

Chapter 10
Land – Geology, Geomorphology, Topography and Soils

ESMERALDA GRAPHITE PROJECT

aarc ENVIRONMENTAL SOLUTIONS
APEM Group

GRAPHINEX

Table of Contents

Glossary, acronyms and abbreviations 1

10 Land – geology, geomorphology, topography and soils 1

10.1 Environmental objectives 1

10.2 Existing environment 2

10.2.1 Topography 2
10.2.2 Land use 2
10.2.3 Geology 5
10.2.4 Soils 10
10.2.5 Land suitability assessment 30
10.2.6 Agricultural land classification 32
10.2.7 Acid sulphate soils 37

10.3 Potential impacts 38

10.3.1 Topography 38
10.3.2 Hydrology 38
10.3.3 Land use 38
10.3.4 Geology 39
10.3.5 Land contamination 42
10.3.6 Soils 43
10.3.7 STP effluent disposal 46

10.4 Mitigation and management measures 52

10.4.1 Land 52
10.4.2 Soils 53
10.4.3 Irrigation water and effluent 59

10.5 TOR Reconciliation table 61

List of Figures

Figure 10-1: Regional topography 4
Figure 10-2: Stratigraphy and target resource 9
Figure 10-3: Soil profile classes and observation sites 11
Figure 10-4: Assessed Agricultural Land Classification 34
Figure 10-5: Assessed crop land use suitability 35
Figure 10-6: Assessed pasture and beef cattle grazing land use suitability 36
Figure 10-7: Predicted regional topography in Year 63 41
Figure 10-8: Proposed irrigation area 50
Figure 10-9: Sewage irrigation area with regional ecosystem context 51
Figure 10-10: Indicative locations for soil stockpiles 57

List of Tables

Table 10-1: Typical stratigraphic sequence at the Project area 6
Table 10-2: Summary of mineralogical results, adapted from RGS (2026) 7
Table 10-3: Graphinex Esmeralda Project reserve (as of 2024) 7
Table 10-4: Composite graphitic granite breccia ore body sample (RGS 2026) 8
Table 10-5: Soil profile classes 10
Table 10-6: Chemical fertility of topsoil (0 – 0.1 m) in SPC 1Cl(Ck), sampled at D1 12
Table 10-7: Physical properties of SPC 1Cl(Ck), sampled at D1 13
Table 10-8: Land summary SPC 1Cl(Ck) – analysed site D1 13
Table 10-9: Chemical fertility of topsoil (0–0.1 m) in SPC 2Cl(Ck), sampled at D2 15
Table 10-10: Physical properties of SPC 2Cl(Ck), sampled at D2 15
Table 10-11: Land summary SPC 2Cl(Ck) – analysed Site D2 16
Table 10-12: Chemical fertility of topsoil (0–0.1 m) in SPC 3Cl(Ck), sampled at D3 18
Table 10-13: Physical properties of SPC 3Cl(Ck), sampled at D3 18
Table 10-14: Land Summary SPC 3Cl(Ck) – Analysed Site D3 18
Table 10-15: Chemical fertility of topsoil (0 – 0.1 m) in SPC 4Cl(Ck), sampled at D7 20
Table 10-16: Physical properties of SPC 4Cl(Ck), sampled at D7 20
Table 10-17: Land Summary SPC 4Cl(Ck) – Analysed Site D7 21
Table 10-18: Chemical fertility of topsoil (0-0.1m) in SPC 5Cl(Nm), sampled at D11 22
Table 10-19: Physical properties of SPC 5Cl(Nm), sampled at D11* 22
Table 10-20: Land Summary SPC 5Cl(Nm) – analysed Site D11 23
Table 10-21: Chemical fertility of topsoil (0 – 0.1 m) in SPC 6Cl(El), sampled at D16 24
Table 10-22: Physical properties of SPC 6Cl(El), sampled at D16* 25
Table 10-23: Land Summary SPC 6Cl(El) – Analysed Site D16 26
Table 10-24: Chemical fertility of topsoil (0 – 0.1 m) in SPC 7Cl(Nm), sampled at D20 28
Table 10-25: Physical properties of SPC 7Cl(Nm), sampled at D20 28
Table 10-26: Land Summary SPC 7Cl(Nm) – Analysed Site D20 29
Table 10-27: Land suitability classes 30
Table 10-28: Summary of crop land use suitability for each SPC 31
Table 10-29: Summary of pasture and grazing land use suitability for each SPC 31
Table 10-30: ALC description 32
Table 10-31: Summary of ALC for each SPC 33
Table 10-32: Acid Sulphate Soil Assessment 37
Table 10-33: Notifiable activities for the Project 42
Table 10-34: Summary of geochemical characteristics for mine materials 43
Table 10-35: Potential impacts from soil disturbance and relevant management measures 44
Table 10-36: Potential growth medium stripping depth and estimated volumes 45
Table 10-37: MEDLI output summary 47
Table 10-38: Effluent quality 48
Table 10-39: Nutrient Loading 48
Table 10-40: Flow weighted nitrate concentration 48
Table 10-41: Summary of application or management measures on mine materials 53

