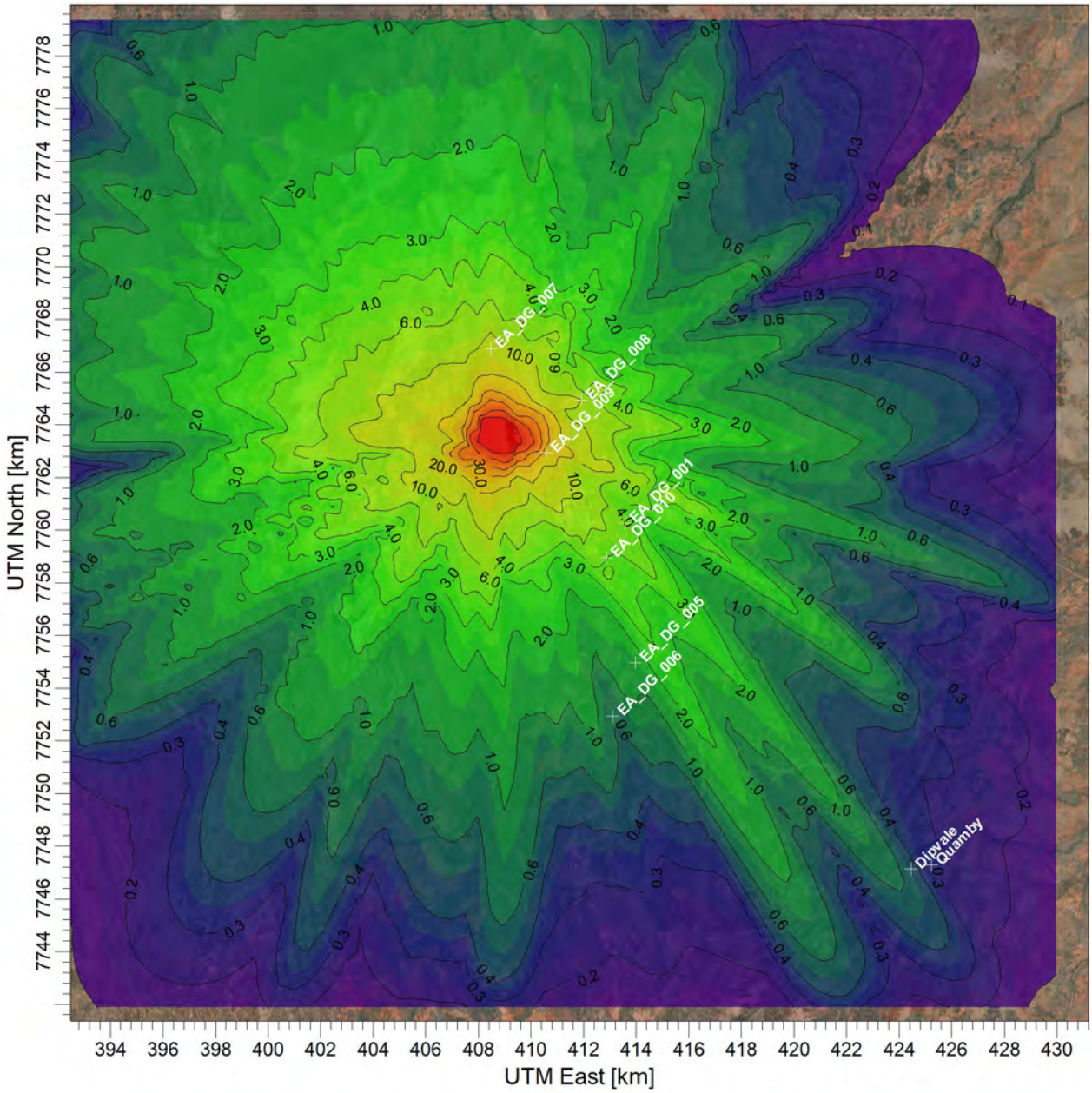
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - PM10 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 357.1 [ug/m**3] at (X = 408974.00, Y = 7763376.00)

0.1 0.2 0.3 0.4 0.6 1.0 2.0 3.0 4.0 6.0 10.0 20.0 30.0 40.0 60.0 100.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

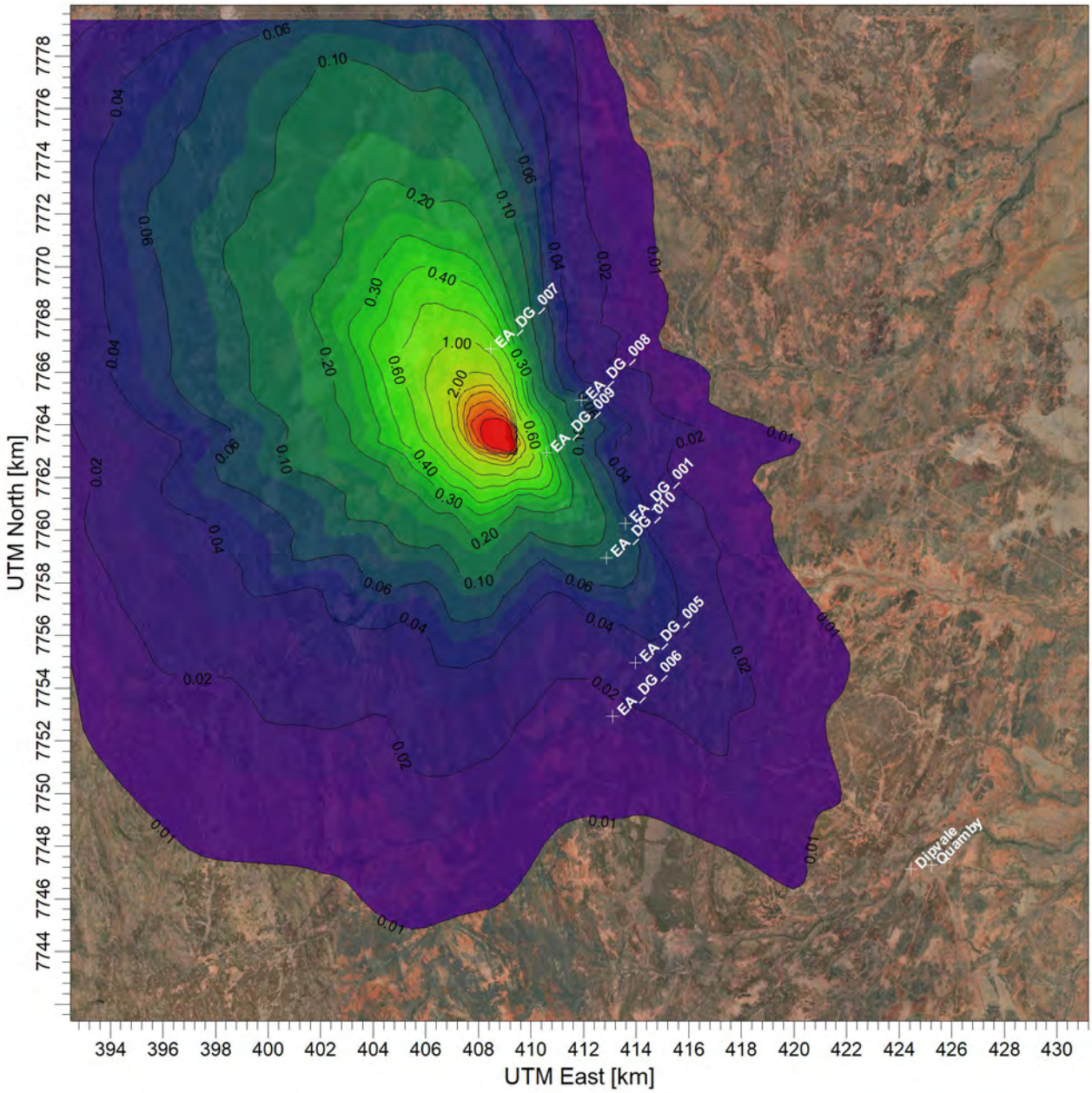
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - PM10 Annual Average



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 74.42 [ug/m**3] at (X = 408974.00, Y = 7763376.00)

0.01 0.02 0.04 0.06 0.10 0.20 0.30 0.40 0.60 1.00 2.00 3.00 4.00 6.00 10.00 20.00

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

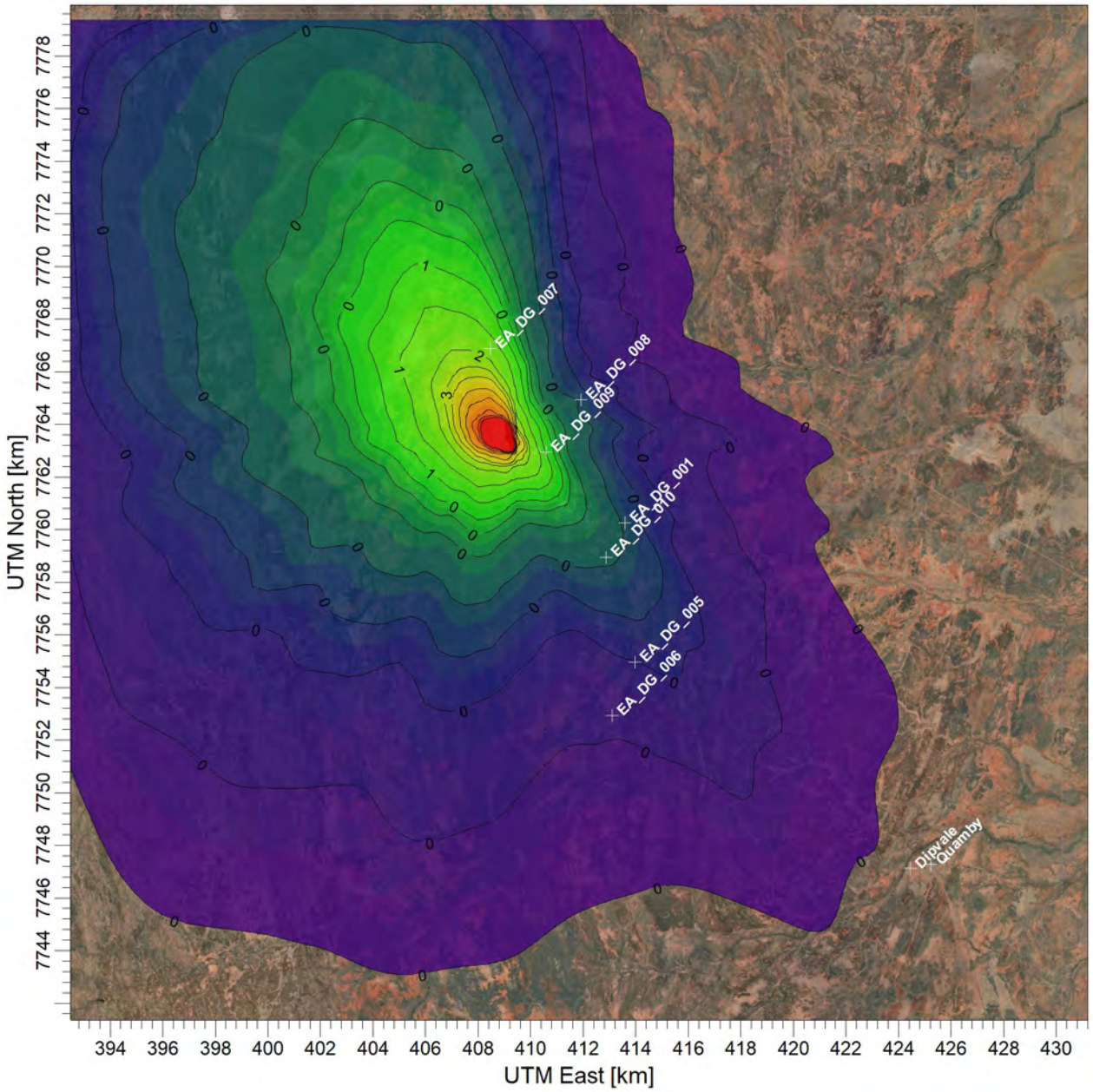
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - TSP Annual Average



VALUE RUN LENGTH AVERAGE CONCENTRATION (TSP) ug/m**3

Max = 195 [ug/m**3] at (X = 408974.00, Y = 7763376.00)

0 0 0 0 0 0 0 0 1 1 2 3 4 6 10 20 30 40

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

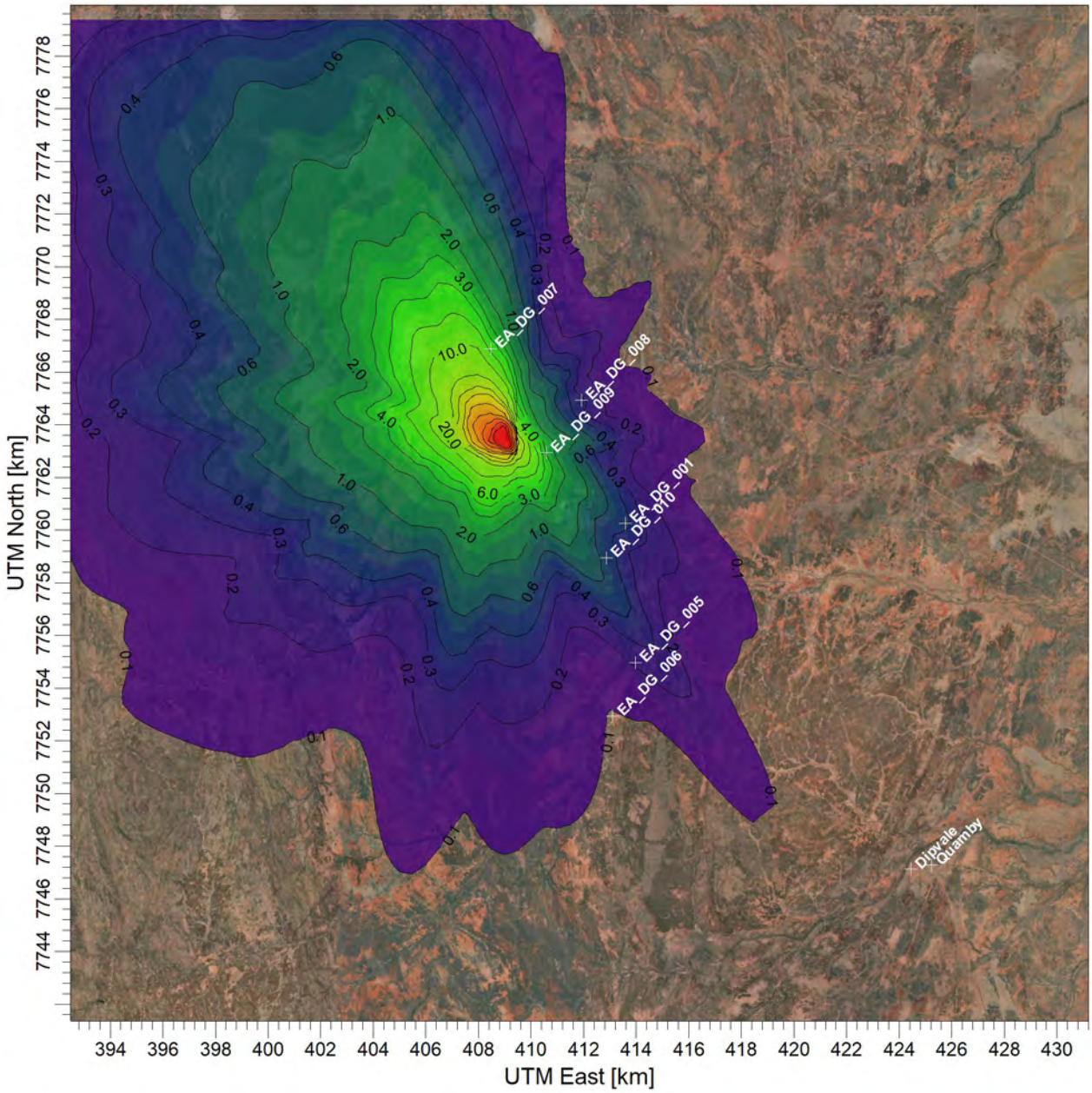
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
Tailings Dam - Dust Deposition Max Month



1 RANK 720 HOUR AVERAGE DRY DEPOSITION (TSP) mg/m**2/day

Max = 794.8 [mg/m**2/day] at (X = 408974.00, Y = 7763376.00)

0.1 0.2 0.3 0.4 0.6 1.0 2.0 3.0 4.0 6.0 10.0 20.0 30.0 40.0 60.0 100.0 200.0 300.0 400.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

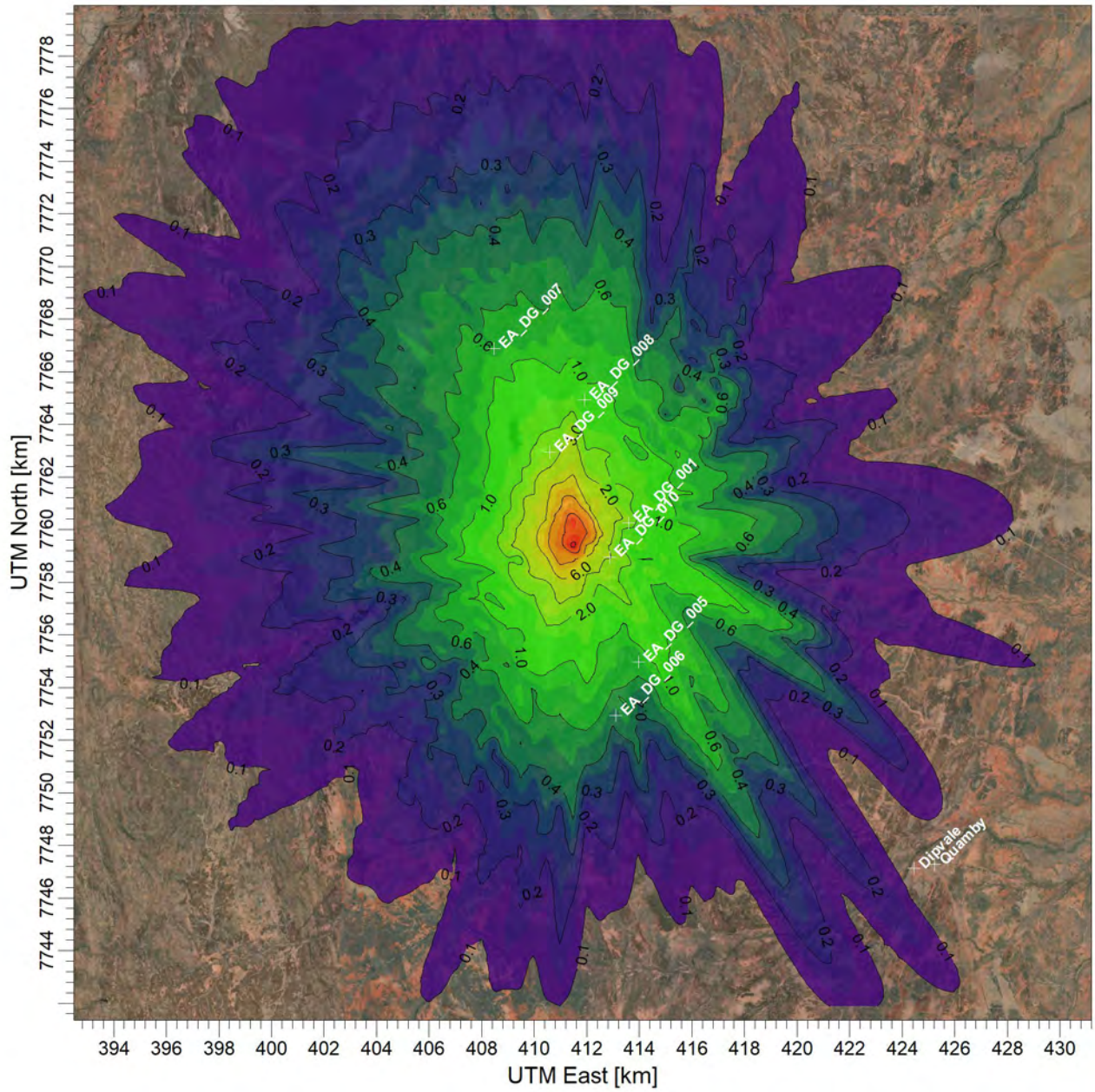
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion - PM2.5 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM2.5) ug/m**3

Max = 32.9 [ug/m**3] at (X = 411474.00, Y = 7759376.00)

0.1 0.2 0.3 0.4 0.6 1.0 2.0 3.0 6.0 10.0 20.0 30.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

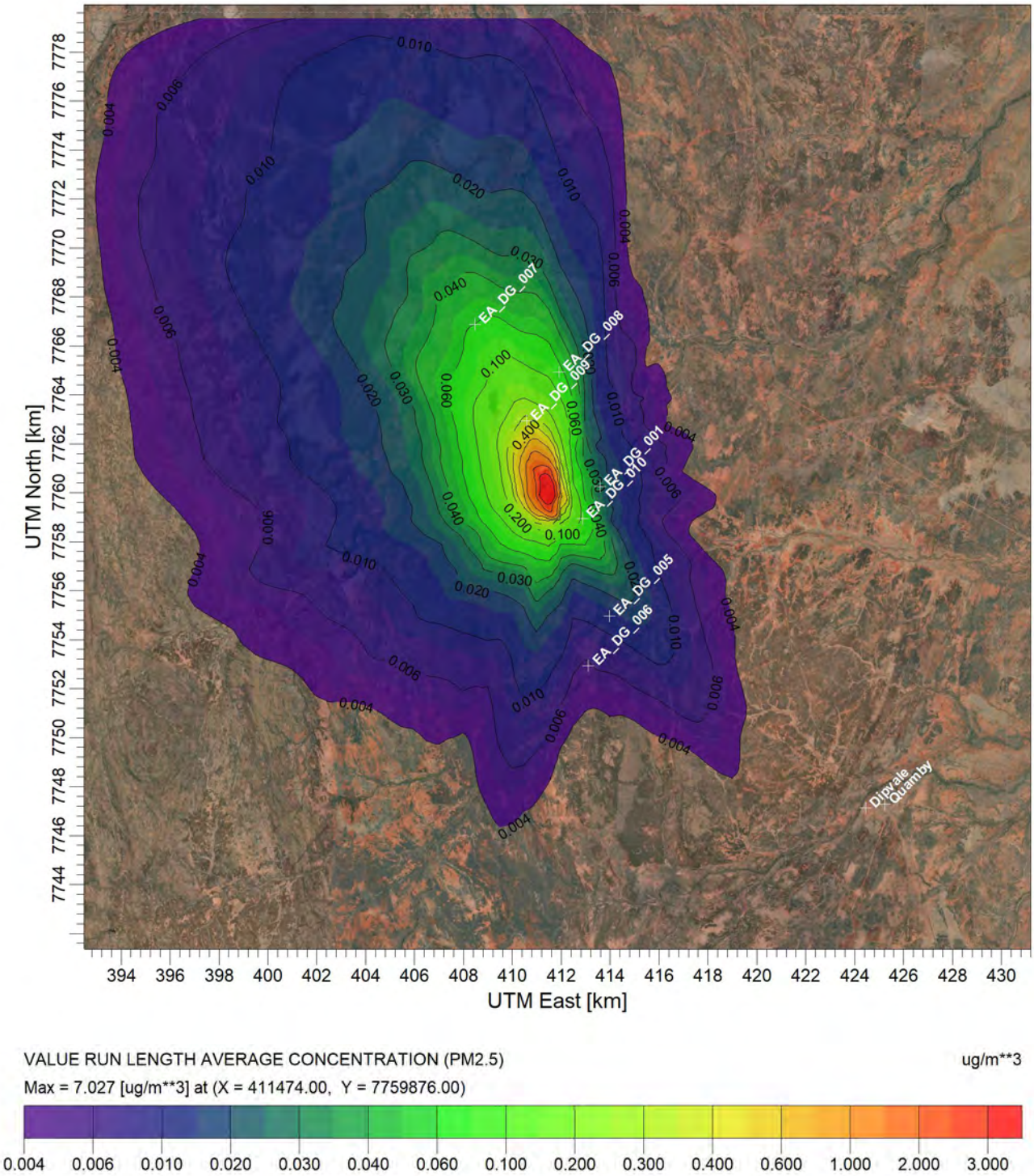
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion - PM2.5 Annual Average



COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

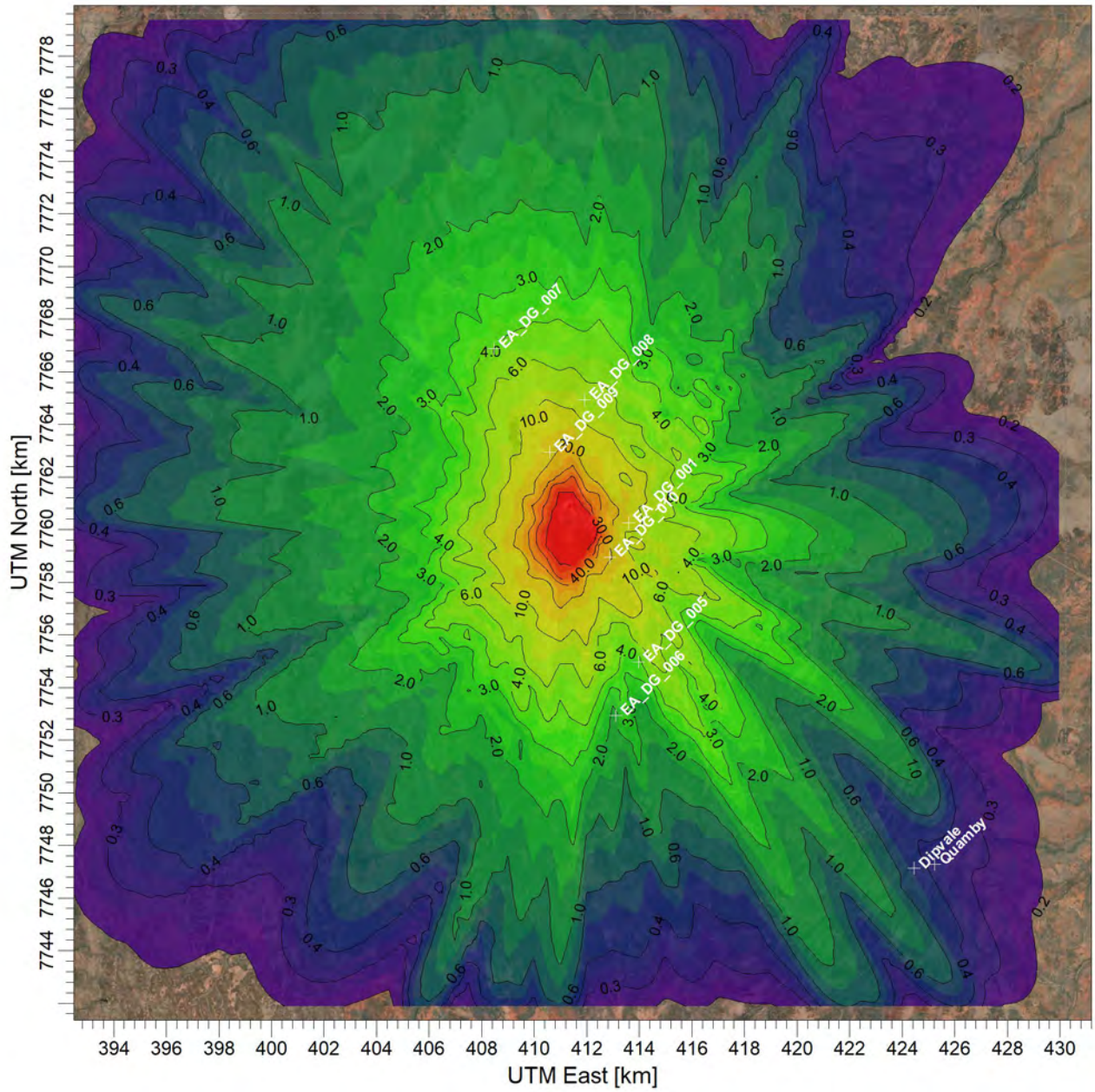
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion - PM10 24 Hour Maximum



1 RANK 24 HOUR AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 257.5 [ug/m**3] at (X = 411474.00, Y = 7759376.00)

0.2 0.3 0.4 0.6 1.0 2.0 3.0 4.0 6.0 10.0 20.0 30.0 40.0 60.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

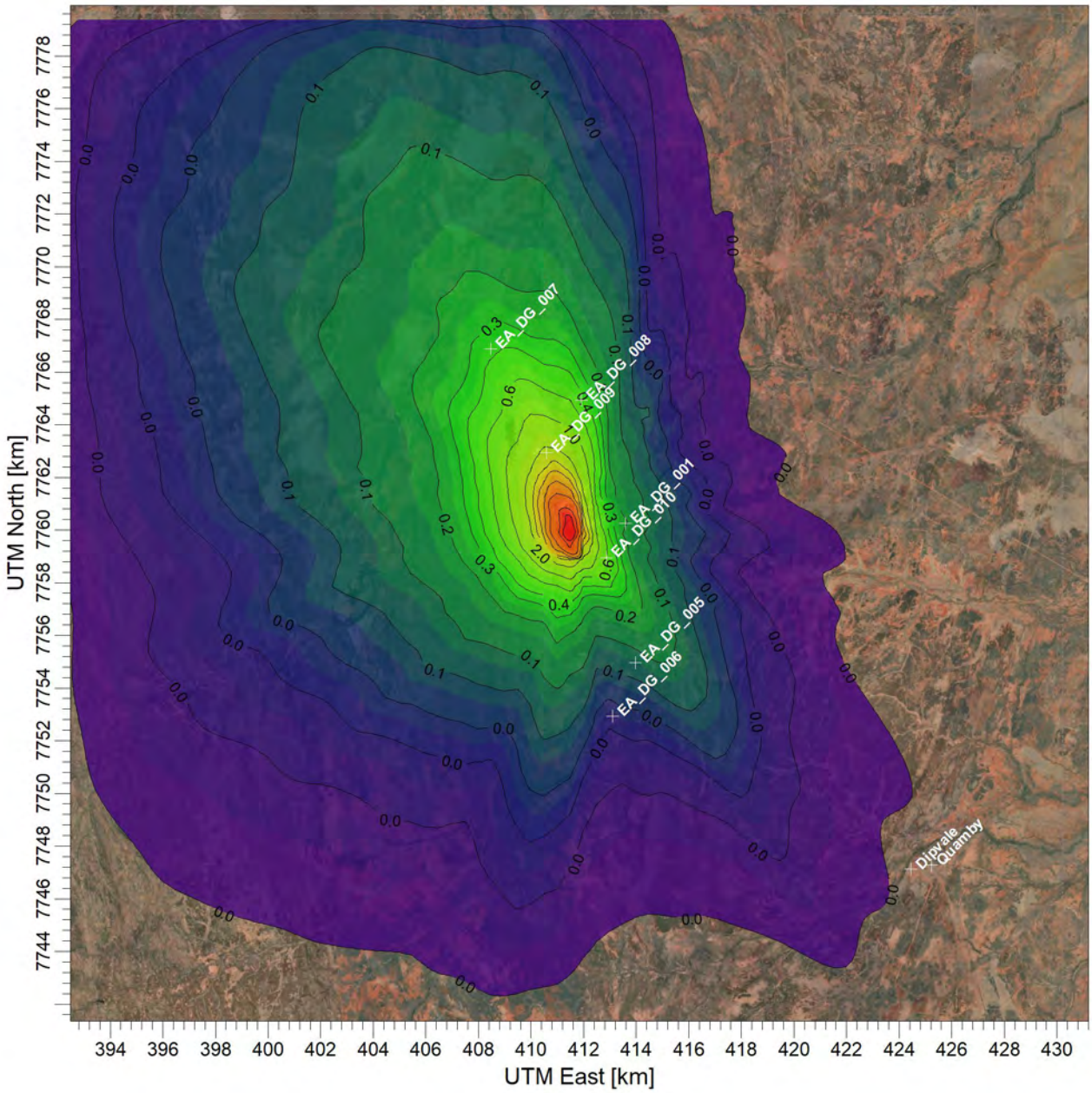
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion - PM10 Annual Average



VALUE RUN LENGTH AVERAGE CONCENTRATION (PM10) ug/m**3

Max = 54.3 [ug/m**3] at (X = 411474.00, Y = 7759876.00)

0.0 0.0 0.0 0.0 0.1 0.1 0.2 0.3 0.4 0.6 1.0 2.0 3.0 4.0 6.0 10.0 20.0 30.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

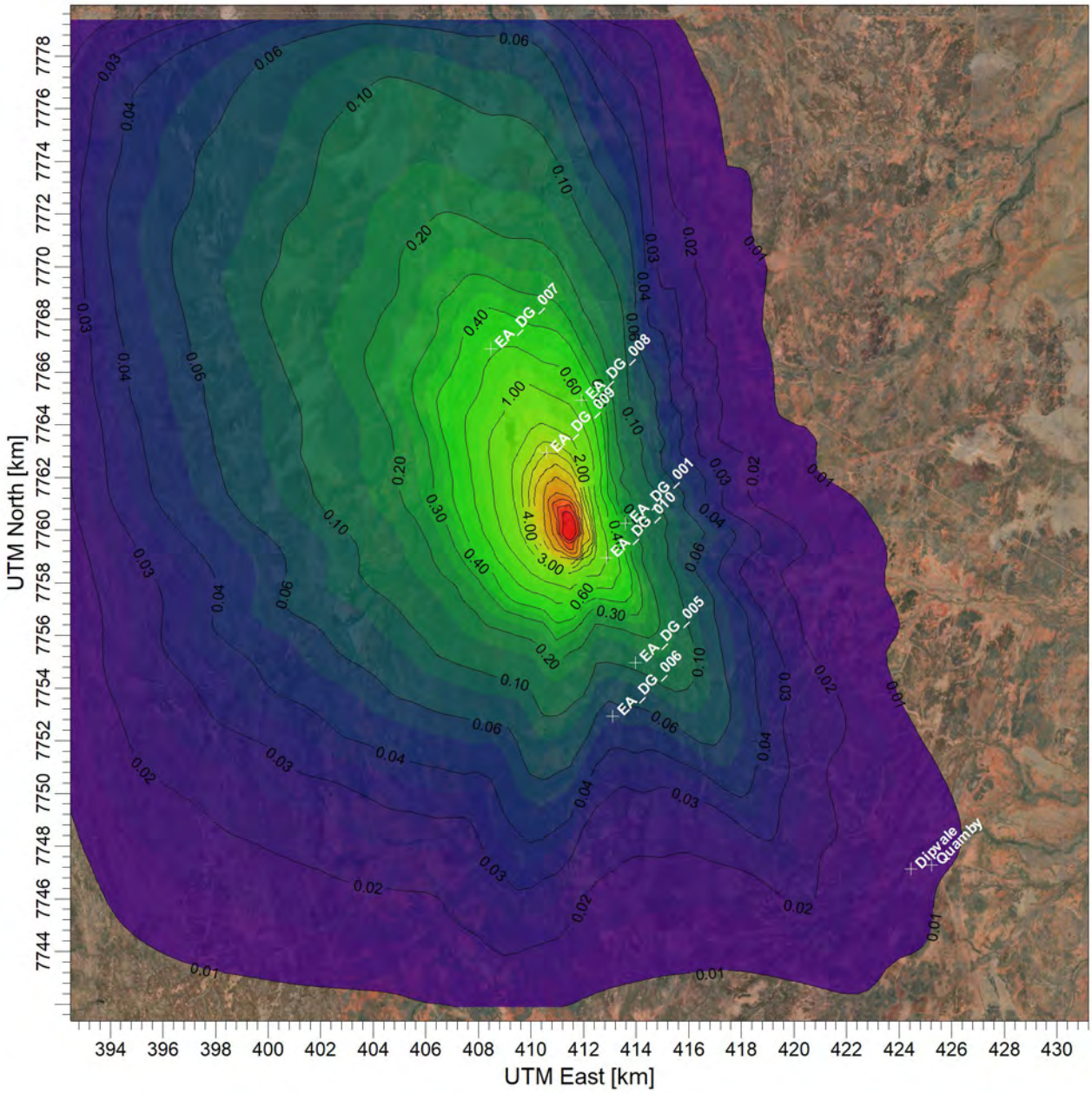
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion -TSP Annual Average



VALUE RUN LENGTH AVERAGE CONCENTRATION (TSP) ug/m**3

Max = 112.98 [ug/m**3] at (X = 411474.00, Y = 7759876.00)

0.01 0.02 0.03 0.04 0.06 0.10 0.20 0.30 0.40 0.60 1.00 2.00 3.00 4.00 6.00 10.00 20.00 30.00 40.00 60.00

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

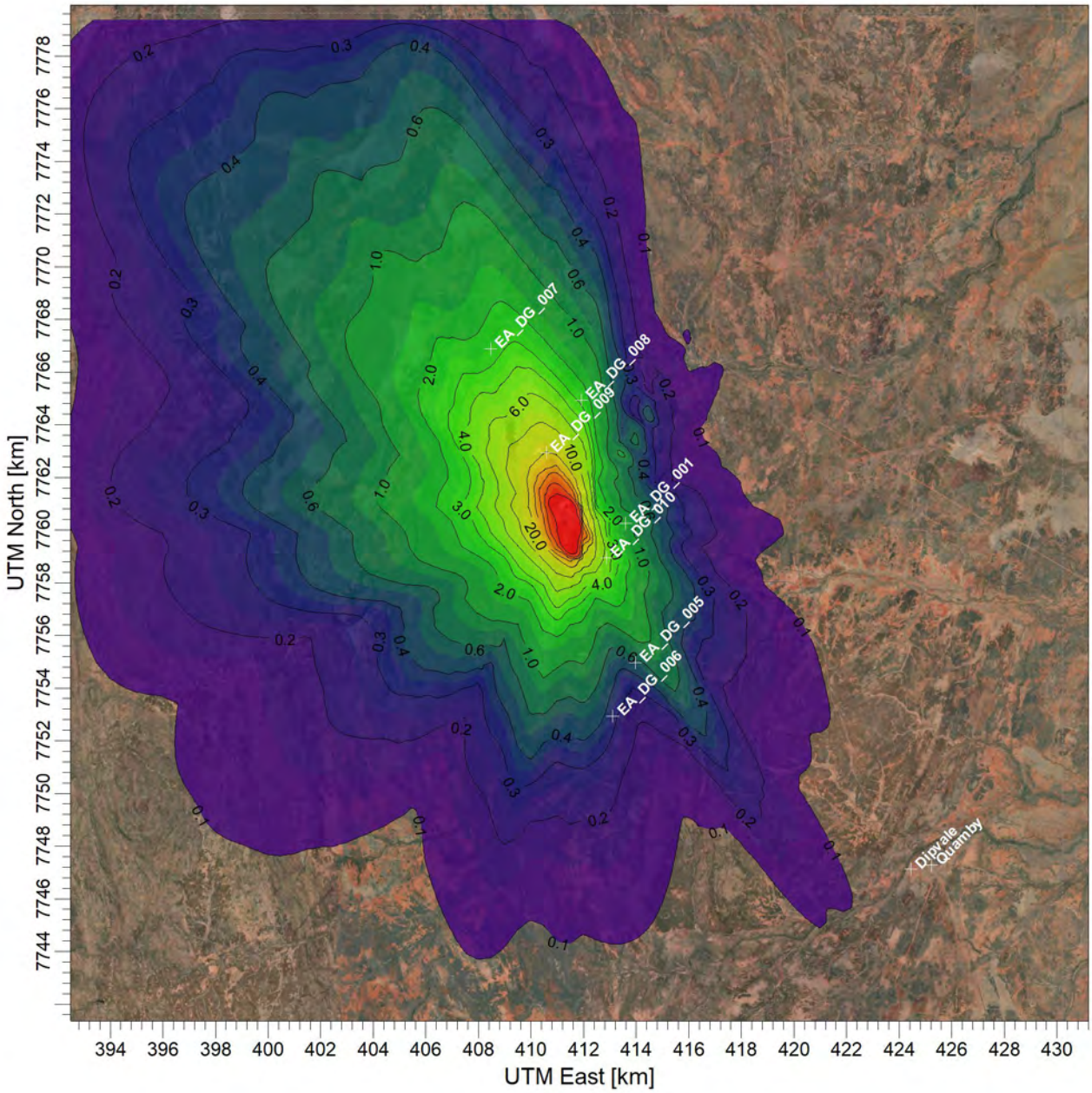
13/02/2025

PROJECT NO.:

240710

PROJECT TITLE:

Dougal River Mine Tailings Dam Lift and PAF Pad Expansion
PAF Pad Expansion - Dust Deposition Max Month



1 RANK 720 HOUR AVERAGE DRY DEPOSITION (TSP) mg/m**2/day

Max = 374.3 [mg/m**2/day] at (X = 411474.00, Y = 7760376.00)

0.1 0.2 0.3 0.4 0.6 1.0 2.0 3.0 4.0 6.0 10.0 20.0 30.0 40.0 60.0 100.0

COMMENTS:

COMPANY NAME:

Simpson Engineering Group

MODELER:

Chris Simpson

SCALE: 1:250,000

0 5 km

Simpson Engineering Group

DATE:

13/02/2025

PROJECT NO.:

240710

APPENDIX K: Groundwater Impact Assessment for the Dugald River Mine TSF (CDM Smith, 2025)

CDM SMITH AUSTRALIA

Suite 1, Level 4, 140 Ann Street
Brisbane City QLD 4000
australia@cdmsmith.com

Report

Groundwater Impact Assessment for the Dugald River Mine TSF

PREPARED FOR:

Wulguru Technical Services Pty Ltd

PO Box 2553
Idalia QLD 4810

CDM Smith
listen. think. deliver.

Table of contents

Section 1 Introduction ... 1

1.1 Project description ... 1

1.2 Scope of assessment ... 1

1.3 Report structure ... 4

Section 2 Queensland regulatory framework ... 5

2.1 Water Act 2000 ... 5

2.2 Environmental Protection Act 1994 ... 5

2.3 Environmental Authority ... 6

Section 3 Project setting ... 8

3.1 Location and land use ... 8

3.2 Climate ... 8

3.3 Topography and drainage ... 11

3.4 Geology ... 13

Section 4 Methodology ... 15

4.1 Desktop study ... 15

4.1.1 Groundwater bore database searches ... 15

4.1.2 Dugald River groundwater monitoring database ... 15

4.1.3 Other database searches and government mapping ... 15

4.1.4 Literature review ... 18

4.2 Data analysis and conceptualisation ... 18

4.3 Numerical modelling ... 18

Section 5 Existing groundwater regime ... 22

5.1 Overview ... 22

5.2 Cainozoic sediments ... 24

5.3 Lady Clayre Formation and Coocerina Formation ... 25

5.4 Mount Roseby Schist ... 25

5.5 Knapdale Quartzite ... 26

5.6 Groundwater interactions with surface water ... 27

5.7 Groundwater quality ... 28

5.8 Tailings ... 28

5.9 Groundwater users 28

Section 6 Impact assessment 30

6.1 Overview of proposed Stage 3 TSF activities 30

6.2 Groundwater modelling predictions 30

6.3 Project impacts 31

6.3.1 Impacts on groundwater resources 31

6.3.2 Impacts on groundwater supply bores 31

6.3.3 Impacts on surface drainage 31

6.3.4 Impacts on wetlands 32

6.3.5 Impacts on groundwater dependent ecosystems 32

6.3.6 Cumulative impacts 32

6.3.7 Impacts on groundwater quality 32

Section 7 Post-mining land use 34

7.1 Current and potential future uses of groundwater 34

7.2 Final landform 34

7.3 Post-mining site hydrogeology 34

7.4 Post-mining groundwater quality 34

Section 8 Groundwater monitoring and management 35

8.1 Approved groundwater monitoring program 35

8.2 Additional site monitoring 35

8.2.1 Groundwater monitoring 36

8.3 Management measures 37

Section 9 Conclusion 38

Section 10 References 39

Section 11 Abbreviations 41

Figures

Figure 1-1 Location plan ... 2
Figure 1-2 Tailings Storage Facility Extent ... 3
Figure 2-1 Gulf Water Plan ... 7
Figure 3-1 Dugald River Mine layout ... 9
Figure 3-2 Monthly average climate data ... 10
Figure 3-3 Cumulative deviation from the mean – 2012 to 2024 ... 11
Figure 3-4 Topography and drainage ... 12
Figure 3-5 West to east conceptual geological cross-section (adapted from GSQ Geological Maps) ... 13
Figure 3-6 Regional surface geology ... 14
Figure 4-1 Registered groundwater bore locations ... 16
Figure 4-2 Groundwater monitoring network ... 17
Figure 4-3 Numerical model cross section (west to east) ... 19
Figure 5-1 Groundwater elevation ... 23
Figure 5-2 Conceptual hydrogeological model (CDM Smith, 2021) ... 24
Figure 5-3 Hydrographs – Mount Roseby Schist ... 26
Figure 5-4 Hydrographs – Knapdale Quartzite ... 27
Figure 5-5 Piper plot ... 29
Figure 6-1 Groundwater dependent ecosystems ... 33

Tables

Table 3-1 Climate averages ... 8
Table 4-1 Numerical model hydraulic parameters ... 20
Table 4-2 Sensitivity analysis hydraulic parameter settings ... 21
Table 8-1 Groundwater monitoring bore construction details ... 36
Table 8-2 Additional groundwater monitoring network bores ... 36

Appendices

Appendix A Registered groundwater bores ... 42

Document history & status

Revision	Date issued	Reviewed by	Approved by	Date approved	Revision type
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Last Saved:	17 April 2025
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Author:	Éamon Lai
Project Manager:	Amanda Clements
Client:	Wulguru Technical Services Pty Ltd
Document Title:	**Groundwater Impact Assessment for the Dugald River Mine TSF**
Document Version:	Rev 1
Project Number:	1001826

Section 1 Introduction

CDM Smith was commissioned by Wulguru Technical Services Pty Ltd (WTS) to complete a groundwater impact assessment to support an Environmental Authority (EA) and Progressive Rehabilitation Closure Plan (PRCP) amendment for the Dugald River Mine (DRM).

1.1 Project description

Dugald River Mine (DRM) is an underground zinc mine located approximately 65 km northwest of Cloncurry, in north-western Queensland (Figure 1-1). DRM encompasses 40 mining leases (ML) and one mineral development lease (MDL). Infrastructure at the site includes a processing plant, tailings storage facility (TSF), stockpiles, water management structures, and support infrastructure including accommodation village, powerlines and roads. The mine produces approximately 1.7 million tonnes (Mt) of ore annually and has an expected mine life of 22 years (until 2047).

The mine is operated in accordance with Environmental Authority (EA) EPML00731213, effective as of 21 April 2023.

TSF development is occurring in alignment with production via staged raises of the TSF embankment wall (ATC Williams, 2015). Two stages of TSF embankment lifts have been completed to date. The Stage 3 Tailings Dam Lift (this project) will involve increasing the height of the downstream TSF embankment from 243.1 mAHD to 253.5 mAHD. This will bring the TSF embankment height to that approved as part of the 2010 Environmental Impact Statement (EIS) completed for DRM (AARC, 2010). At the conclusion of mining the final TSF will require rehabilitation, which will be addressed via the Progressive Rehabilitation and Closure Plan (PRCP).

The Stage 3 lift will increase the footprint of the TSF from 79.5 hectares (ha) to 91.9 ha (Figure 1-2).

1.2 Scope of assessment

The scope of this report is limited to groundwater understanding attached to the proposed Stage 3 raise of the existing TSF. To achieve this scope of work, the groundwater assessment includes:

- A review of the relevant groundwater, geological and environmental reports related to the TSF and the surrounding area to develop an appreciation of the hydrogeological setting of the TSF.
- A review of the hydrogeological data held by the Department of Local Government, Water and Volunteers (DLGWV) groundwater database (GWDB) to identify water supply bores.
- The development of a conceptual hydrogeological model for the TSF area and its surrounds, based on all available data.
- The development of a numerical model to simulate the effect of the proposed TSF raise on groundwater levels and flow directions within the vicinity of the TSF.
- An assessment of the groundwater related impacts associated with the proposed TSF raise and development of feasible mitigation and management strategies, where necessary.
- A review of the groundwater monitoring program and management measures for the proposed TSF raise.

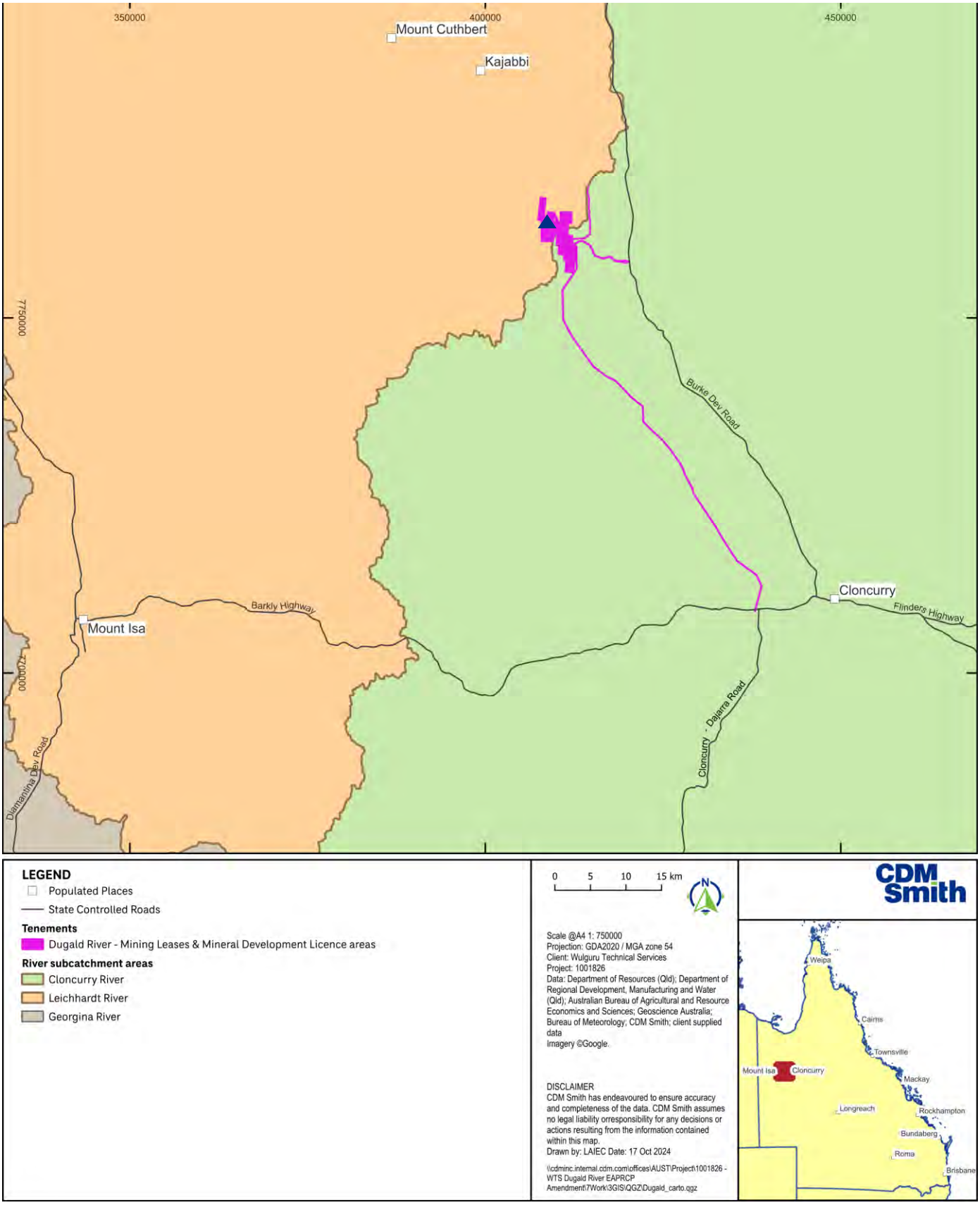

Figure 1-1 Location plan

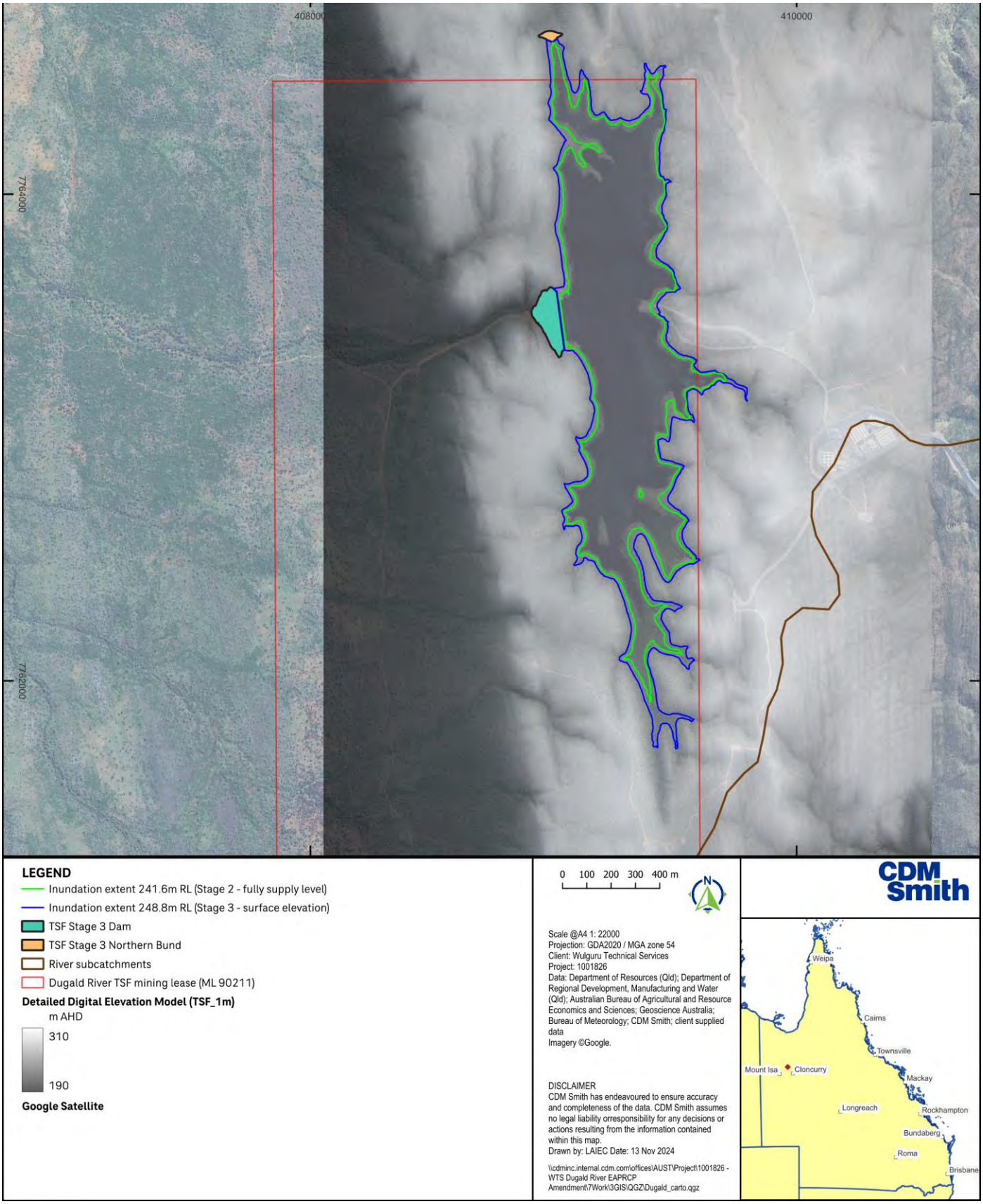

Figure 1-2 Tailings Storage Facility Extent

1.3 Report structure

The report has been arranged in the following structure:

- Section 1 – Introduction: provides an overview of the project and the assessment scope.
- Section 2 – Queensland Regulatory Framework: describes the regulatory setting relating to groundwater.
- Section 3 – Project Setting: describes the environmental and geological setting, including land use, climatic and physiographic factors, geology, groundwater bores.
- Section 4 – Methodology: describes the assessment method including the collection of relevant data and numerical groundwater modelling.
- Section 5 – Existing Groundwater Regime: discusses the existing groundwater regime for the TSF area and surrounding area.
- Section 6 – Impact Assessment: provides a detailed description of the proposed TSF activities and the predicted effects on the local groundwater regime. This section also presents an assessment of the potential impacts on groundwater users and the receiving environment.
- Section 7 – Post-mining Land Use: describes the post-mining land use and groundwater regime.
- Section 8 – Groundwater Monitoring and Management: describes the groundwater monitoring and management measures implemented at DRM.
- Section 9 – Conclusions.
- Section 10 to 11 – Comprising references and abbreviations.