Glossary, acronyms and abbreviations

Acronym or Abbreviation	Meaning
AARC	AARC Environmental Solutions Pty Ltd
AASS	Actual Acid Sulphate Soils
ADWF	Average Dry Weather Flow
AEP	Annual Exceedance Probability
AHD	Australian Height Datum
ALC	Agricultural Land Classification
AMD	Acid mine drainage
AS	Australian Standard
ASC	Australian Soil Class
ASRIS	Australian Soil Resource Information System
CEC	Cation exchange capacity
DEHP	Department of Environment and Heritage Protection
DES	Department of Environment and Science
DESI	Department of Environment, Science and Innovation
DETSI	Department of the Environment, Tourism, Science and Innovation
DNRM	Department of Natural Resources and Mines
DOR	Department of Resources
DSITI	Department of Science, Information Technology and Innovation
EC	Electrical Conductivity
ECEC	Effective cation exchange capacity
EIS	Environmental Impact Statement
EOBH	End of Borehole
EP Act	*Environmental Protection Act 1994*
EP Regulation	Environmental Protection Regulation 1999
ERA	Environmentally Relevant Activities
ESCP	Erosion and Sediment Control Plan
ESP	Exchangeable sodium percentage
ESPC	Erosion and Sediment Control Plan
GALE	Guidelines for Agricultural Land Evaluation

Acronym or Abbreviation	Meaning
HG	High grade
IECA	International Erosion Control Association
IMP	Irrigation Management Plan
JORC	Joint Ore Reserves Committee
LG	Low grade
LSC	Land Suitability Class
MEDLI	Model for Effluent Disposal using Land Irrigation
ML	Mining Lease
MLA	Mining Lease Application
NAF	Non-acid forming
PAF	Potential acid forming
PASS	Potential Acid Sulphate Soils
PMLU	Post-mining land use
PRCP	Progressive Rehabilitation and Closure Plan
RE	Regional Ecosystem
ROM	Run-of-Mine
SLSA	Soils and Land Suitability Assessment
SPC	Soil profile classes
SSA	Soil Science Australia
STP	Sewage treatment plant
TGC	Total graphitic carbon
TN	Total Nitrogen
TOR	Terms of reference
TP	Total Phosphorus
TSF	Tailings Storage Facilities
UMA	Unique Mapping Areas
WEPP	Water Erosion Prediction Project
WRD	Waste rock dump
XRD	X-Ray Diffraction

10 Land – geology, geomorphology, topography and soils

This chapter describes the existing land, including geology, geomorphology, topography and soils, within and around the Esmeralda Graphite Project (the Project).

To determine the Project's potential impacts to land, the following assessments were undertaken:

- Soils and Land Suitability Assessment (Appendix H), prepared by GT Environmental (2026);
- Geochemistry assessment of mine materials and tailings (Appendix U), prepared by RGS (2026); and
- Model for Effluent Disposal using Land Irrigation Assessment (Appendix M), prepared by AARC (2026).

10.1 Environmental objectives

This chapter has been prepared to enable an assessment of the Project with respect to the environmental objectives stated in the Terms of Reference (TOR) in relation to land. A compliance check of this chapter content against the relevant components of the TOR can be found in Section 10.5 of this chapter. The objective of this chapter is to identify the existing environment of the land within and around the impact assessment area, assess the potential impacts and identify appropriate mitigation measures to address such impacts.