Appendix A presents details of the registered groundwater bores within the vicinity of the TSF.

Section 2 Queensland regulatory framework

CDM Smith have considered the proposed activities and connection to groundwater against the various legislation produced by the Queensland government and relevant Environmental Authorities. Relevant legislation is summarised below.

2.1 Water Act 2000

The *Water Act 2000* (Water Act), supported by the subordinate *Water Regulation 2016*, is the primary legislation regulating groundwater resources in Queensland. The purpose of the Water Act is to provide for the sustainable management and efficient use of water resources by establishing a system for the planning, allocation and use of water. The Water Act is enacted under a framework of catchment specific water plans.

Water resources at the DRM are covered by the Queensland Governments legislated *Water Plan (Gulf) 2007* (Gulf Water Plan) (Figure 2-1). From a surface water perspective, the TSF is located within the Leichardt River catchment area and the Lower Leichhardt River sub-catchment area. However, the TSF is not located within a Groundwater Management Area as defined under the Gulf Water Plan.

The TSF also is not located within the Great Artesian Basins and Other Regional Aquifers (GABORA) Water Plan.

2.2 Environmental Protection Act 1994

The aim of the *Environmental Protection Act 1994* (EP Act) is to protect Queensland waters via the establishment of environmental objectives and values and then driving development, implementation and operating strategies that protect these objectives. Under the EP Act, the *Environmental Protection (Water and Wetland Biodiversity) Policy 2019* (EPP Water) provides the framework for the protection of environmental values (i.e. uses) associated with Queensland aquifers.

The EPP Water sets out environmental values for specific catchments and drainage areas. The EPP Water does not specify any environmental values or water quality objectives for DRM and the surrounding area.

As no EVs have been specified for the DRM and surrounding area, potential environmental values for groundwater under the EPP Water include:

- Aquatic ecosystems
- Irrigation
- Farm supply and use
- Stock water
- Aquaculture
- Human consumers
- Primary recreation
- Secondary recreation
- Visual recreation
- Drinking water
- Industrial use
- Cultural and spiritual values

The existing groundwater quality within the TSF area and it's surrounds (Section 5.7) currently precludes environmental values for aquatic ecosystems, irrigation, farm supply and use, aquaculture, human consumers and drinking water.

There are no known primary recreation, secondary recreation, visual recreation or cultural and spiritual values associated with groundwater within the vicinity of the DRM. The environmental values of groundwater at the DRM are assessed to be limited to stock water and industrial use.

The groundwater users within the TSF area and its surrounds are described in Section 5.9.

2.3 Environmental Authority

An Environmental Authority (EA) (EPML00731213), effective as of 7 November 2024, has been issued to MMG Dugald River Pty Ltd, which is a wholly owned subsidiary of MMG. The EA sets out the obligations for managing environmentally relevant activities at DRM. Groundwater conditions are detailed in EA Conditions C35 to C39.

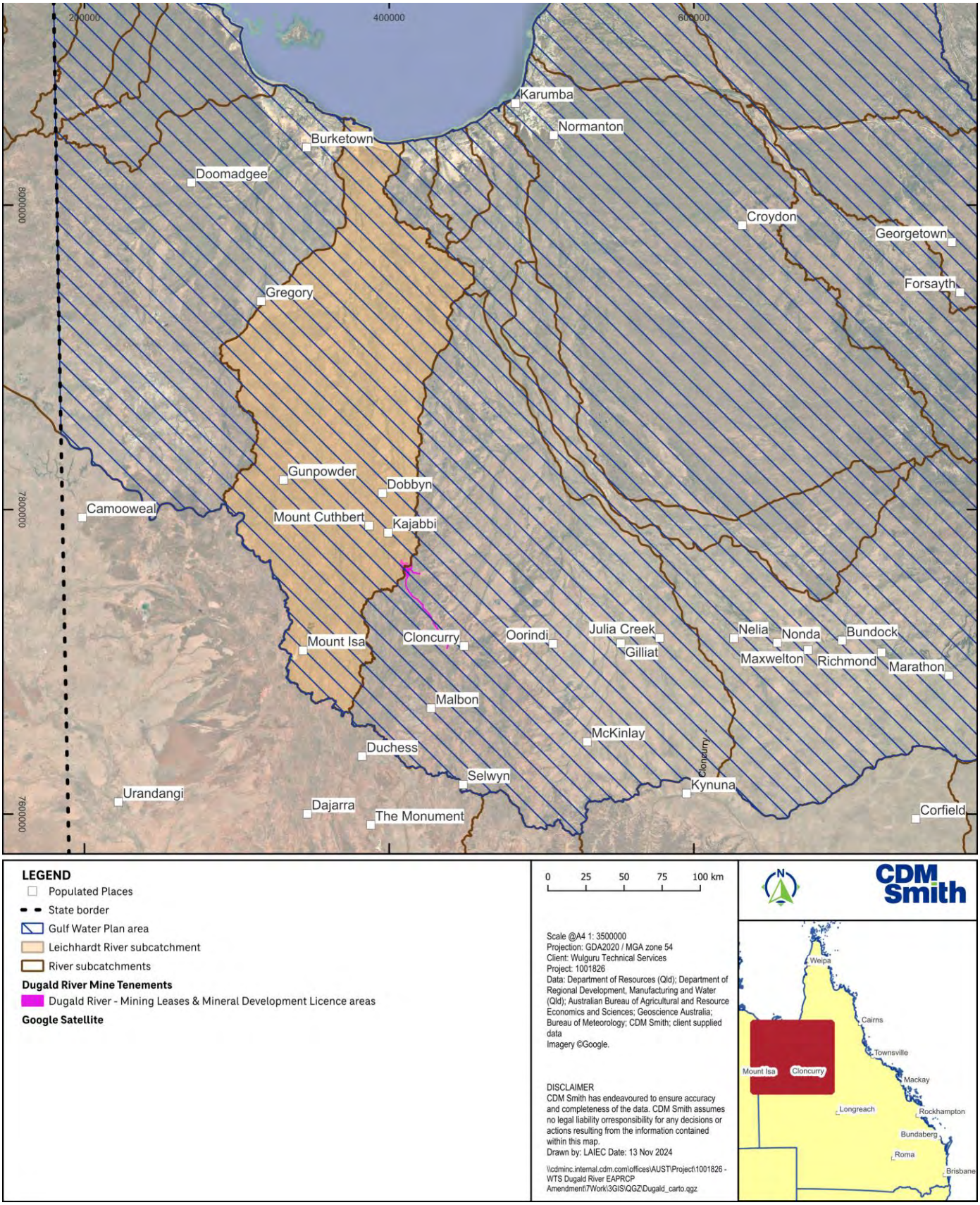

Figure 2-1 Gulf Water Plan

Section 3 Project setting

This section describes the environmental setting of the DRM, including its location and land use, climate, topography and drainage, and local geology.

3.1 Location and land use

The DRM is located approximately 65 km north of Cloncurry (Figure 1-1) and has a disturbance of approximately 340 ha. The TSF is located within ML90211 (Figure 3-1).

The surrounding land use comprises active mining areas associated with the existing approved underground mine and associated mine infrastructure, and cattle grazing.

No other existing mining operations are located within the vicinity of the DRM TSF.

The potential for cumulative groundwater impacts due to the TSF raise and surrounding land uses is discussed in Section 6.3.6.

3.2 Climate

The DRM area is classified as arid, with hot monsoonal summers and cold dry winters. The DRM area is classified as summer rainfall dominant, with the majority of rainfall occurring between November and March.

The nearest Bureau of Meteorology (BoM) weather station is located at Cloncurry Airport (Station 29141), located approximately 65 km to the southeast of the DRM. Site-specific rainfall data is also collected at DRM.

An interpolated site-specific dataset was downloaded from the Department of Environment, Science and Innovation (DESI) Scientific Information for Land Owners (SILO) dataset for the DRM area (at location -20.25°S, 140.15°E). The data is a grid point data set, meaning that the data has been interpolated for this location from surrounding station data.

A summary of the temperature, rainfall and evaporation data available for DRM is shown in Table 3-1 and Figure 3-2.

Table 3-1 Climate averages

Statistics	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean min temp (°C) BoM Cloncurry station	24.5	23.9	22.7	19.1	15.1	11.7	10.3	12.2	15.6	20	22.8	24.2	18.5
Mean max temp (°C) BoM Cloncurry station	37.3	35.6	34.7	32	28.3	25	24.7	27.5	31.2	35.1	37.1	38	32.2
Mean rainfall (mm) BoM Cloncurry station	128.2	103.7	87.6	11.1	15.2	11.8	13.9	4.7	7.4	11.4	39.1	60.5	494.4
Mean rainfall (mm) DRM site data	116.0	130.0	99.0	6.6	23.8	11.1	9.3	5.3	10.1	14.2	47.0	56.6	509.6
Mean evaporation (mm) Interpolated SILO dataset	285.0	237.6	253.3	230.1	190.8	157.5	169.7	213.7	257.5	319.6	319.5	319.4	2,936.4

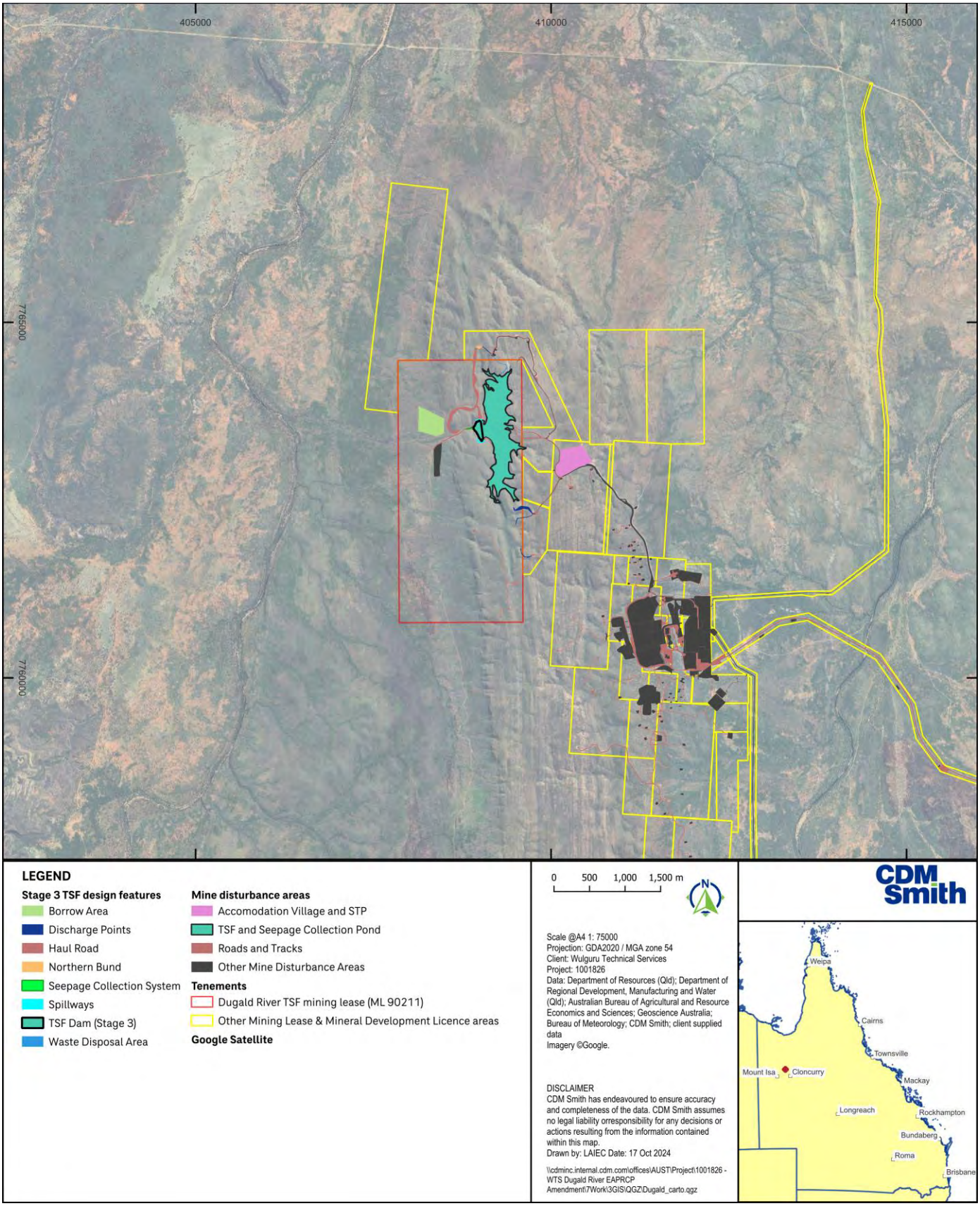

Figure 3-1 Dugald River Mine layout

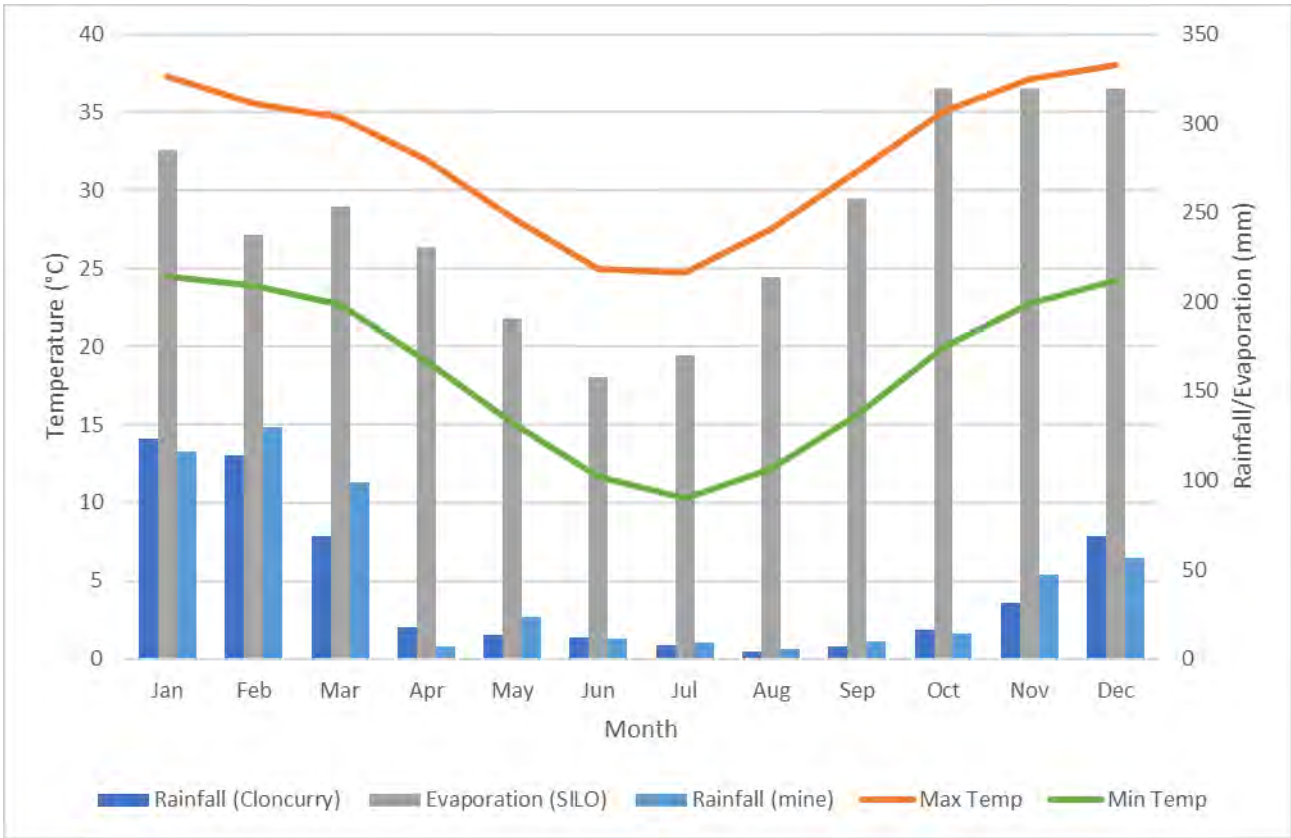

Figure 3-2 Monthly average climate data

The average annual rainfall for the area is approximately 500 mm and the average annual evaporation is approximately 2,900 mm. Monthly evaporation rates exceed monthly rainfall for all months of the year, highlighting a net evaporative loss over a year.

Recent rainfall at DRM has been put into a historical context using the Cumulative Deviation From the Mean (CDFM) method. CDFM is calculated by subtracting the long-term average monthly rainfall from the actual monthly rainfall and provides a monthly deviation from the average conditions. A rising trend indicates periods of above average rainfall, while a falling trend indicates periods of below average rainfall. The CDFM graph, shown below in Figure 3-3, indicates the DRM area has generally experienced above average rainfall since early 2022.

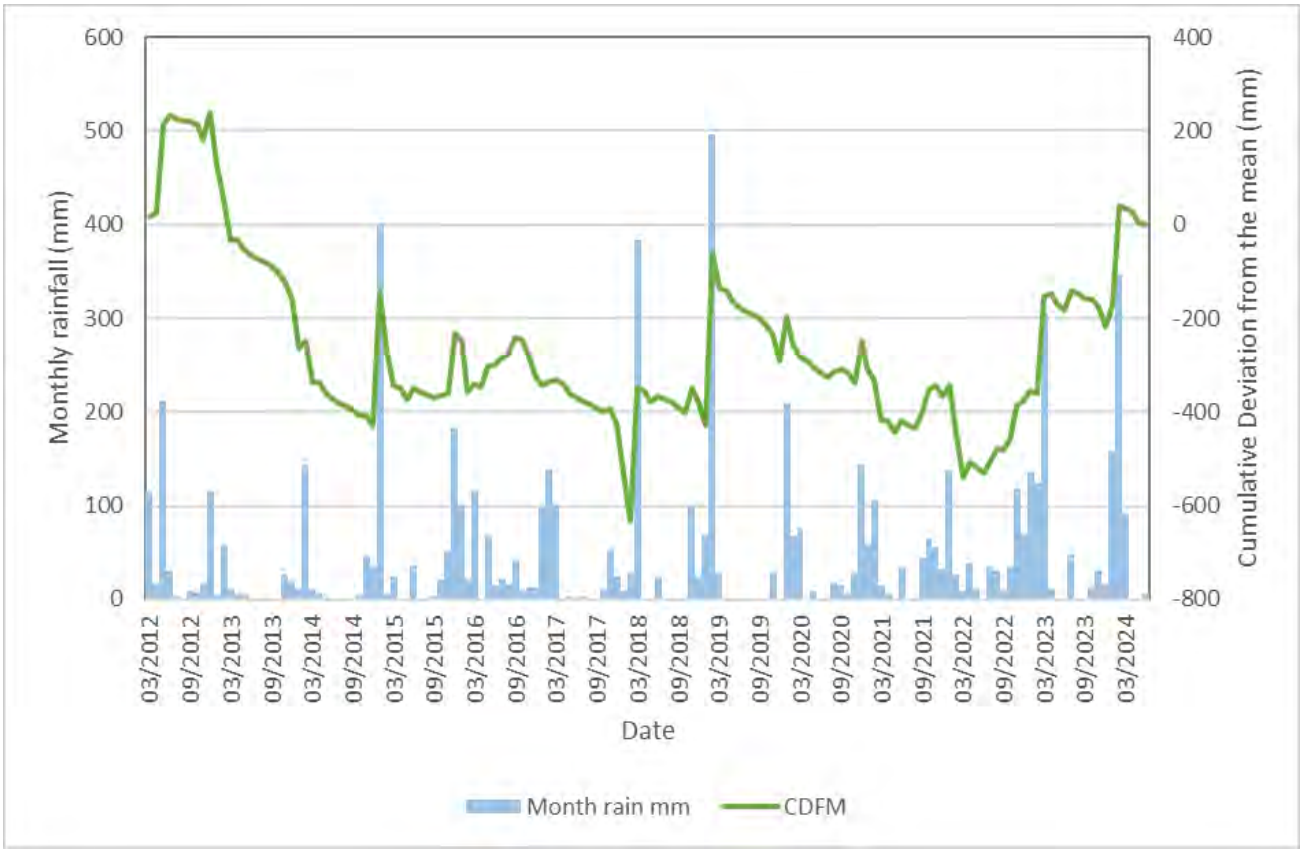

Figure 3-3 Cumulative deviation from the mean – 2012 to 2024

3.3 Topography and drainage

The local topography and drainage are shown in Figure 3-4.

The regional topography is dominated by the Knapdale Range, a north-south trending ridgeline approximately 14 km long and approximately 2.5 km wide with an elevation of 310 mAHD. To the east and west of the Knapdale Range, the ground elevation quickly drops to approximately 190 mAHD.

The DRM area is drained by overland sheet flow and ephemeral drainage features.

The Knapdale Range forms part of the catchment divide between the Leichhardt and Flinders rivers that drain northwards to the Gulf of Carpentaria (WTS, 2023). Locally, the watercourses include:

- Watercourses on the east side of the Knapdale Range, including North Creek and Silvermine Creek are ephemeral in nature and drain eastwards towards Dugald River. Dugald River flows northwards into the Cloncurry River, which in turn flows to the Flinders River.
- West and north of the Knapdale Range lie several unnamed tributaries of Cabbage Tree Creek. Cabbage Tree Creek flows northwards into the Leichhardt River. The creek and its tributaries are ephemeral in nature, with brief, episodic flows following rainfall in the project area.

The TSF is located along an incised drainage line that drains westward toward Cabbage Tree Creek.

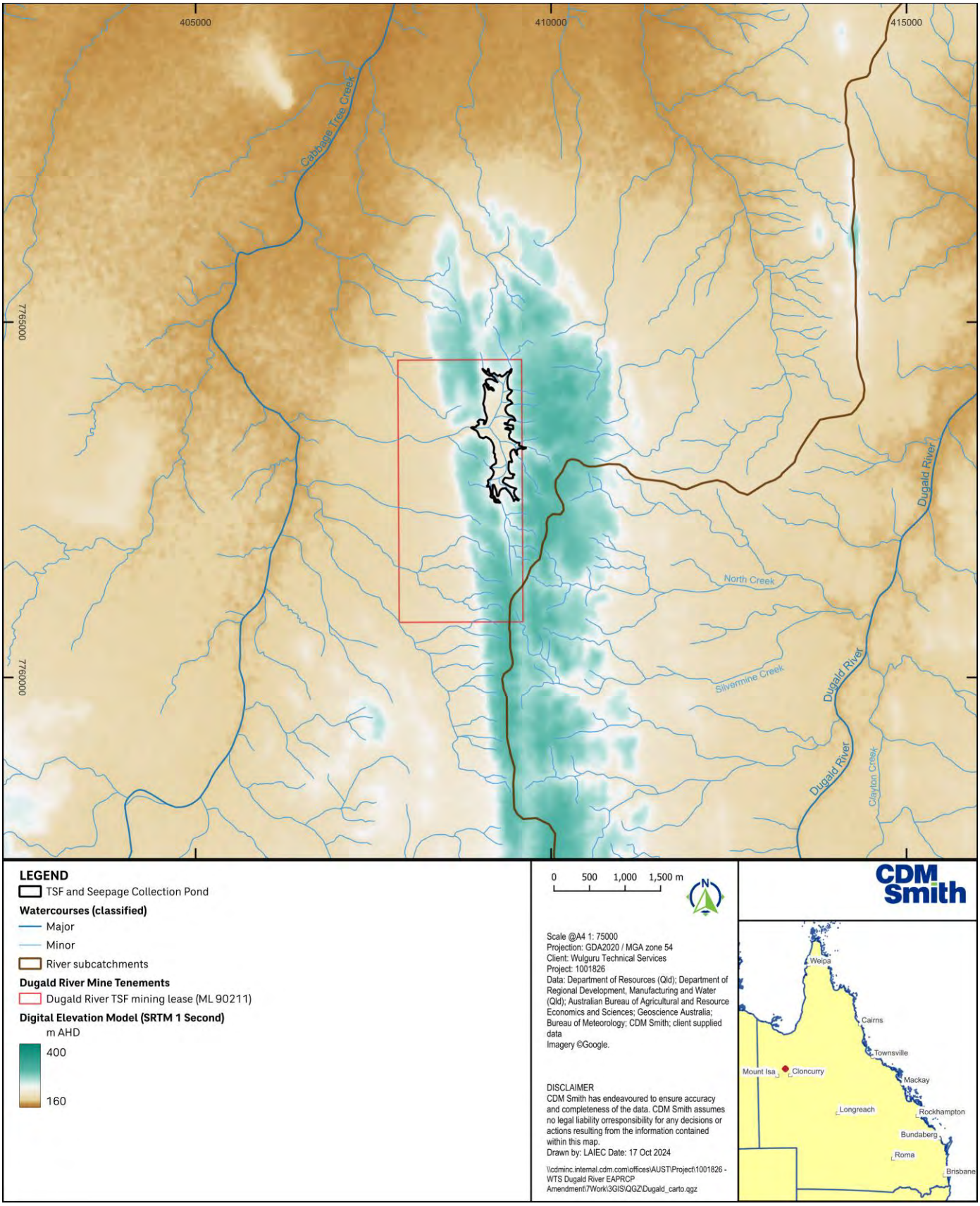

Figure 3-4 Topography and drainage

3.4 Geology

DRM is located within the Mary Kathleen Domain of the Mount Isa Province, a heavily mineralised terrain containing large deposits of copper, lead and zinc. The geology at DRM is well understood from multiple previous studies (Blake, 1987; Creus et al, 2023). The geology within the vicinity of the TSF is composed of five main lithological units (as shown in Figure 3-5 and Figure 3-6), listed below from youngest to oldest:

- Unconsolidated Cainozoic sediments, including Tertiary and Quaternary alluvial deposits associated with Cabbage Tree Creek and Dugald River
- Proterozoic Mount Albert Group, comprising:
  - Lady Clayre Formation, comprised of dolomite and dolomitic siltstone and with minor fine-grained quartz sandstone, micaceous sandstone and siltstone. This unit is locally referred to as the Footwall Limestone.
  - Coocerina Formation, comprised of schist, slates and calc-silicates
  - Mount Roseby Schist, comprised of calcareous silicate metasediments.
  - Knapdale Quartzite, comprised of a massive quartzite. This unit forms the elevated Knapdale Range and underlies the location of the TSF.

The surface geology of the DRM and its surrounds is shown in Figure 3-6.

At surface, outcrops of the Proterozoic units can be seen. Minor patches of Cainozoic sediments are mapped to the east and west of the Knapdale Formation (Figure 3-6), including alluvium, colluvium and residual soils. Quaternary alluvial deposits occur along the extent of the Cabbage Tree Creek and Dugald River.

From a structural perspective, fractures are present near surface in each of the main lithological units. Generally, this near-surface fracturing is present to a depth of approximately 70 m below surface, although fractures within the Knapdale Quartzite are limited to a depth of 10 m below surface (RLA, 2010). The Knapdale Quartzite is bound by north-south striking faults to the east and west, associated with the sharp change in elevation seen in the Knapdale Range.

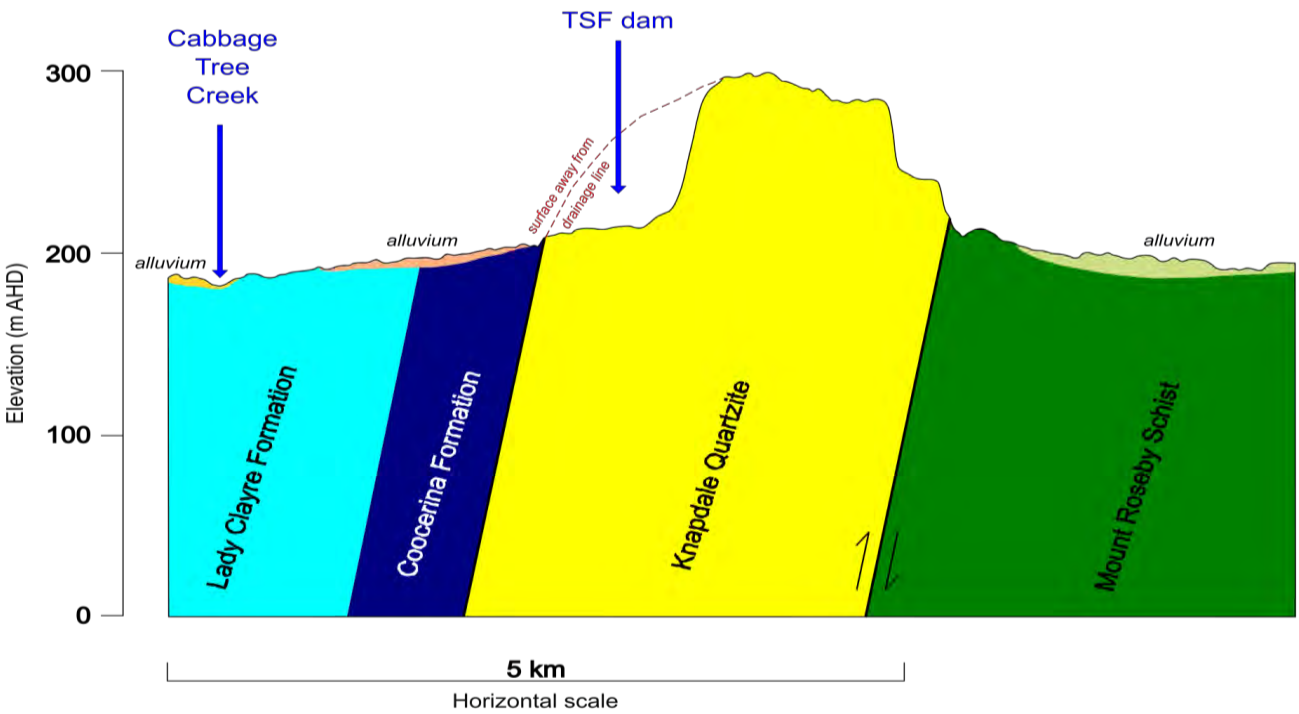

Figure 3-5 West to east conceptual geological cross-section (adapted from GSQ Geological Maps)

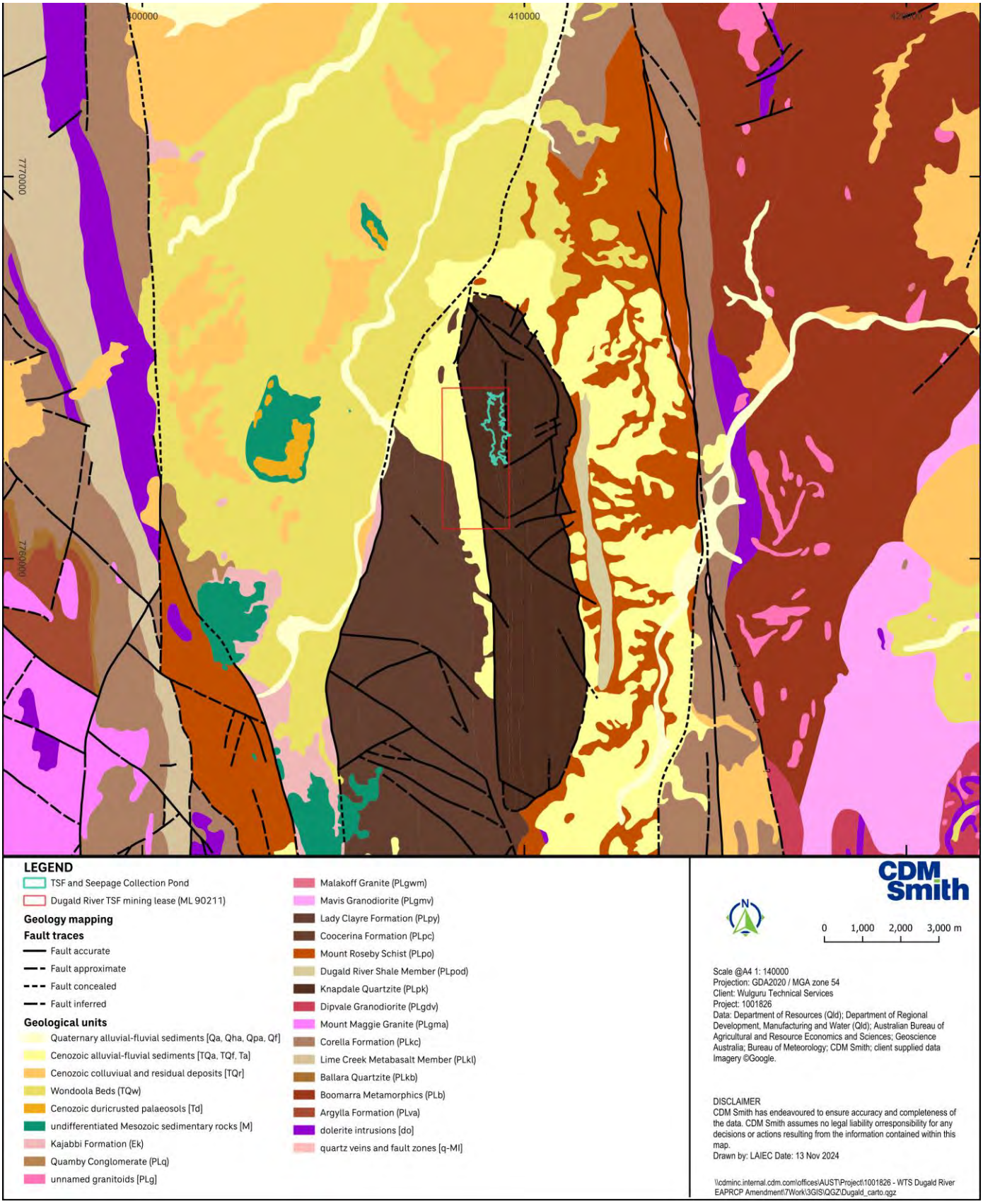

Figure 3-6 Regional surface geology

Section 4 Methodology

This section describes the groundwater assessment and numerical model methodologies applied in this assessment. Select results are presented here, while the remainder of the study findings relative to the groundwater conceptualisation are presented in **Error! Reference source not found.**.

4.1 Desktop study

4.1.1 Groundwater bore database searches

A search was undertaken of the Department of Local Government, Water and Volunteers (DLGWV) groundwater database of registered groundwater bores. Information stored in the database includes bore location, groundwater levels, construction details, stratigraphic logs, hydrogeological testing, and groundwater quality.

The database records for groundwater bores located within a 5 km radius of the TSF were collated and used to assess the site geology, groundwater levels and groundwater quality.

The registered groundwater bore locations are shown in Figure 4-1. A total of 31 registered groundwater bores were identified from the DLGWV database within 5 k of the TSF.

The registered bores are summarised below according to purpose. The 31 registered bores comprise:

- 27 groundwater monitoring bores. All 27 groundwater monitoring bores are recorded as existing.
- 4 registered bores. 1 bore is recorded as abandoned and destroyed, and 3 bores are recorded as existing.
- Of the 3 bores recorded as existing, 1 is recorded as being for industrial water supply purposes, 1 is recorded as being for water supply purposes. The use of the remaining 1 existing bore is unknown.

Details of the registered bores are listed in Appendix A.

4.1.2 Dugald River groundwater monitoring database

The proponent maintains a dedicated groundwater monitoring network in accordance with the requirements of the DRM EA. The EA groundwater monitoring network includes 15 groundwater monitoring bores located within DRM and its surrounds with 7 groundwater monitoring bores are located within the vicinity of the TSF (Figure 4-2).

Groundwater levels are measured quarterly at each bore. Field measurements of groundwater quality are measured quarterly at the 6 compliance bores and 3 background bores. Groundwater quality samples are also collected monthly for the compliance and background bores and are analysed for physio-chemical parameters (pH, electrical conductivity (EC), major ionic constituents and metals/metalloids).

4.1.3 Other database searches and government mapping

Supporting data were also collected from a search of the following databases and maps:

- Queensland state geological mapping and explanatory notes
- Queensland state watercourse identification mapping
- Scientific Information for Land Owners (SILO) climate data online (evaporation data)
- DLGWV records for spring locations and types, and
- BoM records of groundwater dependent ecosystems (GDEs).

Climate data were compiled and analysed to inform the project setting. Databases regarding water management and regulation were accessed to ensure that this report meets the legislative requirements for assessing project impacts.

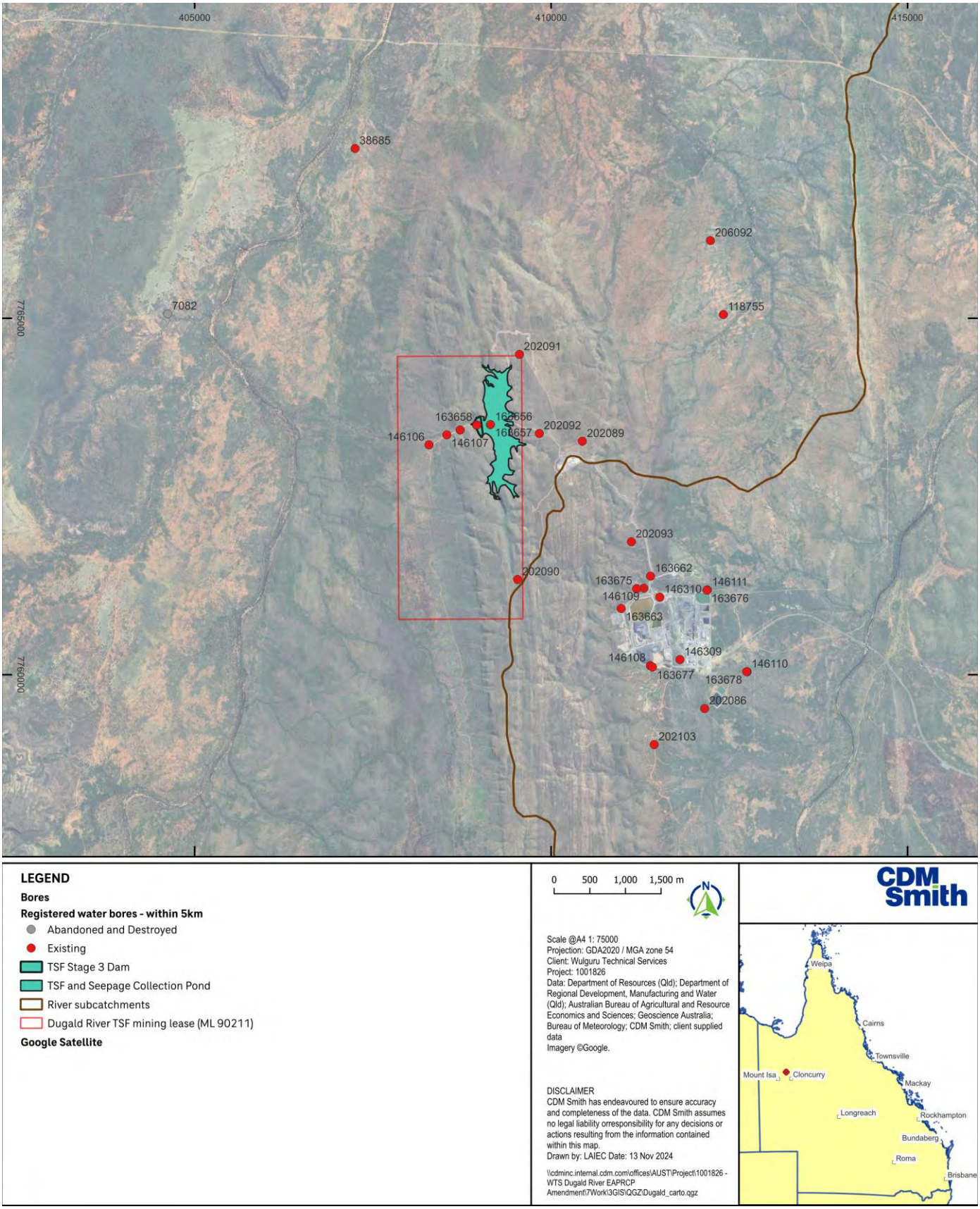

Figure 4-1 Registered groundwater bore locations

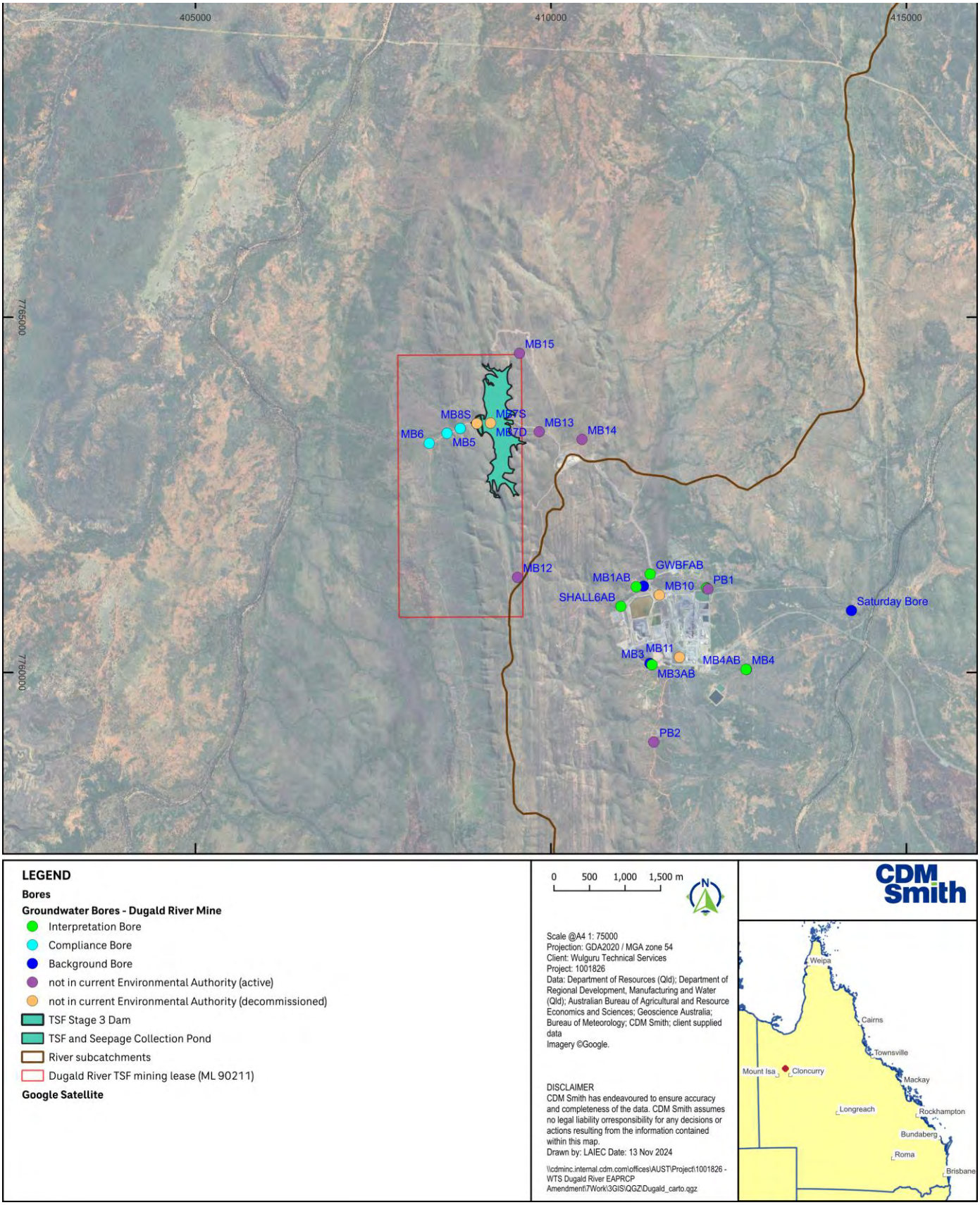

Figure 4-2 Groundwater monitoring network

4.1.4 Literature review

A number of hydrogeological studies have been completed for DRM. The following studies undertaken at DRM were reviewed:

- Dugald River Mining Project Environmental Impact Statement Groundwater Aspects (RLA, 2010). This report was prepared to support the Dugald River Mine EIS and outlines the pre-mining groundwater conditions and expected impact of the mine on the groundwater regime.
- Dugald River Mine Annual Groundwater Monitoring Report for 2013 (Big Dog Hydrogeology, 2014a). This report was prepared to provide a summary of the groundwater conditions at the site.
- Dugald River Mine Biennial Groundwater Review (CDM Smith, 2019). This report was prepared to provide a summary of the groundwater conditions at the site.
- Technical Memorandum: MMG Dugald River Mine Progressive Rehabilitation and Closure Plan – Groundwater Requirements (CDM Smith, 2020). This report summarises the groundwater conditions at the site.
- Dugald River Mine Biennial Review of Groundwater Monitoring Data: 2019-2020 (CDM Smith, 2021). This report was prepared to provide a summary of the groundwater conditions at the site.
- Dugald River Mine TSF lift bore specification (AGE, 2022). This report provides the rationale behind the monitoring bores installed at the TSF.
- Report on Test Pumping Analyses - PB1 and PB2 (RLA, 2023a). This report outlines the results of hydrogeological testing.
- Dugald River Mining Project: Review of Saturday Bore as a Groundwater Monitoring Bore in the Environmental Authority (RLA, 2023b). This report reviews the groundwater monitoring network.
- Hydraulic Conductivity Testing, Dugald River Mine Tailings Storage Facility (RLA, 2023c). This report outlines the results of hydrogeological testing.
- Progressive Rehabilitation and Closure Plan – Dugald River Mine (WTS, 2023). This report outlines the proposed rehabilitation and closure plan.
- Dugald River Mining Project: Biennial Review of Groundwater Monitoring Program 2021 and 2022 (RLA, 2024). This report was prepared to provide a summary of the groundwater conditions at the site.

4.2 Data analysis and conceptualisation

All relevant data was collated and analysed to develop a conceptual understanding of the groundwater regime, including the key geology, groundwater flow and groundwater quality characteristics. The collated data has been summarised and is presented as part of the conceptual groundwater regime discussed in Section 5.

4.3 Numerical modelling

A numerical model was developed to predict groundwater seepage rates in response to the proposed TSF Stage 3 raise and assess the potential impact on the surrounding groundwater system.

A two-dimensional steady-state numerical groundwater model was constructed using GeoStudio SEEP/W software to represent the conceptual hydrogeological model and hydrogeological regime discussed in Section 5. The model was developed in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al, 2012).

The model contained two scenarios that represented the Stage 2 and Stage 3 TSF designs. The impact of the Stage 3 TSF raise was calculated as the difference between the two scenarios.

The model represents the key geological unit (the Knapdale Quartzite) and the construction details of the TSF dam wall. The model represents a 1.4 km long cross-section across the Knapdale Range, the TSF extent and dam wall. The model extent includes the TSF area and its surrounds.

The physical structure of the groundwater model was based on the geological interpretation of the area (discussed in Section 3.4), and the construction design of the TSF dam wall as provided by the proponent (ATC Williams, 2015; ATC Williams, 2024). The structure of the model is presented below in Figure 4-3.

The Knapdale Quartzite is the prominent geological feature and has been modelled as three sub-layers based on the observed decrease in weathering with depth. The sub-layers align with the assumptions of the TSF dam design (ATC Williams, 2015). The sub-layers were defined as:

- Qu_top – Knapdale Quartzite from surface to a depth of 5 m below surface.
- Qu_mid – Knapdale Quartzite with a depth between to 5 m to 10 m below surface.
- Qu_base – Kanpdale Quartzite deeper than 10 m below surface.

Given the absence of geological structural data specific to the TSF area, the model did not explicitly incorporate discrete fracture zones. Instead, a conservative approach was taken by assuming a uniform hydraulic conductivity for each sub-layer and modelling the TSF under steady-state conditions. This simplification minimises model uncertainty while ensuring the model remains reliable for impact assessment purposes.

Hydraulic properties for each the upper sub-layers (Qu_top and Qu_mid) were based on those presented in ATC Williams (2015, 2024, 2025). Hydraulic properties for the deeper sub-layer (Qu_base) were based on the hydraulic conductivities derived from slug tests, which were considered to provide a more representative value of the hydraulic characteristics of the Knapdale Quartzite at depth. Volumetric water content values were adopted from Morris and Johnson (1967).

The hydraulic properties of the TSF construction were sourced from the Stage 3 design drawings (ATC Williams, 2024) and relevant literature sources (Freeze and Cherry, 1979; Bear, 1972; Weber and Zornberg, 2005). Elements of the TSF and related infrastructure in the numerical model were aligned with the construction of the TSF (ATC Williams, 2015; ATC Williams, 2024).

The numerical model was constructed as a west to east section and is illustrated below in Figure 4-3. The hydraulic parameters applied to the model are presented in

Table 4-1. Key boundary conditions applied to the numerical model include:

- Western boundary – a constant head of 203 m was applied, representing the interpreted regional groundwater level.
- Eastern boundary – a constant head of 118.14 m was applied, representing the measured groundwater level in MB06.
- Recharge – a uniform recharge rate of 1 x 10^{-8} $m^3/sec/m^2$ was applied, equivalent to 10% of the long-term average rainfall rate.

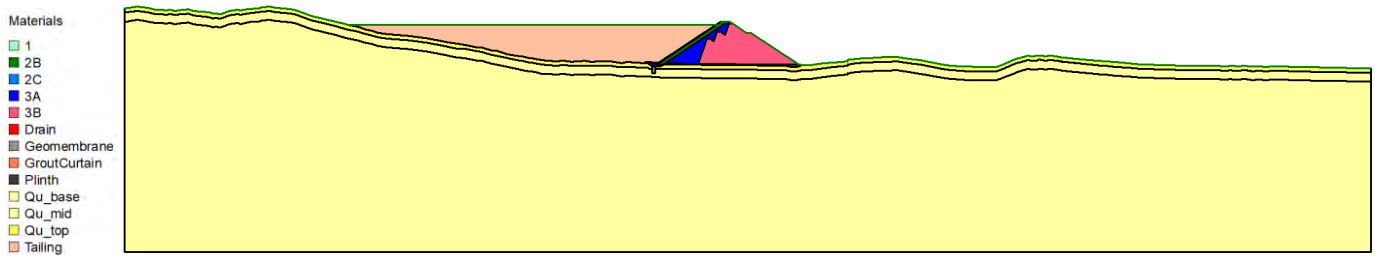

Figure 4-3 Numerical model cross section (west to east)

Table 4-1 Numerical model hydraulic parameters

Name	Description	Hydraulic material model	Volumetric water content	Saturated Kx (m/sec)	Ky/Kx ratio
1	Clay core	Saturated/unsaturated	0.345	1×10^{-7}	1
2B	Drainage layer	Saturated/unsaturated	0.25	0.05	1
2C	Granular filter	Saturated/unsaturated	0.3	0.001	1
3A	Transition rockfill	Saturated/unsaturated	0.37	0.001	1
3B	General rockfill	Saturated/unsaturated	0.37	0.001	1
Drain	Drain under dam	Saturated/unsaturated	0.37	0.1	1
Geomembrane	Geomembrane across upper dam surface	Saturated/unsaturated	0.0001	$2 \times 10\text{-}^{15}$	1
GroutCurtain	Grout curtain	Saturated/unsaturated	0.03	2.6×10^{-7}	1
Plinth	Concrete plinth	Saturated/unsaturated	0.18	4.5×10^{-8}	1
Qu_base	Quartzite >10 m below surface	Saturated/unsaturated	0.3	5.58×10^{-6}	1
Qu_mid	Quartzite 5 – 10 m below surface	Saturated/unsaturated	0.3	1×10^{-7}	1
Qu_top	Quartzite <5 m below surface	Saturated/unsaturated	0.3	1×10^{-6}	1
Tailing	Tailings material	Saturated/unsaturated	0.1	1.15×10^{-7}	1

To assess the robustness of the model predictions, a sensitivity analysis was conducted by the varying hydraulic properties. This analysis provides for a comparison of the influence of these properties on the outcomes of predictions made by the model. The saturated hydraulic conductivity (Kx) values were varied by plus and minus an order of magnitude. The results of the sensitivity analysis (discussed further in Section 6.2) validates the appropriateness of the selected hydraulic parameters and indicates that the numerical model is suitable for assessing the impact of the project.

The framework for the modelling process and modelling was undertaken in accordance with the *Australian Groundwater Modelling Guidelines* (Barnett et al., 2012).

As per the classification system for model confidence outlined in Barnett et al. (2012), the numerical groundwater model developed is classified as a Class 1 (low confidence) model, and on this basis is. The model is therefore considered suitable for evaluating projects with defined as low risk (Barnett et al., 2012).

Table 4-2 Sensitivity analysis hydraulic parameter settings

Name	Description	Saturated Kx (m/sec)	Decreased saturated Kx (m/sec)	Increased saturated Kx (m/sec)
1	Clay core	1×10^{-7}	1×10^{-8}	1×10^{-6}
2B	Drainage layer	0.05	0.005	0.5
2C	Granular filter	0.001	0.0001	0.01
3A	Transition rockfill	0.001	0.0001	0.01
3B	General rockfill	0.001	0.0001	0.01
Drain	Drain under dam	0.1	0.01	1
Geomembrane	Geomembrane across upper dam surface	2×10^{-15}	2×10^{-16}	2×10^{-14}
GroutCurtain	Grout curtain	2.6×10^{-7}	2.6×10^{-8}	2.6×10^{-6}
Plinth	Concrete plinth	4.5×10^{-8}	4.5×10^{-9}	4.5×10^{-7}
Qu_base	Quartzite >10 m below surface	5.58×10^{-6}	5.58×10^{-7}	5.58×10^{-5}
Qu_mid	Quartzite 5 – 10 m below surface	1×10^{-7}	1×10^{-8}	1×10^{-6}
Qu_top	Quartzite <5 m below surface	1×10^{-6}	1×10^{-7}	1×10^{-5}
Tailing	Tailings material	1.15×10^{-7}	1.15×10^{-8}	1.15×10^{-6}

Section 5 Existing groundwater regime

The information collected from the desktop study and previous field investigations were compiled and analysed to develop a conceptual model of the groundwater regime (i.e. a conceptual hydrogeological model). The conceptual hydrogeological model describes the relevant hydrogeological units, groundwater recharge, movement, depth, distribution and discharge, groundwater quality, and groundwater interactions with surface water.

This section summarises the conceptual hydrogeological model.

5.1 Overview

Within the vicinity of the TSF, the conceptual hydrogeological model can be summarised as follows:

- Rainfall provides direct recharge to the local groundwater system when rainfall exceeds evaporation. Infrequent rainfall patterns result in episodic flow and short periods of potential recharge to the groundwater system during surface water flow events.
- Unconsolidated alluvial sediments are present along the extent of Cabbage Tree Creek and Dugald River. As the creeks and drainage features within the vicinity of the TSF are ephemeral, the presence of groundwater within the alluvium is sporadic and related to rainfall events where the creeks and drainage features flow.
- The Knapdale Quartzite, which underlies the TSF, is considered to be an aquitard (i.e., a unit that contains groundwater but has very low yields).
- The direction of groundwater flow reflects topography. A groundwater divide is associated with the elevated Knapdale Range.
- Groundwater flow is in a westerly direction within the Lady Clayre Formation, Coocerina Formation and Mount Roseby Schist located to the west of the Knapdale Quartzite. Groundwater flow is in an easterly direction within the Mount Roseby Schist located to the east of the Knapdale Quartzite.
- Groundwater flow generally occurs within a thin fracture zone at surface.
- Shallow and deep groundwater comprise a single continuous groundwater flow system, with no separate shallow groundwater system (CDM Smith, 2021). This is supported by the geology, with basement rocks extending to the surface or near the surface.
- Groundwater levels measured near the TSF do not indicate any rise in groundwater elevation since tailings deposition commenced in 2017, indicating minimal to no seepage from the TSF has occurred.

Groundwater elevations within the vicinity of the TSF are presented in Figure 5-1

The local groundwater regime is illustrated in Figure 5-2.

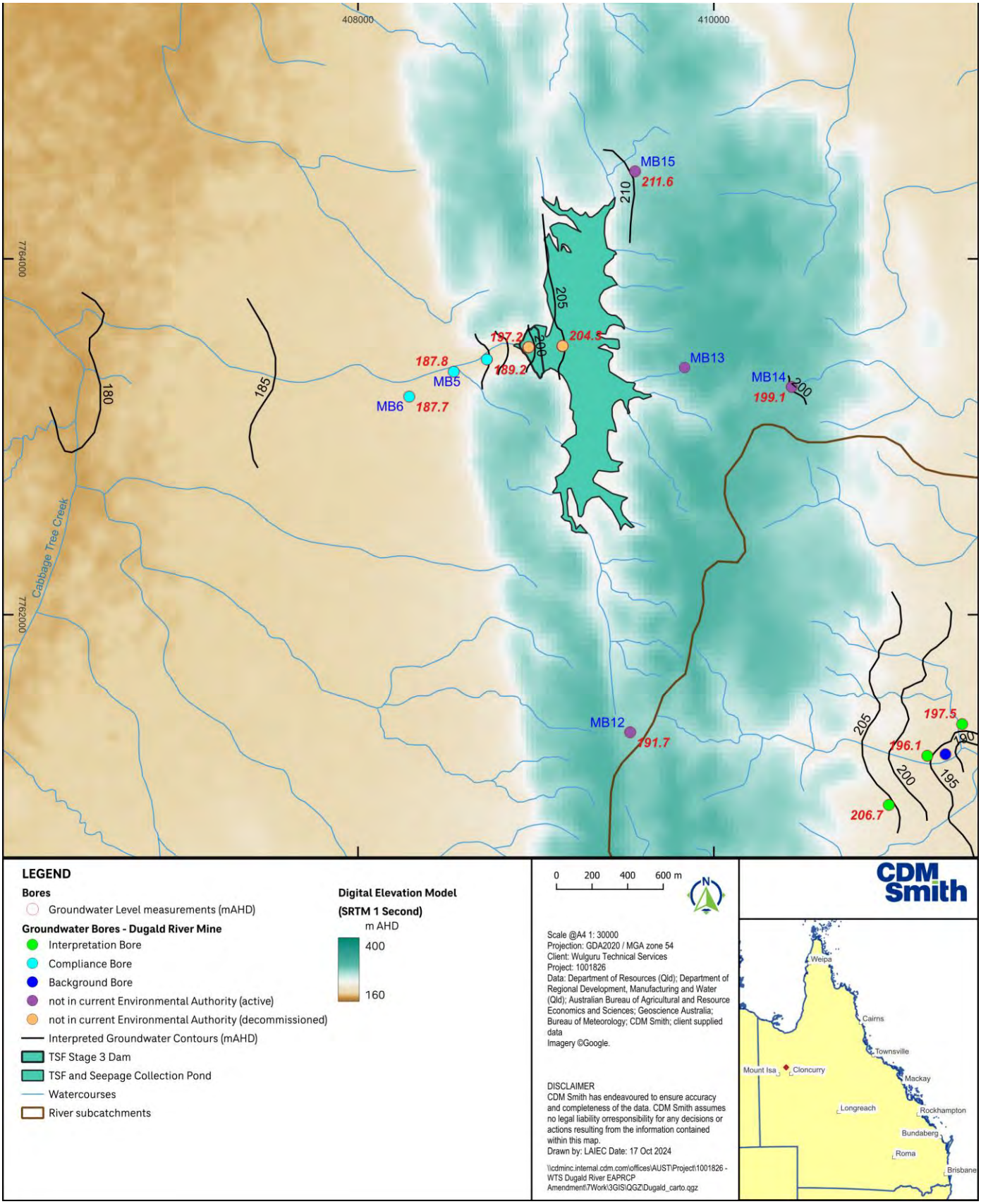

Figure 5-1 Groundwater elevation

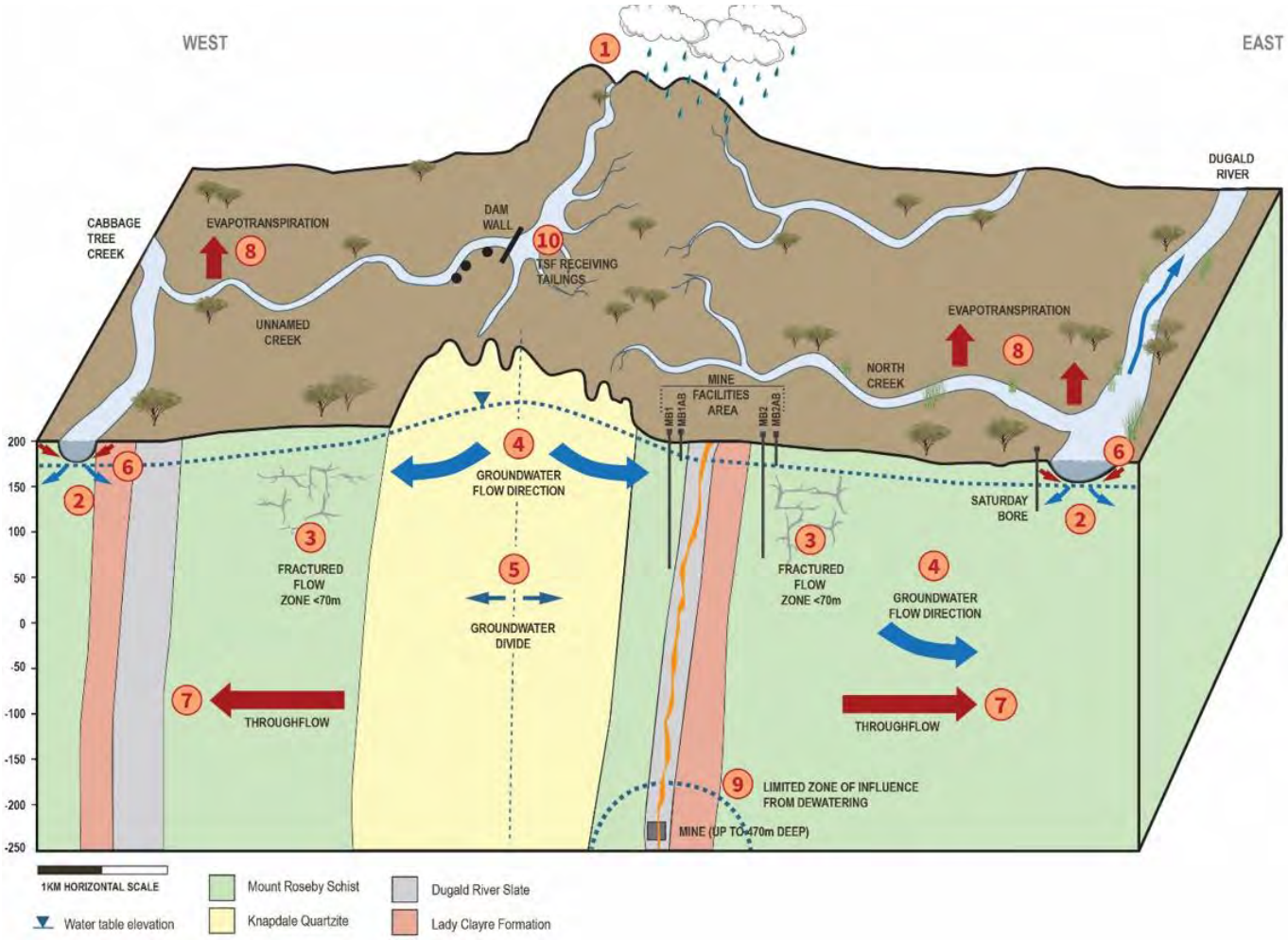

Figure 5-2 Conceptual hydrogeological model (CDM Smith, 2021)

5.2 Cainozoic sediments

Minor patches of Cainozoic sediments have been mapped to the east and west of the Knapdale Formation (Figure 3-6), including alluvium, colluvium and residual soils. Quaternary alluvial deposits occur along the extent of the Cabbage Tree Creek.

As the uppermost hydrostratigraphic unit, the Cainozoic sediments are recharged via rainfall. Groundwater is present within the alluvial sediments following rainfall events and this groundwater flows in the direction of surface drainage (generally east to west within the vicinity of the TSF).

Groundwater within the Cainozoic sediments recharges the underlying Lady Clayre Formation, Coocerina Formation and Mount Roseby Schist.

There are no DRM groundwater monitoring bores constructed within the Cainozoic sediments.

5.3 Lady Clayre Formation and Coocerina Formation

The Lady Clayre and Coocerina formations occur at or close to surface to the west of the Knapdale Range (Figure 3-6).

The Lady Clayre and Coocerina formations are generally recharged via rainfall where they outcrop at surface, with a minor amount of localised recharge occurring from seepage associated the minor extent of the overlying Cainozoic sediments. Limited discharge from the Lady Clayre and Coocerina formations may occur via lateral seepage to the west.

The dolomite of the Lady Clayre Formation is not karstic, and therefore solution channels or cavities are not present (RLA, 2024).

There are no DRM groundwater monitoring bores constructed within the Lady Clayre or Coocerina formations.

5.4 Mount Roseby Schist

The Mount Roseby Schist occurs at or close to surface to the west and east of the Knapdale Range (Figure 3-6).

Groundwater within the Mount Roseby Schist is limited to occurring within the surficial fractured zone, through secondary porosity features such as joints and fractures. The secondary porosity features form a discrete, isolated fracture system that is poorly connected. The fractured zone in the Mount Roseby Schist is present to a depth of approximately 70 m below surface (Big Dog Hydrogeology, 2014a).

Within the vicinity of the TSF, the depth to groundwater within the Mount Roseby Schist is generally in the order of 10 to 20 m below surface.

Permeability within the Mount Roseby Schist is associated with the surficial fracturing. The hydraulic conductivity of the Mount Roseby Schist in the vicinity of the TSF ranges from 2.23×10^{-3} m/day to 9.21×10^{-2} m/day.

The Mount Roseby Schist is recharged via rainfall where it outcrops at surface, with a minor amount of localised recharge occurring from seepage associated with the minor extent of the overlying Cainozoic sediments. Limited discharge from the Mount Roseby Schist may occur via lateral seepage to the east (where the Mount Roseby Schist is located to the east of the Knapdale Range) or west (where the Mount Roseby Schist is located to the west of the Knapdale Range).

Figure 5-3 presents a groundwater level hydrograph of the groundwater monitoring bores within the vicinity of the TSF that are screened within the Mount Roseby Schist. As the Mount Roseby Schist is recharged by rainfall events, the overall trend in groundwater levels seen in Figure 5-3 reflects the historical rainfall trends discussed in Section 3.2.

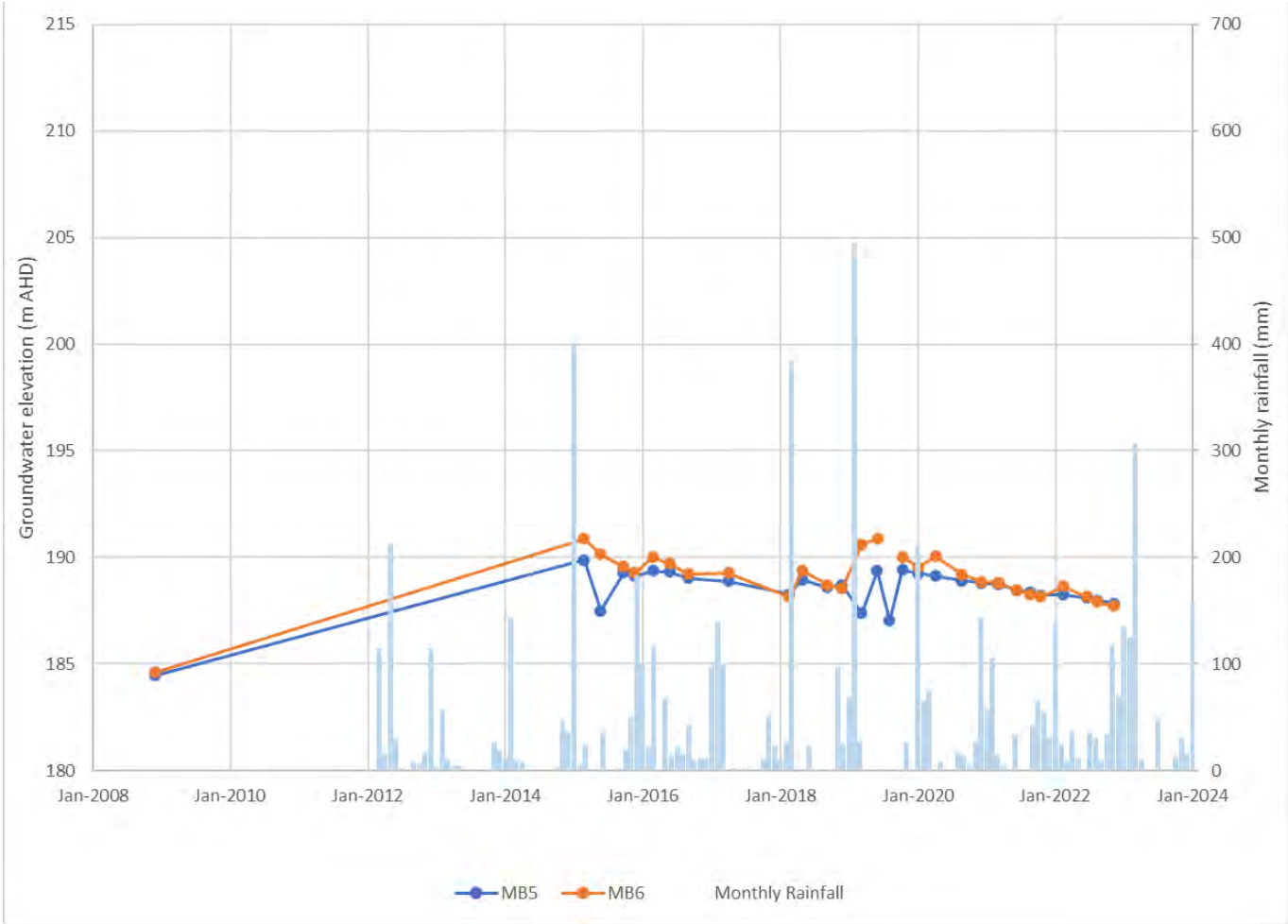

Figure 5-3 Hydrographs – Mount Roseby Schist

5.5 Knapdale Quartzite

The Knapdale Quartzite forms the Knapdale Range and underlies the extent of the TSF (Figure 3-6), with the range associated with a groundwater divide aligned roughly north-south. The Knapdale Quartzite is bound by north-south striking faults to the east and west.

Within the vicinity of the TSF, the depth to groundwater within the Knapdale Quartzite is generally in the order of 15 m below surface.

Permeability within the Knapdale Quartzite is associated with the surficial fracturing. Hydraulic conductivity in the Knapdale Quartzite ranges from 9.49×10^{-4} m/day to 7.80×10^{-2} m/day. Packer tests conducted in the Knapdale Quartzite within the extent of the TSF returned calculated permeabilities of 4.0×10^{-8} m/sec to 3.5×10^{-6} m/sec (RLA, 2010). The very low hydraulic conductivity is consistent with the concept that the Knapdale Quartzite is nearly impervious (RLA, 2023c).

Due to the very low permeability of the quartzite, and the steep slopes of the Knapdale Range, most rainfall is expected to convert to surface run-off to drainage features, resulting in minor groundwater recharge via rainfall.

Due to the very low permeability of the Knapdale Quartzite, limited groundwater discharge is expected to occur to the east and west into the Mount Roseby Schist.

Figure 5-4 presents a groundwater level hydrograph of the groundwater monitoring bores within the vicinity of the TSF that are screened within the Knapdale Quartzite. The hydrograph indicates that groundwater levels within the Knapdale Quartzite are historically relatively stable, with isolated occurrences of groundwater seen in the shallower

screened bores. The stable groundwater levels seen over time in MB09D indicate that there is no increase in groundwater level associated with the deposition of tailings material in the TSF after 2017.

Groundwater within the Knapdale Quartzite is limited to occurring within the surficial fractured zone, through secondary porosity features just as joints and fractures. The secondary porosity features form a discrete, isolated fracture system that is poorly connected. The fractured zone in the Knapdale Quartzite is present to a depth of approximately 10 m below surface (Big Dog Hydrogeology, 2014a).

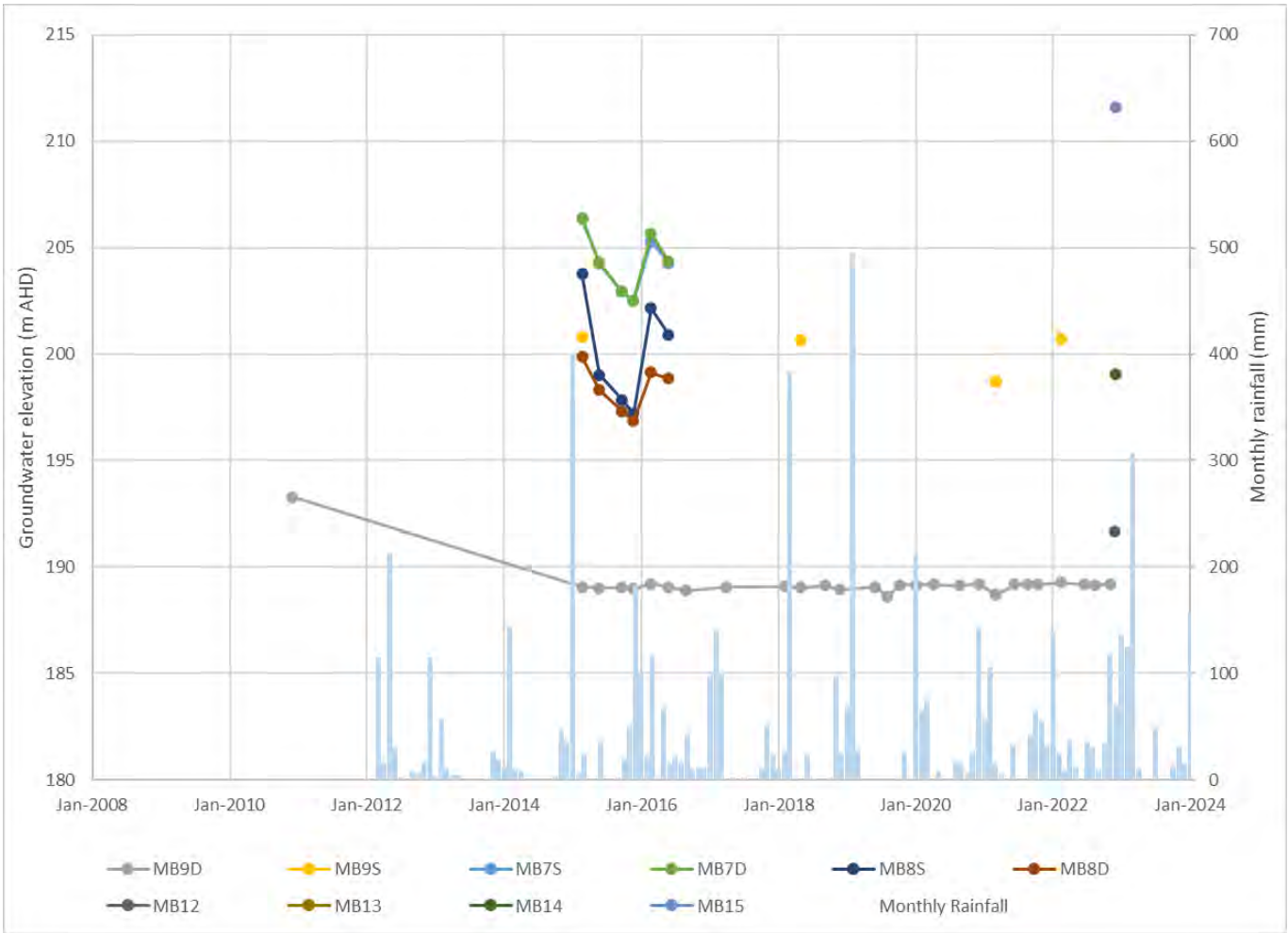

Figure 5-4 Hydrographs – Knapdale Quartzite

5.6 Groundwater interactions with surface water

The ephemeral nature of the watercourses within the vicinity of the DRM means that the watercourses are dry for the majority of the time. Short-term flow within the watercourses is seen following heavy rainfall or rainfall of a longer duration.

Within the vicinity of the DRM, the groundwater table is naturally deep, recharge to the groundwater system is minimal, and the depth of incision of watercourses is shallow (RLA, 2010). This indicates that groundwater does not contribute baseflow to the ephemeral surface water system at the DRM. Additionally, no groundwater seepage occurs through creek beds or banks to provide baseflow.

Given the deep groundwater table that lies well below the base of the watercourses, and the ephemeral nature of surface water features within the vicinity of the DRM, it is concluded that there is no significant surface-groundwater interaction within the DRM area.

5.7 Groundwater quality

Groundwater quality within the vicinity of the TSF is classified as slightly acidic to slightly alkaline, with pH ranging from 5.1 to 8.2. Groundwater is typically fresh to brackish, with measured electrical conductivity (EC) values ranging from 3 to 1,790 µS/cm.

A Piper plot (Figure 5-5) categorises water type based on the normalised, relative proportion of each major anion and cation. The Piper plot indicates that the major ion chemistry of the groundwater in the area is varied, ranging from magnesium bicarbonate type to calcium chloride type. This reflects rainfall recharge into the groundwater system with a short residence time (magnesium bicarbonate type) mixing with deeper, older groundwater with an extended resident type (calcium chloride type).

There is generally little variation in groundwater chemistry over time for each groundwater monitoring bore, with the exception of MB6, which has seen a decrease in sulfate concentration over time.

Metal and metalloid concentrations in groundwater within the vicinity of the TSF are typically below laboratory detection limits. Elevated levels of arsenic, copper, manganese and zinc are seen in groundwater monitoring bores within the vicinity of the TSF, however, the concentrations do not exceed the livestock drinking water guideline values (ANZECC, 2000).

5.8 Tailings

Tailings deposition at DRM commenced in 2017. Tailings at DRM are deposited as a slurry (comprising approximately 55% solids [Rohde et al, 2022]) into the TSF. Tailings are considered to be potentially acid forming (ATC Williams, 2015) with little acid-neutralising capacity (SGM Environmental, 2019).

The tailings are contained within the valley topography of the Knapdale Range (Figure 3-4), with the exception of the downstream embankment build on the western side of the valley to contain the tailings.

No seepage from the TSF has been observed (CDM Smith, 2020; CDM Smith 2021). There has been no change in groundwater level in the nearby monitoring bores installed in the Knapdale Quartzite. Additionally, there has been no change in groundwater chemistry seen in surrounding monitoring bores that may indicate the presence of seepage from the TSF. The consistent groundwater levels and groundwater chemistry indicate that the deposition of tailings has not affected the regional groundwater system.

Recharge to the TSF occurs from rainfall. However, due to the very low permeability of the underlying Knapdale Quartzite, it is considered unlikely for seepage to occur from the TSF to the groundwater system. Groundwater discharge from the TSF is not expected to occur.

There are no DRM groundwater monitoring bores constructed within the deposited tailings.

5.9 Groundwater users

Two registered groundwater supply bores are located within the vicinity of the TSF:

- RN 118755 (BPB001) is located approximately 3 km to the east of the TSF and is screened in the Mount Roseby Schist
- RN 206092 (BPB002) is located approximately 3.2 north-east of the TSF and is screened in the Mount Roseby Schist.

Both groundwater supply bores are used for industrial supply purposes at DRM. The location of the water supply bores is shown in Figure 4-1.

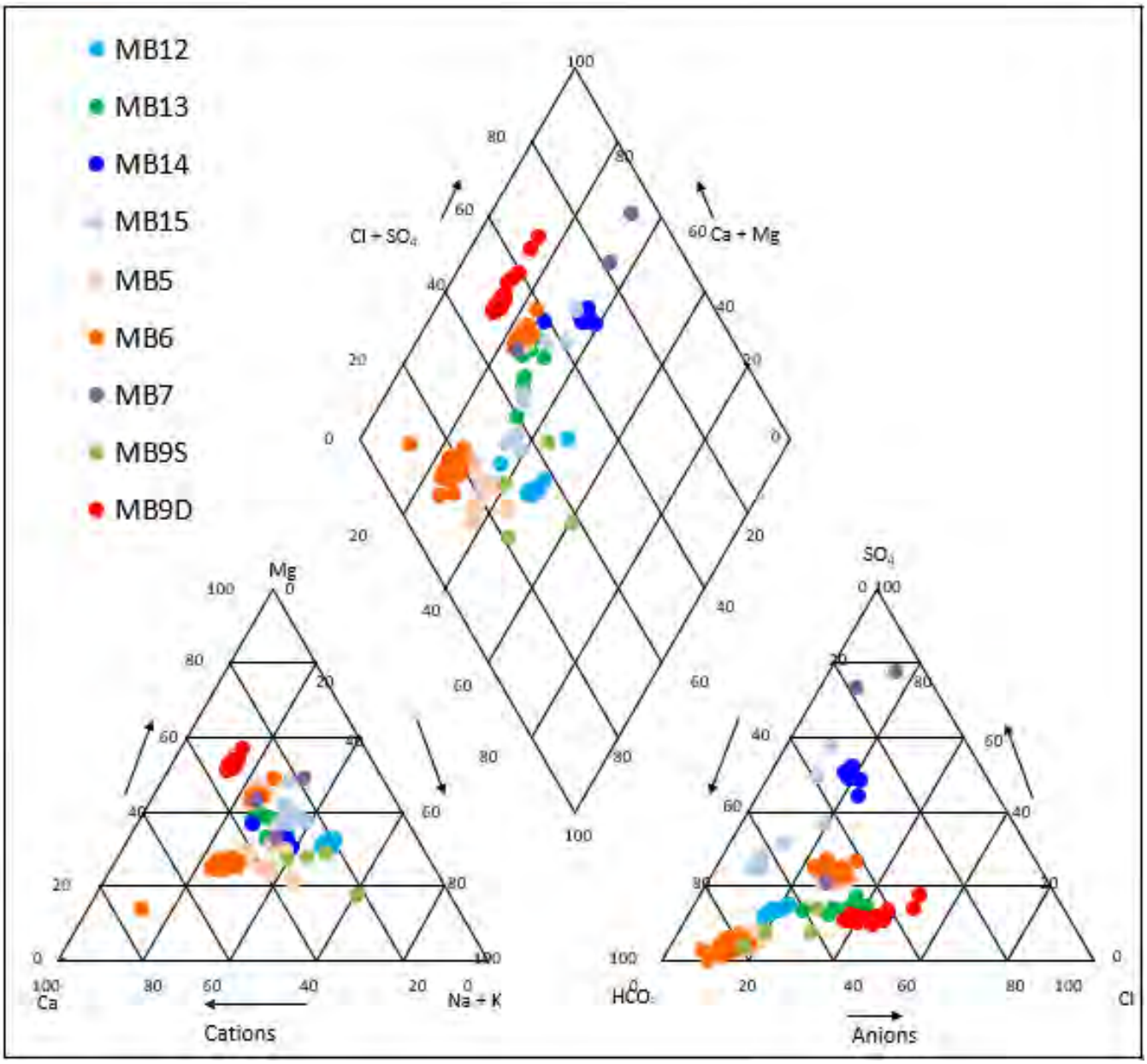

Figure 5-5 Piper plot

Section 6 Impact assessment

This section outlines the impact of the proposed Stage 3 TSF raise on the groundwater regime considering the conceptual model developed and the numerical model outcomes.

6.1 Overview of proposed Stage 3 TSF activities

The proposed Stage 3 TSF raise will involve increasing the height of the downstream TSF embankment from 243.1 mAHD to 253.5 mAHD. The extent of the TSF footprint will increase as a result of the heightened TSF embankment from 79.5 ha to 91.9 ha (Figure 1-2).

The Stage 3 TSF raise will provide tailings storage for the remainder of the mine life. No further TSF raises are currently proposed prior to mine closure. At mine closure, the TSF will be rehabilitated.

6.2 Groundwater modelling predictions

This section describes the predicted changes to the rate of seepage into the Knapdale Quartzite due to the project. The associated impacts on groundwater users and the surrounding environment (where groundwater impact is noted) are described in Section 6.3.

The numerical model outputs from the two scenarios (Stage 2 TSF and Stage 3 TSF) were compared to assess the impact of the project, which was defined as the difference between the two scenarios. Groundwater levels and seepage rates from the TSF were assessed.

The model results indicate that the Stage 3 TSF raise will not result in increased groundwater levels, suggesting no significant impact on regional groundwater conditions.

Groundwater flux is defined as the rate of groundwater movement through an aquifer and represents the rate of seepage predicted to occur from the TSF. The numerical model for the Stage 2 TSF (base case) returned a groundwater flux of 5.5×10^{-8} $m^3/sec/m^2$, in comparison to a result of 6.2×10^{-8} $m^3/sec/m^2$ for the Stage 3 TSF. The difference between the two models is considered to be within the margin of error for the numerical modelling process. These results indicate that there will be no increase in seepage from the TSF as a result of the proposed Stage 3 TSF lift.

A sensitivity analysis was performed to assess the response of the numerical model to varying hydraulic properties. This analysis provides for a comparison of the influence of these properties on the outcomes of the predictions made by the model. Impacts to the predicted groundwater levels and seepage rates due to the changes in properties were examined.

No significant changes in groundwater levels were seen as a result of the varied hydraulic conductivity values tested during the sensitivity analysis.

The rate of groundwater seepage predicted during the sensitivity analysis reflected the change in saturated hydraulic conductivity values applied to the model, with a modelled groundwater flux of 4.5×10^{-7} $m^3/sec/m^2$ for the increased hydraulic conductivity scenario, and 1.8×10^{-8} $m^3/sec/m^2$ for the decreased hydraulic conductivity scenario. These results reflect the order of magnitude changes made to the modelled hydraulic conductivity values.

The results of the sensitivity analysis indicate that the predicted groundwater levels and rates of groundwater seepage are not significantly affected by changes in the hydraulic conductivity values used in the numerical model. Therefore, the model predictions are assessed as reliable.

6.3 Project impacts

The possible effects of the TSF raise were used to assess the potential impacts of the project on groundwater users and the surrounding environment. Potential impacts include:

- Impacts on groundwater resources
- Impacts on groundwater supply bores
- Impacts on surface drainage
- Impacts on wetlands
- Impacts on groundwater dependent ecosystems (GDEs)
- Cumulative impacts (i.e., due to the operation of the TSF and other groundwater users on creeks, surface drainage, groundwater dependent ecosystems, and groundwater resources and users), and
- Impacts on groundwater quality.

6.3.1 Impacts on groundwater resources

As discussed in Section 2.1, the TSF and its surrounds are located within the Gulf Water Plan.

Due to the very low permeability of the Knapdale Quartzite and the nature of TSF construction preventing seepage from the tailings into the groundwater regime, no impacts to groundwater resources are predicted as a result of the Stage 3 TSF raise.

6.3.2 Impacts on groundwater supply bores

A search of the DLGWV Groundwater Database (GWDB) indicated that there are three registered water supply bores within the vicinity of the TSF. This small number reflects the fractured nature of the aquifers in the area providing highly variable yields.

No groundwater supply bores are present within the TSF area or its surrounds.

There are two registered groundwater supply bores located within the vicinity of the TSF:

- RN 118755 (BPB001) is located approximately 3 km to the east of the TSF and is screened in the Mount Roseby Schist
- RN 206092 (BPB002) is located approximately 3.2 north-east of the TSF and is screened in the Mount Roseby Schist.

Due to the distance between these registered water supply bores and the TSF, and the presence of the very low permeability Knapdale Quartzite underlying the TSF, neither bore is expected to experience any change to groundwater levels or groundwater quality as a result of the Stage 3 TSF raise.

6.3.3 Impacts on surface drainage

Figure 3-4 shows the drainage within and surrounding the project site.

The nearest creek is Cabbage Tree Creek, located approximately 2.6 km to the west of the TSF. The creek is ephemeral, with flows limited to short periods of time during and immediately after rainfall events.

As discussed in Section 5.6, recharge to the groundwater system is limited due to the low porosity of the units, and the depth of incision of watercourses is shallow. The groundwater table does not intersect the ground surface in the creek bed, and there is no groundwater seepage through the creek bed and banks. On this basis, groundwater does not provide baseflow to the creek and there is no groundwater-surface water interaction.

Therefore, the Stage 3 TSF raise is not predicted to have any impact on the baseflow or the natural flow regime of Cabbage Tree Creek and its tributaries. The project is not expected to give rise to any adverse impacts on any aquatic habitats and ecosystems associated with creeks, not any downstream surface water users (e.g., farm dams).

6.3.4 Impacts on wetlands

There are no wetlands or other surface water features (that are not directly associated with creeks) located within the vicinity of the TSF. Therefore, no impacts on wetlands or other surface water features are predicted.

6.3.5 Impacts on groundwater dependent ecosystems

The potential for groundwater dependent ecosystems (GDEs) to be present within the vicinity of the TSF was reviewed through a search of the Bureau of Meteorology (BoM) GDE Atlas.

A search of the BoM GDE mapping indicates that a moderate potential terrestrial GDE is mapped within the vicinity of the TSF (Figure 6-1)

However, due to the absence of any expected effect on the groundwater regime as a result of the project, it is assessed that there will be no impacts to groundwater dependent ecosystems as a result of the Stage 3 TSF raise.

6.3.6 Cumulative impacts

There are no other approved resource projects or other land uses in the vicinity of the TSF that could potentially contribute to cumulative impacts. Therefore, there are no cumulative groundwater impacts associated with the Stage 3 TSF raise identified at this time.

6.3.7 Impacts on groundwater quality

The Stage 3 TSF raise is an extension of the existing DRM TSF that is apparated as part of the approved DRM.

The project will utilise existing infrastructure for storing tailings associated with mineral processing. Therefore, there is no potential for contamination from new surface infrastructure areas.

The Stage 3 TSF raise has the potential to affect local groundwater quality due to limited seepage of potential acid mine drainage contaminated water migrating from the TSF into the underlying groundwater regime. However, due to the very low permeability of the Knapdale Quartzite underlying the TSF, and the absence of any evidence of seepage from the TSF since tailings deposition commenced in 2017, impacts on groundwater quality associated with local contamination from TSF seepage are considered highly unlikely.

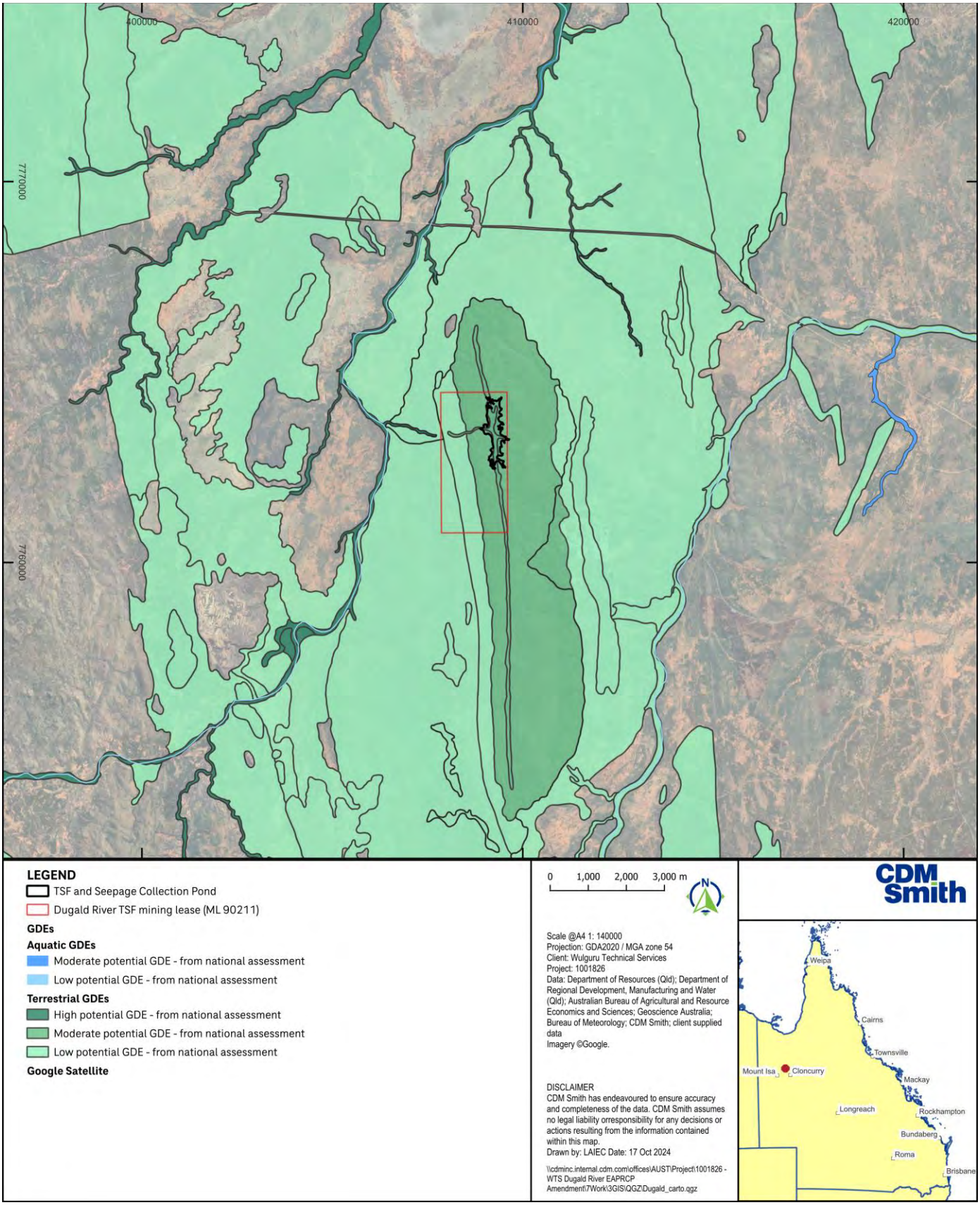

Figure 6-1 Groundwater dependent ecosystems

Section 7 Post-mining land use

7.1 Current and potential future uses of groundwater

A search was undertaken of the Department of Regional Development, Manufacturing and Water (DLGWV) groundwater database of registered groundwater bores (see Section 4.1.1).

Two registered groundwater bores are utilised for water supply purposes within the vicinity of the TSF:

- RN 118755 (BPB001) is located approximately 3 km to the east of the TSF and is screened in the Mount Roseby Schist
- RN 206092 (BPB002) is located approximately 3.2 north-east of the TSF and is screened in the Mount Roseby Schist.

As there is no predicted impact to the groundwater system as a result of the proposed Stage 3 TSF raise, the potential for impacts to users of groundwater from the project is expected to be low.

7.2 Final landform

At closure, the TSF will be rehabilitated to a native ecosystem landform (WTS, 2023a).

The TSF will be capped to reduce infiltration from rainfall into the tailings. Limiting infiltration into the tailings will prevent any acidic seepage and mobilisation of metals occurring into the groundwater system (Rhode, 2022). Shallow rooting native species will be used to revegetate the capping layer in order to reduce erosion and maintain the long-term stability of the capping layer.

7.3 Post-mining site hydrogeology

Post-closure, recharge from rainfall will decrease within the extent of the TSF as a result of the installation of the capping.

Due to the very low hydraulic conductivity of the Knapdale Quartzite underlying the TSF, no seepage from the TSF to the groundwater system is expected post-mining. The potential for seepage from the TSF to the groundwater regime is expected to decrease post-closure as the tailings progressively dewater and the TSF cap minimises rainfall recharge.

No other changes to the groundwater system within the vicinity of the TSF are predicted to occur post-mining. The groundwater system is predicted to remain as described in **Error! Reference source not found.**.

7.4 Post-mining groundwater quality

As described in Section 5.7, the existing groundwater quality within the vicinity of the TSF is fresh to brackish, with generally low concentrations of metals and metalloids.

The TSF is a potential source of contamination at DRM post-closure due to the potentially acid forming (PAF) material that is deposited as tailings (WTS, 2023a).

However, given no seepage is expected to occur from the TSF post-closure due to the reduction in rainfall infiltration as a result of capping the TSF, the expected dewatering of the tailings over time, and the very low hydraulic conductivity of the Knapdale Quartzite preventing seepage from the TSF into the groundwater system, no change to groundwater quality is expected post-mining.

Section 8 Groundwater monitoring and management

8.1 Approved groundwater monitoring program

The DRM operates under Environmental Authority (EA) (EPML00731213), effective as of 7 November 2024.

MMG maintains a groundwater monitoring network for the DRM in accordance with the EA. The approved EA groundwater monitoring network comprises 15 monitoring bores located across the DRM extent (Figure 4-2). The existing monitoring bores are listed in Table 8-1.

The EA groundwater monitoring network is used to collect groundwater data and monitors the effects of the approved mining activities at the DRM on groundwater levels and groundwater quality. The groundwater monitoring bores will continue to be utilised through the remaining mine life of the DRM to confirm the actual extent of groundwater impacts from mining activities at the DRM.

Quarterly groundwater sampling will continue as per the EA.

In accordance with the requirements of the EA, the approved groundwater monitoring program includes the following:

- Groundwater levels recorded on a quarterly basis. This data is used to enable groundwater levels to be monitored for potential groundwater level impacts due to dewatering as a result of the mining activity.
- Groundwater quality monitoring is undertaken on a quarterly basis to detect any changes in groundwater quality due to mining activity. In accordance with the EA, groundwater samples are analysed for a broad suite of parameters, including:
  - pH, electrical conductivity, hardness and total dissolved solids
  - major ions (calcium, magnesium, sodium, potassium, chloride, bicarbonate and total alkalinity, sulfate, and fluoride), and
  - metals and metalloids (aluminium, arsenic, cadmium, copper, cyanide, lead, manganese, nickel and zinc).

Groundwater quality trigger levels and contaminant limits are set out in the EA. All groundwater data is compared to the approved groundwater quality trigger levels and contaminant limits defined in the EA. If a contaminant limit is exceeded, DESI is required to be notified and an investigation into the cause of the exceedance is to be completed.

8.2 Additional site monitoring

The DRM groundwater monitoring network has been expanded to include an additional four groundwater monitoring bores located within the vicinity of the TSF (Figure 4-2). The additional monitoring bores are listed in Table 8-2.

The additional monitoring bores target the Knapdale Quartzite within the vicinity of the TSF. The groundwater monitoring network is therefore considered suitable for identifying and monitoring the potential effects of the Stage 3 TSF raise on the groundwater regime.

Groundwater levels are recorded on a quarterly basis. Groundwater quality monitoring is undertaken on a quarterly basis in accordance with the current EA requirements. The information collected us used to detect any changes in groundwater quality due to mining activity. Groundwater samples are analysed for the approved EA groundwater quality parameters, including:

- pH, electrical conductivity, hardness and total dissolved solids
- major ions (calcium, magnesium, sodium, potassium, chloride, bicarbonate and total alkalinity, sulfate, and fluoride), and
- metals and metalloids (aluminium, arsenic, cadmium, copper, lead, manganese, nickel and zinc).

Table 8-1 Groundwater monitoring bore construction details

Bore	Aquifer	Easting	Northing	Elevation (mAHD)	Depth (m)	Screened interval (m)
Interpretation bores						
GWBFAB	Dugald River Slate	411395	7761383	209.2	12.3	6.3 - 12.3
MB1AB	Mt Roseby Schist	411199	7761205	207.6	15.7	9.7 - 15.7
MB2AB	Mt Roseby Schist	412187	7761185	196.8	15.2	9.2 - 15.2
MB3AB	Mt Roseby Schist	411421	7760107	208.4	15.3	9.3 - 15.3
MB4AB	Mt Roseby Schist	412744	7760042	195.4	15	9 - 15
SHALL6AB	Mt Roseby Schist	410983	7760929	216.3	15.3	9.3 - 15.3
Compliance bores						
MB2	Mt Roseby Schist	412191	7761189	196.3	99	21 - 99
MB4	Mt Roseby Schist	412749	7760041	195.2	99	46 - 99
MB5	Mt Roseby Schist	408537	7763364	203	99	18 - 99
MB6	Mt Roseby Schist	408287	7763224	199	99	46 - 99
MB9D	Knapdale Quartzite	408723	7763433	204.3	30	18 - 30
MB9S	Knapdale Quartzite	408724	7763433	204.2	10	6 - 10
Background bores						
MB1	Mt Roseby Schist	411301	7761214	205.5	99	11 - 99
MB3	Mt Roseby Schist	411931	7760127	209.5	99	11 - 99
TBA	TBA	TBA	TBA	TBA	TBA	TBA

Table 8-2 Additional groundwater monitoring network bores

Bore	Aquifer	Easting	Northing	Elevation (mAHD)	Depth (m)	Screened interval (m)
MB12	Knapdale Quartzite	409528.7	7761337	276.864	95	83 – 95
MB13	Knapdale Quartzite	409834.5	7763387	294.965	112	100 – 112
MB14	Knapdale Quartzite	410436.7	7763278	288.167	103	91 – 103
MB15	Knapdale Quartzite	409556.1	7764491	272.476	85	73 - 85

8.2.1 Groundwater monitoring

A Groundwater Monitoring Plan (GMP) has been developed for the DRM (Big Dog Hydrogeology, 2014b). The GMP is based on the conceptual groundwater model outlined in this report and describes the relevant aspects of the groundwater regime. It specifically considers local aquifers and aquitards, groundwater movement (recharge, flow and discharge), and any mining activities with the potential to impact groundwater levels and/or quality.

8.3 Management measures

No management measures are currently required at as part of the project. There are no groundwater impacts predicted for water supply bores, other groundwater users or surface water systems in relation to TSF activities at this time.

Impacts to groundwater quality or environmental values are considered highly unlikely. Should monitoring and subsequent assessment determine potential impacts, management strategies will be considered commensurate with the level and risk of environmental impact.

Section 9 Conclusion

The key conclusions of the groundwater assessment are:

- The Stage 3 TSF lift involves increasing the height of the downstream TSF embankment, and a subsequent increase in the footprint of the TSF.
- The main hydrostratigraphic units in the TSF area and surroundings include:
  - Unconsolidated Cainozoic sediments
  - Proterozoic Mount Albert Group, comprising:
    - Lady Clayre Formation
    - Coocerina Formation
    - Mount Roseby Schist, and
    - Knapdale Quartzite, which underlies the TSF.
- The Stage 3 TSF raise will not impact surface water or sensitive environmental features because:
  - The deep groundwater table does not intersect the ground surface in the creek beds located within the vicinity of the TSF. Groundwater does not provide baseflow to any surface water features within the DRM area.
  - The very low permeability of the Knapdale Quartzite that underlies the TSF prevents any impact to the groundwater regime within the vicinity of the TSF.
- There is a very low potential for groundwater contamination as a result of the Stage 3 TSF raise.

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Section 11 Abbreviations

BoM: Bureau of Meteorology

CDFM: Cumulative Deviation From the Mean

DESI: Department of Environment, Science and Innovation

DLGWV: Department of Local Government, Water and Volunteers

DRM: Dugald River Mine

EA: Environmental Authority

EC: Electrical conductivity

EIS: Environmental Impact Statement

EP Act: *Environmental Protection Act 1994*

EPP Water: *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*

GABORA: Great Artesian Basins and Other Regional Aquifers Water Plan

GDE: Groundwater dependent ecosystem

GMP: Groundwater Monitoring Plan

Gulf Water Plan: *Water Plan (Gulf) 2007*

GWDB: Groundwater Database, currently managed by the DRDMW

ha: Hectares

mAHD: metres (above) Australian Height Datum

MDL: Mineral development lease

mg/L: milligrams per litre

ML: Mining lease

Mt: Million tonnes

PAF: Potentially Acid Forming

PRCP: Progressive Rehabilitation and Closure Plan

SILO: Scientific Information for Land Owners

The Project: Stage 3 TSF raise

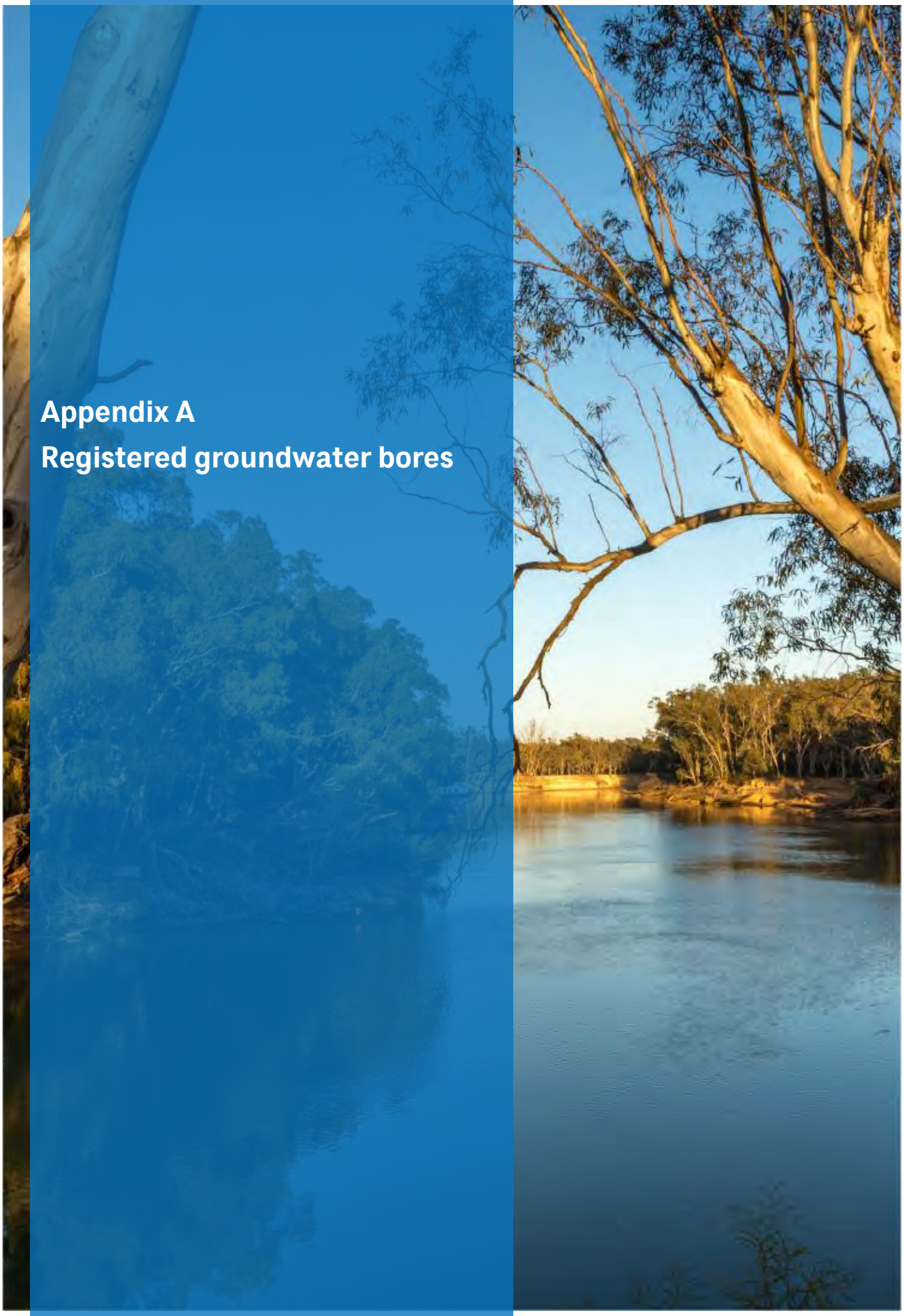
TSF: Tailings storage facility

µS/cm: microsiemens per centimetre

Water Act: *Water Act 2000*

WTS: Wulguru Technical Services Pty Ltd

Appendix A
Registered groundwater bores



RN	Name	Status	Drilled date	Role	Latitude	Longitude	Easting	Northing	Elevation	Depth	Screened interval	Target unit
7082	MAIL CHANGE WELL	Abandoned and Destroyed			-20.2096005	140.0870198	404614	7765048				
38685	TOP SOAK BORE	Existing	1/01/1972		-20.18876692	140.1122971	407242	7767368		45.7		
118755	BPB001	Existing	1/04/2006	Water supply	-20.2100594	140.1616281	412416	7765052		230	42 - 216	Schist
146106	MB6	Existing	25/11/2008	Mine monitoring	-20.22638183	140.1220108	408287	7763224		100	48 - 99	Mount Roseby Schist
146107	MB5	Existing	26/11/2008	Mine monitoring	-20.22512883	140.124411	408537	7763364		100	18 - 99	Mount Roseby Schist
146108	MB3	Existing	22/11/2008	Mine monitoring	-20.25451069	140.1515717	411391	7760127	209.65	100	11 - 99	Schist
146109	MB1	Existing	21/11/2008	Mine monitoring	-20.24468501	140.1507634	411301	7761214	205.36	100	11 - 99	Schist
146110	MB4	Existing	18/11/2008	Mine monitoring	-20.25535017	140.1645693	412749	7760041	195.3	100	46 - 99	Schist
146111	MB2	Existing	20/11/2008	Mine monitoring	-20.24495193	140.1592827	412191	7761189	196.68	100	21 - 99	Schist
146309	MB11 SOUTH PORTAL	Existing	23/01/2011	Mine monitoring	-20.25376191	140.1555587	411807	7760212			18 - 36; 90 - 108	Mudstone, quartz, mica schist
146310	MB10 NORTH PORTAL	Existing	26/01/2011	Mine monitoring	-20.24583379	140.1528922	411524	7761088		108	36 - 50; 90 - 108	Mudstone
163656	MB7S	Existing	1/12/2010	Mine monitoring	-20.2238568	140.1302669	409148	7763508		10	6 - 10	Quartzite
163657	MB7D	Existing	1/12/2010	Mine monitoring	-20.22384781	140.1302765	409149	7763509		30	18 - 30	Quartzite
163658	MB8S	Existing	1/12/2010	Mine monitoring	-20.22391094	140.1284287	408956	7763501		10	6 - 10	Knapdale Quartzite
163659	MB8D	Existing	1/12/2010	Mine monitoring	-20.223902	140.1284479	408958	7763502		30	18 - 30	Knapdale Quartzite

RN	Name	Status	Drilled date	Role	Latitude	Longitude	Easting	Northing	Elevation	Depth	Screened interval	Target unit
163660	MB9S	Existing	1/12/2010	Mine monitoring	-20.22451431	140.1262045	408724	7763433		10	6 - 10	Knapdale Quartzite
163661	MB9D	Existing	1/12/2010	Mine monitoring	-20.22451426	140.1261949	408723	7763433		30	18 - 30	Knapdale Quartzite
163662	GWBF	Existing	1/11/2012	Mine monitoring	-20.24316237	140.1516717	411395	7761383	209.18	12.3	6.3 - 12.3	Mount Roseby Schist
163663	SHALL6AB	Existing	1/11/2012	Mine monitoring	-20.24724534	140.147705	410983	7760929	216.34	15.3	9.3 - 15.3	Mount Roseby Schist
163675	MB1AB	Existing	1/11/2012	Mine monitoring	-20.24476159	140.1497865	411199	7761205	207.56	15.7	9.7 - 15.7	Mount Roseby Schist
163676	MB2AB	Existing	1/11/2012	Mine monitoring	-20.24498789	140.1592442	412187	7761185	196.79	15.2	9.2 - 15.2	Mount Roseby Schist
163677	MB3AB	Existing	1/11/2012	Mine monitoring	-20.25469279	140.151858	411421	7760107	208.42	15.3	9.3 - 15.3	Mount Roseby Schist
163678	MB4AB	Existing	1/11/2012	Mine monitoring	-20.25534086	140.1645119	412743	7760042		15	9 - 15	Mount Roseby Schist
202086	MB19	Existing	8/12/2022	Mine monitoring	-20.25998518	140.158838	412153	7759525		199	9 - 199	Schist
202089	MB14	Existing	29/11/2022	Mine monitoring	-20.22602279	140.1426036	410438	7763275		103	91 - 103	Quartzite
202090	MB15	Existing	1/12/2022	Mine monitoring	-20.24350878	140.1338052	409529	7761335		85	73 - 85	Quartzite
202091	MB12	Existing	26/11/2022	Mine monitoring	-20.21497621	140.1342216	409556	7764493		95	83 - 95	Quartzite
202092	MB13	Existing	28/11/2022	Mine monitoring	-20.22500965	140.1368369	409835	7763384		114	100 - 112	Quartzite
202093	MB16	Existing	11/12/2022	Mine monitoring	-20.23879482	140.1491201	411126	7761865		199	6 - 199	Quartzite, schist

RN	Name	Status	Drilled date	Role	Latitude	Longitude	Easting	Northing	Elevation	Depth	Screened interval	Target unit
202103	MB18	Existing	9/01/2023	Mine monitoring	-20.26451546	140.152044	411446	7759020		199	24 - 42; 180 - 198	Schist
206092	BPB002	Existing	9/11/2023	Industrial water supply	-20.20068012	140.1599513	412236	7766089			80.5 - 179.5	Schist

APPENDIX L: Air Quality Monitoring Locations (SEGroup, 2025b)

Simpson Engineering Group

31 Lionheart Street
Forestdale, QLD 4118
Phone: (07) 3117 2468
www.SEGroup.com.au
Inc: Noise Mapping Australia

Wednesday, 23 April 2025

MMG Dugald River Pty Ltd
C/- Wulguru Technical Services
PO Box 2553
Idelia, QLD 4810

Attn: Madison Jackson

Subject: Relocation of Air Quality Monitoring Locations

Dear Madison,

It is understood that Wulguru Technical Services (WTS) is the study management consultant for the MMG Dugald River Tailings Dam Lift Project. As part of that project SEG has been requested to make recommendations regarding the relocation of dust deposition gauges currently located on adjoining mining lease.

Background.

MMG Dougald River Mine has been operating under EPML00731213. It is an underground zinc-lead-silver mine and concentrate processing facility. Construction commenced in 2012 and first concentrate commenced in 2015 with full operations in 2018.

In September 2024 Eva Copper mine was issued Environmental Authority EPML00899613 to permit open cut copper mining and processing on several large expansive leases surrounding MMG to the north, east and south. It should be noted that Eva are much closer to the closest sensitive receptor (Roseby Homestead) than MMG. The extent of each of the mining operations are shown in Figure 1 together with the closest sensitive receptor.

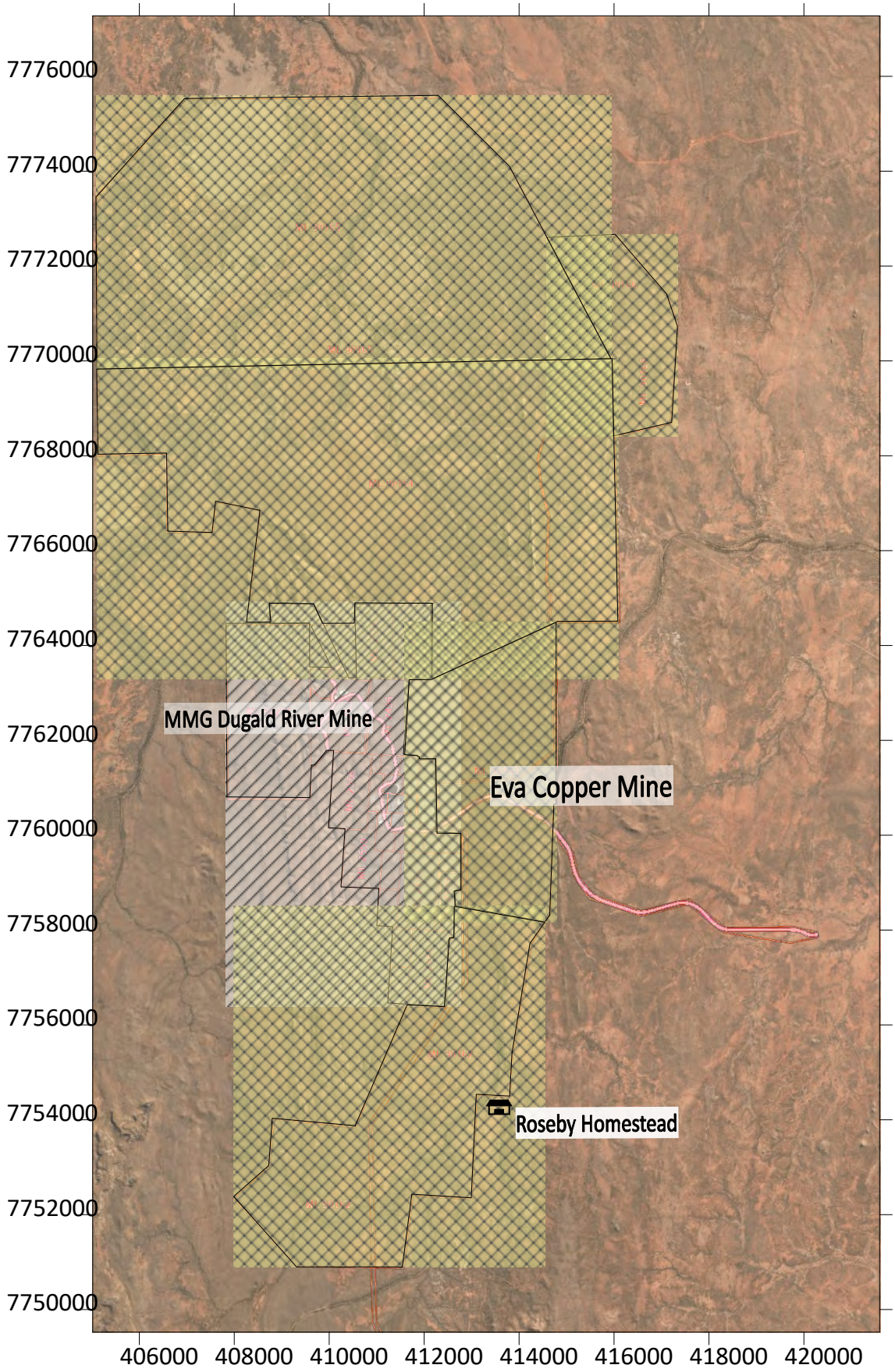


FIGURE 1: LOCATION OF MMG DUGALD RIVER MINE AND EVA COPPER MINE AND CLOSEST SENSITIVE RECEPTOR (GDA94 MGA S54)

Following the issue of the Eva EA it was evident that several of the MMG dust monitoring locations are situated on the Eva lease, refer to Figure 2. To avoid potential conflict and travelling over adjoining mining leases, it is proposed to relocate several dust monitoring locations namely, EA_001, EA_007, EA_008 and EA_010

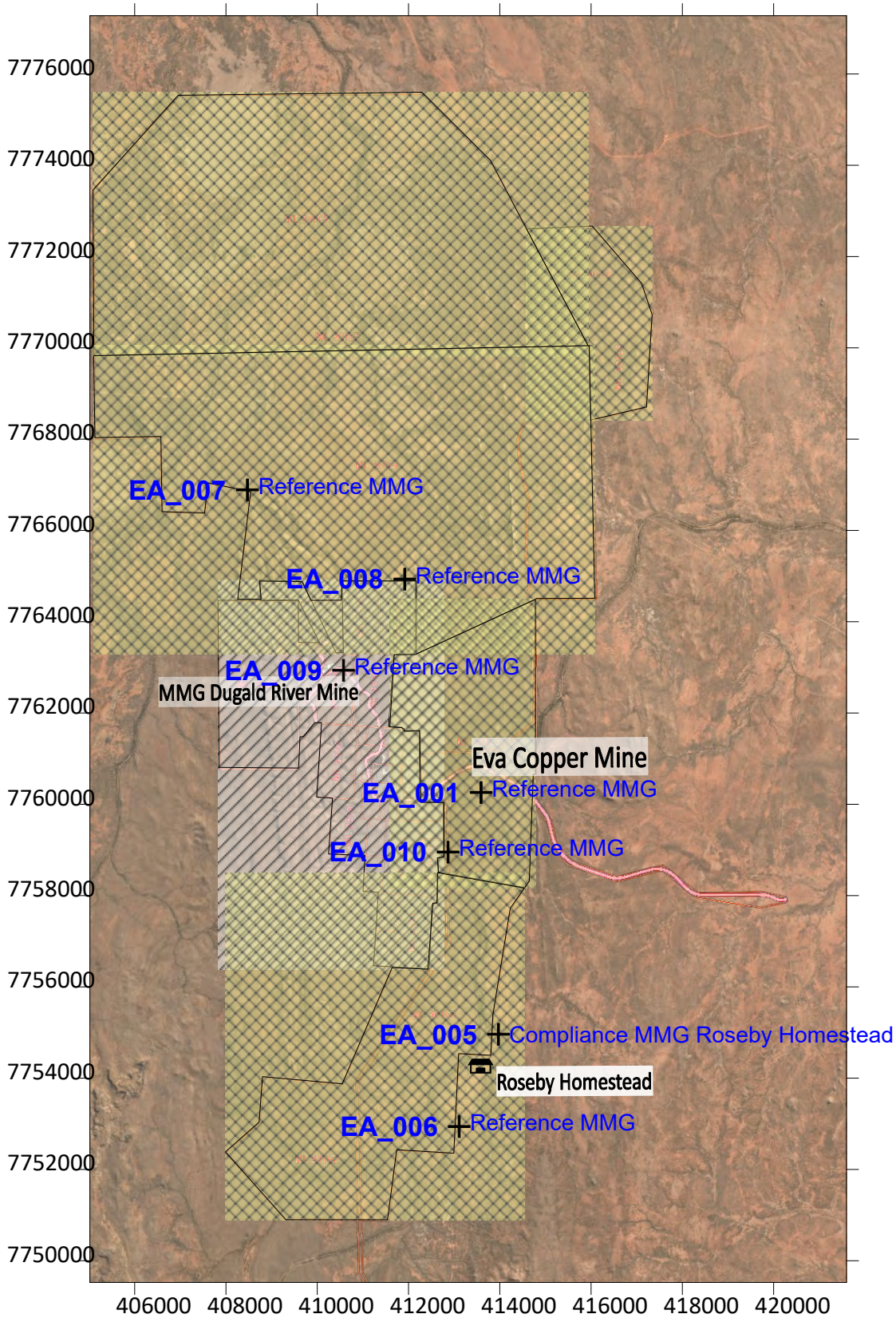


FIGURE 2: MMG DUGALD RIVER DUST SAMPLING LOCATIONS (SOURCE EPML00731213)

It is noted that Eva Copper mine is an open pit mining operation. This mining operation has a much higher potential for dust exposure at Roseby Homestead (due to proximity and the nature of the operations) than MMG. Refer to Figure 3 for the MMG approved monitoring sites relative to Eva approved uses. This figure helps identify if any of the MMG monitoring locations are potentially adversely impacted by Eva copper mining operations. It is evident that EA_005 the compliance location is adjacent to the several Eva Copper pits (Scanlan, Bedford etc.). There will also be haul roads and light vehicle access to the accommodation village in the southern parts of the Eva copper site. These Eva operations are situated between Roseby Station and MMG operations. Any future measurements of dust levels will include dusts from both MMG and Eva copper.

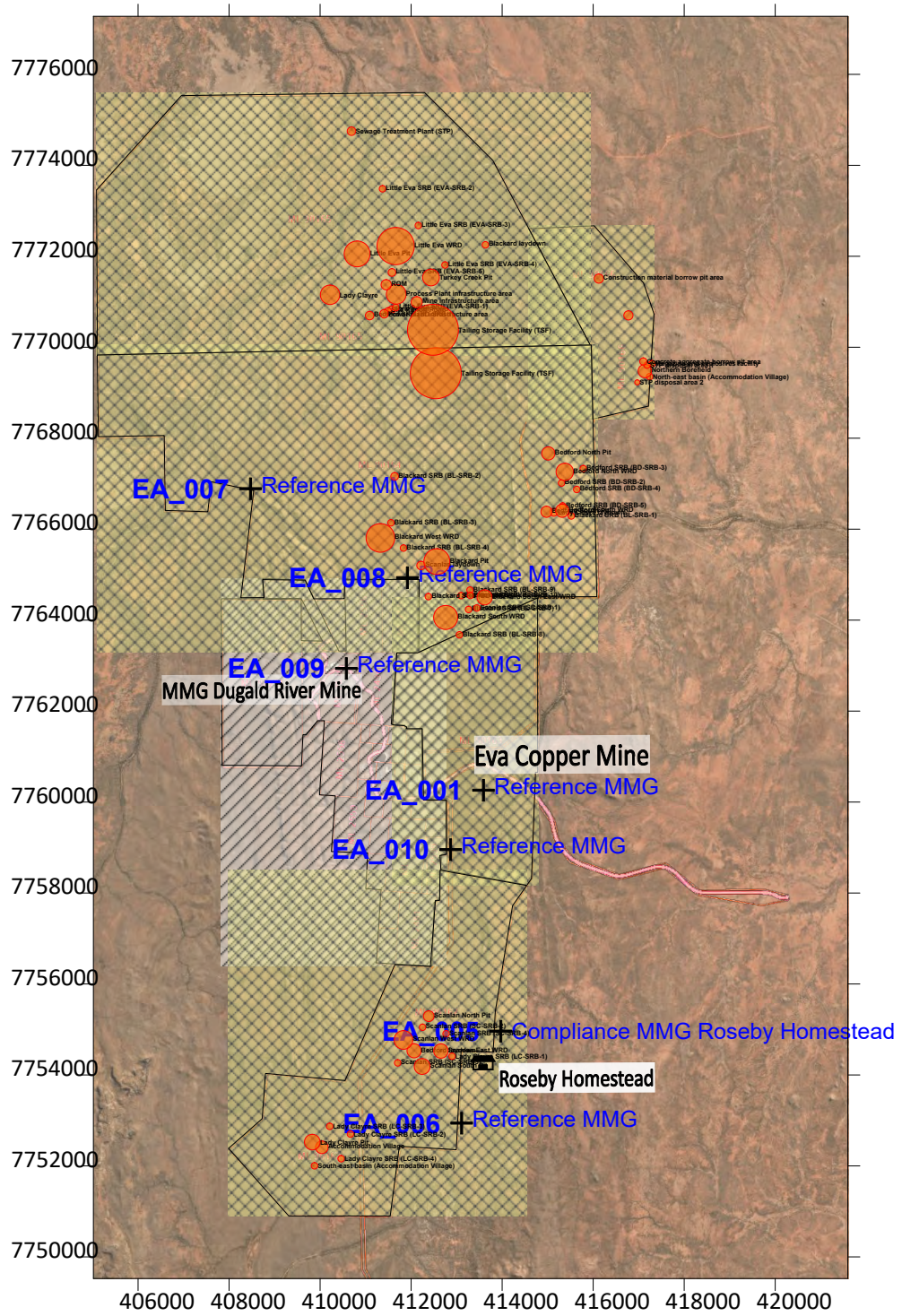


FIGURE 3: EVA COPPER MINE APPROVED USES AND MMG SAMPLING LOCATIONS

For completeness, the dust monitoring locations for the Eva copper mine are shown in Figure 3. None of the Eva dust monitoring locations are situated on MMG Dugald River mining lease and are mostly clustered close to Eva operations, unlike MMG dust monitoring locations.

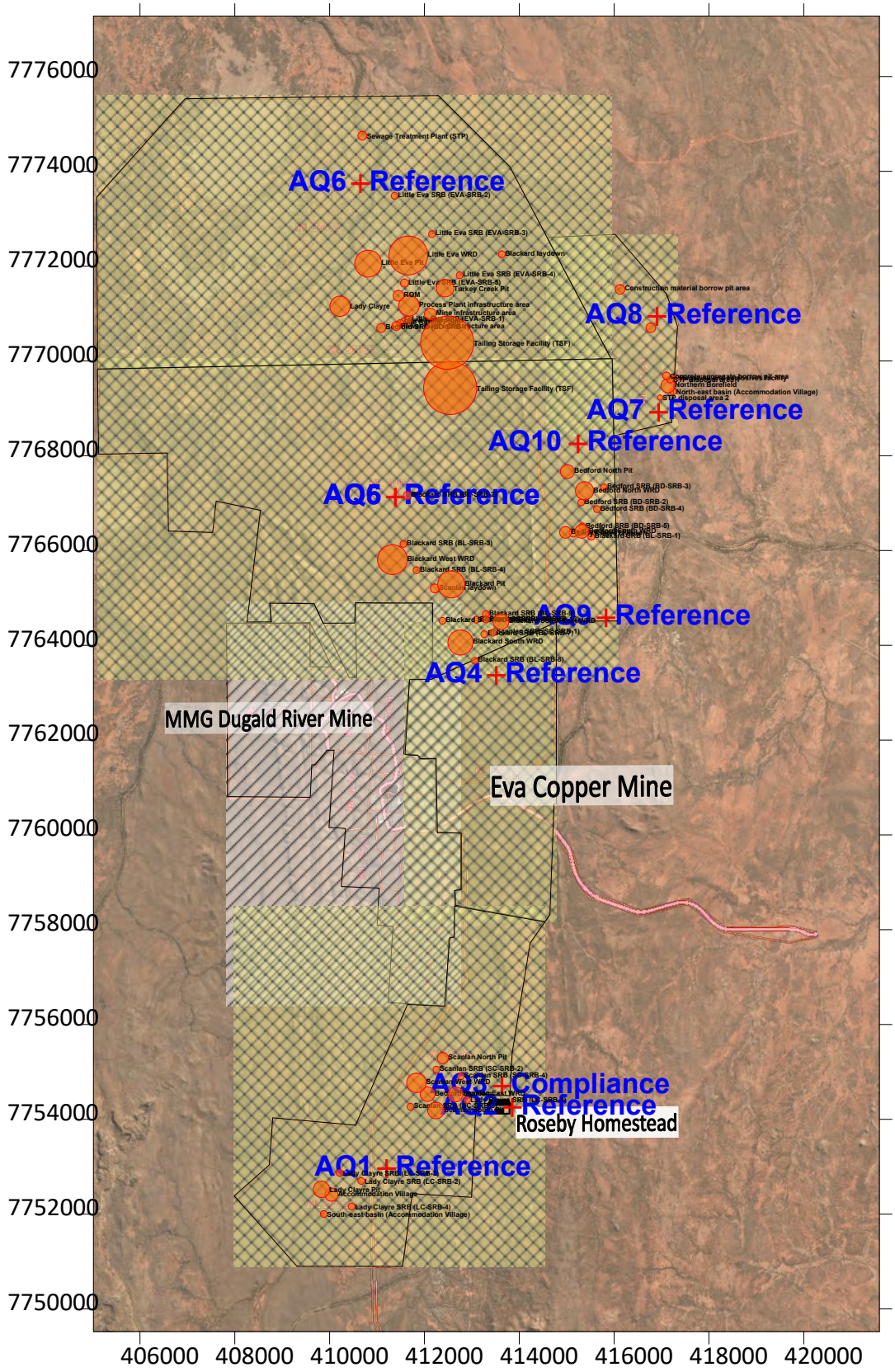


FIGURE 4: EVA COPPER MINE APPROVED USES AND EVA SAMPLING LOCATIONS

Proposed Changes to the MMG EA Dust Monitoring Locations

It is proposed to relocate the four air quality monitoring locations currently situated within the Eva lease. It is recommended that the shift be as small as possible whilst still retaining good separation to Eva operations. The existing and proposed locations are contained in Table 1 together with the distance and direction the relocation. The new locations are shown in Figure 5.

TABLE 1: EXISTING AND PROPOSED FUTURE DUST MONITORING LOCATIONS

Site	Existing Location (GDA94 MGA s54)		Proposed Location (GDA94 MGA s54)		Distance Moved (m)	Direction
	Easting	Northing	Easting	Northing		
EA_005	413970	7754962	413970	7754962	0	N.A.
EA_007	408471	7766889	408400	7766800	114	SW
EA_008	411918	7764933	410600	7764850	883	WSW
EA_009	410576	7762936	410576	7762936	0	N.A.
EA_006	413110	7752939	413110	7752939	0	N.A.
EA_001	413589	7760259	412500	7760000	1102	WSW
EA_010	412867	7758953	412600	7758100	275	S

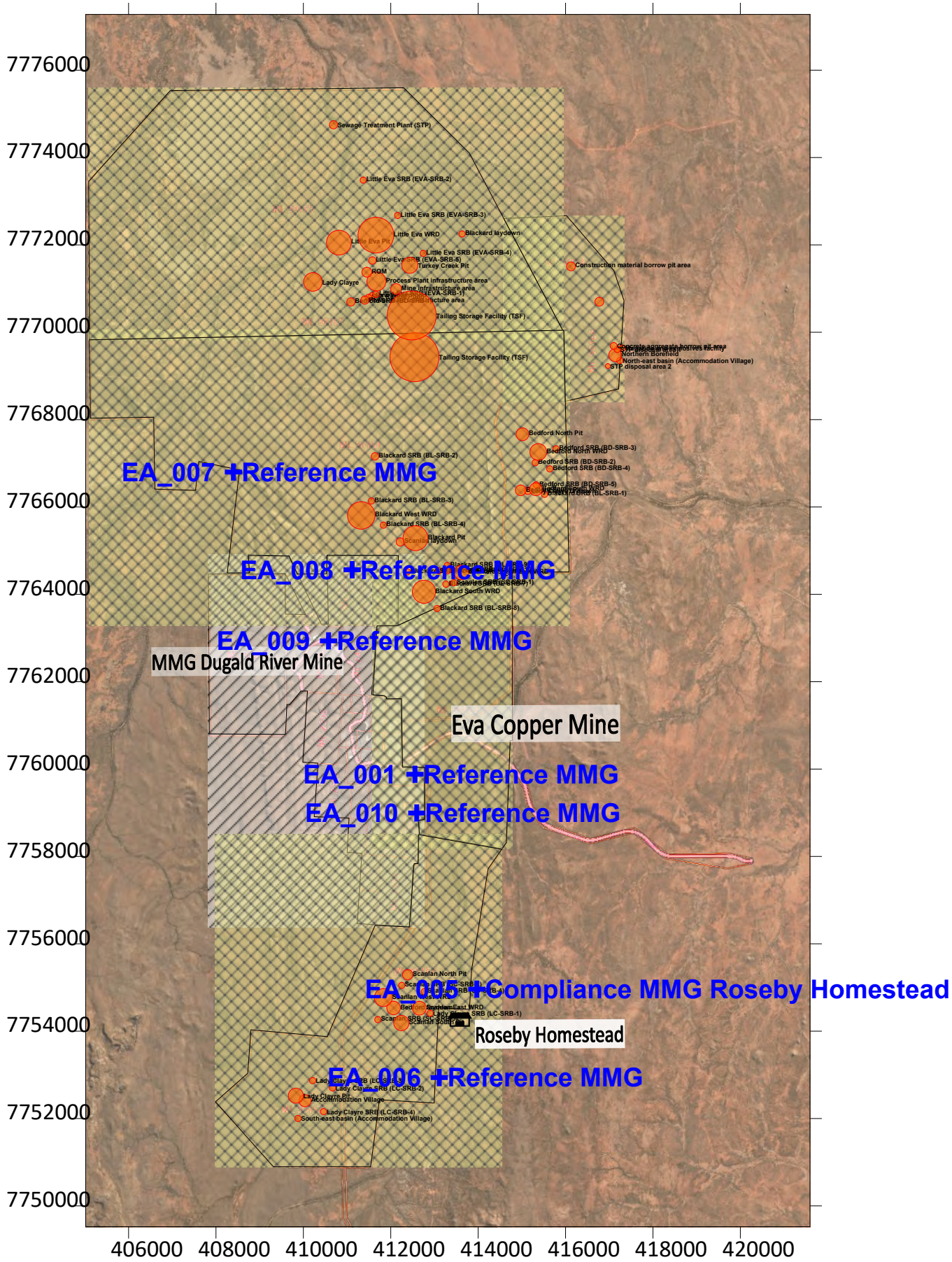


FIGURE 5: PROPOSED REVISED DUST MONITORING LOCATIONS

It is noted that MMG dust monitoring locations EA_005 and EA_006 are almost duplications of Eva dust monitoring locations AA_002 and AQ_003. Additionally, it it is beyond the Eva lease area. It is recommended further investigations be undertaken to determine whether EA_005 and EA_006 remain relevant post construction and operation of Eva copper mine.

Should you have any questions on this matter please contact me by phone on (07) 31172468 at any time or by email on mark@segroup.com.au.

Yours faithfully
Simpson Engineering Group

Mark Simpson
Principal Engineer RPEQ 6224

APPENDIX M: Erosion Modelling (ATCW, 2025c)

MEMORANDUM

TO	Amy Harburg; Kate Brosnan; Robert James	**COMPANY**	MMG Dugald River Mine
FROM	Natascha Kotze; Philippe Garneau	**OFFICE**	Brisbane
EMAIL	NataschaK@atcwilliams.com.au PhilippeG@atcwilliams.com.au	**PHONE**	07 3352 7222
PROJECT TITLE	Dugald River Mine – TSF Conceptual Closure Design		
SUBJECT	DRM – Landform Conceptual Design – Erosion Modelling		
DATE	27 February 2025	**OUR REF**	240189.M04 Rev0

1 INTRODUCTION

MMG Dugald River Pty Ltd (MMG) is an underground lead and zinc mining operation, located approximately 60 kilometres (km) northwest of Cloncurry in North West Queensland. It is owned and operated by MMG, a wholly owned subsidiary of MMG Australia Limited.

Dugald River Mine (DRM) is authorised by the Department of Environment, Tourism, Science and Innovation (DETSI) under Environmental Authority (EA) EPML00731213 and resides on 40 Mining Leases (ML) and one Mineral Development Lease (MDL).

This memo provides details on the erosion assessment and modelling for the conceptual final landform for the Tailings Storage Facility (TSF).

2 BACKGROUND

MMG proposes to increase the capacity of the TSF by raising the crest height of the main embankment (the Stage 3 embankment raise design concept) **[1]**. This requires a major amendment to the EA, triggering the requirements for updated Progressive Rehabilitation and Closure Plan (PRCP) and PRCP Schedule.

ATC Williams Pty Ltd (ATCW) has been engaged by MMG to develop a conceptual closure design for the TSF. The conceptual closure design must be consistent with the approved PRCP **[2]**, and meet the minimum information requirements in the PRCP Guideline **[3]**. The conceptual closure design includes the landform conceptual design, which involves doing erosion assessment for the closure landform. Development of a Landform Evolution Model (LEM) for the facility has been excluded at this conceptual stage of work.

2.1 Closure Concept

Concept design for the final TSF geometry has been undertaken by ATCW **[4]**. An overview of the closure concept developed is summarised as follows:

Deposition during the operational life of the TSF will be undertaken to optimise the balance between operational requirements and earthworks required to form a suitable surface for closure. Generally, deposition occurs from the north and south extents of the facility, forming the decant area in the centre of the TSF, against the embankment. To form the final surface for closure, reshaping of the tailings beach would be undertaken to form a uniform gradient within the tailings beach, and partially fill the decant area. These reshaping works would be undertaken to form a self-draining landform with shallow slopes on the rehabilitated tailings beach to reduce erosion. The former decant area will be filled and the landform's surface flows report to an outlet structure to the North of the embankment (re-established Stage 2 spillway). The final tailing beach is shown in **DIAGRAM 1** with a section depicting the tailings beach following final deposition and the reshaped tailing beach shown in **DIAGRAM 2**.

Following reshaping of the tailings beach, a cover system will be constructed over the final tailings surface, comprised of site soils won from a borrow area near the TSF and including a reduced-permeability layer (natural materials or synthetic liner).

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The Stage 3 embankment will comprise steep batters (1.5H:1V). For closure, the embankment is proposed to be reprofiled to a 6.5H:1V continuous batter. Reprofiling the embankment will be undertaken by decreasing the embankment height and using excess fill to flatten batters, as shown in **DIAGRAM 3**. The Stage 3 embankment shell will be constructed out of coarse rockfill and would therefore be resistant to erosion.

DIAGRAM 1: CONCEPT CLOSURE FINAL TAILINGS SURFACE (RESHAPE)

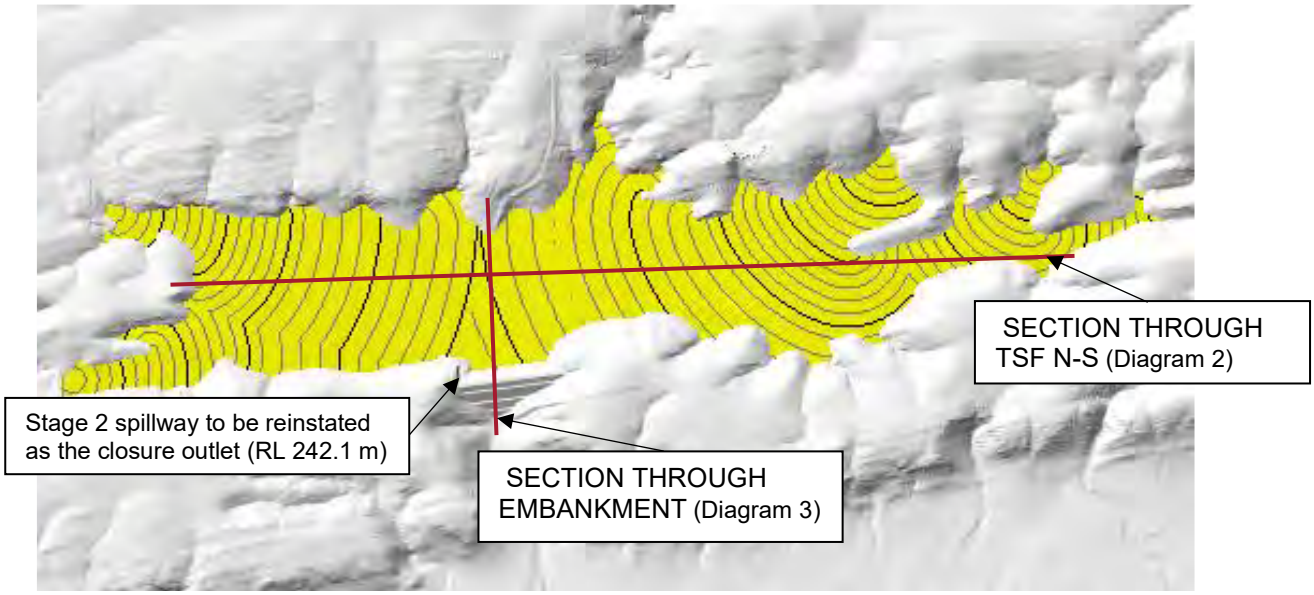

DIAGRAM 2: CONCEPTUAL FINAL TAILINGS SURFACE – SECTION THROUGH TSF N-S

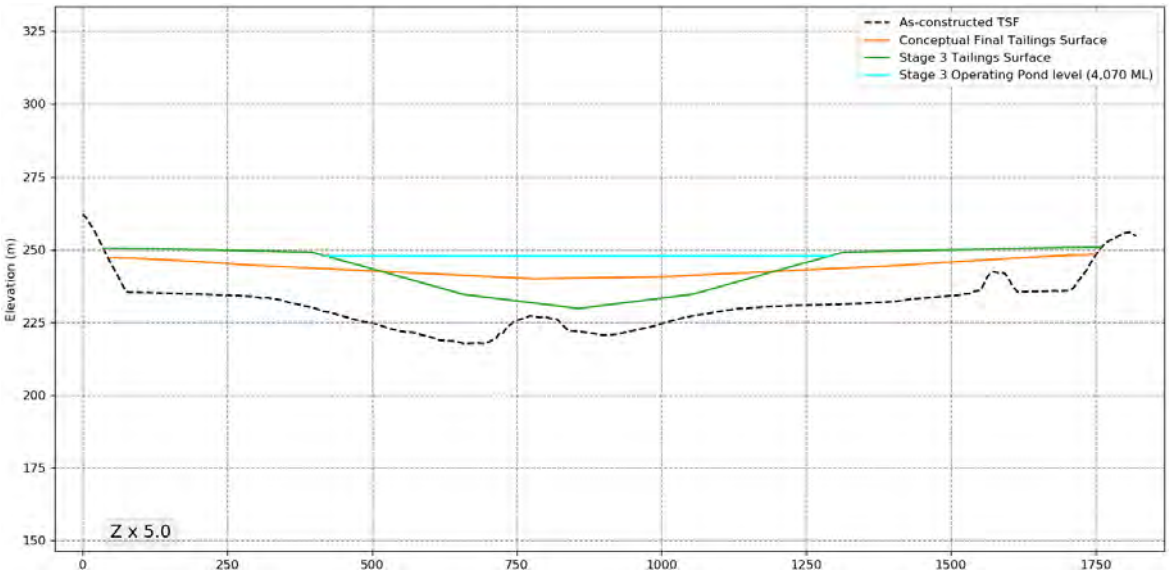

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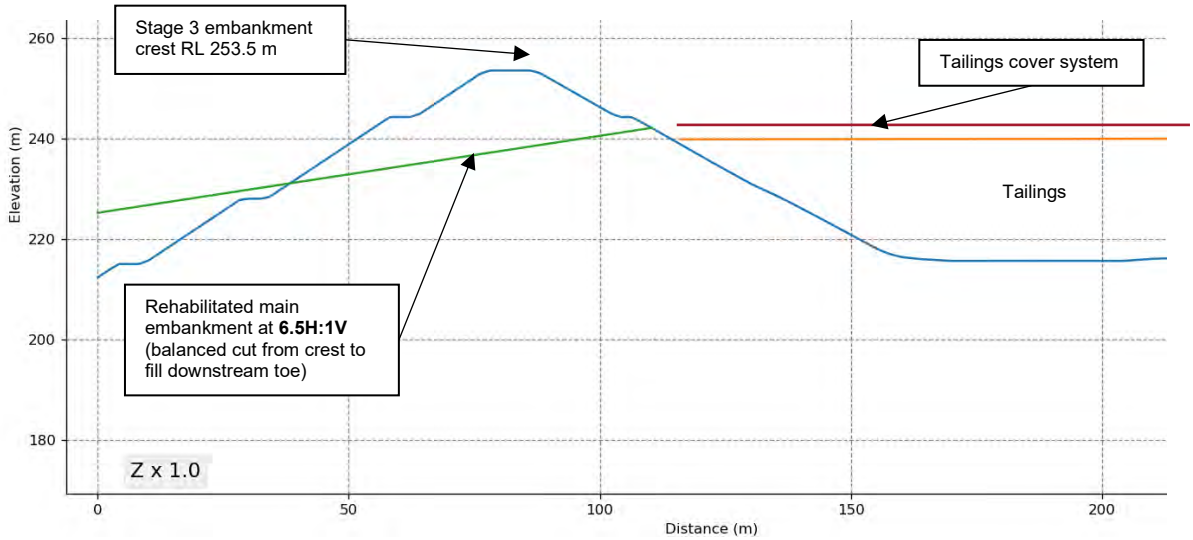
DIAGRAM 3: CONCEPTUAL EMBANKMENT AT CLOSURE – SECTION (FROM DIAGRAM 6 IN [4])



2.2 Closure Performance Objectives - Erosion

The primary objectives for the TSF closure landform with respect to erosion are to:

- Avoid erosion which would impact the performance of the cover system (i.e. through reducing thickness of the cover system and impacting cover system performance).
- Prevent exposure of the underlying tailings.
- Ensure long-term erosional stability of the landform.

The key driver for preventing erosion will be to establish and maintain vegetation over the rehabilitated landform. For the purpose of this assessment, a target soil loss rate of 5 t/ha/yr has been assigned as the maximum average soil loss rate for all years of modelling **[2]**.

2.3 Assessment Methodology

At closure, the surface of tailings beach and the embankment will comprise cover soils and rockfill, respectively. The difference in material at surface warrants different approaches to assess erosion. The methodology adopted to assess erosion for each of these surfaces is summarised as follows:

Tailings beach:	Modelling using Water Erosion Prediction Project (WEPP), as discussed in **Section 3**.
Embankment:	Assessed using flood study results undertaken by ATCW **[10]**, as discussed in **Section 4**.

3 WEPP MODELLING

Average annual erosion rates for the final landform were estimated using the Water Erosion Prediction Project (WEPP) model. The WEPP model is a continuous simulation erosion prediction model developed by the United States Department of Agriculture (USDA). The WEPP model incorporates hydrology, vegetation science, hydraulics, and soil mechanics to simulate the erosion process (both detachment and transport) at a two-dimensional hillslope scale. The purpose of WEPP modelling is to estimate the net soil loss for rehabilitated areas.

3.1 Model Duration

A model duration of 50 years was adopted based on the following:

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- Vegetation is assumed to be established at the beginning of the model start time, as erosion control structures would remain in place until sufficient ground cover is established, nominally to be established by a construction and rehabilitation works completion date. Vegetation coverage is discussed in **Section 3.5**.
- The 50-year period adopted includes years of high and low rainfall, allowing assessment of loss rates for varying climatic conditions.
- A 50-year period allows sufficient time for initial erosional features to develop and to address any required change in erosion management during the post-closure adaptive management period.

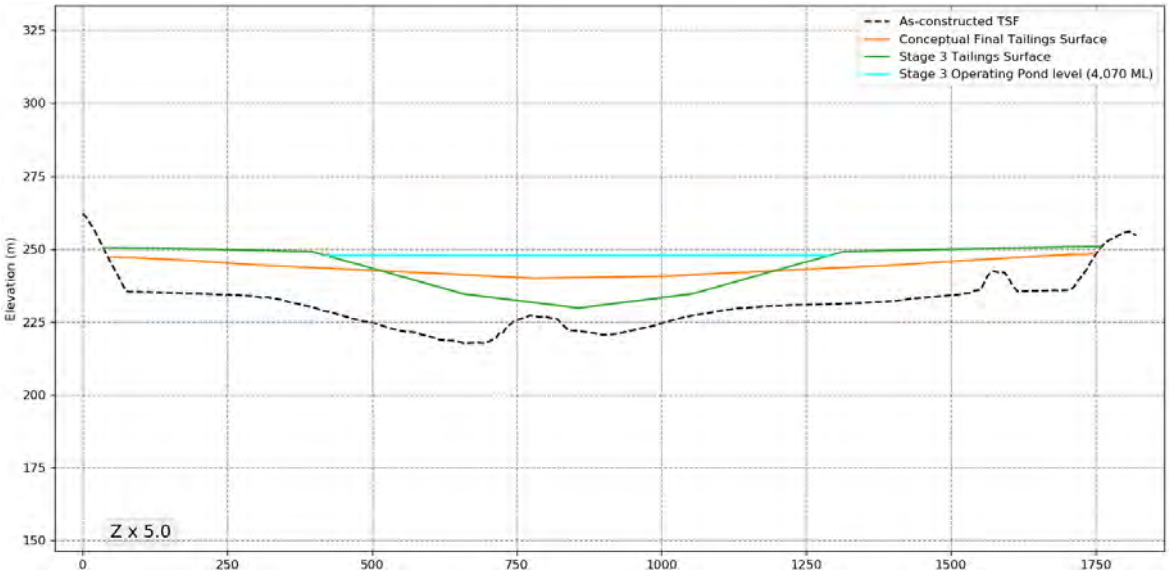
3.2 Geometry

Geometry for the model was adopted from the concept TSF Closure Landform Design **[4],** undertaken by ATCW. As outlined in this report, generally, the final tailings beach slopes are 1.5% for first 500m (top 1/3 of beach), 1% for second 500m (middle 1/3 of beach) and 0.67% for remaining slopes (bottom 1/3 of beach), as shown in **DIAGRAM 4**.

WEPP recommends that flow path lengths do not exceed 100m **[12]**, with potential to overestimate the erosion rates for slope lengths that exceed this distance. For the purpose of the model, a flow path length of 500m at 1.5% was adopted. This flow path is conservative recognising the following:

- WEPP states that erosion is likely to be overestimated for slope lengths greater than 100, therefore results are likely conservative.
- The maximum flow path length is limited to around 500m by surface water drains as discussed in **Section 5**.

DIAGRAM 4: CONCEPT FINAL TAILINGS SURFACE – SECTION (DIAGRAM 6 [4])



3.3 Climate Data

A 50 year synthetic climate file was generated using the CLIGEN stochastic weather generator. Fifty years (1975 to 2024) of patched daily temperature (maximum and minimum) and rainfall data was imported into CLIGEN.

The annual rainfall for the years 1975 to 2024 are shown in **GRAPH 1**. The modelled period includes years of low rainfall (2013, 93.5 mm) and high rainfall (2011, 1,092.4 mm), compared to a mean annual rainfall of 475.6mm.

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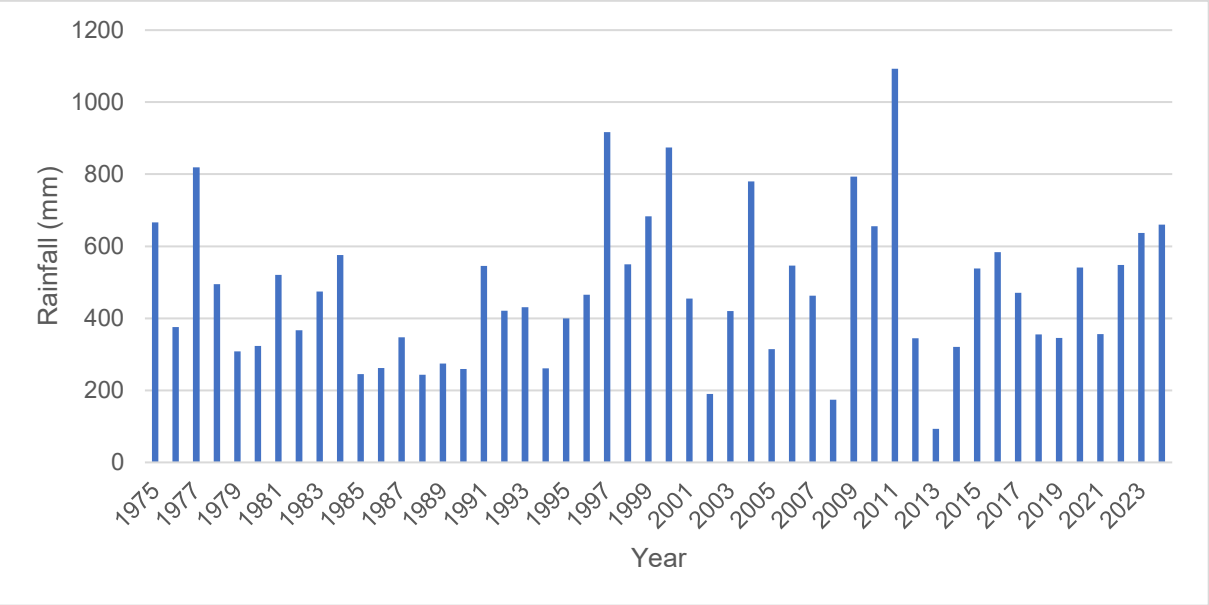
GRAPH 1: ANNUAL RAINFALL



3.4 Soil Input Parameters

WEPP modelling was undertaken prior to receiving the entirety of laboratory results from the 2024 borrow source investigation **[5]**. In the absence of laboratory test data from the borrow source investigation, material parameters were informed by historical investigation for the TSF embankment **[6]** and experience with similar sites. Visually, materials from the previous investigation and the samples obtained from the 2024 **[5]** investigation were similar. Additionally, laboratory results obtained following completion of the modelling, and prior to writing this report further demonstrated consistency, with the permeability results within the same order of magnitude, and PSD results were very similar to the Mix 1 from **[6]** used as the topsoil material.

The Organic Matter and Cation Exchange Capacity has not been previously assessed for site, these were based on known values from materials with similar properties **[12]**.

The soil input parameters adopted in the WEPP model, for the TSF beach slope, are summarised in **TABLE 1**.

TABLE 1: WEPP MODEL SOIL INPUT PARAMETERS

Parameter	Topsoil	Sub-Soil (ISL)
Clay (%)	14	33
Sand (%)	17	18
Rock (%)	69	49
Organic Matter (%)	1.1	0.5
Cation Exchange Capacity (meq/100g)	10	10

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3.5 Vegetation

The Post-Mining Land Use (PMLU) for the site is native ecosystem **[2]**, which will support a range of native grasses and shrubs. The vegetation endemic to the region has a regional ecosystem code of RE 1.11.2a/1.7.7a and RE 1.11.3a/1.3.13a **[7]**. Descriptions of individual regional ecosystems and vegetation communities are shown in **TABLE 2 [8]**.

TABLE 2: REGIONAL ECOSYSTEM CODE DESCRIPTIONS

RE code	Description
1.11.2a	*Eucalpyptus leucophloia* often with *Corymbia spp*., *Terminalia aridicola* and *E. leucophylla* low open woodland
1.7.7a	*Corymbia capricornia* low open woodland on silcrete
1.11.3a	*Eucalyptus leucophylla* low open woodland often with *Corymbia terminalis*, *C. aparrerinja* and *E. leucophloia*
1.3.13a	*Eucalyptus leucophylla* and/or *Corymbia* terminalis woodland on levees and minor drainage lines

The approved PRCP rehabilitation objective for vegetation is to achieve a ground cover 70%. Three vegetation scenarios were used in the WEPP model: no vegetation (0 %) (worst case), 30%, and 70 %. Static vegetation cover was adopted for all scenarios (i.e., vegetation does not grow or die off over the course of the simulation), aligning with the performance criteria. Noting that static vegetation cover may not represent site conditions (e.g., seasonal dieback and extended wet or dry seasons).

It is highlighted that plant parameters are influenced by a wide range of factors including climate conditions, plant species and conditions. No plant specific inputs for the particular species listed in **Table 2** were available, and as such, values were adopted based on similar project experience

3.6 Model Limitations

The following limitations are noted:

- The WEPP model results are based on static (no change in vegetation cover over time), or no vegetation cover as stated in the modelling assumptions. No allowance has been made for seasonal dieback and increased soil loss rates as a result of rainfall after a dry period with reduced vegetation density.
- The WEPP model results are based on a simplified cross section geometry (e.g. 500 m slope at 1.5 %). Localised erosion rates are likely to occur which exceed the average annual soil loss rates presented, which represent the annual average soil loss rates for the entire slope length.
- Some material parameters used are not based on site specific data, as described in Section 3.4. Variation to soil properties would impact the WEPP model outcomes (percentages of clay, sand and rock, organic matter and cation exchange capacity).

3.7 Results and Discussion

The primary output from WEPP is the estimated soil loss rate expressed in tonnes per hectare per year (t/ha/yr). The objective is to achieve an average soil loss rate of less than 5 t/ha/yr. The average annual soil loss rates predicted by the WEPP model are summarised in **TABLE 3**.

Results indicated that for the TSF beach slope, with 70% vegetation cover, the soil loss rates were 1.11 t/ha/yr, which is less than a quarter of the target soil loss rate. At 30% cover, the soil loss rates were 3.89 t/ha/yr, which still achieves the target loss rate. At the worst case scenario of 0% cover, the soil loss rates were 12.7 t/ha/yr, which does not achieve the target soil loss rate.

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Results indicate while acceptable erosion rates can be achieved with proposed final landform, vegetation will be critical to successful rehabilitation

TABLE 3: TSF BEACH SLOPE AVERAGE ANNUAL SOIL LOSS

70 % Vegetation Cover	30 % Vegetation Cover	0 % No Vegetation Cover
1.11	3.89	12.70

4 TSF EMBANKMENT

As outlined in **Section 2.1**, rehabilitation of the embankment will comprise flattening the batter from 1.5H:1V to 6.5H:1V, undertaken by pushing excess fill material from the crest of the embankment to fill the downstream toe of the embankment. **Table 4** summarises the specification for embankment zone 3B fill for the Stage 1 embankment fill.

TABLE 4: ZONE 3B – ACCEPTABLE RANGE OF PARTICLE SIZE DISTRIBUTION (FROM TABLE 8.5 IN [11])

Particle Size (mm)	Zone 3B
800	100
400	100 – 55
150	55 – 10
100	–
26.5	45 – 0
19.0	35 – 0
4.75	15 – 0
0.075	10 – 0

A hydraulic assessment has been undertaken by ATCW **[10]**, which indicates flow velocity on the embankment would range from 1.5m/s at the crest to 2.1m/s at the toe of the embankment. Recommended D50 rock sizing for this range of flow velocities range from 150mm to 300mm. These particle sizes are generally in accordance with the upper and lower bounds of the zone 3B material specification. Notwithstanding, careful consideration during earthworks would be required to preferentially place the larger particles towards the base of the embankment, where flow velocities are higher.

It is highlighted that the ATCW study was primarily focused on the TSF beach and is considered conservative with respect to flow velocities on the embankment. A relatively low manning's value for the embankment surface (0.035) was adopted considering the surface would comprise rockfill with D50 ranging from 150mm to 300mm.

5 WATER MANAGEMENT

Erosion modelling indicated very low erosion rates on the TSF. Notwithstanding, the external catchment to the TSF has multiple, natural gullys reporting to the TSF. Natural gullys would introduce concentrated flows to the rehabilitated tailings surface, likely to cause localised erosion and scour. To reduce the risk of erosion and scour, a network of surface channels is proposed to convey flows from the upstream catchments to the discharge outlet structure.

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The proposed conceptual general arrangement for the final drainage of the TSF is shown in **Diagram 5**. The drainage channels shown are conceptual only, intended to allow for the capture of runoff from upstream external catchment sources, rather than incidental rainfall on the TSF itself. The TSF closure surface was modelled to incorporate the shedding surface to convey runoff from the upstream connected catchments towards the repurposed Stage 2 emergency spillway **[10].** As part of detailed design, the surface will be modelled with the conceptual drainage channels to ensure there is no ponding on the TSF surface post closure to reduce the potential for seepage in channels with low to no longitudinal grade.

The channel dimensions are to maintain low velocity by maximising channel width (compared to depth). The channel is to be rock lined with a geotextile underlay, as shown in **Diagram 6**. The drains will be designed to convey peak flows to a suitable design event.

DIAGRAM 5: CONCEPTUAL SURFACE WATER DRAINAGE

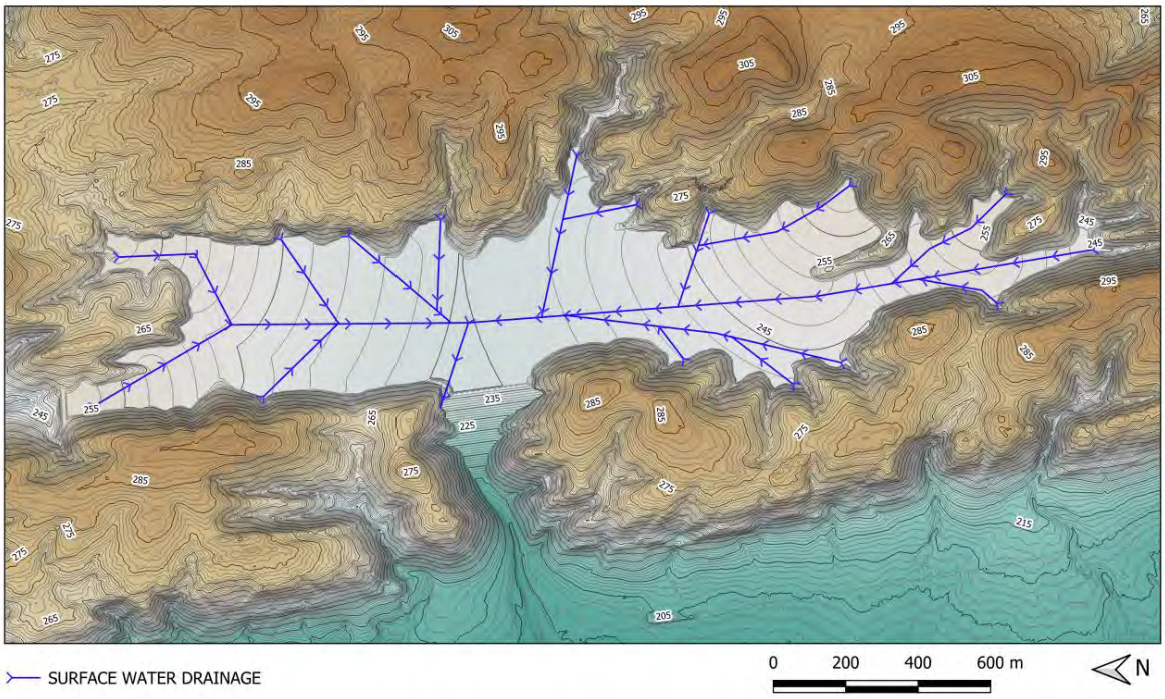
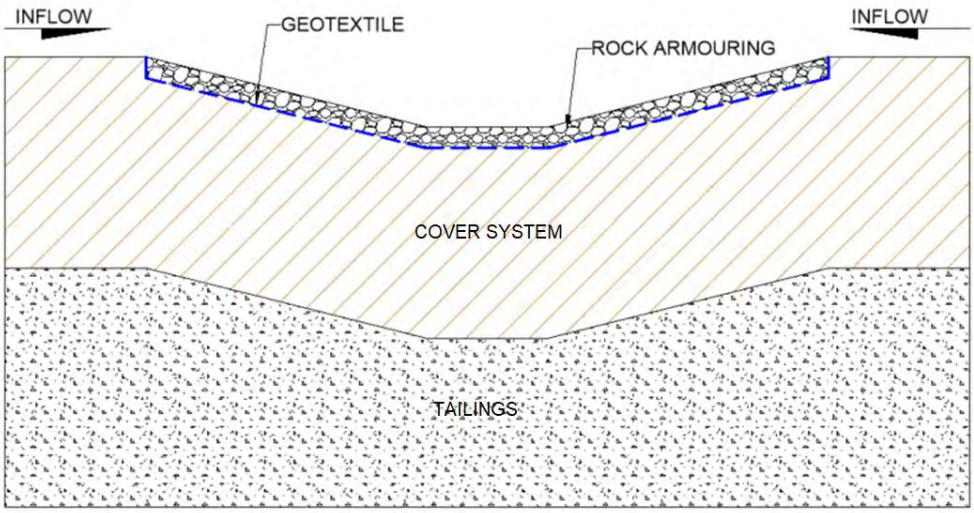


DIAGRAM 6: DRAIN CONCEPT SECTION



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6 CONCLUSION

The WEPP erosion modelling conducted as part of the conceptual closure design for the Tailings Storage Facility (TSF) provides important insights into the long-term stability and sustainability of the final landform. WEPP modelling was conducted for the rehabilitated tailings surface.

The key findings from the WEPP modelling include:

- A 50-year model duration was adopted, which captures high and low rainfall periods and allows sufficient time for initial erosional features to develop.
- The modelling was based on a conservative flow path length of 500 m at a 1.5% slope, recognizing that WEPP tends to overestimate erosion for slope lengths greater than 100 m.
- WEPP modelling indicates that the conceptual closure design can achieve long-term stability, with average annual soil loss rates estimated to be within acceptable limits.
- Identified limitations highlight the need for further detailed design and site-specific data collection to refine the erosion assessment and closure plan.
- Ongoing monitoring and adaptive management will also be critical to ensure the long-term sustainability of the final TSF landform.

Embankment erosion was assessed using flood study results undertaken by ATCW, as discussed in Section 4. This assessment was focused on the embankment surface, which will comprise coarse rockfill that is resistant to erosion. The flood study results were considered conservative with respect to flow velocities on the embankment and resulted in a recommended rockfill surface with a D50 ranging from 150-300 mm.

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APPENDIX N: PAF Pad Expansion – Stage 4 Design Report (ATCW, 2025d)

REPORT

MMG DUGALD RIVER
ABN: 19 083 405 556

Dugald River Mine
PAF Pad Expansion

Stage 4 Design Report

240261.04-R01 REV 0
December 2025

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CONTENTS

1 INTRODUCTION 1

1.1 Overview 1
1.2 Scope of Works 1
1.3 Exclusions 2
1.4 Definitions and Abbreviations 2

2 REGULATORY REQUIREMENTS 3

2.1 Dams 3
2.2 PAF Pads 4

3 BASIS OF DESIGN 4

3.1 Conceptual Design and Staging 4
3.2 PAF Pad Requirements 4
3.3 Design Considerations 5
3.4 Geotechnical Investigation 5
3.4.1 Investigation Scope 5
3.4.2 Findings and Design Implications 5

4 EXISTING PROCESS AREA STRUCTURES 6

4.1 Stage 1 PAF Pad 6
4.2 Stage 1 PAF Dam 6
4.2.1 Overview 6
4.2.2 Storage & CCA Assessment 6
4.3 Stage 2 PAF Pad 6
4.4 Stage 2 PAF Dam 7
4.4.1 Overview 7
4.4.2 Storage & CCA Assessment 7
4.5 Stage 3 8
4.5.1 Overview 8
4.5.2 Stage 3 PAF Pad 8
4.6 Water Management 8
4.6.1 Overview 8
4.6.2 PAF PAD Perimeter Drainage 8

5 PAF PAD STAGE 4 DESIGN 9

5.1 Overview 9
5.2 Stage 4 Options 9
5.2.1 Overview 9
5.2.2 Stage 4 Design Options 9
5.2.3 Selected Stage 4 Design 10
5.3 Stage 4 PAF Pad 10
5.4 Stage 4 PAF Perimeter Drainage System 11
5.4.1 Design Approach 11
5.4.2 Stage 4 PAF Perimeter Drain 11
5.4.3 Existing Perimeter Drain Modification 12
5.4.4 Perimeter Drain Rock Armouring 12
5.5 Stage 1 Pad Encapsulation 13
5.6 Stage 4 PAF Pad Stability 13
5.7 Inlet Channels 14
5.8 Hydraulic Modelling 14
5.8.1 Overview 14
5.8.2 Model Development 14
5.8.3 Results 15

TAILINGS.WATER.WASTE.

5.8.3.1 Critical Storm Events *15*
5.8.3.2 Flood Extent *16*
5.8.3.3 Flow Velocity for Riprap Design *16*
5.8.3.4 Water Levels *17*
5.8.3.5 Flow Hydrographs *20*
5.9 Stage 4 Construction Materials 21
5.9.1 Type 2 Capping Layer (Cohesive Earthfill) *21*
5.9.2 Type 2 Material Source *21*
5.9.3 PAF Rockfill *21*
5.9.4 NAF Rockfill *22*
5.9.5 Crushed NAF Rockfill *22*
5.9.6 NAF Rock Armour *22*
5.9.7 Geofabric *22*
5.10 Stage 4 Construction 23
5.10.1 Overview *23*
5.10.2 Foundation Preparation *23*
5.10.2.1 Type A – Natural Surface Foundation Preparation *23*
5.10.2.2 Type B – Existing Surface Foundation Preparation *23*
5.10.3 PAF Rockfill Placement *23*
5.10.4 NAF Rockfill Placement *24*
5.10.5 Type 2 - Capping Layer Placement *24*
5.10.6 Stage 4 PAF Perimeter Drains and Modifications *24*
5.10.7 Clean Water Drainage *25*
5.10.8 PAF Dam 1 Removal *25*
5.11 Stage 4 Water Balance Modelling 25

6 CLOSURE 26

REFERENCES 27

TABLES

TABLE 1: DEFINITIONS AND ABBREVIATIONS 3
TABLE 2: STAGE 2 PAF DAM CONFIGURATION [16] 7
TABLE 3: SUMMARY OF STAGE 4 DESIGN OPTIONS 10
TABLE 4: ADOPTED STRENGTH PARAMETERS 13
TABLE 5: HYDRAULIC MODEL INPUT SUMMARY 14
TABLE 6: TYPE 2 MATERIALS CHARACTERISTICS SUMMARY 21
TABLE 7: ROCK ARMOUR SIZE REQUIREMENTS 22

FIGURES

FIGURE 1: PROCESS PLANT AREA STRUCTURES 2
FIGURE 2: PAF PAD 1 - OPTION 1B ENCAPSULATION DETAIL 10
FIGURE 3: MODELLED STORAGE WATER LEVEL – STAGE 4 PAF DAM 2 26

TAILINGS.WATER.WASTE.

DIAGRAMS

DIAGRAM 1: WEST PERIMETER DRAIN FLOOD LEVELS LONG SECTION 18
DIAGRAM 2: EAST PERIMETER DRAIN FLOOD LEVELS LONG SECTION 19
DIAGRAM 3: EXTRACTED CHANNEL HYDROGRAPHS 20

APPENDICES

APPENDIX A: STAGE 4 PAF PAD EXPANSION DESIGN DRAWINGS (IFR)
APPENDIX B: STAGE 4 PAF PAD STABILITY ASSESSMENT
APPENDIX C: STAGE 4 PAF PAD HYDRAULIC MODEL FIGURES

TAILINGS.WATER.WASTE.

1 INTRODUCTION

1.1 Overview

MMG Australia Pty Ltd (MMG) operates the Dugald River Mine (DRM), located 65 km northwest of Cloncurry, Queensland. The mine predominantly produces zinc concentrate, extracted via underground mining and processed on-site.

As part of its mining operations, DRM manages Potentially Acid Forming (PAF) and Non-Acid Forming (NAF) waste rock materials, which are stored within designated Waste Rock Dumps (WRD) and dedicated PAF and NAF Waste Rock Pads. To facilitate appropriate containment of these materials and manage associated runoff, the existing infrastructure includes the Stage 1 and Stage 2 PAF Pads and their respective lined runoff dams.

The need for additional waste storage capacity led to the planned expansion of the PAF Pads, forming the Stage 3 and Stage 4 PAF Pad developments. The expansion strategy, as outlined in the PAF Pad Expansion Conceptual Options Study **[1]**, adopted a phased approach:

- Stage 3 involved combining the existing Stage 1 and Stage 2 PAF Pads into a single, larger pad while retaining PAF Dams 1 and 2 with modifications to the external perimeter water drainage system to accommodate design peak flows.
- Stage 4 extends the PAF Pad footprint further by incorporating the PAF Dam 1 area, necessitating its decommissioning and conversion into a raised, clay-lined NAF rockfill pad designed to divert runoff into PAF Dam 2.

These staged developments align with the DRM Environmental Authority (EA) EPML00731213 requirements **[1]**, ensuring that all PAF materials remain temporarily stored within the expanded PAF Pad footprint and are ultimately returned to mining voids at the end of mine life.

Runoff from the expanded PAF Pad system will continue to be directed into PAF Dam 2, with design refinements ensuring compliance with regulatory performance standards. The Stage 2 PAF Pad Runoff Dam remains a Regulated Structure under the EA, requiring adherence to operational and reporting obligations.

At the time of writing this report, the design for the Stage 3 PAF Pad expansion had been completed, however, construction was still in the planning phase and had not yet commenced.

Figure 1 provides an overview of the DRM Process Plant area, existing PAF and NAF WRD.

1.2 Scope of Works

In anticipation of PAF Pad capacity exhaustion, DRM engaged ATC Williams Pty Ltd (ATCW) to undertake a conceptual options assessment for expanding the existing PAF Pads. A conceptual options study **[1]** was submitted to DRM on 22nd July 2024. Following this, ATCW provided a Stage 3 and 4 detailed design Budget Proposal **[2]** 240261-P01 Rev A, dated 4th October 2024.

The Stage 3 detailed design works have been completed and are documented in the Stage 3 PAF Pad Design Report by ATCW **[3]**. The scope of work detailed in this report is confined to the Stage 4 PAF Pad expansion and includes the following:

- Design of Stage 4 PAF PAD.
- Design of perimeter drainage infrastructure for effective management of surface water runoff.
- Geotechnical design works and assessments, including subgrade preparation, placement of NAF rockfill, installation of a low-permeability capping layer to minimise infiltration and stability assessment for the loads presented by the ultimate PAF PAD height.

TAILINGS.WATER.WASTE.

- Water balance assessment and hydraulic modelling to evaluate storage capacity and spill risk mitigation within PAF Dam 2.
- Compliance with regulatory requirements, ensuring all design modifications align with the Dugald River Mine EA and relevant dam safety standards.
- Provision of Issued-for-Construction (IFC) Drawings, construction Technical Specifications.

FIGURE 1: PROCESS PLANT AREA STRUCTURES

1.3 Exclusions

As outlined in the ATCW Budget Proposal exclusions and per discussions with MMG representative **[2],** the following items are not covered in this Stage 4 design report:

- PAF PAD access roads and drain culvert design works.
- PAF PAD southern road raise works.
- PAF PAD Southern haul road water diversion.
- PAF WRD development and emplacement works.
- PAF Dam 1 decommissioning specifications.
- Geochemical and groundwater assessments relating to PAF emplacement.

1.4 Definitions and Abbreviations

Table 1 lists definitions and meanings of words and abbreviations used within this report.

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TABLE 1: DEFINITIONS AND ABBREVIATIONS

Abbreviations	Definitions
AEP	Annual Exceedance Probability, the probability that a given rainfall event will be exceeded in a particular year.
ANCOLD	Australian National Committee on Large Dams.
ATCW	ATC Williams Pty Ltd
CCA	The consequence category defined for a dam (using the ANCOLD guideline methodologies) that reflects the consequences of failure with respect to human life or the environment.
DEM	Digital Elevation Model
DRM	Dugald River Mine
DSA	Design Storage Allowance
DETSI	Queensland Department of Environment, Tourism, Science and Innovation
EA	Means environmental authority under the Environmental Protection Act 1994.
EoR	Engineer of Record
GI	Geotechnical Investigation
HPC	Heavily Parallelised Compute
MMG	MMG Australia Pty Ltd
MRL	Mandatory Reporting Level
Regulated Structure	Regulated Structure means any structure in the significant or high consequence category as assessed using the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933) published by the administering authority.
RL	Reduced Level, meaning the height (in metres) above sea level.
RoG	Rain-on-Grid
SMDD	Standard Maximum Dry Density
TSF	Tailings Storage Facility.
PAF	Potentially Acid Forming waste rock
NAF	Non-Acid Forming waste rock
WRD	Waste Rock Dump

2 REGULATORY REQUIREMENTS

2.1 Dams

Tailings and Mine Water Dams at Dugald River Mine are subject to Statutory Dam Safety Requirements and must adhere to Queensland's Department of Environment, Tourism, Science and Innovation (DETSI) regulations. The Engineer of Record (EoR) and the Dam Owner hold responsibility for ensuring compliance with these regulatory frameworks throughout the design, construction, operation, and closure phases.

Dams and Tailings Storage Facilities (TSFs) at the Dugald River Mine may be classified as Regulated Structures under the Environmental Authority (EA) EPML00731213 **[4]**. This designation requires a Consequence Category Assessment (CCA) conducted in accordance with the Manual for Assessing Consequence Categories and Hydraulic Performance of Structures.

According to the Dugald River Mine EA EPML00731213 **[4]**:

- The Stage 2 PAF Dam is designated as a Regulated Structure and must comply with all DETSI operational and management requirements.
- Other water management structures are assessed for hydraulic performance and spill risk mitigation.

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2.2 PAF Pads

Schedule H – Mineral Waste of the DRM EA EPML00731213 **[4]** provides requirements for the management of waste rock material on approved MMG DRM locations. Some of the key Schedule H clauses relevant to the PAF Pads are provided below:

- Clause H3: All potentially acid forming (PAF) waste material is to be returned to the North or South Decline at the end of mine life and must not cause environmental harm.
- Clause H8: The waste rock dumps must be designed, constructed and operated to minimise the infiltration of incidental rainfall into the waste rock dump.
- Clause H9: Any seepage from the waste rock dump must be captured and directed to an appropriately engineered and maintained storage authorised to receive seepage in accordance with Schedule D – Regulated Structures of the EA.

NAF/PAF Waste Rock Pads and other surface stockpiles at Dugald River Mine are managed per the requirements of the DRM EA and DRM Design, Construction and Management of Surface Stockpiles requirements **[5].** DRM produced document provides specific guidance on the design, material placement, compaction, and long-term stability of waste rock storage facilities to facilitate compliance with environmental and operational best practices.

3 BASIS OF DESIGN

3.1 Conceptual Design and Staging

The conceptual design for the Stage 4 PAF Pad Expansion was developed through a phased evaluation process, ensuring optimal storage capacity, environmental compliance, and integration with existing infrastructure. The key stages are outlined as follows:

1. Initial Options Review – A range of layout configurations were assessed during the Conceptual Design phase, considering storage efficiency, operational access, and water management requirements.
2. Preferred Design Selection – The Stage 4 expansion was selected to integrate the existing PAF Pad into a single, continuous facility, improving waste placement efficiency.
3. Staged Construction Approach:

- Stage 1 (Existing Infrastructure): Incorporates the current PAF Pads and associated runoff dams.
- Stage 2 (Existing Expansion): Expanded Pad 2 to provide additional storage capacity and upgraded drainage infrastructure.
- Stage 3 (Planned Expansion): Merged Pad 1 and Pad 2 into a consolidated storage facility, optimising material placement and further improving surface water management.
- Stage 4 (Current Expansion): Decommissioning of PAF Dam 1, with subsequent development of the area into an expanded pad that will integrate with previous stages, ensuring seamless operational continuity.

This multistage approach enables a progressive expansion strategy that aligns with operational demands while ensuring regulatory compliance.

3.2 PAF Pad Requirements

The Stage 4 PAF Pad Expansion is designed to provide safe and environmentally compliant storage for PAF waste materials generated during mining operations. The facility must:

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- Prevent contamination of surface water and groundwater through engineered drainage system and seepage control measures.
- Allow for efficient material handling to support ongoing mining activities (achieved via the MMG DRM stockpile management requirements **[5]**).
- Integrate with existing and planned (Stage 3) PAF Pads while providing additional PAF storage capacity.

The Stage 4 PAF PAD design incorporates a low-permeability capping layer, a perimeter drainage system, and a designated water collection system (Dam 2) to manage surface runoff.

3.3 Design Considerations

The design of the Stage 4 PAF Pad Expansion has been developed based on regulatory compliance, operational requirements, and geotechnical considerations. Key factors influencing the design include:

- Environmental Authority (EPML00731213) Compliance – The Stage 4 expansion must meet all regulatory obligations for PAF material management and storage as discussed in **Section 2.2**.
- Geotechnical considerations – The Stage 4 Pad and proposed new drainage channels will require raising and excavation of the existing surface levels to divert water into the approved PAF Dam 2. As such, geotechnical design considerations will include, but are not limited to, foundation preparation and the placement of suitable NAF rockfill and a low-permeability capping layer to minimise seepage. The results of the recent ATCW geotechnical investigation, detailing the identified suitable materials, are briefly discussed in **Section 3.4**.
- Water Management – All surface runoff or basal seepage water from the WRD must be captured via the perimeter drainage channels and ultimately directed to authorised PAF Dam 2 via inlet channel.

3.4 Geotechnical Investigation

A comprehensive Geotechnical Investigation (GI) was conducted **[6]** to support the Stage 3 and 4 PAF Pad Expansion, including assessment of borrow material suitability and subsurface conditions. The investigation comprised test pitting and laboratory analysis to determine the geotechnical properties of materials required for construction.

3.4.1 Investigation Scope

- Subsurface Conditions – 22 test pits were excavated across the proposed PAF Pad footprint and borrow areas to assess foundation conditions, soil strength, permeability, and material stratigraphy.
- Material Suitability – Laboratory tests, including particle size distribution, Atterberg limits, and permeability tests, were conducted to confirm the suitability of NAF rockfill and low-permeability capping layer (Type 2 material) for PAF Pad construction.

3.4.2 Findings and Design Implications

- Foundation Conditions: The subsurface profile predominantly consists of stiff clay and dense gravel, with refusal depths ranging from 0.1 m to 3.8 m. To facilitate a stable base for pad construction, foundation preparation will involve the removal of topsoil, vegetation, wet material, and any identified loose or unsuitable materials. The prepared surface will then be proof rolled to confirm competency before placement of engineered fill.

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- Borrow Area Suitability: The investigation confirmed that Sandy Clay (red brown) from the borrow pits met the permeability and compaction requirements for Type 2 material, with a target saturated permeability of $1x10^{-9}$ m/s.
- Seepage Control: Laboratory permeability tests validated that compacted clay sourced from the borrow areas meets the low permeability criteria, ensuring effective containment of PAF runoff.

The GI confirmed that the borrow materials, and drainage measures proposed for Stage 4 PAF Pad expansion meet design and operational requirements. The findings have been incorporated into the Stage 4 detailed design for environmental compliance and long-term performance of the PAF WRD.

4 EXISTING PROCESS AREA STRUCTURES

4.1 Stage 1 PAF Pad

The Stage 1 PAF Pad is located immediately south of the Stage 1 PAF Dam, as shown in **Figure 1,** to provide controlled storage for PAF waste. The pad base consists of a 1 m thick compacted NAF rockfill layer, overlain by a 0.5 m thick compacted low-permeability Type 2 capping material, over which PAF waste rock is placed.

To manage surface runoff and infiltration, perimeter drains collect water and direct it into Stage 1 PAF Dam via two concrete inlets positioned at the eastern and western ends of the dam's southern embankment. An earth bund was constructed around the pad perimeter to contain runoff and prevent uncontrolled discharge **[7]**.

The Stage 1 Pad perimeter featured v-notch drains, typically 250 mm deep and 1,500 mm wide. These drains were lined with a 150 mm thick layer of low permeability clay material, with a maximum design permeability of 1×10^{-9} m/s.

4.2 Stage 1 PAF Dam

4.2.1 Overview

The Stage 1 PAF Dam (previously known as Pond B) was designed by Jacobs Engineering Group and constructed in 2012 to manage runoff from Stage 1 PAF Pad **[7]**. The dam features four perimeter embankments with internal batter slopes of 1V:2.5H, constructed using zoned, compacted earth fill (Zone 1 & Zone 3) and an HDPE geomembrane liner to contain runoff and infiltration water **[7]**.

A 12.8 m wide, 0.5 m deep spillway at 209.5 m RL in the northwest corner facilitates controlled discharge through a rock-lined channel leading to an existing diversion drain **[7]**.

4.2.2 Storage & CCA Assessment

The Stage 1 PAF Dam was initially classified as a High Hazard facility by the Department of Environment and Resource Management (DERM) (now DETSI). However, following a 2014 reassessment, it was reclassified as a Low Consequence Category facility **[8]**.

4.3 Stage 2 PAF Pad

The Stage 2 PAF Pad and Dam were designed by Jacobs Engineering Group and constructed by Gradco in 2013 **[9]**. The PAF Pad covers approximately 77,400 m² and is located immediately south of the Stage 2 PAF Dam. Initial earthworks were carried out to establish the required surface levels, with excavation on the western side and additional fill placement on the eastern side **[9]**.

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The pad foundation comprises an approximately 1.5 m thick compacted NAF rockfill layer, overlain by a 0.5 m thick compacted low-permeability Type 2 capping material, consistent with the Stage 1 PAF Pad design. An earth bund was constructed along the perimeter to restrict runoff, while all surface water and infiltration was directed into the Stage 2 PAF Dam through a concrete inlet channel located at the northern end **[9]**.

The Stage 2 Pad perimeter drain consists of v-notch and trapezoidal drains with varying dimensions. The v-notch drains are 300 mm deep and 1.5 m wide, while the trapezoidal drains are 500 mm deep, with top widths ranging from 3 to 4.5 m and base widths from 0.5 to 1.0 m. As with Stage 1 drains, the perimeter water drains for Stage 2 are designed to be relatively impervious with a 150 mm thick liner of low permeability clay material.

4.4 Stage 2 PAF Dam

4.4.1 Overview

The Stage 2 PAF Dam, constructed in 2013, is irregularly shaped, consisting of six embankments and cut faces. The embankments, located on the eastern half, feature internal slopes of 1V:2.5H and external slopes of 1V:3H, while the western section is excavated in situ. The base and side slopes are lined with an HDPE geomembrane underlain by geotextile **[9]**. A double HDPE-lined basin at the dam's low point has a 4 ML storage capacity. A collection system with slotted pipes directs seepage to a well at the dam's downstream toe **[9]**.

Flood management is controlled via a 38 m wide, 0.75 m deep emergency spillway at RL 209.75 m. with an outlet chute that discharges downstream via a rock-lined channel **[9]**. **Table** 2 provides a summary of Stage 2 PAF Dam configuration.

TABLE 2: STAGE 2 PAF DAM CONFIGURATION [16]

Description	Specifications
Type	HDPE lined
Construction Material	Formed in excavation, with rockfill embankments
Dam Crest Level	210.5 m AHD
Spillway Crest (full supply) level	209.75 m AHD
Spillway Base Width	38 m
Minimum spillway Side Slope	3(H) to 1(V)
Storage Capacity to Spillway	205 ML
Storage Area	8.0 Ha

4.4.2 Storage & CCA Assessment

The Stage 2 PAF Dam is classified as a Significant Consequence Category facility due to its Failure to Contain - Dam Break risk. The 2023 reassessment confirmed this classification under the EA EPML00731213, requiring compliance with regulated spillway capacity, management, and reporting obligations. However, the risk of Failure to Contain - Overtopping was assessed as Low, removing the requirement for Dam Storage Allowance (DSA) and Mandatory Reporting Level (MRL) maintenance.

The conceptual design assessment **[1]** considered options for integrating the existing PAF Pads while retaining PAF Dam 2 for runoff management. PAF Dam 2 Storage Capacity assessment works were completed as part of the conceptual design stage where it was concluded that the facility can accommodate additional Stage 4 flows with no changes to its CCA **[1]**. The Stage 4 PAD Dam 2 storage capacity is discussed in detail in the ATCW PAF PAD conceptual design report **[1]**.

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4.5 Stage 3

4.5.1 Overview

The Stage 3 PAF Pad combines the existing Stage 1 and Stage 2 PAF Pads to support ongoing PAF emplacement and progressive development of the DRM PAF Pad to its ultimate footprint, as outlined in the conceptual design **[1]**. The area between the current Stage 1 and 2 Pads primarily consists of open ground and drainage infrastructure capturing clean runoff from surrounding areas.

As part of the Stage 3 expansion, approximately 10,000 m² of additional surface area is planned to be incorporated into the PAF Pad. At the time of reporting, construction works for Stage 3 had not yet commenced

4.5.2 Stage 3 PAF Pad

The Stage 3 Pad is located between the existing Stage 1 and Stage 2 PAF Pads. Surface runoff from the Stage 3 expansion will report to Dam 1, while seepage water will be directed to both Dam 1 and 2 **[3]**. A storage capacity assessment for PAF Dams was completed during the conceptual design phase, which concluded that both PAF Dams can accommodate the additional Stage 3 flows without requiring any changes to the CCA. Details of the Stage 3 PAF Dam storage capacity are provided in the ATCW PAF Pad Conceptual Design Report **[1]**.

The Stage 3 Pad foundation comprises approximately 1.5 m of compacted NAF rockfill, overlain by 300 mm of crushed NAF rockfill and a 0.5 m thick compacted low-permeability Type 2 capping material. As part of the Stage 3 expansion, the existing perimeter drains for the Stage 1 and Stage 2 PAF Pads were assessed and where necessary were modified to accommodate flows from the 1% Annual Exceedance Probability (AEP) design event **[3]**.

The Stage 3 Pad perimeter drains are trapezoidal in shape, with varying depths and dimensions, and a varying base width. The main southern and eastern perimeter drain consist of 3 m wide invert to allow for drain maintenance and pad access. Existing drain modifications for Stage 1 & 2 drain as part of Stage 3 expansion consist of 1.5 m wide invert base. As with the earlier stages, the Stage 3 drains are lined with 500 mm of Type 2 material to minimise infiltration **[3]**.

4.6 Water Management

4.6.1 Overview

Water management at the DRM PAF Pad area consists of clean water and PAF runoff systems. Clean water channels exist around the PAF Pads and Dams to capture and divert clean water while the PAF runoff drainage systems are purely associated with the catchment of runoff and seepage water from the engineered PAF PADs.

As part of the Stage 4 expansion works, a section of the clean water diversion drain (western side of the existing PAF Dam 1) will be closed off to construct Stage 4 PAF Pad.

Appendix A – Drawing 240261.03-001 illustrates the existing clean water diversion channels and PAF runoff drainage system.

4.6.2 PAF PAD Perimeter Drainage

PAF WRD surface runoff and basal seepage must be managed and contained within authorised dams per the DRM EA requirement. PAF Pad perimeter drains direct all captured runoff water into existing PAF Dam 1 & 2.

As part of the Stage 4 expansion, PAF Dam 1 will be decommissioned, and new perimeter drains will be installed to the north and northeast of the Stage 4 PAF Pad while also requiring minor modifications of the existing drains to accommodate peak design flows. The design of the Stage 4 PAF perimeter drains and required modifications are discussed further in **Section 5.4** of this report.

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5 PAF PAD STAGE 4 DESIGN

5.1 Overview

As discussed in **Section 1**, PAF Pad expansion is planned to be carried out in two progressive stages, Stage 3 and Stage 4. Following Stage 3 construction works execution, Stage 4 PAF Pad expansion works will involve the following:

- PAF Dam 1 Removal.
- Stage 1 PAF Pad encapsulation works to allow water to be directed towards Dam 2.
- Required earthworks involving construction of Stage 4 PAF Pad and perimeter drain.

The following sections further discuss the Stage 4 PAF Pad expansion design and construction details.

5.2 Stage 4 Options

5.2.1 Overview

The Stage 4 PAF Pad expansion was initially presented in the conceptual design report **[1]**. These early designs were preliminary and did not include detailed development of the perimeter drains or PAF Pad levels.

Following commencement of Stage 4 works, it was identified that raising the Stage 4 Pad and constructing perimeter drains to the conceptual design levels would create a low point in the existing Pad 1 area, due to its as-built levels within the ultimate PAF Pad footprint. This would result in water pooling, with no provisions for water removal.

As Pad 1 was not designed to permanently retain water (only to direct runoff toward the respective PAF Dams), this issue was raised with MMG stakeholders. A meeting was held on 22nd August 2025 to present and discuss three potential design solutions. MMG stakeholders were asked to select one option to proceed with for finalising the Stage 4 PAF Pad design. The proposed and selected options are briefly discussed in the following sections.

5.2.2 Stage 4 Design Options

The following three options (Option 1A, 1B, and 2) were proposed by ATCW to MMG for consideration and selection. Options 1A and 1B were relatively similar, both involving encapsulation of the existing Pad 1 PAF waste rock.

- Option 1A proposed the use of geosynthetics in lieu of clay, due to a known shortage of suitable material onsite.
- Option 1B proposed encapsulation of Pad 1 using locally sourced clay material. Required additional borrow sources to be explored by MMG to locate suitable materials.
- Option 2 proposed the installation of a collection sump with active pumping to remove ponded water in the Pad 1 vicinity. This was deemed unsuitable due to its active nature, requiring ongoing operation, maintenance, and associated costs.

Table 3 provides a summary of the advantages and disadvantages considered of each option presented.

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TABLE 3: SUMMARY OF STAGE 4 DESIGN OPTIONS

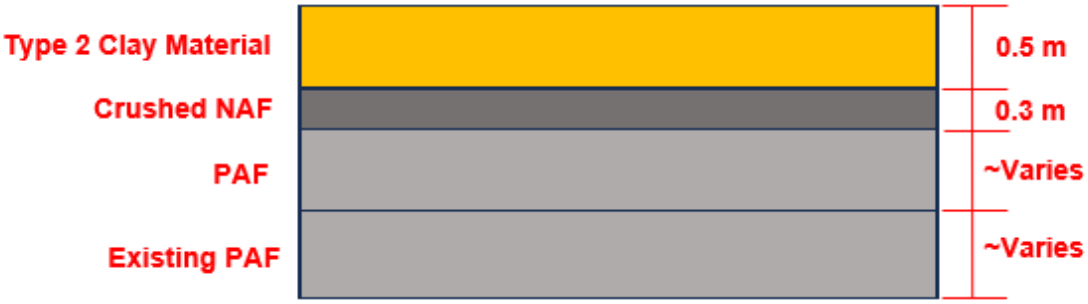
Option	Advantages	Disadvantages
1A- Encapsulating Pad 1 (Geomembrane)	Better permeability control No more GI to identify suitable clay materials	Slightly higher construction cost (though permeability better)
1B- Encapsulating Pad 1 (Clay Liner) - SELECTED	Potentially lower cost (if suitable materials are available)	Shortage of suitable clay materials onsite More GI to identify suitable materials
2 - Pumped Operations	No need for Pad raise	Requires ongoing inspection and maintenance Needs diesel/power for pumps Restricts current ultimate dump design

5.2.3 Selected Stage 4 Design

Option 1B - Encapsulating Pad 1 (Clay Liner) was selected by MMG to progress the Stage 4 PAF Pad design. Concerns regarding the availability of suitable clay material were addressed, as only one of the three identified clay borrow sources had been explored during the 2024 GI **[6]**. It was noted that MMG will explore the other two potential borrow sources to locate suitable low permeability materials per Stage 3 and 4 PAF Pad expansion technical specification requirements.

A schematic detailing the encapsulation design for Option 1A (the selected option) is presented in the following section.

FIGURE 2: PAF PAD 1 - OPTION 1B ENCAPSULATION DETAIL



5.3 Stage 4 PAF Pad

The Stage 4 PAF Pad expansion comprises an open area that has hosted PAF Dam 1 and drains to capture clean water run-off from around the PAF Pads. The Stage 4 PAF Pad expansion will be undertaken by removing PAF Dam 1, raising the existing surface level and constructing a 500 mm thick Type 2 material capping layer of compacted low permeability earth fill.

The rock lined Stage 3 Pad northern drain alignment falls from west to east into PAF Dam 1, this drain will also be filled and raised to prevent water ponding in this region. In addition, the existing PAF within Pad 1 will be encapsulated to create a compacted low permeability earthfill surface that promotes runoff towards Pad Dam 2 and perimeter drains.

The capping layer will be extended onto the existing (Stage 1 and 2 Pads) and planned (Stage 3) capping layers and suitably tied-in to provide a continuous layer. As with Stage 3 **[3]**, Type 2 cohesive earthfill materials (typically red-brown sandy clay) with a maximum permeability of $1x10^{-9}$ m/s shall be used for the Stage 4 PAF Pad expansion. Limited suitable materials have been

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identified south of the NAF WRD as part of ATCW 2024 GI**,** with potential for additional suitable material availability in other MMG-proposed borrow sources. Suitable Type 2 material characteristics and minimum requirements have been discussed further in **Section 5.5**.

The Stage 4 Pad has been profiled so all surface runoff and infiltration water are directed to the Stage 2 PAF Dam via a concrete inlet channel located at the northern end of the Stage 2 PAF Pad. The existing northeastern Stage 2 drains and associated bunds will require removal and filling to prevent localised water ponding and Stage 4 PAF Pad flow restriction. To maintain the integrity of the Stage 3 & 4 Pad low permeability capping layers during PAF placement, an initial lift of 300 mm thick PAF waste rock is proposed to be placed.

During PAF waste rock emplacement, there is a risk of oversize rocks rolling into the PAF perimeter drain. This will reduce the capacity of the drain, hence a minimum 3 m buffer between the PAF Pad perimeter drain and the waste rock toe should be maintained. Ongoing care and maintenance of the drainage channel should be undertaken to identify signs of deficiencies that could lead to violations of regulatory requirements discussed in **Section 2**.

Appendix A – Drawings 240261.04-002 provides an overview of the Stage 4 PAF Pad expansion, while Drawings 240261.04-004, 240261.04-005, and 240261.04-009 present details of the Stage 4 PAF Pad tie-in to the planned and existing PAF Pads.

5.4 Stage 4 PAF Perimeter Drainage System

5.4.1 Design Approach

The planned Stage 3 PAF perimeter drain has been designed to be compatible with the Stage 4 PAF Pad development, minimising the need for rework during Stage 4 expansion.

This study encompasses the development of hydraulic modelling to route the overland flows on a two-dimensional surface across the entire proposed PAF Pad catchment for the detailed design. An iterative process was undertaken during the civil design by adjusting the drainage dimensions and invert levels to ensure the proposed drainage system has enough capacity to accommodate 1% AEP storm event suggested by ARR 2019 **[10]**. Model development and results discussions are detailed in **Section 5.8**.

The extension from Stage 3 PAF perimeter drains to Stage 4 has been designed as clay lined trapezoidal drains, to accommodate the 1% AEP peak flows.

Based on the calculations and verification using the hydraulic model, the Stage 4 typical perimeter drain geometrical detail consist of the following:

- Internal slopes of 3:1 (H:V),
- Invert width of 3 m, and
- Varying drain depth.

Stage 4 PAF perimeter drain design and required modification details are further discussed in the following sections.

5.4.2 Stage 4 PAF Perimeter Drain

As the Stage 3 drainage system was designed to be compatible with the Stage 4 expansion, the new Stage 4 perimeter drains will be constructed and extended around the Stage 4 PAF Pad. Since the existing Stage 3 pad and drains are at a higher level than the existing ground, the surface levels along the Stage 4 perimeter drains will need to be raised accordingly to improve drainage and to direct PAF runoff towards the PAF dam. The new Stage 4 drains will have a fall of approximately 0.27% to direct surface runoff toward PAF Dam 2, forming the final PAF Pad perimeter drainage system. Modifications required to existing perimeter drains are further discussed in **Section 5.4.3**.

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It is proposed that Type 2 cohesive materials adopted for the PAF Pad capping layer works is used within the PAF perimeter drains to create a 500 mm thick impervious layer. Material placement methodologies, testing criteria and acceptability shall be per the requirements described within the Stage 4 PAF Pad expansion Technical Specification.

Due to the placement of rock armour and slight buffer modelled into the Stage 4 perimeter drains, general earthfill bund are not considered to be necessary.

Appendix A – Drawings 240261.04-004, 240261.04-008 and 240261.04-009 provide typical cross-sectional details of the Stage 4 PAF perimeter drainage channels.

5.4.3 Existing Perimeter Drain Modification

As part of the Stage 4 expansion, modifications will be made to the existing Stage 2 Pad perimeter drain (near the inlet) and the Stage 3 PAF perimeter drain. The Stage 2 perimeter drain near the PAF Dam 2 inlet will require resizing to accommodate the design 1% AEP event. The Stage 3 modifications are required due to the Stage 3 design incorporating a chute (featuring an approximate 1 m drop at the eastern inlet of Dam 1) to safely direct water into PAF Dam 1. The existing NAF rock armour at and leading up to the Stage 3 chute will need to be removed, and the entire drain invert will require raising (using Type 2 and NAF fill materials) to provide positive drainage towards PAF Dams 2.

Aside from the minor modifications at the northeastern corner of PAF Pad 1 and near PAF Dam 2 inlet, no further modifications to the existing drains are required beyond those already proposed in the Stage 3 PAF Pad expansion design.

Appendix A – 240261.04-008 and 240261.04-009 provide typical cross-sectional detail of the required modifications to the existing PAF perimeter drainage and Stage 3 planned PAF perimeter drainage channel.

5.4.4 Perimeter Drain Rock Armouring

Hydraulic modelling (**Section 5.8)** of the Stage 4 has indicated high velocities at several of the ultimate PAF Pad perimeter drain sections.

As such to manage concentrated inflows, rock armour installation is required to:

- Dissipate energy from incoming flows,
- Mitigate erosion risks, and
- Control sediment transport to prevent clogging of the downstream system.

Appendix A – Drawing 240261.03-002 provides an overview of the sections requiring rock armouring. Rock armouring is required to be suitably tied into existing clay lined drains to provide a flowing drain profile and to prevent ponding within rock armour layers. The Stage 4 perimeter drain rock armour sizing has been selected based on the modelled flow velocity to facilitate stability under peak flow conditions.

The adopted D50 size of the rock armour for the Stage 4 PAF perimeter drains and associated modifications is 150 mm. The proposed rock armour shall be carefully placed over Bidim A64 geotextile underlay to provide erosion protection. Where Type 2 capping material intersects with the NAF rock armour, the drain invert shall be graded appropriately to ensure it remains free-draining and prevents water ponding. Any low points resulting from NAF rock armour placement shall be regarded as necessary to eliminate localised ponding and maintain positive drainage towards PAF Dam 2.

The calculation method used to determine the D50 size is detailed in **Section 5.8.3.3**.

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5.5 Stage 1 Pad Encapsulation

As noted in **Section 5.2**, to prevent water ponding within Pad 1, the Stage 4 expansion will require encapsulation of the PAF Pad 1 area. This will ensure that infiltrated water is directed towards PAF Dam 2 or the perimeter drains. The encapsulation will be achieved by raising the existing surface level within Pad 1 using PAF waste rock, followed by the placement of a 300 mm crushed NAF rockfill and 500 mm thick Type 2 capping layer consisting of compacted low-permeability earth fill. Approximately 15,000 m³ of PAF material is present within PAF Pad 1, with thickness varying across the pad. In the northern half, the PAF material is approximately 1.5 m thick, while the southern half contains between 0 and 0.5 m. To allow for placement of a 500 mm thick Type 2 layer and a 300 mm thick crushed NAF layer, PAF material from the northern half will need to be pushed into the southern half and compacted prior to placement of the capping layers.

The capping layer will be extended onto the planned Stage 3 and Stage 4 capping layers and suitably tied to the Pad and perimeter drains to provide a continuous layer. As with Stage 3 **[3]**, Type 2 cohesive earth fill materials (typically red-brown sandy clay) with a maximum permeability of $1x10^{-9}$ m/s shall be used for the PAF Pad 1 encapsulation. Limited suitable materials have been identified south of the NAF WRD as part of ATCW 2024 GI**,** with potential for additional suitable material availability in other MMG-proposed borrow sources. Suitable Type 2 material characteristics and minimum requirements have been discussed further in **Section 5.5**.

The Pad 1 encapsulation surface has been profiled so all surface runoff and infiltration water are directed to the Stage 2 PAF Dam or the perimeter drains. Captured water is directed into PAF Dam 2 via a concrete inlet channel located at the northern end of the Stage 2 PAF Pad. To maintain the integrity of the Stage 4 Pad 1 encapsulation low permeability capping layer during PAF placement, an initial lift of 300 mm thick PAF waste rock is proposed to be placed.

During PAF waste rock emplacement, there is a risk of oversize rocks rolling into the PAF perimeter drain. This will reduce the capacity of the drain, hence a minimum 3 m buffer between the PAF Pad perimeter drain and the waste rock toe should be maintained.

Appendix A – Drawings 240261.04-002 provides an overview of the Stage 4 PAF Pad 1 encapsulation.

5.6 Stage 4 PAF Pad Stability

Static stability assessment for the Stage 4 PAF Pad development of the PAF WRD was undertaken to evaluate the overall stability of the Stage 4 PAF Pad under long-term conditions. The material strength parameters were adopted from existing PAF Dam 2 stability assessments **[11]**, geotechnical investigation laboratory results **[6]** and the DRM Design, Construction and Management of Surface Stockpiles requirements **[5]**.

Stability analyses were performed using GeoStudio SLOPE/W software, employing the Morgenstern-Price limit equilibrium method, which satisfies both force and moment equilibrium. The analyses considered the long term design scenario for the selected Stage 4 PAF Pad section with ultimate WRD height.

Adopted strength parameters for each material zone are presented in **Table 4**.

TABLE 4: ADOPTED STRENGTH PARAMETERS

Material	Unit Weight	Tau/Sigma	C'	Angle' (Phi)
Type 3 Colluvium	18		2	32*
Weathered Rock	22		30	30
PAF	20		0	37.5
NAF	22		0	37.5

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Material	Unit Weight	Tau/Sigma	C'	Angle' (Phi)
Type 2 Capping	16	0.3	0	36

**** The Stage 2 PAF Dam stability assessment previously adopted a friction angle of 25° for the existing ground and clay foundation materials. However, for the current assessment, a higher friction angle of 32° has been adopted based on recent GI, which identified the foundation materials to comprise dense gravelly soils rather than cohesive clay.***

Overall, the results indicate that the Stage 4 PAF Pad expansion achieves adequate stability under assessed conditions, with computed FoS within the Stage 4 PAF PAD generally exceeding 1.5. **Appendix B** presents the lowest FoS (1.49) captured within the Stage 4 PAF PAD.

5.7 Inlet Channels

Runoff from the PAF Pad area will discharge directly into PAF Dam 2 via concrete-lined channel. The inlet channel for PAF Dam 2 is a trapezoidal channel, 6 m wide and 0.5 m deep, with a 2% slope based on the survey. The existing drainage capacity is 11.7 m^3/s, which is assessed as sufficient to safely accommodate peak runoff for Stage 4 expansion.

It should be noted that all Stage 4 drain will be required to be properly integrated into the concrete-lined inlet channels to ensure water flows freely without causing any ponding.

5.8 Hydraulic Modelling

5.8.1 Overview

This section details the development of a two-dimensional hydraulic model to simulate overland flow across the proposed PAF Pad catchment. The objective was to ensure the proposed drainage system could effectively accommodate the 1% Annual Exceedance Probability (AEP) storm event, as recommended by ARR 2019 **[10]**. To achieve this, an iterative design process was employed, refining drainage dimensions and invert levels to optimize system capacity.

This section and **Appendix C** summarises the development of the hydraulic model and presents the final 1% AEP flood modelling results for the proposed Stage 4 PAF Pad drainage system.

5.8.2 Model Development

A 1D/2D hydraulic model has been developed using TUFLOW within the study area. Heavily Parallelised Compute (HPC) schemes that significantly reduced model run times have been used to improve model efficiency.

The hydraulic model elements and inputs are summarised in **Table 5**. The setup of the model is illustrated in **Appendix C** – Figure 1, and the model roughness is shown in **Appendix C** – Figure 2.

TABLE 5: HYDRAULIC MODEL INPUT SUMMARY

Element/Input	Description
Hydrological Inputs	A direct rainfall or Rain-on-Grid (RoG) approach was adopted for this project, allowing the rainfall to be applied directly across the 2D model domain without the need for a separate hydrologic model to define inflow boundaries. Design events for 1% Annual Exceedance Probability (AEP) were simulated for the drainage design. The hydraulic model was run for storm durations ranging from 1 to 12 hours, incorporating 10 temporal patterns (full ensemble) to capture critical flood events across the site. The modelled results were then post-processed to identify the most critical events for drainage design.

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Element/Input	Description
	Given that the PAF Pad was constructed using Type 2 cohesive earthfill materials with low permeability, initial and continuous rainfall losses were assumed to be zero. This assumption provides a conservative approach, ensuring the drainage system is adequately sized for extreme conditions.
Overland Flow Paths	Water flowing on the surface across different land materials was modelled as 2D elements defined by topography and roughness. The Digital Elevation Model (DEM) is based on the site survey undertaken in April 2024 that covers the catchment upstream of PAF Pad Dam 1 & 2. A 1 m grid cell size was adopted throughout the model. A 1-meter grid cell size was adopted across the model domain, with Quadtree mesh refinement **[12]** applied to perimeter drainage areas, achieving a finer resolution of 0.25 m. This refinement allows for a more detailed representation of key drainage features, such as channel bottom width and batter slopes. The hydraulic roughness has been determined based on the latest aerial imagery and Stage 4 design surface, with Manning's 'n' values suggested by Innovyze **[13]**.
Drainage Asset	Identified drainage assets have been modelled explicitly as 1D elements in the model. Two culverts have been included in the hydraulic model with assumptions based on aerial imagery and topographic survey. As the conditions of drainage assets are unknown, a conservative roughness manning's 'n' value of 0.015 was selected. For reference, the typical 'n' value for concrete pipes in good condition is 0.011.
Downstream Boundary Conditions	HQ (head vs discharge) boundaries have been adopted along the downstream of the model to allow overland flows exiting the model extent. These were set to match the gradient of the topography extracted from the survey data.
Results Processing	Given the rainfall was applied across the whole model domain, flood extents with shallow depths (less than 5 cm) were filtered and excluded. The results of the ensemble simulation were then post processed in accordance with ARR 2019 **[10]**: • Sampling the results at each grid cell and selecting the median value among ten temporal patterns for each duration • Sampling the results at each grid cell and selecting the maximum value among each duration to produce the envelop results

5.8.3 Results

The post processed results for the modelled 1% AEP maximum flood depths and velocities are presented in **Appendix C** – Figure 3 and **Appendix C** – Figure 4. The outcomes including the critical storm events, drainage sizes, riprap design, water levels and flows are discussed in the following sections.

5.8.3.1 Critical Storm Events

Due to the limited size of the study catchment (approximately 0.12 km^2), short duration storms tend to produce higher peak flows than longer durations. A range of storm events that produce the highest peak flood levels along the perimeter drains were identified as critical durations based on the results processing method discussed in **Table 5**. These critical events include:

- 1% AEP 10 mins TP09
- 1% AEP 15 mins TP07

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- 1% AEP 15 mins TP08
- 1% AEP 20 mins TP10
- 1% AEP 30 mins TP03

Depending on the contributing catchment sizes, the perimeter drains at different sections experience different critical durations. The channel at upstream section with less contributing catchment typically results in a relatively shorter critical durations, around 10 mins. While the channel towards the downstream section has relatively longer critical durations, around 30 mins.

5.8.3.2 Flood Extent

Appendix C – Figure 3 shows the modelled flood extent using the maximum depth results for 1% AEP storm event. This gridded depth result is the combination of maximum depths from all modelled critical events as mentioned in **Table 5**. The modelled extent shows the runoff from the stockpile area is retained within the extended PAF Pad without exceeding the drainage capacity. The existing inlet channel for PAF Dam 2 also have enough capacity as no spilling over the crest was identified.

5.8.3.3 Flow Velocity for Riprap Design

Appendix C – Figure 4 shows the modelled maximum velocity results for 1% AEP storm event. This gridded depth result is the combination of maximum velocities from all modelled critical events as mentioned in **Table 5**.

The results have suggested a number of areas along the drainage channel are subject to high flow velocities up to 4 m/s, as results of changing flow directions and steeper slopes. Channel erosion is anticipated resulting from long-term scouring and high flow velocities during flood events. Placement of riprap across these areas is therefore proposed to protect channel banks and beds from erosion.

The areas with 1% AEP velocities exceeding 1.5 m/s along the channels were extracted from the model outputs to identify areas that requires protection by placing riprap. The 1.5 m/s threshold is chosen to indicate areas subject to potential erosion, as recommended surface water flow velocities for erosion protection typically range between 1.2 to 2.0 m/s for clay material **[14]**.

The sizing of the riprap D50 (median stone size) was undertaken by the recommended design equation for sizing rock used in the lining of drainage channels **[15]**. This equation represents a modification of the equation originally presented by Isbash (1936).

$$D_{50} = \frac{K_1 . V^2}{2 . g . K^2 (S_r - 1)}$$

Where:

K_1= correction factor for rock shape, 1.0 for angular rock, 1.36 for rounded rock

V = design flow velocity

g = acceleration due to gravity (m/s^2)

K = equation constant based on flow conditions (degree of local turbulence) K = 1.1 for low-turbulent deepwater flow, 1.0 for low-turbulent shallow water flow, and 0.86 for highly turbulent flow

S_r= specific gravity of rock (typically 2.6)

Based on the rock sizing equation above, five areas exposed to high velocities shown in **Appendix C** – Figure 4 require riprap D50 of 150 mm rocks. The riprap layer should be thick enough to resist the erosive forces of the flow, typically around 1.5 to 2 times the D50 value.

It should be noted that the velocity results presented in **Appendix C** – Figure 4, have already accounted for the increased roughness across the areas where riprap are proposed and hence

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leading to reduced velocities. The modelled results assuming no riprap were used to identify areas that needs protection.

5.8.3.4 Water Levels

The maximum 1% AEP water level profile along the perimeter channel have been extracted in two separate sections. The perimeter drains along the west and east side of the Stage 4 PAF Pad are shown in Appendix C – Figure 5, with water level profiles presented in **DIAGRAM 1** and

DIAGRAM 2, respectively. Water levels at PAF Dam 2 inlet channels are also presented in

DIAGRAM 2.

The average slopes for the west and east perimeter channels are 0.6% and 0.3%, respectively, as determined by the constraints of the existing PAF Pad elevations. Consequently, the modelled results indicate that the 1% AEP flows exhibit an average depth of approximately 0.6 metres and a moderate velocity not exceeding 1.5 m/s.

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DIAGRAM 1: West Perimeter Drain Flood Levels Long Section

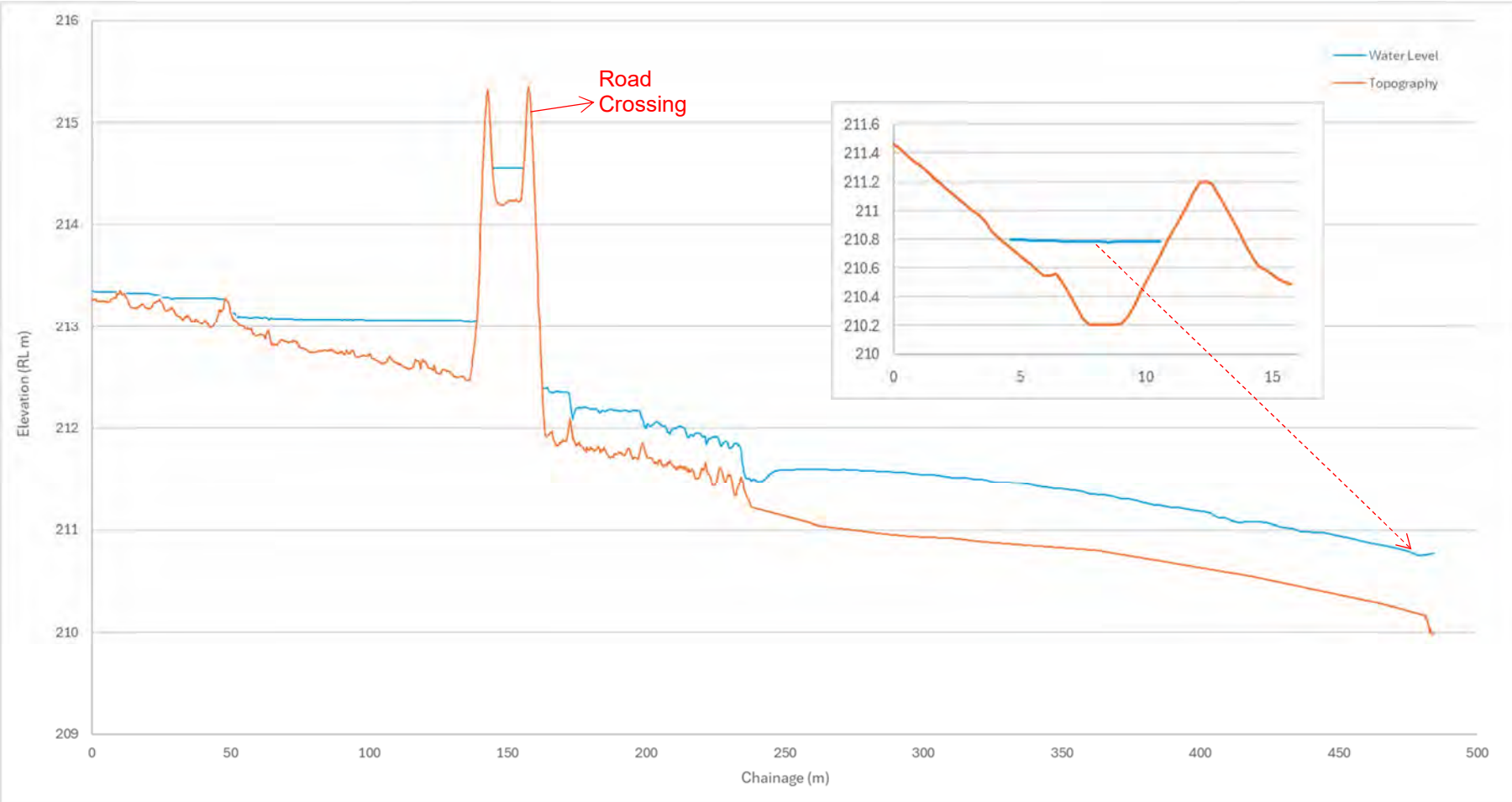

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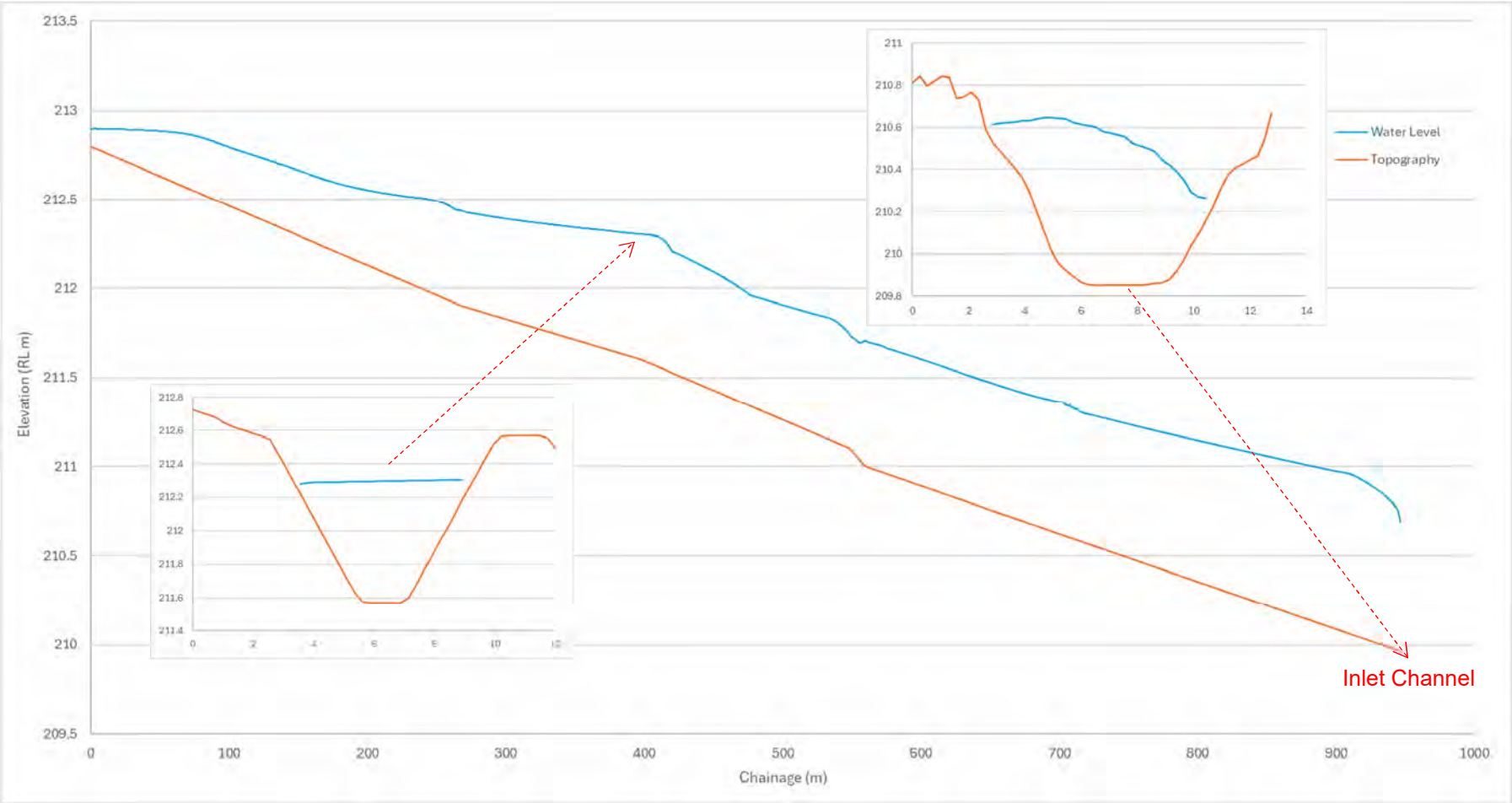
DIAGRAM 2: EAST PERIMETER DRAIN FLOOD LEVELS LONG SECTION



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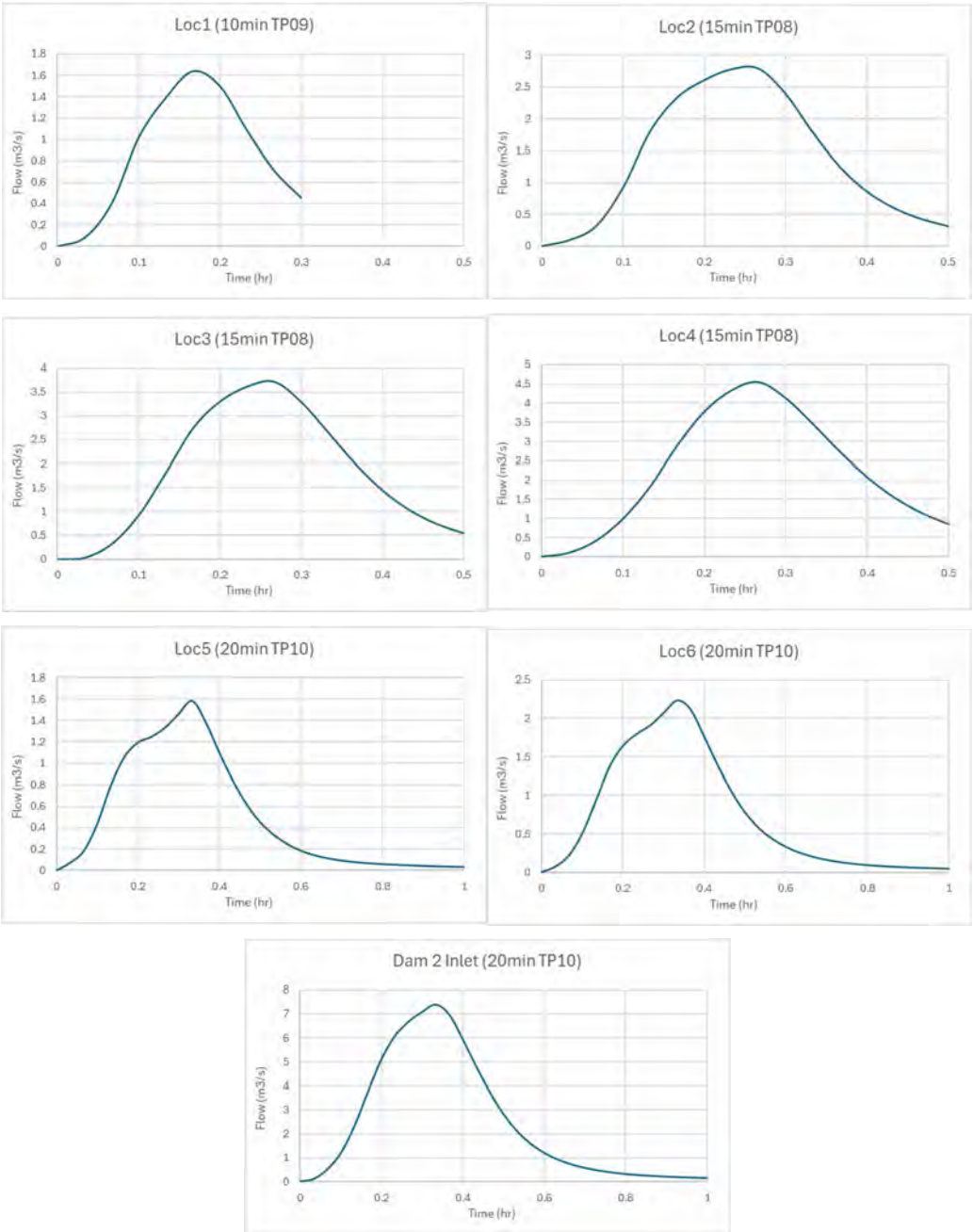
5.8.3.5 Flow Hydrographs

Hydrographs that produce the highest peak flows along the channels at a number of locations shown in **Appendix C** – Figure 6 are extracted from the modelled results. These hydrographs are presented in **DIAGRAM 3**.

DIAGRAM 3: EXTRACTED CHANNEL HYDROGRAPHS



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5.9 Stage 4 Construction Materials

5.9.1 Type 2 Capping Layer (Cohesive Earthfill)

As part of the Stage 4 PAF Pad design, a 500 mm thick capping layer of Type 2 material over the surface of the PAF Pad is proposed to create a low permeability clay liner that prevents PAF runoff from infiltrating into groundwater or impacting the downstream environment. ATCW undertook GI at DRM proposed borrow areas to find suitable Type 2 materials in 2024. The laboratory testing confirmed that the identified Sandy CLAY (red brown) material meets the necessary geotechnical characteristics for use as a Type 2 capping layer material **[6]**.

Per the GI, Type 2 materials shall comply with minimum requirements provided in **Table 6**. Detailed results of the laboratory testing and borrow investigation are provided in the ATCW PAF borrow GI letter **[6]**.

TABLE 6: TYPE 2 MATERIALS CHARACTERISTICS SUMMARY

Material Characteristic	Acceptable Range
Particle Size Distribution (PSD)	Percentage passing by weight: Clay: 20-50 Silt: 20-65 Sand: 30-80 Gravel: 80-100
Liquid Limit (Atterberg Limits)	25% - 40%
Plastic Limit (Atterberg Limits)	15% - 25%
Plasticity Index (Atterberg Limits)	10% - 20%
Emerson Class Number	4 - 6
Permeability (Falling Head - Remoulded)	$\leq 1 \times 10^{-9}$ m/s

5.9.2 Type 2 Material Source

Following the geotechnical investigation, limited quantities of suitable Type 2 material were identified immediately south of the NAF WRD. Most of the test pits conducted during the investigation were terminated in sandy clay material due to refusal, indicating that additional depths of potentially suitable Type 2 material may exist below. It is estimated that the borrow source identified in the 2024 GI will be exhausted (or close to exhaustion) by the end of Stage 3 construction.

With the proposed Pad 1 encapsulation, Type 2 material quantity required for Stage 4 has increased. As such, to identify additional suitable material, two of the other initially proposed borrow areas by MMG will be explored by MMG for potential Type 2 material sources.

Appendix A – Drawing 240261.03-010 shows the identified Type 2 material borrow location, along with the additional MMG proposed borrow areas to be investigated for suitable material.

The sourced Type 2 material is required to be excavated, moisture conditioned, hauled and placed per the requirements of Stage 4 Technical Specification.

5.9.3 PAF Rockfill

The Stage 4 PAF Pad expansion requires encapsulation of Pad 1, which involves raising the existing surface level within Pad 1 using PAF rockfill. Where PAF rockfill is required for the Stage 4 Pad 1 encapsulation works, suitable material shall be sourced from the PAF WRD. PAF rockfill shall

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comprise of durable, highly to slightly weathered rock, and must not degrade under placement. The material is an all-in rockfill mixture and shall exclude material that is primarily clay or silt, wet, or containing high organic content.

Selected PAF rockfill material shall have a maximum particle size of 200 mm, and minimal fines content.

The sourced PAF rockfill material for the Stage 4 expansion works must comply with the requirements outlined in Stage 4 Technical Specification.

5.9.4 NAF Rockfill

The Stage 4 PAF Pad expansion requires foundation and drain level raises to direct PAF runoff toward PAF Dam 2. Therefore, where rockfill is required for Stage 4 works, suitable NAF rockfill shall be sourced from the NAF WRD located directly south of the PAF WRD. NAF rockfill shall comprise of durable, highly to slightly weathered rock, and must not degrade under placement. The material is an all-in rockfill mixture and shall exclude material that is primarily clay or silt, wet, or containing high organic content. Selected NAF rockfill material shall have a maximum particle size of 200 mm, and minimal fines content.

The sourced NAF rockfill and rock armour material for the Stage 4 expansion must comply with the requirements outlined in Stage 4 Technical Specification.

5.9.5 Crushed NAF Rockfill

For regions where NAF and PAF rockfill raise is required, the final 300 mm layer shall consist of crushed NAF material. This finer crushed zone is intended to minimize the risk of fines migration from the Type 2 capping layer in the unlikely event of leakage, and to facilitate shaping of the PAF perimeter drainage and downstream batters following placement. It shall be noted that the 300 mm crushed NAF rockfill (~900 m^3) placed on the downstream shoulders can be omitted if shaping is considered acceptable by MMG.

The crushed NAF rockfill must comply with the material specifications outlined in **Section 5.9.4** and shall have a maximum particle size of 50 mm. Additionally, the final crushed product shall include 5% by weight of crusher dust to enhance gradation of the produced material.

5.9.6 NAF Rock Armour

Erosion protection rockfill shall be placed within the required Stage 4 perimeter drain channels to dissipate flow energies and to minimise surface erosion. Rock armour shall be formed from screened NAF rockfill (source and requirement provided in **Section 5.9.4**). Rock armour size requirements are presented in **Table 7**.

TABLE 7: ROCK ARMOUR SIZE REQUIREMENTS

Location	D50 size	Installation Thickness
Existing Drain Modifications presented in Drawing 240261.04-008 & 240261.04-009 Stage 4 Perimeter drain presented in Drawing 240261.04-004, 240261.04-008 & 240261.04-009	150 mm	225 mm

5.9.7 Geofabric

Application of Bidim A64 non-woven geotextile is required to aid in minimising erosion as an underlay for region where rock armour installation is required. Deployment of the geotextile shall be undertaken per the manufacturer's technical guidelines.

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5.10 Stage 4 Construction

5.10.1 Overview

During the Stage 4 PAF Pad expansion, a new Stage 4 PAF Pad will be created using NAF rockfill and Type 2 capping materials. In addition to the Pad construction, the existing Stage 1 Pad and emplaced PAF material will be encapsulated using PAF, NAF and Type 2 capping materials. The following works will be required for the Stage 4 PAF Pad expansion:

- Removal of PAF Dam 1;
- Foundation preparation;
- Placement of PAF, NAF, and crushed NAF rockfill to encapsulate and raise existing foundation levels;
- Placement of a 0.5 m capping layer on the PAF Pad, including tie-in to existing capping layers; and
- Construction and tie-in of perimeter drains.

Appendix A – Drawing 240261.04-002 shows the required extents of the works to raise Stage 4 PAF Pad and encapsulate PAF Pad 1. The following sections provide a detailed discussion of the required works. Further technical construction details will be outlined in the Stage 4 Technical Specification.

5.10.2 Foundation Preparation

Foundation preparation is required for the modification of the existing drains, Pad 1 encapsulation and for the open area where PAF Dam 1 currently exists. Stage 4 PAF Pad expansion works require Type A and Type B foundation preparation as presented in **Appendix A** – Drawing 240261.04-003.

Type A and Type B foundation preparations are further discussed in the following sections.

5.10.2.1 Type A – Natural Surface Foundation Preparation

Type A foundation preparation shall be conducted in all areas where the Stage 4 expansion works are in contact with the natural foundation. Geotechnical investigation of the PAF Pad found the depth of topsoil to be at a typical depth of 0.2 m **[6]**. Following removal of the topsoil and foundation excavation to a competent surface, the prepared surface shall be proof rolled using a loaded Articulated Dump Truck (ADT) (minimum 45t) or an approved equivalent to identify any defects or soft spots prior to NAF rockfill placement. Where proof rolling the prepared surface using the ADT is not possible, the surface shall be prepared to the required design depths and levels provided in the Stage 4 Design Drawings.

5.10.2.2 Type B – Existing Surface Foundation Preparation

Type B foundation preparation shall be carried out in all areas where Stage 4 works intersect with the existing PAF Pads and drains. In areas where works remain well within the existing PAF, Type 2 or NAF fill materials, the surface should be cleared of all loose or wet materials before placing any new materials. For existing surfaces where any natural material exists, Type A foundation preparation (refer to **Section 5.10.2.1**) shall be conducted. For existing surfaces where any PAF stockpiles exist over the Type 2 material tie-in points, these stockpiles must be excavated as needed to ensure a proper tie-in to the existing Type 2 materials.

5.10.3 PAF Rockfill Placement

Following foundation preparation works, the Stage 1 PAF Pad will require raising to promote surface water flow toward PAF Dam 2 and the perimeter drains. It is proposed that PAF rockfill material, sourced from the PAF WRD, be used to raise surface levels as part of the Pad 1 encapsulation. A total of approximately 16,000 m³ of existing PAF rockfill material is estimated to require spreading and compaction to achieve the specified design lines and levels for the encapsulation. Majority of this material is already located within PAF Pad 1 and will therefore only require re-spreading using a dozer followed by compaction to meet design requirements

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The selected PAF rockfill shall be placed and compacted in 300 mm thick layers, with a minimum of six passes of a vibratory smooth drum roller with a drum mass of at least 10 tonnes. To maintain the integrity and prevent damage to the Stage 3 / 4 low-permeability Type 2 capping layers during PAF placement, an initial 300 mm thick loose layer of PAF waste rock shall be placed on the Type 2 material slopes to buffer the interaction between the Type 2 materials and subsequent PAF placement.

PAF rockfill material selection, placement and compaction shall take place in accordance with the requirements of **Section 5.9.3** and Stage 4 Technical Specification.

5.10.4 NAF Rockfill Placement

Following foundation preparation works, the Stage 4 Pad and some sections of the existing drains will require level raising to promote water flow towards PAF Dam 2. NAF rockfill material sourced from the Southern NAF WRD is proposed to be used to raise surface levels within the Stage 4 works. During the Stage 4 expansion, NAF rockfill and crushed NAF rockfill (max particle size 50 mm) will be required to raise the Stage 4 PAF Pad area. A total of approximately 87,280 m^3 of NAF rockfill material (inclusive of the drain modification, crushed NAF rockfill (~17,000 m^3) and rock armour placement) is estimated for Stage 4 expansion works.

Suitable NAF rockfill material shall be placed and compacted in 300 mm thick layers and compacted with at least six passes of a vibratory smooth drum roller with a minimum 10 tonne drum mass. NAF rockfill material selection, placement and compaction shall take place in accordance with the requirements of **Section 5.9.4** and Stage 4 Technical Specification.

5.10.5 Type 2 - Capping Layer Placement

After the placement and compaction of NAF rockfill to design levels, a 500 mm thick Type 2 capping layer of compacted low permeability earth fill material shall be placed to prevent water infiltration below the Stage 4 PAF Pad and Pad 1 encapsulation surface. A total of approximately 26,800 m^3 of capping layer material (inclusive of drains and Pad 1 encapsulation) is estimated for Stage 4 expansion Pad works. This capping layer will be trimmed and shaped to facilitate basal drainage towards the PAF Dam 2 or PAF perimeter drainage system.

Suitable Type 2 capping layer material has been identified south of the NAF WRD as part of the GI works. With additional borrow sources to be explored for Type 2 materials. Type 2 material characteristics and minimum requirements have been discussed in **Section 5.9.1**.

Type 2 capping layer material shall be suitably moisture conditioned and placed in 250 mm thick layers and compacted to a minimum of 98% Standard Maximum Dry Density (SMDD) with a moisture content variation of between -2% (dry) and + 2% (wet). Compaction shall be achieved by a vibratory pad foot roller, or suitable equivalent. Prior to commencement of the works, field compaction trials shall be undertaken to confirm required minimum compaction efforts.

5.10.6 Stage 4 PAF Perimeter Drains and Modifications

Stage 4 PAF perimeter drainage will be constructed around the entire Stage 4 PAF Pad perimeter for the collection and diversion of surface runoff and PAF stockpile infiltrated waters to associated PAF Dams. The drains will be constructed at varying depths on the natural surface and Stage 2 Pad with a base width of 3 m. 1.5 m drain inverts are also adequate however the size has been increased to 3 m to accommodate for maintenance and pad access per MMGs request. The Stage 4 drains will need to suitably tie into the existing 500 mm thick clay lined drains which are connected to the existing PAF Dam 2 concrete inlet.

To dissipate high flow energies and prevent erosion along the base and walls of the drains, erosion protection rock armour will be installed. This material will be placed in areas with maximum flow velocities, typically at the ends of the drains, at curves, and at significant grade changes. In regions requiring rock armour, the drain inlet must be made free flowing by tying in 500 mm Type 2 material with the existing 500 mm Type 2 materials at the inlet. Once completed, the rock armour will be slightly extended over the existing Type 2 liner drain.

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No modification or updates are deemed necessary to the existing inlet, as such a suitable offset shall be maintained to prevent damage to the concrete inlet channel and sump.

Derivation and adoption of the Stage 4 PAF perimeter drain geometry, and sizing is discussed in **Section 5.4**.

5.10.7 Clean Water Drainage

As part of the Stage 4 expansion, the existing clean water drainage system around the PAF WRD will be modified as follows:

- Filling of the clean water drain situated between PAF Dam 1 and PAF Pad 2 to raise surface levels.

Appendix A – Drawing 240261.03-002 presents the proposed surface water management for Stage 4. The DRM sitewide Water Management Strategy **[17]** should be updated based on this drawing.

5.10.8 PAF Dam 1 Removal

The Stage 4 PAF Pad development is planned in the area currently occupied by PAF Dam 1. As noted in the conceptual design **[1]**, construction of the Stage 4 Pad will require the full removal of the existing PAF Dam 1 structure and associated infrastructure, including the seepage collection well and toe drain outlet pipes, to allow for foundation assessment and preparation.

The Stage 1 PAF Dam comprises of four perimeter embankments constructed using zoned compacted earth fill and lined with an HDPE geomembrane. A rock-lined spillway, measuring 12.8 m wide and 0.5 m deep, is located at the northwest corner of the facility. Materials recovered from Dam 1 may be reused in the construction of the Stage 4 PAF Pad, provided they meet the material requirements outlined in the Stage 4 Technical Specification.

Unsuitable materials must not be used in the works and should be directed to spoil or designated stockpile areas as instructed by MMG representatives for potential future use.

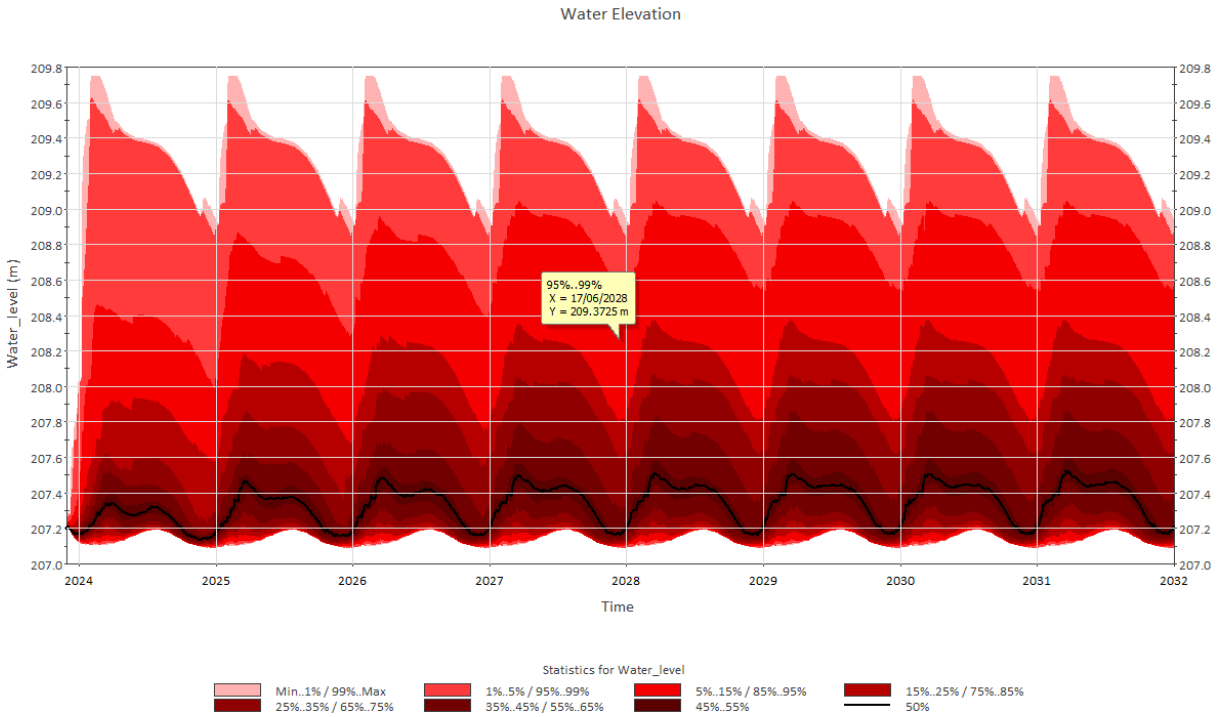
5.11 Stage 4 Water Balance Modelling

The existing water balance model for stage 3 design was modified to include the increase in catchment areas for PAF Dam 2 and decommission of PAF Dam 1. Modelling was then used to assess long-term trends in water levels and annual spill risk.

The modelled water level for PAF Dam 2 in the form of probability plots are presented in **Figure 3**. The modelling results in the form of spill risks for PAF Dam 2 remain at 0.8%. This represents a likelihood of 0.8% for PAF Dam 2 experiencing a spill in any one year. Due to the increased contributing catchment, the median peak water level slightly increases to 207.5 m RL during wet seasons.

The water balance results under Stage 4 suggest that there is sufficient storage capacity in PAF Dam 2 to accommodate the surface water runoff with acceptable spill risk. However, the sensitivity testing undertaken during the conceptual stage **[1]** suggested that any external inflow into the PAF Dam 2 should be limited, and it can only function as a "transfer storage" and be equipped with off-take infrastructure to distribute water for other uses.

FIGURE 3: MODELLED STORAGE WATER LEVEL – STAGE 4 PAF DAM 2



6 CLOSURE

This report has presented detailed design for the expansion of the Dugald River Mine Stage 4 PAF Pad.

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REFERENCES

[1] ATC Williams, "PAF Pad Expansion Conceptual Options Study", Ref 108003.64-R01 REV 0, dated July, 2024.

[2] ATC Williams, "MMG Dugald River Mine PAF PAD Expansion Detailed Design Budget Proposal", Ref 240261-P01 Rev A, dated October 2024.

[3] ATC Williams, "Dugald Rive Mine PAF Pad Expansion – Stage 3 Design Report", Ref 240261.03-R01 Rev 0, dated May 2025.

[4] Department of Environment and Heritage Protection, "MMG Australia Limited - Dugald River Environmental Authority", document reference EPML00731213 v2.06, dated April, 2023.

[5] MMG, "Design, Construction and Management of Surface Stockpile – Work Quality Requirements Dugald River, Ref 8591506 Rev 2, dated June, 2019.

[6] ATC Williams, "Dugald River Stage 3 and 4 PAF Pad Detailed Design – Borrow Investigation", Ref 240261.02-L01, dated February, 2025.

[7] ATC Williams, "MMG Dugald River Mine – Pond B Facility Construction Report", Ref 108003.08-R01, dated June, 2012.

[8] ATC Williams, "MMG Dugald River Mine – Review of Consequence Categories - Stage 1 & 2 PAF Pad Runoff Dams, STP Evaporation Dam, NAF Pad Runoff Dam, and Underground Mine Water Collection Dam", Ref 108003.14-R01, dated June, 2014.

[9] ATC Williams, "MMG Dugald River Mine – Stage 2 Earthworks PAF Pad Runoff Dam Construction Report", Ref 108003.12-R02 Rev 0, dated July, 2013.

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

[11] Jacobs, “Dugald River Project – Stage 2 PAF PAD Runoff Dam – IFC Calculation Sheet”, Ref DUG-CAL-1290-EC-003- REV A, dated September, 2012.

[12] TUFLOW, 2020. TUFLOW Classic and HPC Release Note. https://downloads.tuflow.com/_archive/TUFLOW/Releases/2020-01/Doc/TUFLOW%20Release%20Notes.2020-01.pdf

[13] Innovyze (2019), 'Manning's n Roughness Coefficients – Open Channel', October 2019

[14] Department of Primary Industries and Regional Development, (2021), Suggested maximum velocities of surface water flow.

[15] Queensland. Department of Energy and Water Supply, issuing body & Brisbane (Qld.). Council, Copyright holder & Institute of Public Works Engineering Australia. Queensland Division, Copyright holder. 2013

[16] ATC Williams, "MMG Dugald River Mine – PAF Stage 2 Dam Consequence Category Assessment", Ref 108003.63-R01, dated July, 2023.

[17] MMG, "Dugald River Water Management Strategy", dated May 2023.

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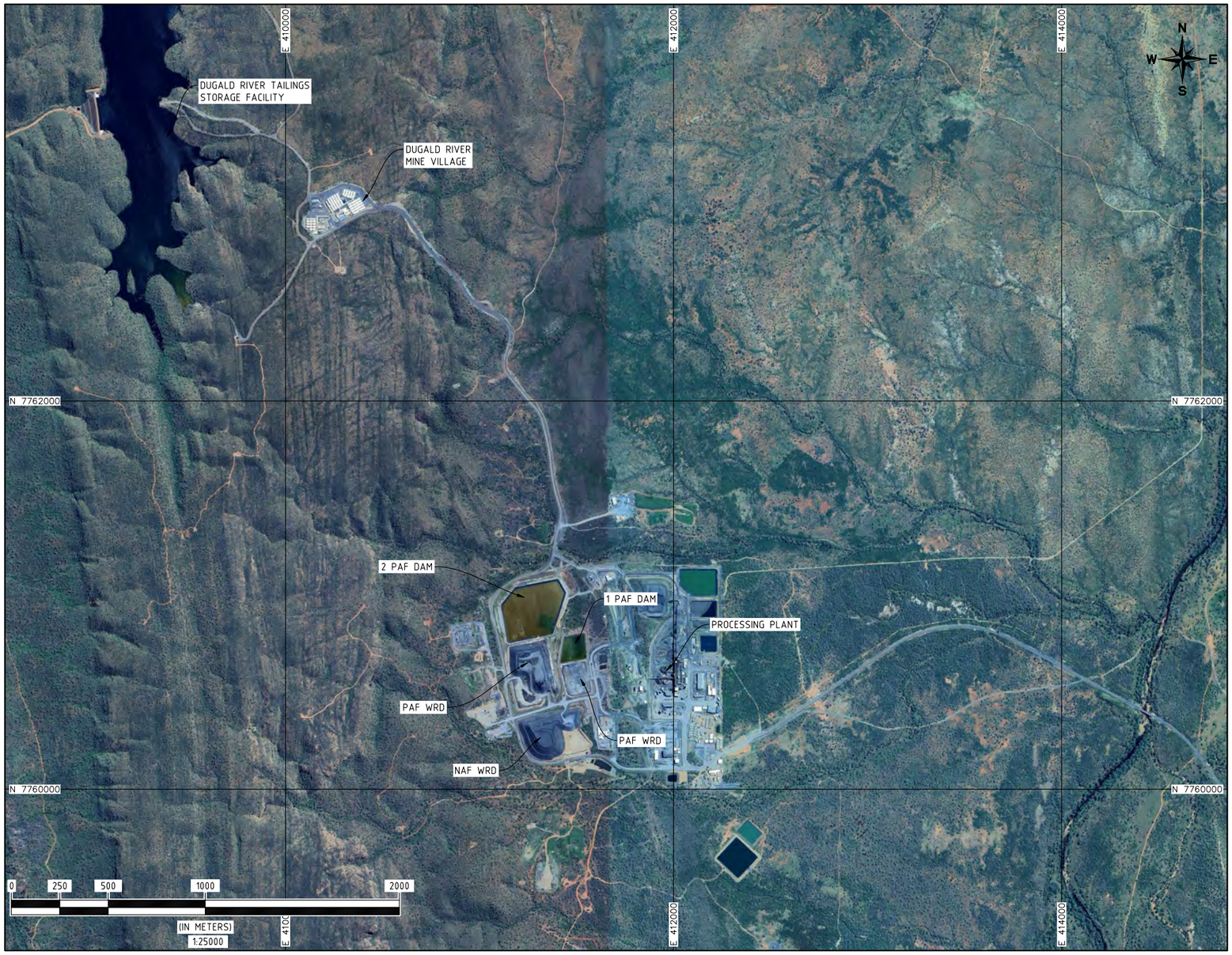
APPENDICES

APPENDIX A – STAGE 4 PAF PAD EXPANSION DESIGN DRAWINGS

MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP
STAGE 4 PAF PAD DETAILED DESIGN



LOCALITY PLAN
SCALE 1:25,000

DRAWING LIST	
DRAWING NUMBER	DRAWING TITLE
240261.04-000	DRAWING LIST & LOCALITY PLAN
240261.04-001	EXISTING CONDITIONS
240261.04-002	GENERAL LAYOUT PLAN
240261.04-003	FOUNDATION PREPARATION PLAN
240261.04-004	STAGE 4 PAF PAD & PAD 1 ENCAPSULATION - SECTIONS (SHEET 1 OF 2)
240261.04-005	STAGE 4 PAF PAD & PAD 1 ENCAPSULATION - SECTIONS (SHEET 2 OF 2)
240261.04-006	STAGE 4 PAF PERIMETER DRAIN - PLAN & LONG SECTION (SHEET 1 OF 2)
240261.04-007	STAGE 4 PAF PERIMETER DRAIN - PLAN & LONG SECTION (SHEET 2 OF 2)
240261.04-008	STAGE 4 PAF PERIMETER DRAIN - SECTIONS (SHEET 1 OF 2)
240261.04-009	STAGE 4 PAF PERIMETER DRAIN - SECTIONS (SHEET 2 OF 2)
240261.04-010	BORROW LOCATION PLAN

SURVEY NOTES:
1.- GRID COORDINATE SYSTEM IN USE MGA 94 Z54.
HEIGHT DATUM: AHD
2.- IMAGE IN USE: GS - EPSG 32754 WGS84 Z54S Dugald River Locality Plan 1200 DPI

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
DRAWING LIST & LOCALITY PLAN

DWG. No. 240261.04-000

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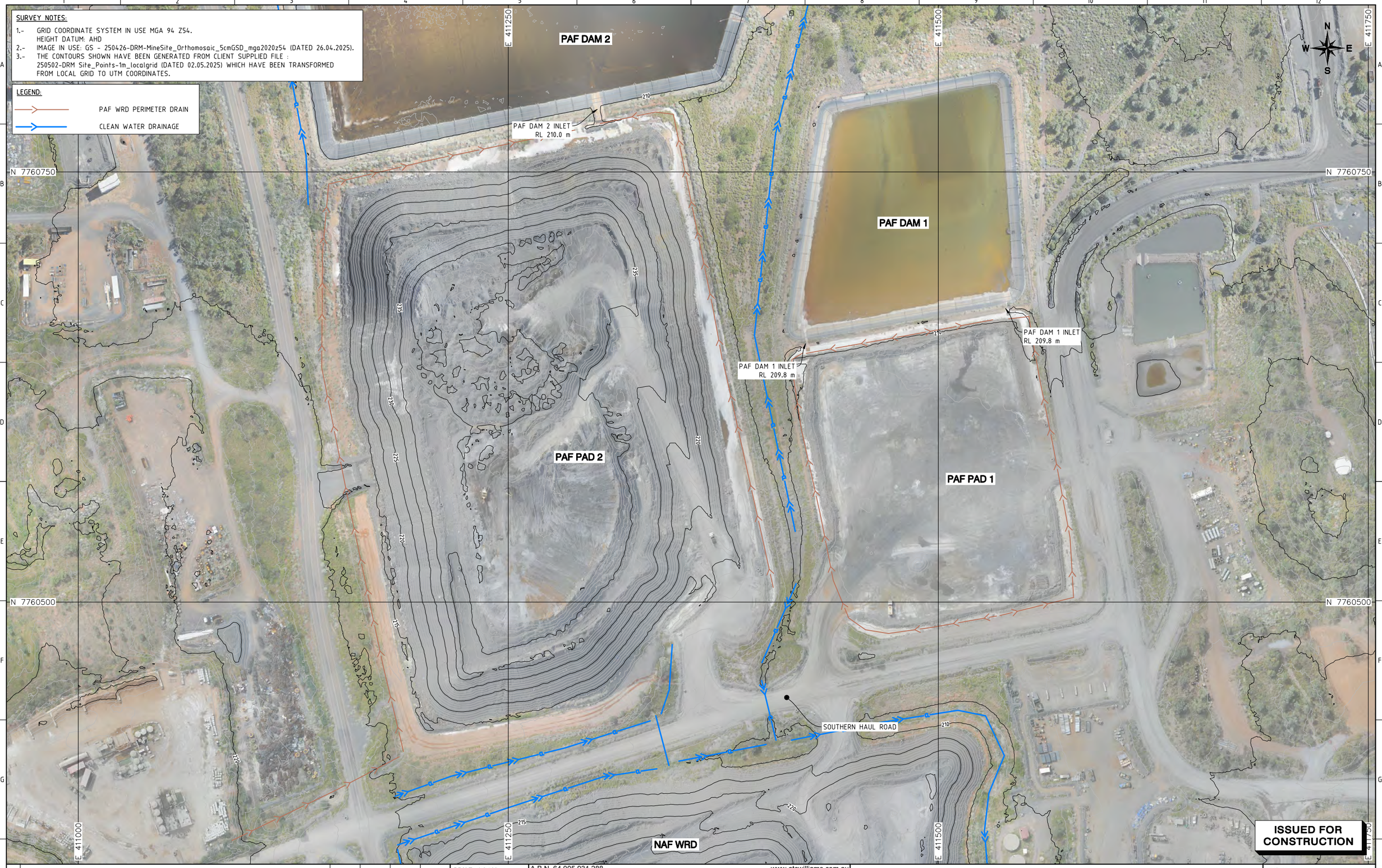
LEGEND:

PAF WRD PERIMETER DRAIN

CLEAN WATER DRAINAGE



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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
EXISTING CONDITIONS

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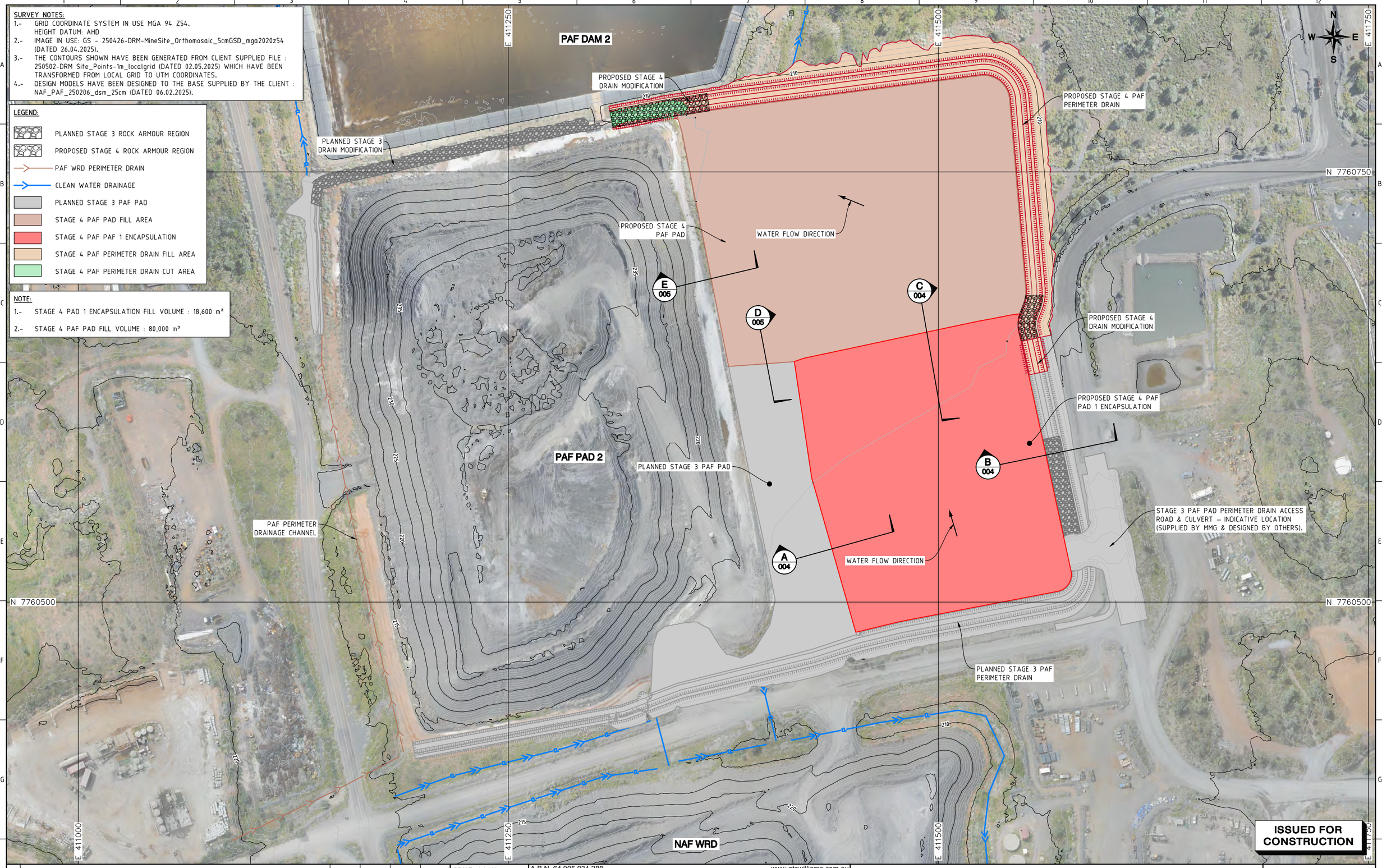
LEGEND:

- PLANNED STAGE 3 ROCK ARMOUR REGION
- PROPOSED STAGE 4 ROCK ARMOUR REGION
- PAF WRD PERIMETER DRAIN
- CLEAN WATER DRAINAGE
- PLANNED STAGE 3 PAF PAD
- STAGE 4 PAF PAD FILL AREA
- STAGE 4 PAF PAF 1 ENCAPSULATION
- STAGE 4 PAF PERIMETER DRAIN FILL AREA
- STAGE 4 PAF PERIMETER DRAIN CUT AREA

NOTE:

1.- STAGE 4 PAD 1 ENCAPSULATION FILL VOLUME : 18,600 m³

2.- STAGE 4 PAF PAD FILL VOLUME : 80,000 m³



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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
GENERAL LAYOUT PLAN

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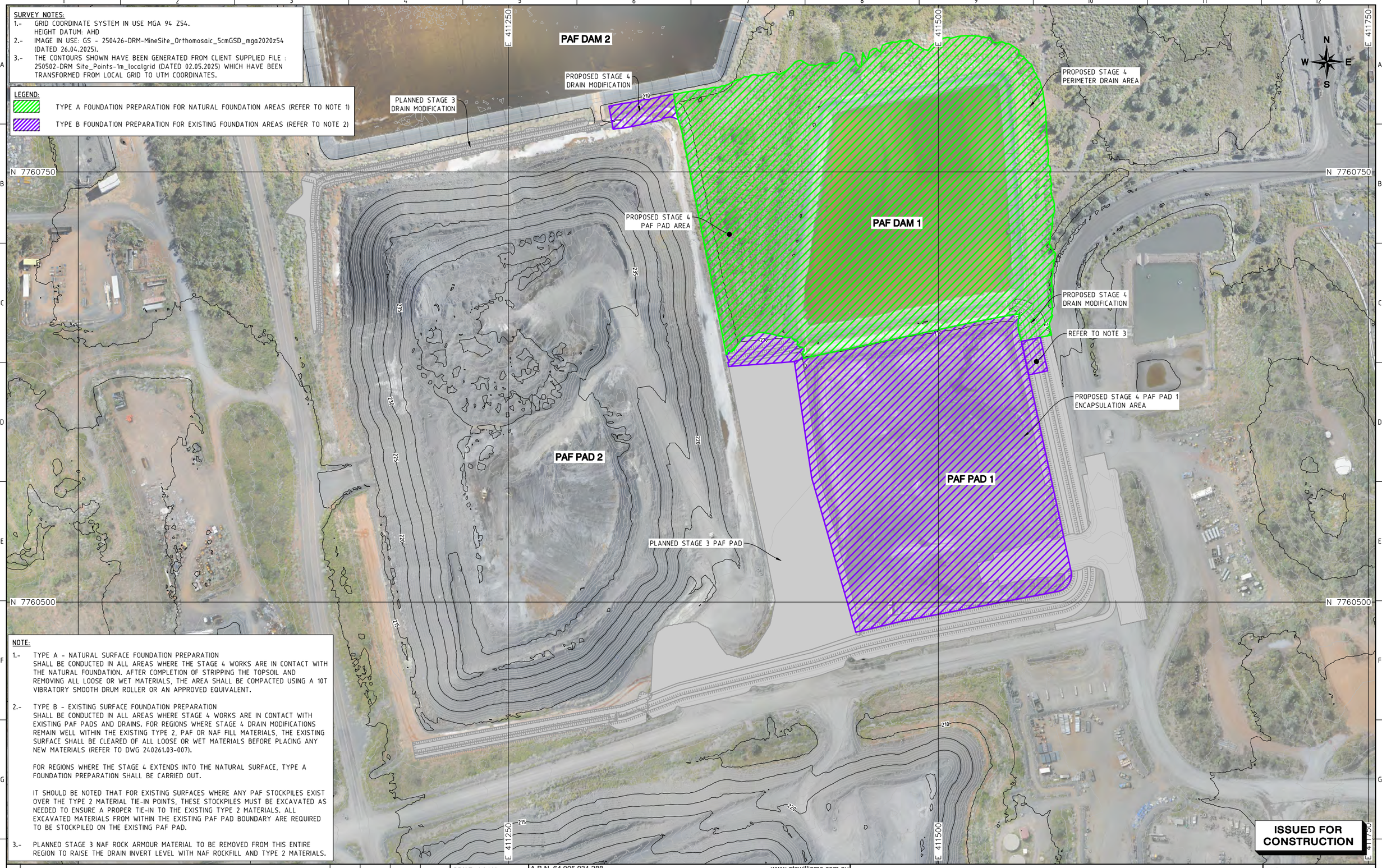
LEGEND:

TYPE A FOUNDATION PREPARATION FOR NATURAL FOUNDATION AREAS (REFER TO NOTE 1)

TYPE B FOUNDATION PREPARATION FOR EXISTING FOUNDATION AREAS (REFER TO NOTE 2)



NOTE:

1.- TYPE A - NATURAL SURFACE FOUNDATION PREPARATION
SHALL BE CONDUCTED IN ALL AREAS WHERE THE STAGE 4 WORKS ARE IN CONTACT WITH THE NATURAL FOUNDATION. AFTER COMPLETION OF STRIPPING THE TOPSOIL AND REMOVING ALL LOOSE OR WET MATERIALS, THE AREA SHALL BE COMPACTED USING A 10T VIBRATORY SMOOTH DRUM ROLLER OR AN APPROVED EQUIVALENT.

2.- TYPE B - EXISTING SURFACE FOUNDATION PREPARATION
SHALL BE CONDUCTED IN ALL AREAS WHERE STAGE 4 WORKS ARE IN CONTACT WITH EXISTING PAF PADS AND DRAINS. FOR REGIONS WHERE STAGE 4 DRAIN MODIFICATIONS REMAIN WELL WITHIN THE EXISTING TYPE 2, PAF OR NAF FILL MATERIALS, THE EXISTING SURFACE SHALL BE CLEARED OF ALL LOOSE OR WET MATERIALS BEFORE PLACING ANY NEW MATERIALS (REFER TO DWG 240261.03-007).

FOR REGIONS WHERE THE STAGE 4 EXTENDS INTO THE NATURAL SURFACE, TYPE A FOUNDATION PREPARATION SHALL BE CARRIED OUT.

IT SHOULD BE NOTED THAT FOR EXISTING SURFACES WHERE ANY PAF STOCKPILES EXIST OVER THE TYPE 2 MATERIAL TIE-IN POINTS, THESE STOCKPILES MUST BE EXCAVATED AS NEEDED TO ENSURE A PROPER TIE-IN TO THE EXISTING TYPE 2 MATERIALS. ALL EXCAVATED MATERIALS FROM WITHIN THE EXISTING PAF PAD BOUNDARY ARE REQUIRED TO BE STOCKPILED ON THE EXISTING PAF PAD.

3.- PLANNED STAGE 3 NAF ROCK ARMOUR MATERIAL TO BE REMOVED FROM THIS ENTIRE REGION TO RAISE THE DRAIN INVERT LEVEL WITH NAF ROCKFILL AND TYPE 2 MATERIALS.

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	19.12.25	HJ	MA	CN

SCALE:	1:2,500
JOB No.	240261.04
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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
FOUNDATION PREPARATION PLAN

DWG. No. 240261.04-003

SHEET SIZE A3 Rev. 0

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SHEET 1 OF 1

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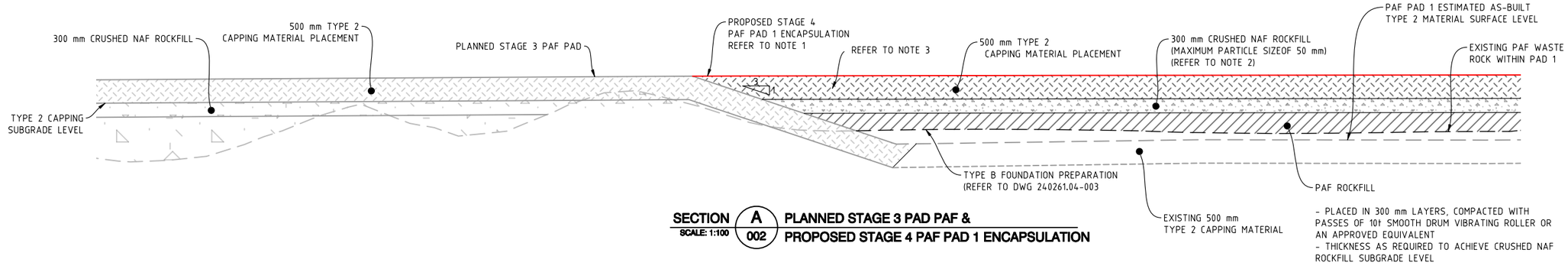
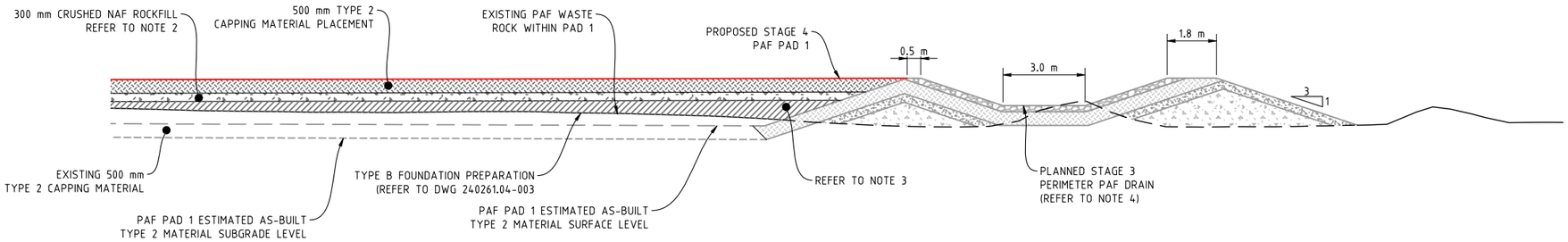


SECTION A 002 SCALE: 1:100 — **PLANNED STAGE 3 PAD PAF & PROPOSED STAGE 4 PAF PAD 1 ENCAPSULATION**

LEGEND

- NAF ROCK ARMOUR
- GEOTEXTILE
- TYPE 2 CAPPING MATERIAL
- CRUSHED NAF ROCKFILL
- NAF ROCKFILL
- PAF ROCKFILL



SECTION B 002 SCALE: 1:200 — **PLANNED STAGE 3 PERIMETER DRAIN & PROPOSED STAGE 4 PAF PAD 1 ENCAPSULATION**

NOTE:

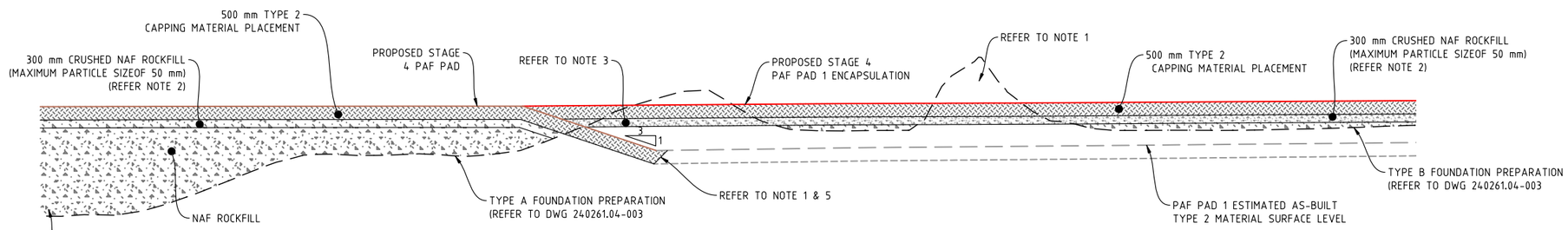
1.- IT SHOULD BE NOTED THAT WHERE PAF ROCKFILL MATERIAL OR STOCKPILES EXIST OVER PROPOSED OR EXISTING TYPE 2 MATERIAL AREAS, THEY MUST BE EXCAVATED AS NECESSARY TO FACILITATE PROPER CONSTRUCTION AND TIE-IN OF TYPE 2 MATERIALS WITH EXISTING OR PLANNED SURFACES.

2.- LAYER CONSISTS OF CRUSHED NAF ROCKFILL MATERIAL WITH MAXIMUM PARTICLE SIZE OF 50 mm. THE PRODUCED CRUSHED MATERIAL SHALL CONSIST OF 5% BY WEIGHT OF THE CRUSHERS DUST.

3.- 300 mm THICK LOOSE LAYER OF PAF WASTE ROCK (WITHIN PAF/NAF ROCK FILL ZONES ONLY) TO BE PLACED ON THE DRAIN SLOPE TO BUFFER THE INTERACTION BETWEEN THE DRAIN SLOPE AND SUBSEQUENT PAF PLACEMENT.

4.- WHERE TYPE 2 CAPPING MATERIAL INTERSECTS NAF ROCK ARMOUR, THE DRAIN INVERT SHALL BE GRADED TO REMAIN FREE DRAINING TO PREVENT WATER PONDING. ANY LOW POINTS CAUSED BY NAF PLACEMENT SHALL BE GRADED AS NECESSARY TO PREVENT LOCALISED WATER PONDING AND TO MAINTAIN POSITIVE DRAINAGE TOWARDS PAF DAM 2.

5.- STAGE 4 TYPE 2 CAPPING MATERIALS TO BE TIED IN AT A MINIMUM 1:1 BATTER TO THE EXISTING TYPE 2 MATERIALS.



SECTION C 002 SCALE: 1:200 — **PROPOSED STAGE 4 PAF PAD & PROPOSED STAGE 4 PAF PAD 1 ENCAPSULATION**

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No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	19.12.25	HJ	MA	CN

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
Stage 4 PAF PAD & PAD 1 ENCAPSULATION
SECTIONS (SHEET 1 OF 2)

DWG. No. 240261.04-004

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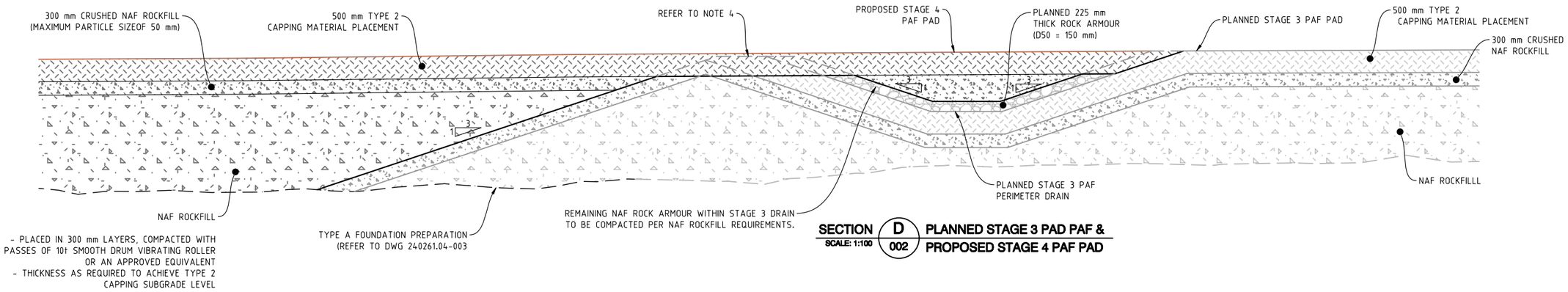
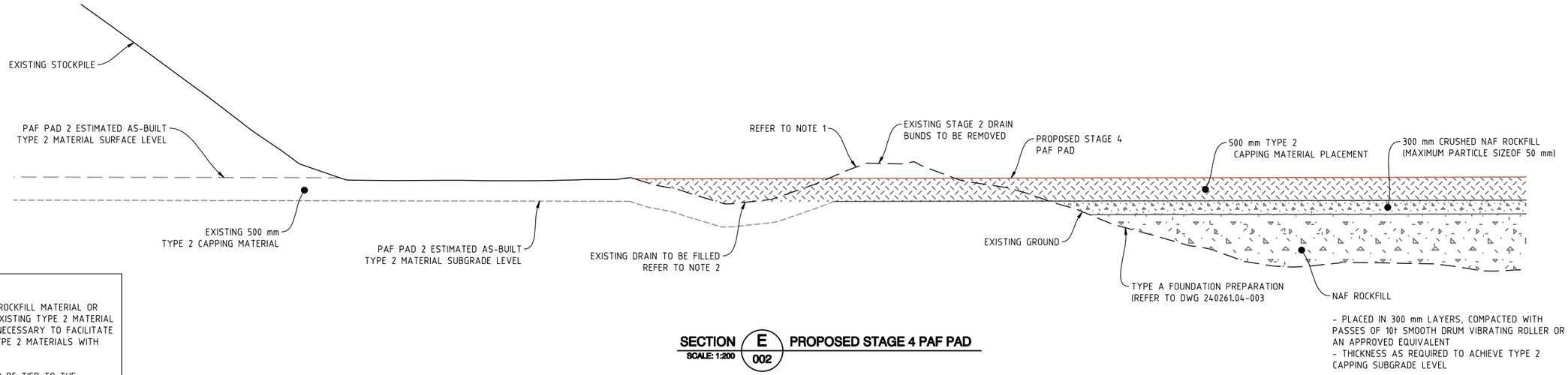
SHEET 1 OF 1

LEGEND

- NAF ROCK ARMOUR
- GEOTEXTILE
- TYPE 2 CAPPING MATERIAL
- CRUSHED NAF ROCKFILL
- NAF ROCKFILL
- PAF ROCKFILL



SECTION D 002 SCALE: 1:100 — **PLANNED STAGE 3 PAD PAF & PROPOSED STAGE 4 PAF PAD**



SECTION E 002 SCALE: 1:200 — **PROPOSED STAGE 4 PAF PAD**

NOTE:

1.- IT SHOULD BE NOTED THAT WHERE PAF ROCKFILL MATERIAL OR STOCKPILES EXIST OVER PROPOSED OR EXISTING TYPE 2 MATERIAL AREAS, THEY MUST BE EXCAVATED AS NECESSARY TO FACILITATE PROPER CONSTRUCTION AND TIE-IN OF TYPE 2 MATERIALS WITH EXISTING OR PLANNED SURFACES.

2.- STAGE 4 TYPE 2 CAPPING MATERIALS TO BE TIED TO THE EXISTING TYPE 2 CAPPING MATERIALS. IN AREAS WHERE THERE IS AN EXISTING DRAIN, THE DRAIN SHALL BE FILLED TO ELIMINATE THE RISK OF FORMING A LOW POINT.

3.- LAYER CONSISTS OF CRUSHED NAF ROCKFILL MATERIAL WITH MAXIMUM PARTICLE SIZE OF 50 mm. THE PRODUCED CRUSHED MATERIAL SHALL CONSIST OF 5% BY WEIGHT OF THE CRUSHERS DUST.

4.- PLANNED STAGE 3 PAF PAD AND PERIMETER DRAIN MATERIALS MAY REQUIRE REMOVAL TO ENABLE CONSTRUCTION OF A CONTINUOUS TYPE 2 CAPPING LAYER, FREE OF LOW POINTS THAT MAY ALLOW WATER PONDING. WHERE REQUIRED, MATERIALS ARE TO BE REMOVED AND THE EXISTING NAF ROCK (WITHIN THE STAGE 3 DRAIN) COMPACTED IN ACCORDANCE WITH NAF ROCKFILL COMPACTION REQUIREMENTS.

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0	ISSUED FOR CONSTRUCTION	19.12.25	HJ	MA	CN

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
Stage 4 PAF PAD & PAD 1 ENCAPSULATION
SECTIONS (SHEET 2 OF 2)

DWG. No. 240261.04-005

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SHEET 1 OF 1

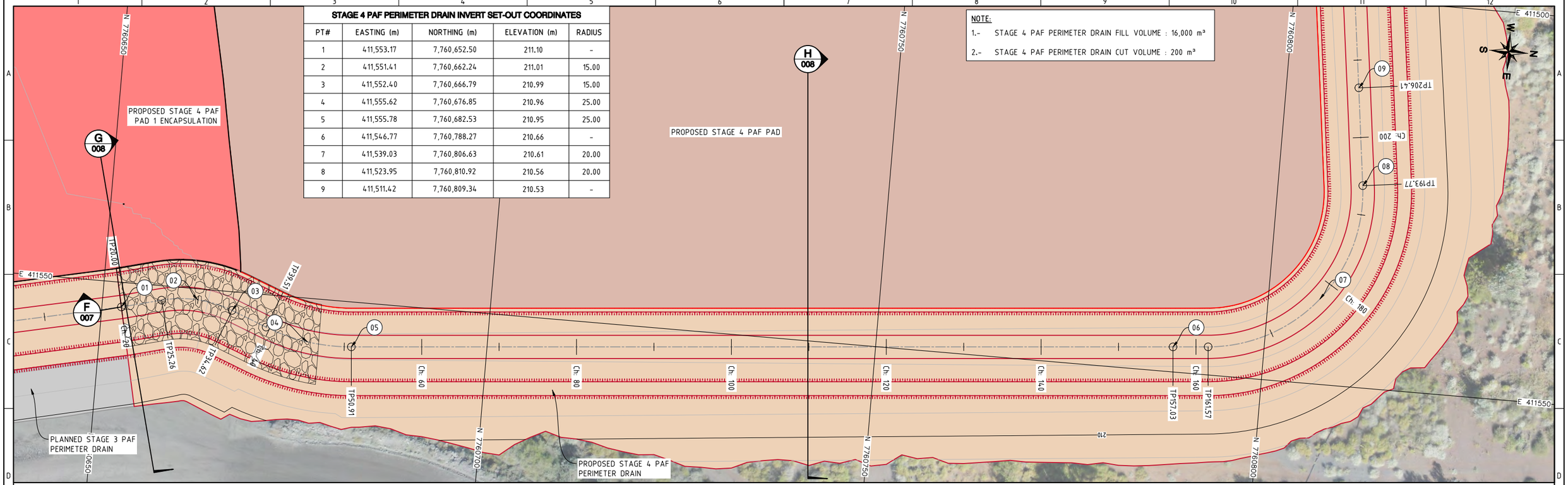
STAGE 4 PAF PERIMETER DRAIN INVERT SET-OUT COORDINATES

PT#	EASTING (m)	NORTHING (m)	ELEVATION (m)	RADIUS
1	411,553.17	7,760,652.50	211.10	-
2	411,551.41	7,760,662.24	211.01	15.00
3	411,552.40	7,760,666.79	210.99	15.00
4	411,555.62	7,760,676.85	210.96	25.00
5	411,555.78	7,760,682.53	210.95	25.00
6	411,546.77	7,760,788.27	210.66	-
7	411,539.03	7,760,806.63	210.61	20.00
8	411,523.95	7,760,810.92	210.56	20.00
9	411,511.42	7,760,809.34	210.53	-

NOTE:

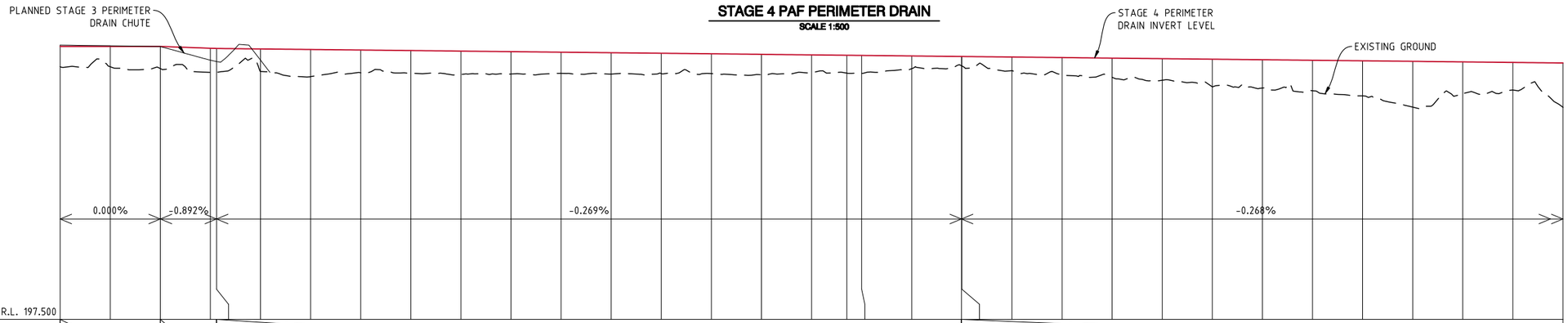
1.- STAGE 4 PAF PERIMETER DRAIN FILL VOLUME : 16,000 m³

2.- STAGE 4 PAF PERIMETER DRAIN CUT VOLUME : 200 m³



STAGE 4 PAF PERIMETER DRAIN

SCALE 1:500



VERTICAL DETAILS	P=0.000% L=19.999				L=11.215		L=148.709															P=-0.269%																		P=-0.268% L=231.391
PLANNED STAGE 3 DRAIN INVERT	211.17	211.13	211.10	210.42	210.35	210.42																																		
PROPOSED STAGE 4 DRAIN INVERT	211.10	211.10	211.10	211.01	211.00	210.98	210.95	210.92	210.90	210.87	210.84	210.81	210.79	210.76	210.73	210.71	210.68	210.66	210.65	210.63	210.60	210.60	210.57	210.55	210.52	210.49	210.47	210.44	210.41	210.39	210.36	210.33	210.30	210.28
EXISTING PAF AREA	210.09	210.09	210.00	209.81	209.81	209.86	209.59	209.79	209.76	209.70	209.73	209.76	209.72	209.75	209.75	209.68	209.81	209.77	209.76	209.99	210.14	210.13	209.89	209.69	209.57	209.42	209.09	209.03	208.89	208.64	208.08	208.78	208.93	208.06
CHAINAGE	0.00	10.00	20.00	30.00	31.22	40.00	50.00	60.00	70.00	80.00	90.00	100.00	110.00	120.00	130.00	140.00	150.00	157.03	160.00	170.00	179.93	180.00	190.00	200.00	210.00	220.00	230.00	240.00	250.00	260.00	270.00	280.00	290.00	300.00

LONG SECTION F - STAGE 4 PAF PERIMETER DRAIN INVERT (CH 0 - CH 300)

SCALE: 1:1,000 (H) 1:250 (V)

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STAGE 4 PAF PAD DETAILED DESIGN
STAGE 4 PAF PERIMETER DRAIN
PLAN & LONG SECTION (SHEET 1 OF 2)

DWG. No. 240261.04-006

SHEET SIZE A3 Rev. 0

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SHEET 1 OF 1

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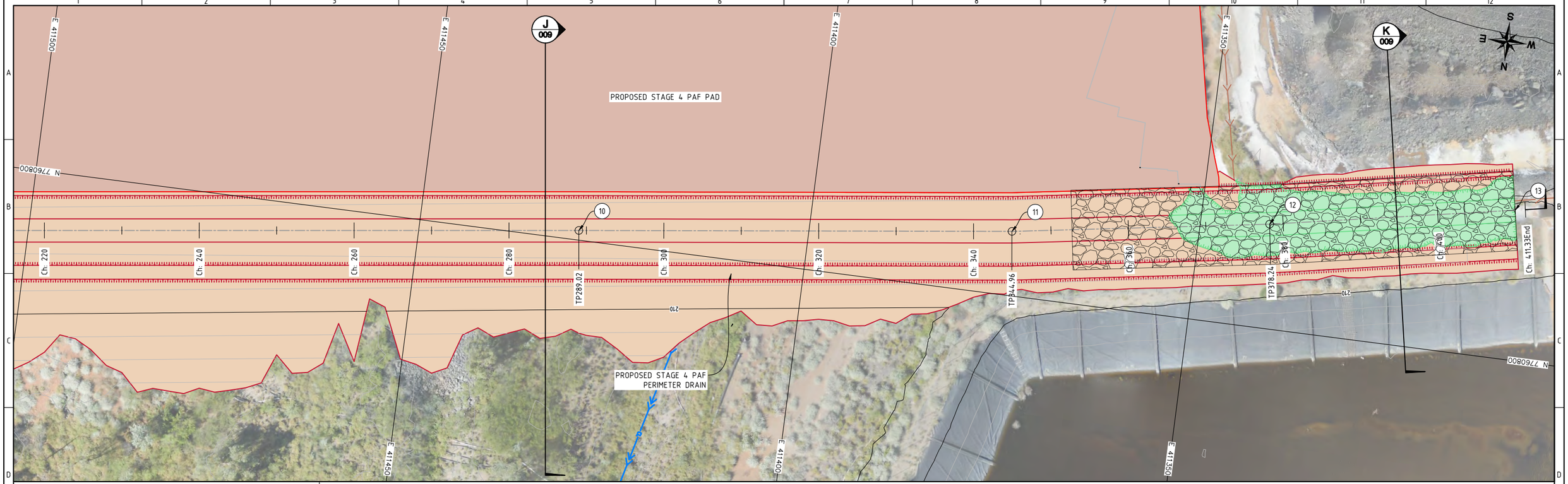
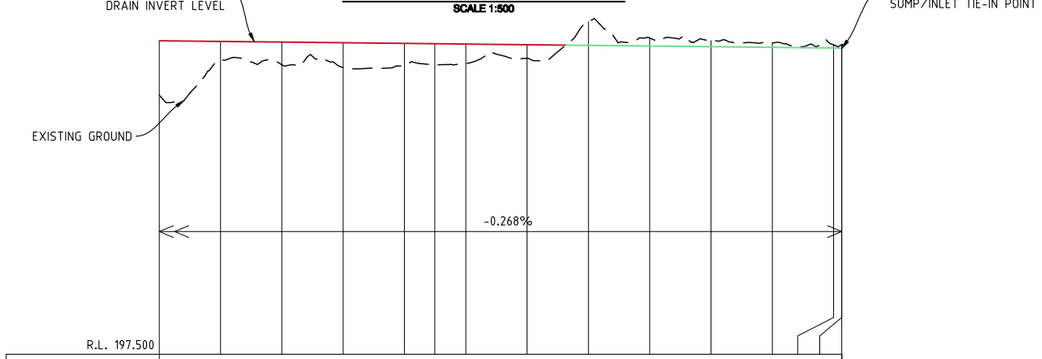


STAGE 4 PAF PERIMETER DRAIN INVERT SET-OUT COORDINATES

PT#	EASTING (m)	NORTHING (m)	ELEVATION (m)	RADIUS
10	411,429.48	7,760,798.76	210.31	-
11	411,373.99	7,760,791.72	210.16	-
12	411,341.12	7,760,786.54	210.07	-
13	411,309.90	7,760,780.69	209.98	-

STAGE 4 PAF PERIMETER DRAIN

SCALE 1:500



VERTICAL DETAILS	L=231.391													P=-0.268%	
PLANNED STAGE 3 DRAIN INVERT															
PROPOSED STAGE 4 DRAIN INVERT	210.28	210.25	210.22	210.20	210.17	210.16	210.14	210.12	210.09	210.06	210.04	210.01	209.98	209.98	
EXISTING PAF AREA	208.06	209.51	209.30	209.18	209.25	209.31	209.35	209.57	211.05	210.39	210.29	210.19	210.11	210.12	210.12
CHAINAGE	300.00	310.00	320.00	330.00	340.00	344.96	350.00	360.00	370.00	380.00	390.00	400.00	410.00	411.32	411.33

LONG SECTION F 006 **STAGE 4 PAF PERIMETER DRAIN INVERT (CH 300 - CH 396.62)**

SCALE: 1:1,000 (H) 1:250 (V)

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STAGE 4 PAF PAD DETAILED DESIGN
STAGE 4 PAF PERIMETER DRAIN
PLAN & LONG SECTION (SHEET 2 OF 2)

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SHEET 1 OF 1

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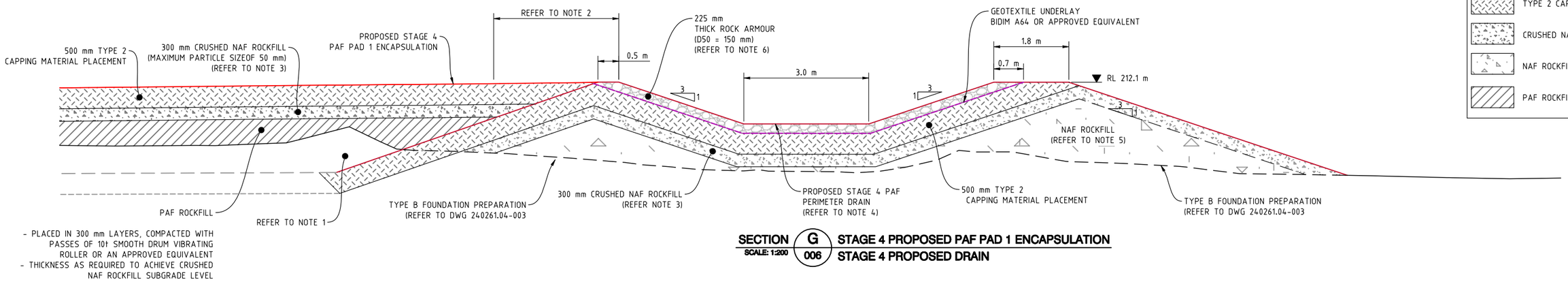
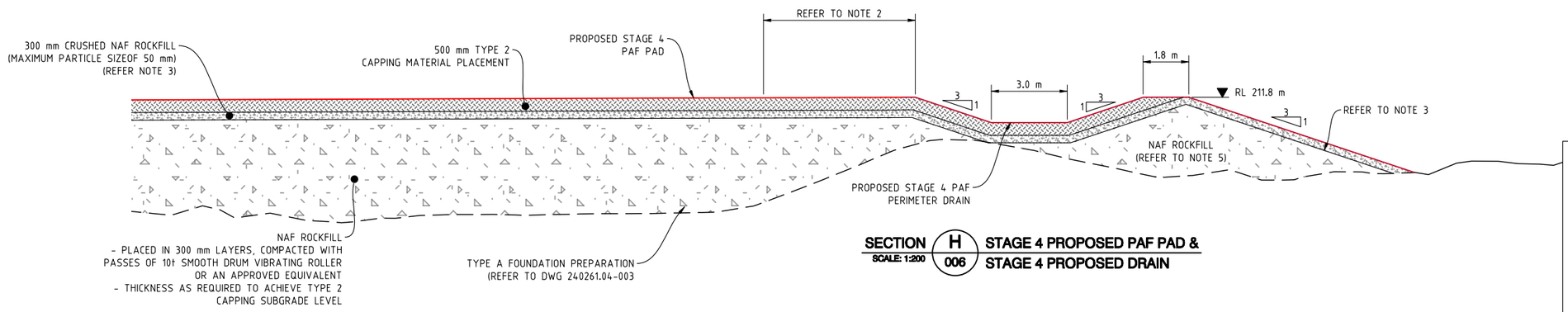


SECTION G / 006 — SCALE: 1:200 — **STAGE 4 PROPOSED PAF PAD 1 ENCAPSULATION**
STAGE 4 PROPOSED DRAIN



SECTION H / 006 — SCALE: 1:200 — **STAGE 4 PROPOSED PAF PAD &**
STAGE 4 PROPOSED DRAIN

LEGEND

- NAF ROCK ARMOUR
- GEOTEXTILE
- TYPE 2 CAPPING MATERIAL
- CRUSHED NAF ROCKFILL
- NAF ROCKFILL
- PAF ROCKFILL

NOTE:

1.- IT SHOULD BE NOTED THAT WHERE PAF ROCKFILL MATERIAL OR STOCKPILES EXIST OVER PROPOSED OR EXISTING TYPE 2 MATERIAL AREAS, THEY MUST BE EXCAVATED AS NECESSARY TO FACILITATE PROPER CONSTRUCTION AND TIE-IN OF TYPE 2 MATERIALS WITH EXISTING OR PLANNED SURFACES.

2.- A MINIMUM OF 3.0 m BUFFER TO BE MAINTAINED ALONG THE ENTIRE STAGE 4 PAF PERIMETER DRAIANGE SYSTEM.

3.- 300 mm CRUSHED NAF ROCKFILL PLACEMENT ON THE DOWNSTREAM SHOULDERS CAN BE OMITTED IF PROFILING IS ACCEPTABLE TO THE PRINCIPAL.

4.- WHERE TYPE 2 CAPPING MATERIAL INTERSECTS NAF ROCK ARMOUR, THE DRAIN INVERT SHALL BE GRADED TO REMAIN FREE DRAINING TO PREVENT WATER PONDING. ANY LOW POINTS CAUSED BY NAF PLACEMENT SHALL BE GRADED AS NECESSARY TO PREVENT LOCALISED WATER PONDING AND TO MAINTAIN POSITIVE DRAINAGE TOWARDS PAF DAM 2.

5.- PLACEMENT OF 300 mm CRUSHED NAF ROCKFILL LAYERS IS ALSO ACCEPTABLE WITHIN SMALLER REGIONS.

6.- SECTION G INCLUDES THE STAGE 3 CHUTE, WHICH COMPRISES 450 mm THICK NAF ROCK ARMOUR. TO AVOID CLUTTER AND CONFUSION, DETAILED STAGE 3 DRAIN INFORMATION IS NOT SHOWN (REFER TO STAGE 3 DRAWINGS FOR SECTION DETAILS). HOWEVER, THIS ROCK ARMOUR SHALL BE REMOVED, AND THE DRAIN INVERT LEVEL RAISED USING APPROPRIATE NAF ROCKFILL AND TYPE 2 MATERIALS, IN ACCORDANCE WITH THE STAGE 4 PERIMETER DRAIN DESIGN LINES AND LEVELS PROVIDED.

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
STAGE 4 PAF PERIMETER DRAIN
SECTIONS (SHEET 1 OF 2)

DWG. No. **240261.04-008**

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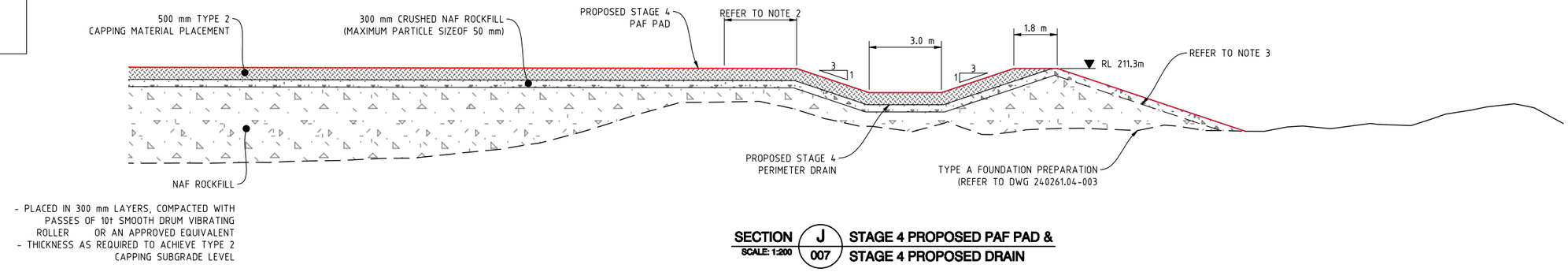
SHEET 1 OF 1

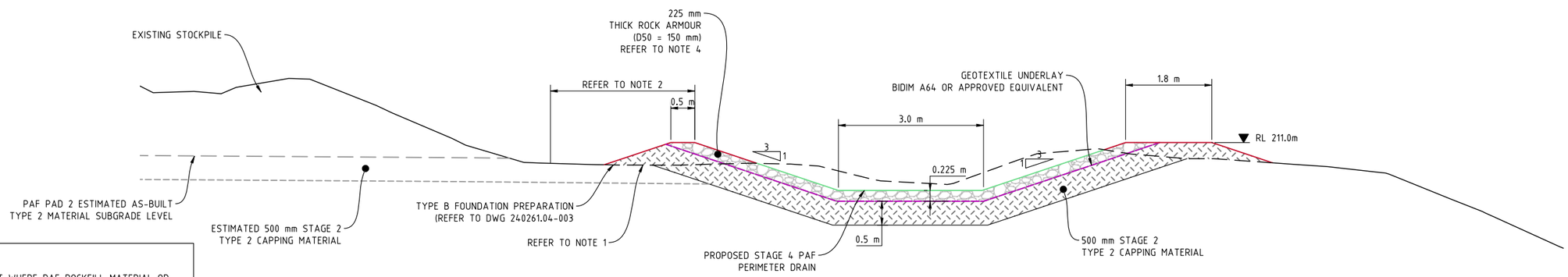
LEGEND

- NAF ROCK ARMOUR
- GEOTEXTILE
- TYPE 2 CAPPING MATERIAL
- CRUSHED NAF ROCKFILL
- NAF ROCKFILL
- PAF ROCKFILL



- PLACED IN 300 mm LAYERS, COMPACTED WITH PASSES OF 10t SMOOTH DRUM VIBRATING ROLLER OR AN APPROVED EQUIVALENT
- THICKNESS AS REQUIRED TO ACHIEVE TYPE 2 CAPPING SUBGRADE LEVEL

SECTION J 007 — SCALE: 1:200 — **STAGE 4 PROPOSED PAF PAD & STAGE 4 PROPOSED DRAIN**



SECTION K 007 — SCALE: 1:100 — **PROPOSED STAGE 4 PROPOSED DRAIN MODIFICATION**

NOTE:

1.- IT SHOULD BE NOTED THAT WHERE PAF ROCKFILL MATERIAL OR STOCKPILES EXIST OVER PROPOSED OR EXISTING TYPE 2 MATERIAL AREAS, THEY MUST BE EXCAVATED AS NECESSARY TO FACILITATE PROPER CONSTRUCTION AND TIE-IN OF TYPE 2 MATERIALS WITH EXISTING OR PLANNED SURFACES.

2.- A MINIMUM OF 3.0 m BUFFER TO BE MAINTAINED ALONG THE ENTIRE STAGE 4 PAF PERIMETER DRAIANGE SYSTEM.

3.- 300 mm CRUSHED NAF ROCKFILL PLACEMENT ON THE DOWNSTREAM SHOULDERS CAN BE OMITTED IF PROFILING IS ACCEPTABLE TO THE PRINCIPAL.

4.- WHERE TYPE 2 CAPPING MATERIAL INTERSECTS NAF ROCK ARMOUR, THE DRAIN INVERT SHALL BE GRADED TO REMAIN FREE DRAINING TO PREVENT WATER PONDING. ANY LOW POINTS CAUSED BY NAF PLACEMENT SHALL BE GRADED AS NECESSARY TO PREVENT LOCALISED WATER PONDING AND TO MAINTAIN POSITIVE DRAINAGE TOWARDS PAF DAM 2.

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 4 PAF PAD DETAILED DESIGN
STAGE 4 PAF PERIMETER DRAIN
SECTIONS (SHEET 2 OF 2)

DWG. No. 240261.04-009

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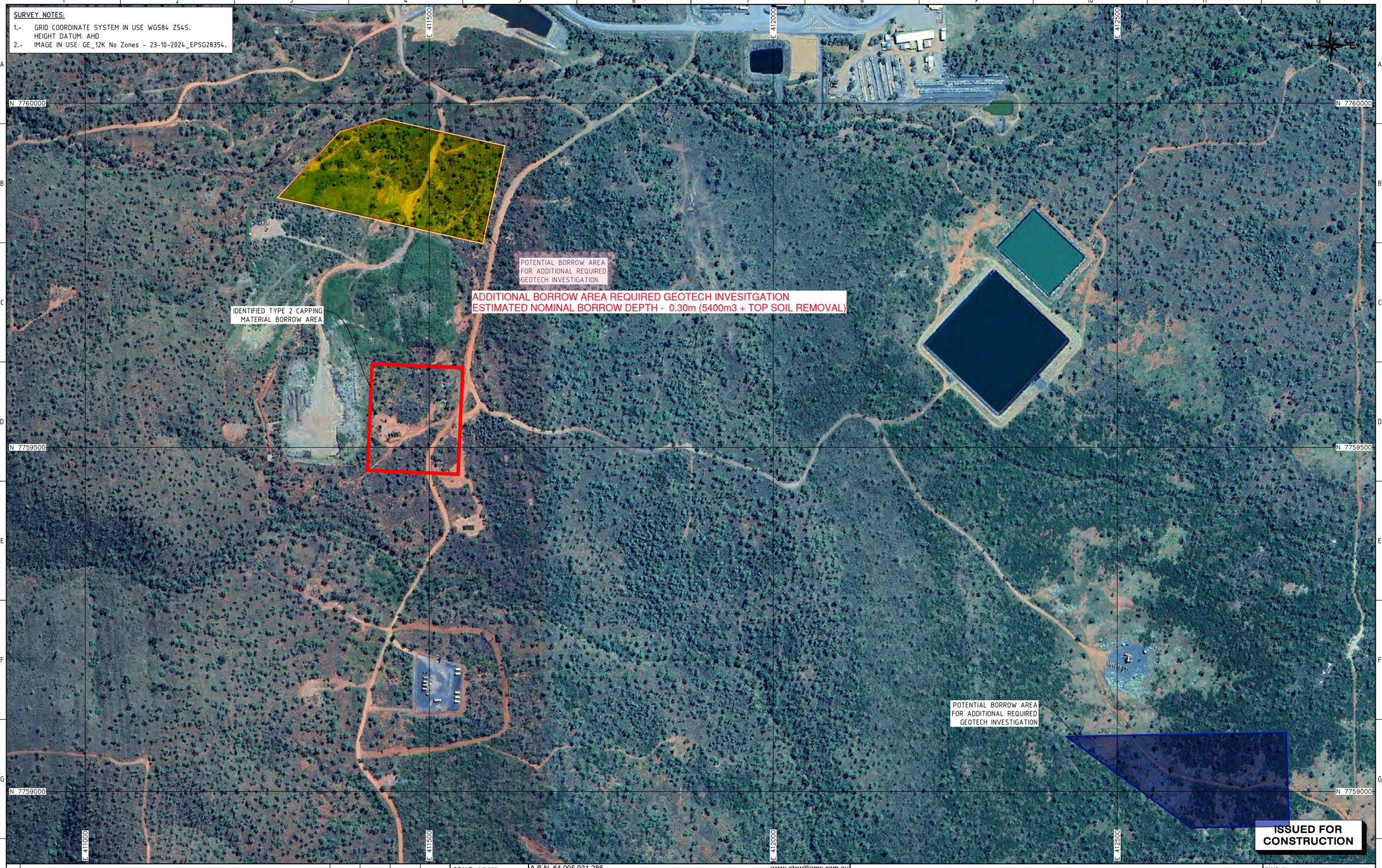
SHEET 1 OF 1

SURVEY NOTES:

1.- GRID COORDINATE SYSTEM IN USE WGS84 Z54S.
HEIGHT DATUM: AHD
2.- IMAGE IN USE: GE_12K No Zones - 23-10-2024_EPSG28354.



No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	19.12.25	HJ	MA	CN

SCALE:	1:5,000
JOB No.	240261.04
DATE	03.09.25
DESIGN	MA
DRAWN	HJ
CHECKED	MA
APPROVED	CN

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MMG DUGALD RIVER MINE
PAF WASTE ROCK DUMP

STAGE 3 PAF PAD DETAILED DESIGN
BORROW LOCATION PLAN

DWG. No.
240261.04-010

SHEET SIZE | Rev. 0

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SHEET 1 OF 1

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Printed on: Friday, 19 December 2025 10:32:10 AM

APPENDIX B – STAGE 4 PAF PAD STABILITY ASSESSMENT

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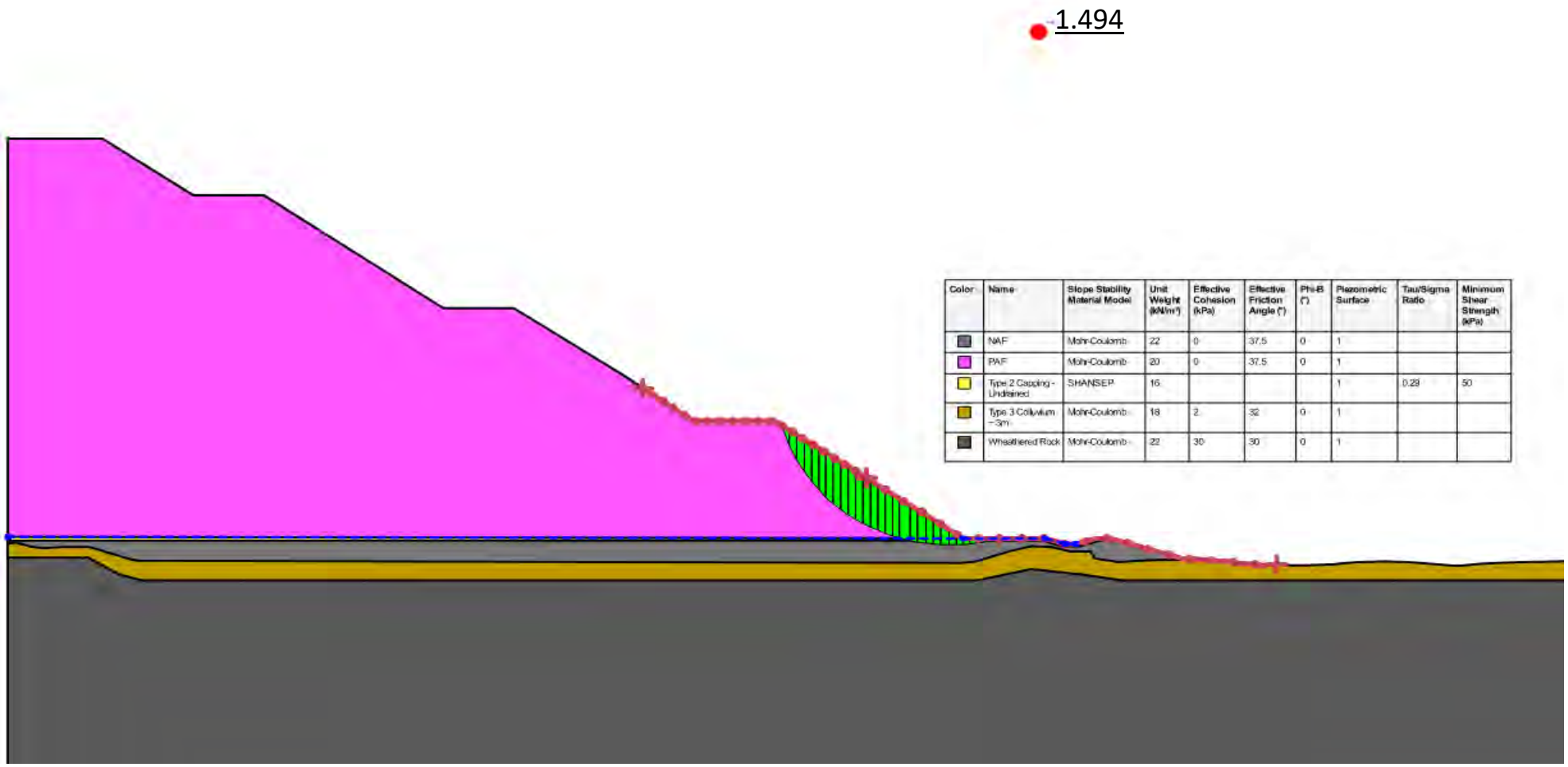

Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)	Phi-B (°)	Piezometric Surface	Tau/Sigma Ratio	Minimum Shear Strength (kPa)
	NAF	Mohr-Coulomb	22	0	37.5	0	1		
	PAF	Mohr-Coulomb	20	0	37.5	0	1		
	Type 2 Capping - Undrained	SHANSEP	16				1	0.29	50
	Type 3 Colluvium - 3m	Mohr-Coulomb	18	2	32	0	1		
	Weathered Rock	Mohr-Coulomb	22	30	30	0	1		

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MMG DUGALD RIVER MINE

Dugald River Mine

Stage 4 PAF Pad Expansion

Stability Assessment - Long Term Static Stability

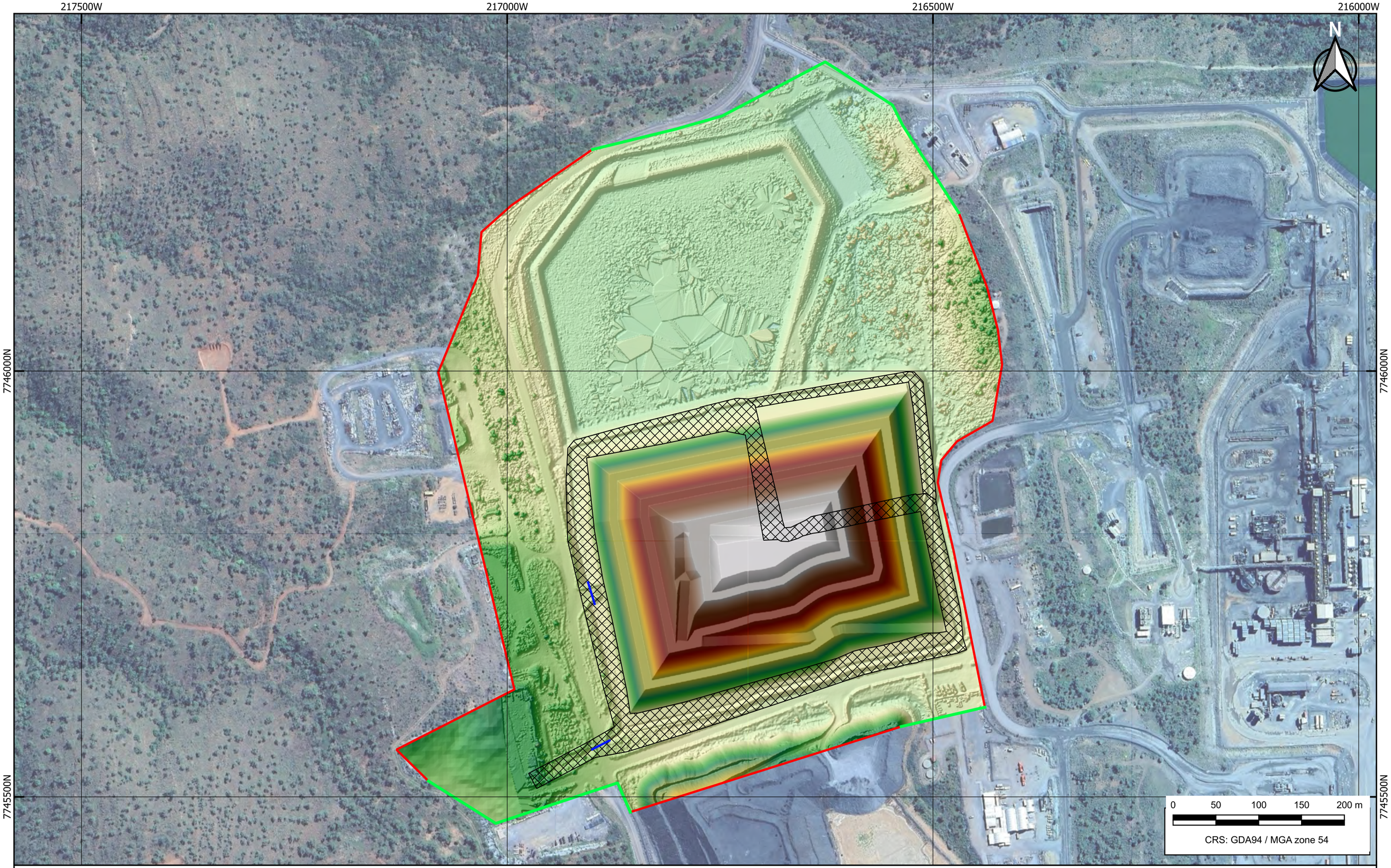
Date: 27/10/2025 **Job No:** 240261.04

FIGURE 1

S:\Dugald\240261 - PAF PAD Detailed Design\Data and Calcs\SlopeW\Stage 4\Figure 1- Stability Results G1

APPENDIX C – STAGE 4 PAF PAD EXPANSION HYDRAULIC MODEL FIGURES

TAILINGS.WATER.WASTE.



LEGEND
- Outflow Boundary
- Culvert
- Model Domain
- Quadtree Coverage

DEM (RL m)
282.2
201.2

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
Hydraulic Model

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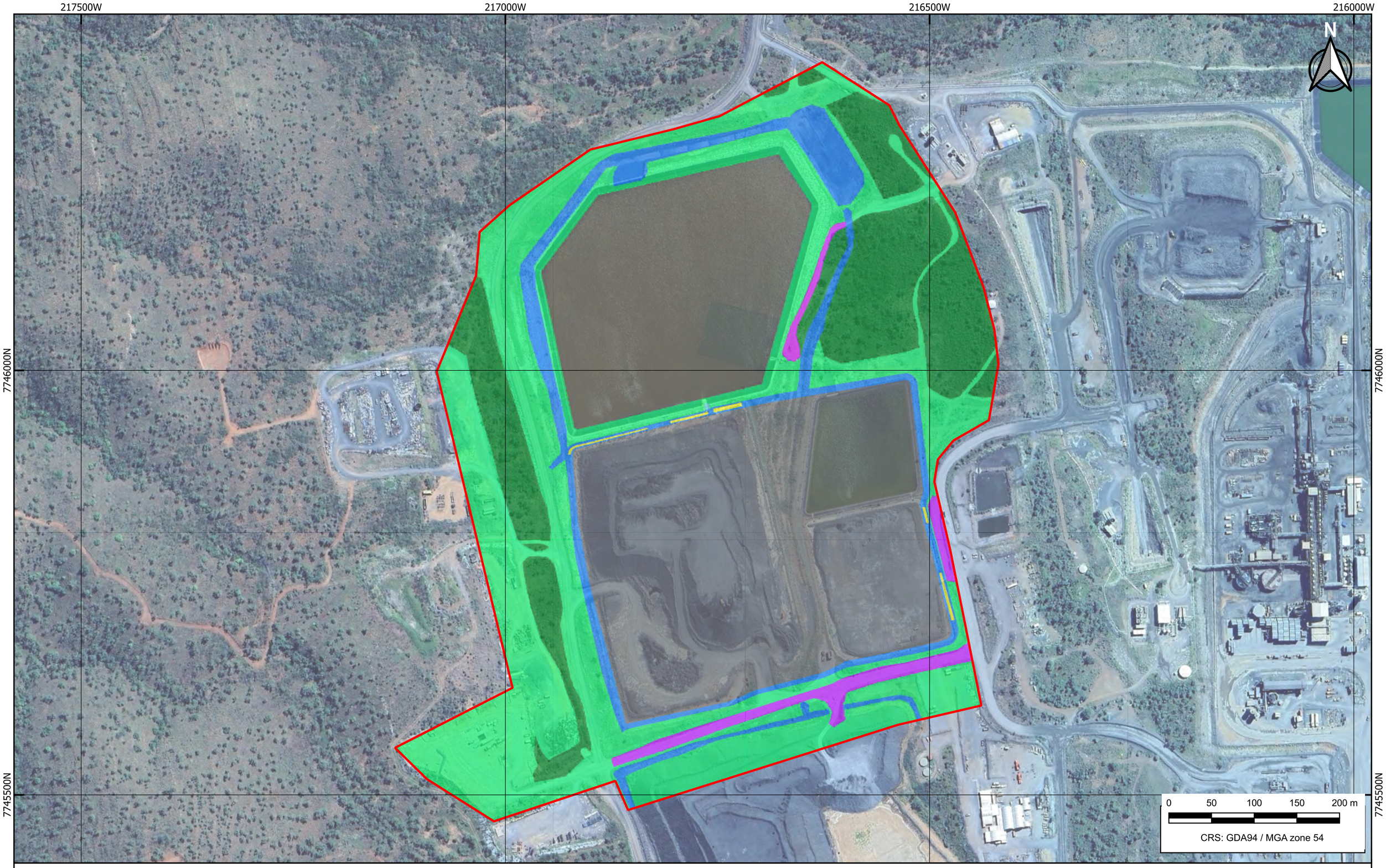
FIGURE 1

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:4000 at A3



LEGEND
- Model Domain
- Area with Medium Vegetation (n=0.06)
- Area with Dense Vegetation (n=0.09)
- Stockpile (n=0.06)
- Inlet Channel (n=0.015)
- Road (n=0.02)
- Drainage Channel (n=0.02)
- Riprap 150 mm (n=0.03)

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
Hydraulic Model Roughness

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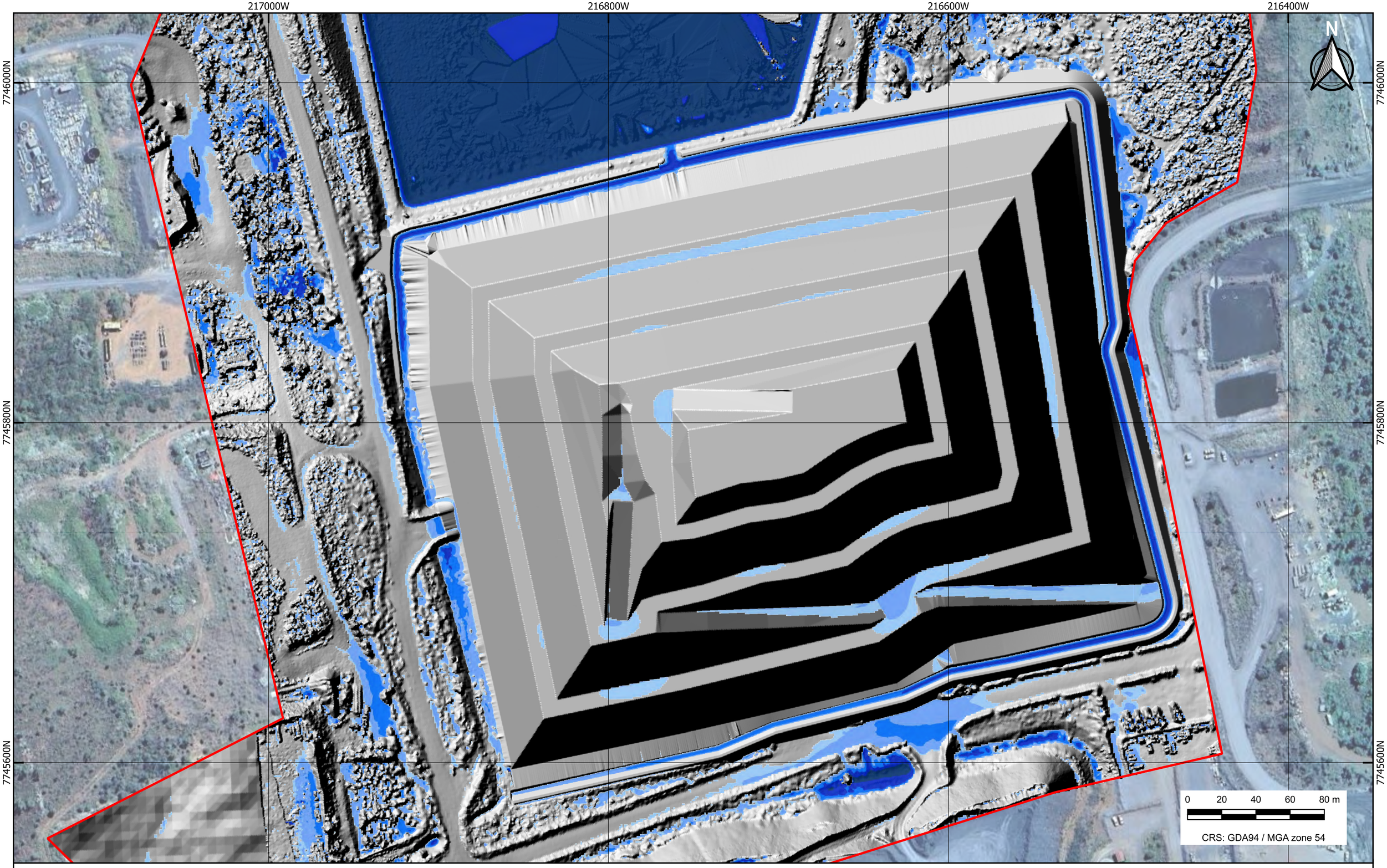
FIGURE 2

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:4000 at A3



LEGEND

Model Domain

1% AEP Max Depth (m)

- < 0.1
- 0.1 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- > 1.0

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
1% AEP Maximum Depth

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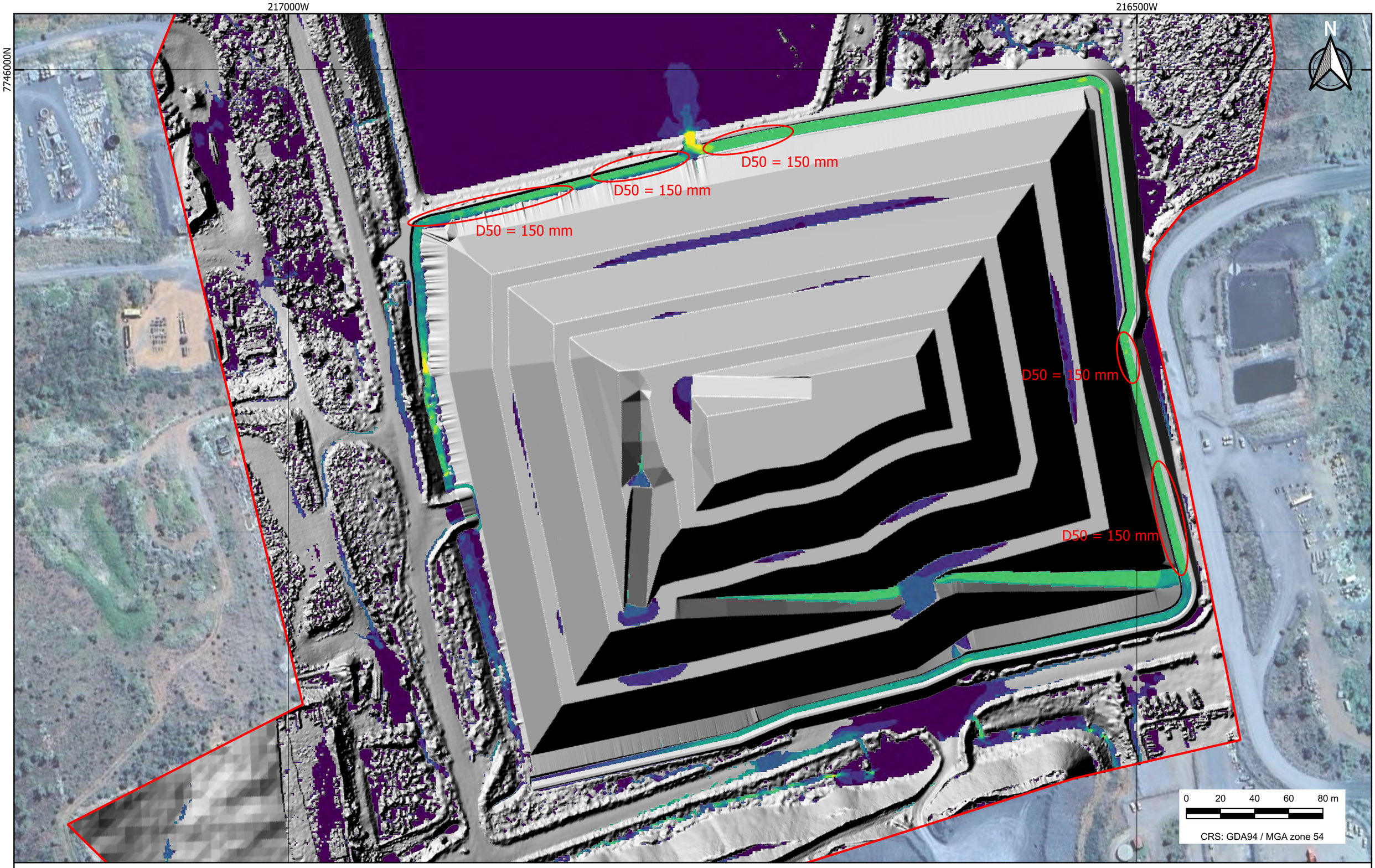
FIGURE 3

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:2000 at A3



LEGEND

- Model Domain

1% AEP Max Velocity (m/s)

- <= 0.10
- 0.10 - 0.25
- 0.25 - 0.50
- 0.50 - 0.75
- 0.75 - 1.00
- 1.00 - 1.50
- 1.50 - 2.00
- > 2.00

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
1% AEP Maximum Velocity

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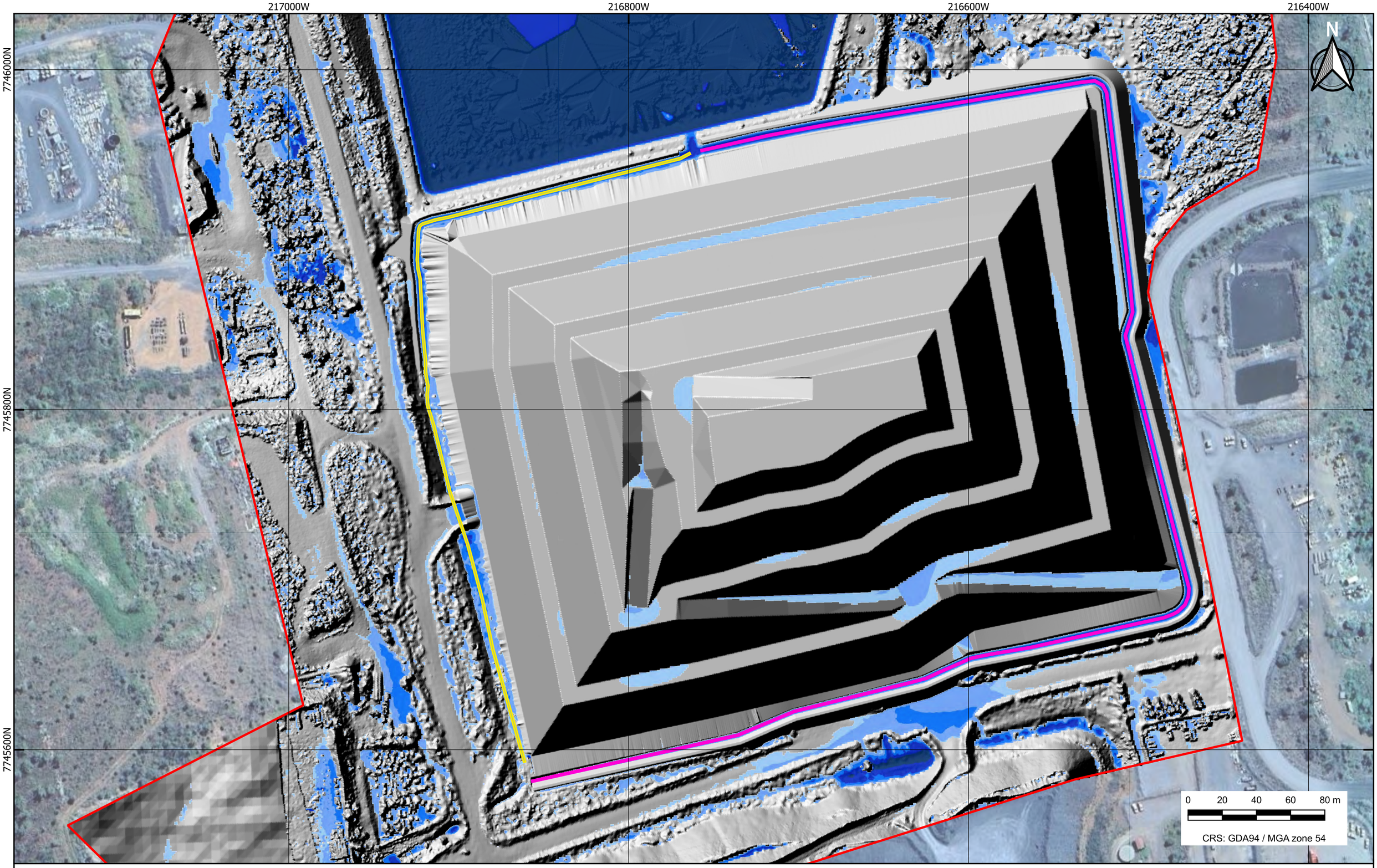
FIGURE 4

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:2000 at A3



LEGEND

- East Perimeter Drain
- West Perimeter Drain
- Model Domain

1% AEP Max Depth (m)

- < 0.1
- 0.1 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- > 1.0

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
Drainage Channel Section

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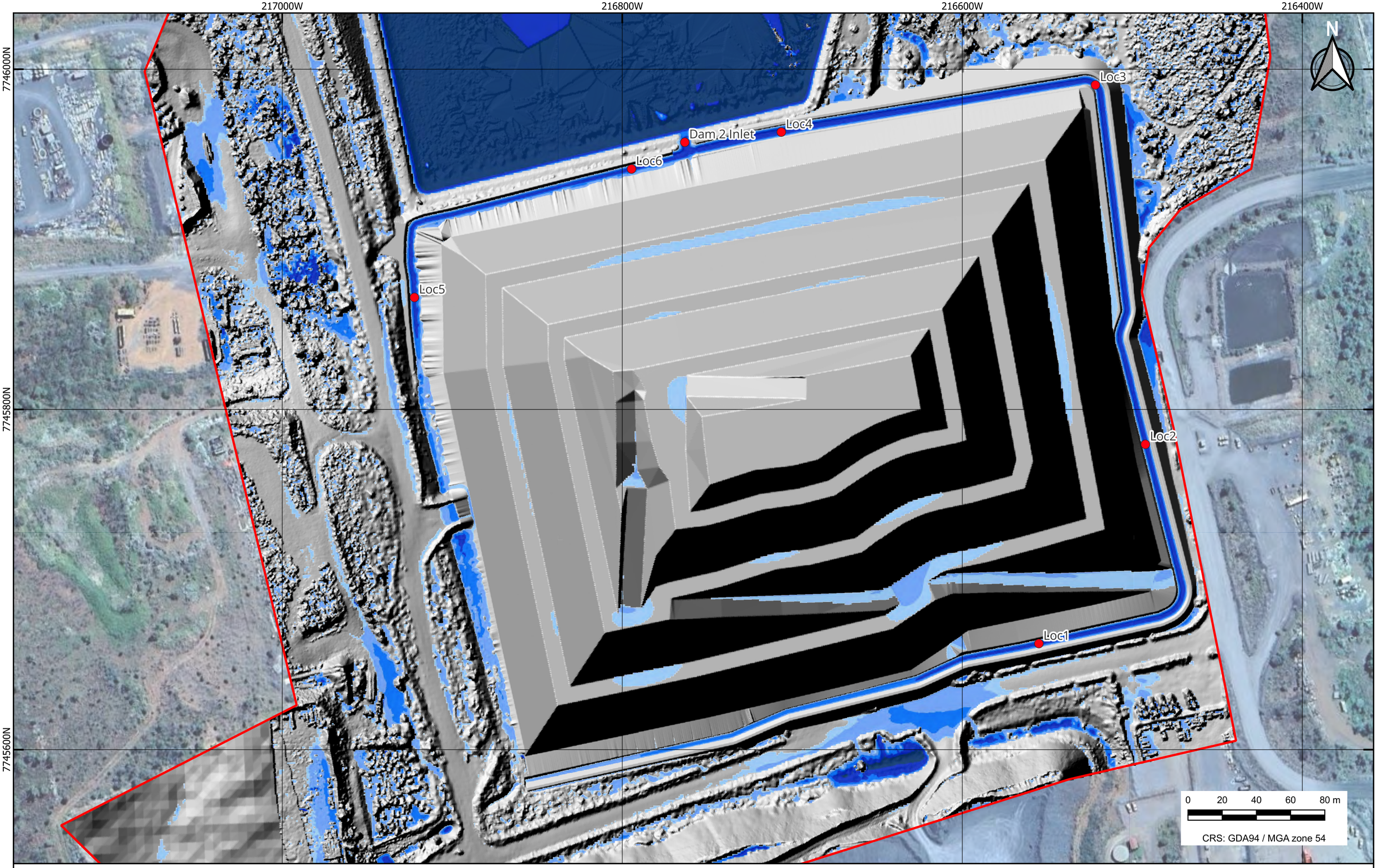
FIGURE 5

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:2000 at A3



LEGEND

- Hydrograph Location
- Model Domain

1% AEP Max Depth (m)

- < 0.1
- 0.1 to 0.3
- 0.3 to 0.5
- 0.5 to 1.0
- > 1.0

MMG DUGALD RIVER
Dugald River Mine PAF Pad Expansion Stage 4

Perimeter Drainage Design
Hydrograph Location

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FIGURE 6

JOB NO. 240261.03
DATE: 03/09/2025
SCALE: 1:2000 at A3

APPENDIX O: Stage 4 PAF Pad Expansion Civil Works – Technical Specification (ATCW, 2026e)

SPECIFICATION

MMG DUGALD RIVER
ABN: 19 083 405 556

Dugald River Mine
PAF Pad Expansion

Stage 4 PAF Pad Expansion Civil Works – Technical Specification

240261.04-S01 Rev 1
February 2026

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Document Control

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Document Title:	Stage 4 PAF Pad Expansion Civil Works – Technical Specification
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Document Number:	240261.04 S01

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1	Final Issue – Typo Correction	09/02/2026	JL	DMR

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CONTENTS

1 SCOPE AND GENERAL PROVISIONS 1

1.1 Introduction 1
1.2 Geotechnical Investigation 1
1.3 Scope 1
1.4 Construction Drawings 2
1.5 Civil Quantities 2
1.6 Definitions of Parties and Personnel Roles 3
1.6.1 Principal 3
1.6.2 Superintendent 3
1.6.3 Design Engineer 3
1.6.4 Contractor 3
1.7 Quality Plan 3
1.7.1 Overview 3
1.7.2 Inspection and Testing Plan (ITP) 3
1.7.3 Request for Information (RFI) 4
1.7.4 Non-Conformance Report (NCR) 4
1.8 Housekeeping 4
1.9 Survey and Setout 4
1.9.1 Set-Out of the Works 4
1.9.2 Required Survey 5
1.9.3 As-Constructed Survey Requirements 5
1.10 Protection of the Works 6

2 EARTHWORKS GENERAL 6

2.1 Existing Conditions 6
2.2 Construction Plant 6
2.3 Traffic Management 6
2.4 Access Tracks and Haul Roads 6
2.5 Dust Suppression 7
2.6 Drainage and Dewatering 7
2.7 Construction Water 7

3 SITE PREPARATION 7

3.1 Site Preparation, Disturbances and Access 7
3.2 Topsoil 7
3.2.1 Definition 7
3.2.2 Stripping and Stockpiling of Topsoil 8
3.2.3 Formation of Stockpiles 8
3.3 Spoil and Unsuitable Material 8
3.3.1 General 8
3.3.2 Disposal 8

4 FOUNDATION PREPARATION 9

4.1 Overview 9
4.2 Type A – Natural Surface Foundation Preparation 9
4.3 Type B – Existing Surface Foundation Preparation 9

5 STAGE 4 CONSTRUCTION MATERIALS 10

5.1 General 10
5.2 Type 2 Capping Material 10
5.3 PAF / NAF Rockfill 10
5.3.1 PAF Rockfill 10
5.3.2 NAF Rockfill 11
5.3.3 Crushed NAF Rockfill 11
5.4 NAF Rock Armour 11

TAILINGS.WATER.WASTE.

5.5 Geotextile 11

6 BORROWS AND STOCKPILE MANAGEMENT 12

6.1 Borrow Area Development 12
6.2 Stockpile Management 12
6.3 Source of Materials 13

7 CONSTRUCTION REQUIREMENTS 13

7.1 General Requirements 13
7.2 Construction Tolerances 13

8 PLACEMENT OF FILL MATERIALS 14

8.1 Type 2 Capping Materials 14
8.1.1 Placement 14
8.1.2 Compaction Requirements 14
8.1.3 Acceptance Testing 15
8.1.4 Remedial Action 15
8.1.5 Moisture Conditioning 15
8.2 Crushed NAF/ NAF / PAF Rockfill 16
8.2.1 Placement 16
8.2.2 Compaction 16
8.2.3 Acceptance Testing 16
8.3 NAF Rock Armour 17

9 INSTALLATION OF GEOTEXTILE 17

9.1 General 17
9.2 Quality Control 17
9.3 Geotextile Installation 17
9.4 Transportation, Labelling, Handling and Storage 18

10 INSPECTION, TESTING AND VERIFICATION 18

10.1 Inspections and Hold Points 18
10.2 Testing Authority & Methods 19
10.3 Quality Control Criteria 20
10.4 Performance Specification Testing 20
10.4.1 Overview 20
10.4.2 Insitu Density Testing 20
10.4.2.1 General Requirements 20
10.4.2.2 Testing Methods 21
10.4.3 Material Compliance Testing 21

REFERENCES 22

TABLES

TABLE 1.1: LIST OF DRAWINGS 2
TABLE 5.1: TYPE 2 MATERIALS CHARACTERISTICS SUMMARY 10
TABLE 5.2: NAF ROCK ARMOUR PARTICLE SIZE REQUIREMENTS 11
TABLE 5.3: NAF ROCK ARMOUR PARTICLE SIZE REQUIREMENTS 12
TABLE 6.1: ANTICIPATED SOURCES OF CONSTRUCTION MATERIALS 13
TABLE 7.1: CONSTRUCTION TOLERANCES 13
TABLE 8.1: TYPE 2 CAPPING MATERIAL PLACEMENT AND COMPACTION REQUIREMENTS ... 15
TABLE 8.2: REMEDIAL ACTION FOR COMPACTED TYPE 2 CAPPING MATERIAL 15
TABLE 8.3: PAF / NAF ROCKFILL AND CRUSHED NAF ROCKFILL PLACEMENT AND COMPACTION REQUIREMENTS 16
TABLE 10.1: TYPE 2 MATERIAL TESTING REQUIREMENTS 20

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APPENDICES

APPENDIX A GEOTECHNICAL INVESTIGATION
APPENDIX B SCHEDULE OF QUANTITIES

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1 SCOPE AND GENERAL PROVISIONS

1.1 Introduction

This Technical Specification sets out the requirements for construction of the Stage 4 PAF Pad Civil Works at the MMG Dugald River Mine (DRM), located approximately 65 km northwest of Cloncurry, Queensland. As part of its mining operations, DRM manages Potentially Acid Forming (PAF) and Non-Acid Forming (NAF) waste rock materials, which are stored within designated Waste Rock Dumps (WRD) and dedicated PAF and NAF Waste Rock Pads. The need for additional waste storage capacity has led to the planned expansion of the PAF Pads, forming the Stage 3 and Stage 4 PAF Pad developments.

The works described in this Specification shall involve construction of the Stage 4 PAF Pad, Stage 4 Perimeter drainage channel and modification of existing perimeter drainage channels. Construction works will involve but not be limited to the following:

- Bulk excavation of the Borrow Areas, south of the NAF WRD. The excavated materials are to be used as the primary Type 2 Capping material source for the Stage 4 PAF Pad and Perimeter drain construction.
- Removing unsuitable materials, undertaking foundation preparation works and raising the natural and PAF surface level by using all-in NAF/PAF and Crushed NAF Rockfill to place a 500 mm thick Type 2 Capping layer.
- Shaping and profiling perimeter drains to place Type 2 Capping materials, Geotextile and select NAF Rock Armour.
- Pulling back of existing PAF stockpiled materials in isolated areas to tie-into the existing Type 2 Capping materials.

This Technical Specification comprises all civil works required to complete the above, hereafter referred to as “the Works”.

1.2 Geotechnical Investigation

Geotechnical investigations and laboratory testing for the DRM Stage 4 PAF Pad Expansion are documented in ATCW letter report 240261.02-L01 **[1],** included as **Appendix A** to this technical specification. This letter report contains factual information pertaining to the geotechnical logs of test pits conducted in the proposed Type 2 capping material (which are proposed to be used as low permeability earth fill) borrow area, as well as the results of laboratory testing for physical properties of materials sampled from the field work.

1.3 Scope

Construction of the DRM Stage 4 PAF Pad Expansion **[2]** shall be in accordance with this Specification and the Drawings. Construction of the Stage 4 PAF Pad shall comprise the following Works:

General:

1. Mobilisation of all necessary plant and materials.
2. Setting out of the Works and initial site preparation.
3. Clearing, grubbing and stripping of topsoil to a nominal depth of 0.2 m within the footprint of the Type A Foundation over Natural Surfaces.
4. Borrow Area Development and Management.

Foundation Preparation and Excavation:

1. Type A - Natural Surface Foundation Preparation at the contact areas between PAF Pad fill and stripped natural ground.

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2. Type B - Existing Surface Foundation Preparation at the contact areas between the PAF Pad fill and the existing PAF Pad / drains. Preparation shall consist of the excavation of all existing loose or wet soil and rockfill to the design lines and levels.

PAF Pad 1 Encapsulation, Stage 4 PAF Pad and Perimeter Drains Construction:

1. Placement, compaction and testing of Type 2 Caping materials (placed in two layers of 250 mm thickness) on PAF Pad and within PAF perimeter drains. To be won from borrow area and/or temporary stockpiles.
2. Placement and compaction of NAF/PAF Rockfill on prepared and approved foundations. To be sourced from PAF and NAF WRD at the directions of the Superintendent.
3. Placement and compaction of 300 mm thick Crushed NAF Rockfill over the compacted and approved NAF/PAF Rockfill layers. NAF Rockfill required to be crushed to produce maximum particle size of 50 mm.
4. Placement of Bidim A64 Geotextile underlay and NAF Rock Armour (erosion protection) rockfill within the PAF Perimeter drains in selected areas requiring additional erosion protection.

Demobilisation:

1. Demobilisation of all plant and materials.

1.4 Construction Drawings

This Specification shall be read together with the Construction Drawings listed in **Table 1.1**.

Any conflicts discovered by the Contractor, between the Specification and the Drawings, must be brought to the attention of the Superintendent and Design Engineer immediately. Work shall be carried out only in accordance with “Issued for Construction” (IFC) Drawings by the Superintendent. No other drawing shall be used unless the Superintendent directs in writing that it shall also constitute a construction drawing.

TABLE 1.1: LIST OF DRAWINGS

Drawing No.	Title
240261.04-000	Drawing List & Locality Plan
240261.04-001	Existing Conditions
240261.04-002	General Layout Plan
240261.04-003	Foundation Preparation Plan
240261.04-004	Stage 4 PAF Pad & Pad 1 Encapsulation – Sections (Sheet 1 of 2)
240261.04-005	Stage 4 PAF Pad & Pad 1 Encapsulation – Sections (Sheet 2 of 2)
240261.04-006	Stage 4 PAF Perimeter Drain – Plan & Long Section (Sheet 1 of 2)
240261.04-007	Stage 4 PAF Perimeter Drain – Plan & Long Section (Sheet 2 of 2)
240261.04-008	Stage 4 PAF Perimeter Drain – Sections (Sheet 1 of 2)
240261.04-009	Stage 4 PAF Perimeter Drain – Sections (Sheet 2 of 2)
240261.04-010	Borrow Location Plan

1.5 Civil Quantities

Estimated quantities for construction of the Stage 4 PAF Pad expansion and associated works described in this Specification are included in the Schedule of Quantities provide in **Appendix B**.

1.6 Definitions of Parties and Personnel Roles

1.6.1 Principal

The Principal is the entity who will own the facilities to be constructed and who is responsible for the property on which it is to be constructed. MMG Dugald River is the Principal.

1.6.2 Superintendent

The person(s) of an organisation who will be directly responsible for managing the Works on behalf of the Principal. The Superintendent is the Principal's Representative.

1.6.3 Design Engineer

The Design Engineer shall be a representative of the design team (ATCW). The Design Engineer will provide guidance to the Superintendent, Principal and/or Contractor to clarify technical issues that may arise with the Drawings or Specification during construction.

1.6.4 Contractor

The entity responsible for the construction of the Works in accordance with the Drawings and Specification, as far as practical, to meet the design intent to the approval of the Superintendent and the Principal.

1.7 Quality Plan

1.7.1 Overview

The Quality Plan shall outline the Contractor's proposals for quality management for the duration of the Contract. A copy of the Quality Plan shall be retained in the Contractor's site office and shall be available for inspection by the Superintendent.

Components of the Quality Plan shall comprise:

1. An Inspection and Testing Plan (ITP).
2. A system for Request for Information (RFI).
3. A system for recording Non-Conformance (Non-Conformance Reports, NCR's) with the Specifications for material compliance testing, and other conformance activities.

1.7.2 Inspection and Testing Plan (ITP)

The Contractor shall prepare an Inspection and Testing Plan (ITP) for each element of the Works. The ITP's shall be updated as required during the Works for each work activity. The ITP's shall cover all material supply, construction, installation, testing and commissioning, as required, for each element of the Works, and shall include:

1. A description of the work element.
2. Details of equipment to be used for the work element.
3. Records of tests performed, as required.
4. Identification and verification of the tests performed in relation to acceptance criteria.
5. Hold points required to be inspected by the Superintendent.

The ITP's shall be provided to the Superintendent for review prior to the commencement of any works for review and approval.

A copy of the ITP's shall be retained in the Contractor's site office.

1.7.3 Request for Information (RFI)

Where the Contractor wishes to clarify any issue with the Works or to suggest changes to the Works as presented in the Specification or on the Drawings, the request shall be made on an RFI. The RFI's shall be numbered sequentially and submitted to the Superintendent. The Superintendent will consider the request and respond in writing to the Contractor. Where necessary, the Superintendent may consult with the Design Engineer on RFI's relating to technical or design queries for direction on the RFI response to the Contractor.

The Contractor shall only accept instructions relating to the Works, which are issued by the Superintendent in writing. Instructions from the Superintendent may also come in the form of a Site Instruction (SI).

Any direction or clarification sought by the Contractor shall be made in writing using an RFI. The Superintendent may provide verbal clarification, but such verbal clarification shall be followed-up in writing by the Contractor via an RFI and the Superintendent will respond within 7 days of receiving the RFI.

1.7.4 Non-Conformance Report (NCR)

A non-conformance of any part of the works may be identified by any relevant party (Superintendent, Design Engineer or Site Engineer, or the Contractor themselves), and be brought to the attention of the Contractor. In the event of any non-conformance with any part of the Specification, the Drawings or the Contractor's Quality Plan, the Contractor shall promptly advise the Superintendent, and prepare an NCR.

The Contractor shall prepare an NCR that states the area and nature of the non-compliance and what rectification works are proposed. In the absence of an NCR from the Contractor, the Superintendent shall have the right to issue an NCR to the Contractor and the Contractor shall present the rectification works that are proposed (if any).

1.8 Housekeeping

The Contractor shall keep the work site tidy. As a minimum, the Contractor shall:

- Keep site offices tidy at all times and make provision for regular cleaning of the floors and fixtures,
- Keep the Works site clean and collect all wrapping and packaging from any materials delivered to site and dispose of in the designated waste area, or as directed by the Superintendent. Wrapping and packaging shall not be allowed to blow around the site,
- Regularly grade and maintain access tracks around the site, and
- Maintain material stockpiles.

1.9 Survey and Setout

1.9.1 Set-Out of the Works

MMG will provide reference benchmarks and coordinate points in the vicinity of the site and the Contractor shall establish all centrelines, offsets, locations and levels necessary to complete the Works in accordance with this Specification and the Drawings.

The coordinate system used in this Contract shall be MGA (Map Grid of Australia), with all levels relating to AHD (Australian Height Datum).

Measuring off the Drawings shall not constitute a method of set out for any part of the works.

Electronic files of the designs will be provided on request to assist with set-out. The Contractor shall check the electronic files provided to ensure alignment with the details provided in the Drawings. Any discrepancies shall be brought to the attention of the Superintendent and the Design Engineer for clarification.

The Contractor shall employ a suitably qualified surveyor for this work and shall be completely responsible for setting out the work in accordance with the Drawings. Data on any temporary benchmarks or setting out points installed by the Contractor shall be made available to the Superintendent on request to facilitate checking of the Works.

On completion of setting out of each Section of the Works, the Contractor shall notify the Superintendent and shall obtain approval before proceeding with the next section of the Works.

Existing surface levels shown on the Drawings have been obtained from previous surveys and may vary from actual surface levels on site. Whilst all survey information is given in good faith, the Contractor shall ascertain the accuracy of such data.

The Contractor shall undertake a detailed survey of the Works prior to commencing any works. The Contractor shall promptly forward the survey to the Superintendent. Failure on the part of the Contractor to conduct the detailed survey will result in the survey used for design purposes being used as the base survey for the calculation of as-constructed volumes.

1.9.2 Required Survey

The Contractor shall be responsible for the submission of interim and ongoing survey of critical items of the works to the Superintendent and Site Engineer necessary for the verification and approval of placed and compacted layer thicknesses. The Superintendent and/or Site Engineer reserves the right to suspend the Works until suitable survey of the layer is provided and verified as conforming to the requirements of this Specification.

The Contractor shall also routinely provide the Principal / Superintendent with sufficient survey information to certify quantities claimed for payment purposes.

In addition to the ongoing surveys, the Contractor shall carry out As-Constructed surveys of all items in accordance with **Clause 1.9.3**.

1.9.3 As-Constructed Survey Requirements

The Contractor shall carry out construction surveys of all principal items for production of As-Constructed 3D CADD models of the Works. Submission of suitable quality As-Constructed 3D models shall be included in and alongside the As-Constructed Red-Line drawings in submission to the Principal and Design Engineer at completion of The Works.

At a minimum, as-constructed surveys shall be conducted for the following:

1. Completion of stripped and prepared foundations of the Works,
2. Completion of the NAF/PAF Rockfill placement,
3. Completion of 300 mm crushed NAF Rockfill placement,
4. Completion of Type 2 capping layer placement,
5. Completion of the PAF Perimeter Drainage installation and modification,
6. Placement of Rock Armour within Perimeter Drainage channel,
7. Borrow areas and stockpile areas following completion of the Works, and
8. Completed facility construction.

The Contractor shall promptly provide the as-constructed surveys in the following formats:

- Electronic format in AutoCAD .dxf, containing 3D polylines of all break lines, and 3D faces of all surfaces. Break lines shall be provided at all changes in slope/grade and at the termination of works.
- .pdf formats (at a suitable scale) to the Superintendent, as requested.

Where the Contractor believes that survey information does not adequately record the construction work, the Contractor shall invite the Superintendent to attend the site for a visual inspection.

1.10 Protection of the Works

The Contractor shall provide necessary protection during the course of the Works to ensure final acceptance of the finished Works by the Superintendent.

The Contractor shall be responsible for ensuring that all existing and finished surfaces are protected from damage while carrying out the Works. This shall include contamination from site conditions, climatic conditions, or any other cause, until the date of Practical Completion of the Works.

In the event that a part of the Works is damaged or otherwise compromised, the Contractor shall make good as necessary and shall repair all damaged and defective materials. It is the Contractor's responsibility to ensure that the Works are completed to the satisfaction of the Superintendent.

2 EARTHWORKS GENERAL

2.1 Existing Conditions

The existing conditions of the Dugald River PAF Pad are shown in Drawing 240261.04-001. The PAF Pad site is based on aerial survey undertaken on April 2025. Aside from PAF WRD development, no civil works have been undertaken at the site since this survey, and this drawing is believed to accurately represent the existing site conditions. Notwithstanding the above, following planned Stage 3 Works completion an updated survey of the existing conditions within the PAF WRD area will be provided and confirmed on site by the Superintendent prior to construction commencing.

2.2 Construction Plant

The Contractor shall be entirely responsible for providing all construction plant of adequate type, capacity and availability to carry out the Works in accordance with this Specification and associated Construction Drawings. All equipment must be approved by the Principal prior to use on the site.

Arrangements shall be made prior to plant coming to site for an offsite inspection by the Principal to ensure all plant is as near as possible to defect free prior to arrival onsite. The inspection shall ensure that all plant is clean and free of soil, weeds, seeds and any other organic matter before arrival on site.

Service and maintenance records for all construction plant proposed to be used in the Works should be up to date and should be made available on request by the Superintendent.

2.3 Traffic Management

The Contractor shall prepare and submit a Traffic Management Plan (TMP) in accordance with the requirements and to the satisfaction of the Principal. The TMP shall, as a minimum, present:

- Methods for access and egress from areas of the site,
- Methods for barricading and closing access to sections of the site (as required),
- Call-up procedures for access to areas of the site (as required), and
- A plan showing areas of the site, inclusive of access points and call-up locations (as required).

The Contractor shall ensure that all its employees and Sub-Contractors who operate at the site are trained in the application of the TMP.

2.4 Access Tracks and Haul Roads

The Contractor shall provide the minimum number of access tracks, ramps and haulage roads to carry out the work in order to minimise disturbance to the surrounding areas.

The Superintendent shall approve all such tracks, ramps and haul roads, subject to their general compliance with the Contractor's traffic management procedures.

TAILINGS.WATER.WASTE.

All access ramps shall have safety bunds constructed on the outer edges to prevent accidents. The safety bunds shall be sized to suit the largest type of construction vehicle utilised by the Contractor.

The Contractor shall be responsible for the upkeep and maintenance of all access tracks, ramps and haul roads. The Contractor shall ensure that tracks or roads are kept free of debris and are available for traffic at all times.

2.5 Dust Suppression

The Contractor shall be responsible for the suppression of dust arising as a result of work being carried out under the Contract. The Contractor shall suppress dust by spraying with water to prevent dust becoming a safety hazard. Suppression shall be to the satisfaction of the Superintendent.

Allowance for dust suppression shall be deemed to be part of the Contractor's Works.

2.6 Drainage and Dewatering

The Contractor shall perform any work found necessary for the diversion, restriction or management of any flow or seepage of surface or groundwater on, into, or around the Works, including borrow and stockpile areas, during the progress of the Contract.

Prior to the commencement of any drainage or dewatering operations, the Contractor shall provide the Superintendent with details of the proposed method of water management and disposal. Any consequence of either ground water or surface water against any structure or construction process shall be the sole responsibility of the Contractor.

Allowance for water management shall be deemed to be part of the Contractor's Works.

2.7 Construction Water

Water required for the purposes of construction, such as conditioning of earthworks fill or dust suppression, will be available from sources as directed by the Superintendent.

The source and arrangements for its access and/or delivery will be confirmed by the Superintendent prior to commencement of the Works.

3 SITE PREPARATION

3.1 Site Preparation, Disturbances and Access

A temporary staging area will be designated at the site for storage of plant and construction materials to be used during the Works.

The work sites are serviced by light vehicle access and haul roads that may need to be extended and/or improved in some places to accommodate construction traffic and provide suitable access to all work areas. The Superintendent shall approve any new haul roads and changes to the existing haul / access roads proposed by the Contractor. Special care must be taken to minimise the impact of construction activities.

The Contractor shall be responsible for the maintenance of all access tracks and haul roads in accordance with the requirements set out in **Clause 2.4**.

3.2 Topsoil

3.2.1 Definition

In the context of this Specification, "topsoil" shall refer to the uppermost layer of natural earth material which supports, or is capable of supporting, vegetation growth. Because the visual distinction between

topsoil and other soil which underlies it can be difficult to make, the limit of thickness of material to be removed and stockpiled shall be determined for each part of the site by the Superintendent.

The Superintendent and/or Site Engineer shall be solely responsible for classifying material as topsoil and may classify some material as topsoil even though it contains no evident grass, roots, humus or other organic material, and irrespective of whether it contains rock, gravel or similar material.

3.2.2 Stripping and Stockpiling of Topsoil

Stripping of topsoil shall be to a nominal depth of 0.2 m, unless otherwise directed by the Superintendent and/or Site Engineer. When removed, topsoil shall be hauled to a suitable location as directed by the Superintendent and formed into stockpiles. 'Forming into stockpiles' shall include any required measures to seal against generation of dust and erosion by wind or water.

When stripped, topsoil shall be carted promptly to one or more locations within 1 km of the Works as directed by Superintendent and formed into stockpile(s). The area(s) set aside for topsoil stockpiling shall have a constant grade and shall be cleared prior to the placement of topsoil.

3.2.3 Formation of Stockpiles

Unless otherwise directed by the Superintendent, stockpiles shall be formed into regular trapezoidal shapes in cross section, such that the height is 2 m and the side slopes are at 1 : 4 (V : H). End ramps at slopes approximately 1 : 8 (V : H) shall also be constructed.

The length of each stockpile shall be as directed by the Superintendent, and the surface shall be crowned and lightly rolled. Slopes to sides and end ramps shall be trimmed and lightly rolled with a smooth drum roller. No departure from specified slopes and dimensions shall be undertaken without the approval or direction of the Superintendent.

"Forming into stockpile" shall include any required measures to seal the stockpile against water or wind erosion, or against dust problems. In the context of this Specification, the minimum compaction requirements to seal the surface of the stockpile shall consist of three (3) passes of a smooth-drum roller of minimum mass 10 tonne. No material shall be removed from stockpiles without the approval of the Superintendent.

3.3 Spoil and Unsuitable Material

3.3.1 General

Material classified as spoil, or as unsuitable material for construction purposes as judged by the Superintendent and/or Site Engineer, shall be stockpiled at a location directed by the Superintendent. Unsuitable material as judged by the Superintendent may include:

- Excavated existing PAF Pad and perimeter drain materials,
- Existing / Excavated foundations that, in the judgement of the Superintendent and/or Site Engineer, cannot be re-worked to produce a competent foundation due to moisture condition or deleterious inclusions,
- Materials claimed by the Contractor to be Type 2, NAF/PAF Rockfill, and Rock Armour materials that do not meet the respective material specifications presented herein,
- Organic materials,
- Materials that may be PAF (except when used in designated PAF placement areas) when exposed to the atmosphere, and/or
- Other similar potentially unsuitable construction materials.

3.3.2 Disposal

Any excavated unsuitable material from within the existing PAF Pads and perimeter drainage channels (whether due to drain modification or other works) must be stockpiled within the existing PAF WRD, due to contamination concerns and at the direction of the Superintendent.

TAILINGS.WATER.WASTE.

Other unsuitable materials shall be transported to designated spoil areas, for later use, at the direction of the Superintendent. The designated spoil areas shall be within 500 m of the Works area. No spoil shall be disposed of in other areas without the approval of the Superintendent.

Areas proposed to be used as spoil areas shall be graded such that vegetation is removed and the area is generally uniform and planar. Windrows from grading may be left in place for later incorporation into the spoil area. Material to be disposed of within spoil areas shall be spread in uniform layers not exceeding 2 m thickness and in such a manner that the spoil areas remain free draining. Compaction shall consist of track rolling with at least two passes of the tracks.

4 FOUNDATION PREPARATION

4.1 Overview

Stage 4 Foundation preparation and excavation requirements for completion of the Works are as follows:

1. Excavation of natural foundation, PAF Pads and existing perimeter drains for modification purposes, and
2. Preparation of subgrade for placement of fill placement.

Excavated unsuitable materials shall be treated as spoil. The Superintendent shall be the sole arbiter of whether a material is classified as suitable or not.

4.2 Type A – Natural Surface Foundation Preparation

Type A foundation preparation shall be conducted in all areas where the Stage 4 expansion works are in contact with the natural foundation.

Following removal of the topsoil in accordance with **Clause 3.2.2** and unsuitable materials in accordance with **Clause 3.3.1**, compaction of the prepared surface shall comprise four (4) passes of a 10t vibratory smooth drum roller or an approved equivalent by the Superintendent.

Following compaction of the prepared surface, the compacted surface shall be proof rolled using a fully loaded Articulated Dump Truck (ADT) (minimum 45t) or an approved equivalent to identify any defects or soft spots prior to NAF rockfill placement. Where proof rolling the prepared surface using the ADT is not possible, the surface shall be prepared to the required design depths and levels provided in the Stage 4 Drawings.

Proof rolling of Type A prepared foundation is a Hold Point and must be approved by the Superintendent and/or Site Engineer.

Fill material shall not be placed over Type A foundation preparation areas prior to inspection and written approval by the Superintendent and/or Site Engineer. Type A foundation preparation areas shall be covered with fill materials within 24 hours of the completion of preparation. If prepared foundation areas are left for a period longer than 24 hours, then those foundations shall be reinspected by the Superintendent and/or Site Engineer for approval. If the condition of the foundation preparation has deteriorated such that it no longer classifies as Type A foundation preparation, than the Superintendent and/or Site Engineer shall request that the area be re-worked until it is deemed to comply, to the satisfaction of the Superintendent and/or Site Engineer. The Contractor shall be responsible for carrying out any remedial works required as a result of the deterioration of previously prepared and approved foundations at their own expense.

4.3 Type B – Existing Surface Foundation Preparation

Type B foundation preparation shall be carried out in all areas where Stage 4 works intersect with the existing PAF Pads and drains.

In areas where Stage 4 works remain well within the existing PAF, Type 2, or NAF fill materials, the surface shall be cleared of all loose or wet materials before placing any new materials. For existing

TAILINGS.WATER.WASTE.

surfaces where any natural material exists, Type A foundation preparation requirements presented in **Clause 4.2** must be followed.

Type B foundation excavation shall be completed to the satisfaction of the Superintendent and/or Site Engineer. No material shall be placed on prepared foundations without the prior written approval of the Superintendent and/or Site Engineer.

It should be noted that where PAF rockfill material or stockpiles exist over proposed or existing Type 2 material areas, they must be excavated as necessary to facilitate proper construction and tie-in of Type 2 materials with existing or planned surfaces. Typical sections where required excavation of existing PAF stockpile material may be required are provided in Stage 4 Drawings 240261.04-004 and 240261.04-009. All excavated PAF materials must be placed within the existing PAF Pads.

5 STAGE 4 CONSTRUCTION MATERIALS

5.1 General

The materials to be used in the Works are described in the Drawings. The following materials shall be required to complete the Works:

- Type 2 capping Material (Cohesive Earthfill)
- PAF/NAF Rockfill & Crushed NAF Rockfill
- NAF Rock Armour
- Geofabric

Rockfill materials will be sourced from existing PAF/NAF stockpiles (produced by sorting and crushing), whilst Earthfill materials will be sourced from on-site borrow sources approved by the Superintendent. No materials shall be used in the Works without the written approval of the Superintendent and/or Site Engineer.

5.2 Type 2 Capping Material

Type 2 capping material forms the low permeability PAF Pad layer that prevents PAF runoff from infiltrating into groundwater or impacting the downstream environment. Type 2 capping material shall exclude topsoil and organic matter, and shall conform to the following USCS soil classifications:

- CL, CI - CLAY, Sandy CLAY, Gravelly CLAY

Type 2 capping material shall meet the minimum requirements provided in **Table 5.1**.

TABLE 5.1: TYPE 2 MATERIALS CHARACTERISTICS SUMMARY

Material Characteristic	Acceptable Range
Particle Size Distribution (PSD)	Min % fines (< 0.075 mm): 40-65 % Maximum Particle Size: 63 mm
Liquid Limit (Atterberg Limits)	25% - 40%
Plasticity Index (Atterberg Limits)	10% - 20%

5.3 PAF / NAF Rockfill

5.3.1 PAF Rockfill

PAF Rockfill is used as fill material to raise the Pad 1 PAF surface levels and primarily forms the crushed NAF rockfill subgrade. PAF rockfill shall comprise of durable, highly to slightly weathered

TAILINGS.WATER.WASTE.

rock, which must not degrade under placement. The material is an all-in rockfill mixture and shall exclude material that is primarily clay or silt, wet, or containing high organic content.

PAF Rockfill material shall have a maximum particle size of 200 mm, and minimal fines content.

5.3.2 NAF Rockfill

NAF Rockfill is used as fill material to raise the existing foundation levels and primarily forms the crushed NAF rockfill subgrade. NAF rockfill shall comprise of durable, highly to slightly weathered rock, which must not degrade under placement. The material is an all-in rockfill mixture and shall exclude material that is primarily clay or silt, wet, or containing high organic content.

NAF Rockfill material shall have a maximum particle size of 200 mm, and minimal fines content.

5.3.3 Crushed NAF Rockfill

Crushed NAF Rockfill is used as a transitioning zone and is intended to minimize the risk of fines migration from the Type 2 capping layer in the unlikely event of leakage, and to facilitate shaping of the PAF perimeter drainage and downstream batters following NAF placement.

The Crushed NAF Rockfill must comply with the material specifications outlined in **Clause 5.3.2** and shall have a maximum particle size of 50 mm. The final crushed product shall not have more than 5% by weight of soft, friable or excessively weathered particles used to enhance gradation of the produced crushed material.

5.4 NAF Rock Armour

NAF Rock Armour shall be placed in specific areas of PAF perimeter drains as a protective layer over the Type 2 capping material in order to minimise surface erosion.

NAF Rock Armour shall consist of select NAF Rockfill. The rock weathering classification of the NAF Rock Armour material shall range from Slightly Weathered to Fresh rock. The material shall consist of clean, hard, durable particles, with no more than 5% by weight of soft, friable or excessively weathered particles.

Rockfill stockpiles for screening shall be as directed by the Superintendent.

NAF Rock Armour material shall be produced from screening of NAF rockfill to produce the Particle Size Requirements are presented in **Table 5.2**.

TABLE 5.2: NAF ROCK ARMOUR PARTICLE SIZE REQUIREMENTS

Location	D50 size	Installation Thickness
Existing Drain Modifications presented in Drawing 240261.04-008 & 240261.04-009 Stage 4 Perimeter drain presented in Drawing 240261.04-004, 240261.04-008 & 240261.04-009	150 mm	225 mm

5.5 Geotextile

Geotextiles shall be used beneath the NAF Rock Armour within the PAF Pad Perimeter Drains. Geotextile shall be a non-woven continuous filament polyester geotextile.

Bidim A64 nonwoven geotextile shall be used beneath NAF Rock Armour material within the PAF Pad Perimeter Drains at required locations. Equivalent materials may be proposed, however, the Contractor shall submit a formal RFI to the Design Engineer with sufficient details of the proposed alternative. No alternatives shall be used in the Works without the written approval from the Design Engineer.