Assessment of the Project's impacts on land were conducted in accordance with the:

- Contaminated land – EIS information guideline (ESR/2020/5300) (DETSI 2026a);
- Quarry material – EIS information guideline (ESR/2020/5306) (DESI 2024);
- Application requirements for activities with impacts to land (ESR/2015/1839) (DETSI 2025);
- Queensland Land Resource Assessment Guidelines – Volume 1: Soil and land resource assessment (DES and DOR 2021);
- Queensland Land Resource Assessment Guidelines – Volume 1: Field tests (DES and DOR 2020);
- Queensland Soil and Land Resource Survey Information Guideline (DOR 2021);
- Queensland Government, Land – EIS information guideline, ESR/2020/5303;
- Queensland Government, Rehabilitation – EIS information guideline, ESR/2020/5308;Soil Science Australia, Guideline for soil survey along linear features (SSA 2015); and
- International Erosion Control Association, Best Practice Erosion and Sediment Control (IECA 2008).

The Project is expected to meet the environmental objectives and performance outcomes of Schedule 8 of the EP Regulation. Specifically, the Project would achieve item 2 of the performance outcomes for land as listed in Schedule 8, Part 3, Division 1 of the EP Regulation as follows:

a) the activities that disturb land, soils, subsoils, landforms and associated flora and fauna would be managed in a way that prevents or minimises adverse effects on the environmental values of land;

b) the areas disturbed by the Project's activities would be rehabilitated or restored to ensure that the sites:

   i) are safe and stable; and

   ii) do not cause environmental harm; and

   iii) are capable of sustaining an appropriate land use after rehabilitation or restoration.

c) the Project's activities would be managed to prevent or minimise adverse effects on the environmental values of land use to unplanned releases or discharges, including spills and leaks of contaminants; and

d) the application of water or waste to the land, during the life of the Project, would be sustainable and managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

Further, the Project would achieve:

a) item 1 of the performance outcomes for land use (Schedule 8, Part 3, Division 2 of the EP Regulation), in relation to site suitability, as follows:

    i) areas of high conservation value and special significance likely to be affected by the proposal are identified and evaluated and any adverse effects on the areas are minimised, including any edge effects on the areas; and

    ii) the activity does not have an adverse effect beyond the site.

b) item 2 of the performance outcomes for land use, in relation to **location on-site**, as follows:

    i) the activity, and components of the activity, are carried out on the site in a way that prevents or minimises adverse effects on the use of surrounding land and allows for effective management of the environmental impacts of the activity; and

    ii) areas used for storing environmentally hazardous materials in bulk are located taking into consideration the likelihood of flooding.

c) item 2 of the performance outcomes for land use, in relation to **critical design requirements**, as follows:

    i) all storage provided for hazardous contaminants would include secondary containment to prevent or minimise releases to the environment from spillage or leaks; and

    ii) regulated structures comply with the document called 'Manual for assessing consequence categories and hydraulic performance of structures', published by Department of Environment and Science (DES) (2016);

    iii) containers are provided for the storage of hazardous contaminants that are secured to prevent the removal of the containers from the site by a flood event;

    iv) the facility is designed to prevent or minimise the production of hazardous contaminants and waste; and

    v) in the event that the production of hazardous contaminants and waste cannot be prevented or minimised (as specified under paragraph (iv) above), the design of the facility is able to contain and treat the hazardous contaminants, rather than releasing them.

10.2 Existing environment

10.2.1 Topography

The local area is generally flat to gently sloping upwards to the south-southeast, with elevations ranging between 120 m and 140 m Australian Height Datum (AHD) (Figure 10-1). The topography of the Project is representative of the surrounding region, being generally flat, covering the landscape of plains and river channels, comprising clay and alluvial soils (DEHP 2015).

10.2.2 Land use

The Project is located within the Gulf Savannah region, about 70 km south from the town of Croydon in the Croydon Shire Council. It is part of the Gulf Plains Bioregion, which encompasses approximately 121,000 km^2 of low-lying country and offshore islands of north-west Queensland.

Land within and surrounding the Project is designated as being within the 'Rural' zone under the *Croydon Shire Planning Scheme 2019*. The land in the Project area is currently used for low-intensity cattle grazing of native vegetation. No historical mining has occurred in the Project area. Exploration drilling has been conducted as part of resource definition and for the development of groundwater monitoring bores.

No Heritage listings are within the Project area.

Further details of the existing land use are provided in Section 9.2.1 of Chapter 9, Land Use Planning.

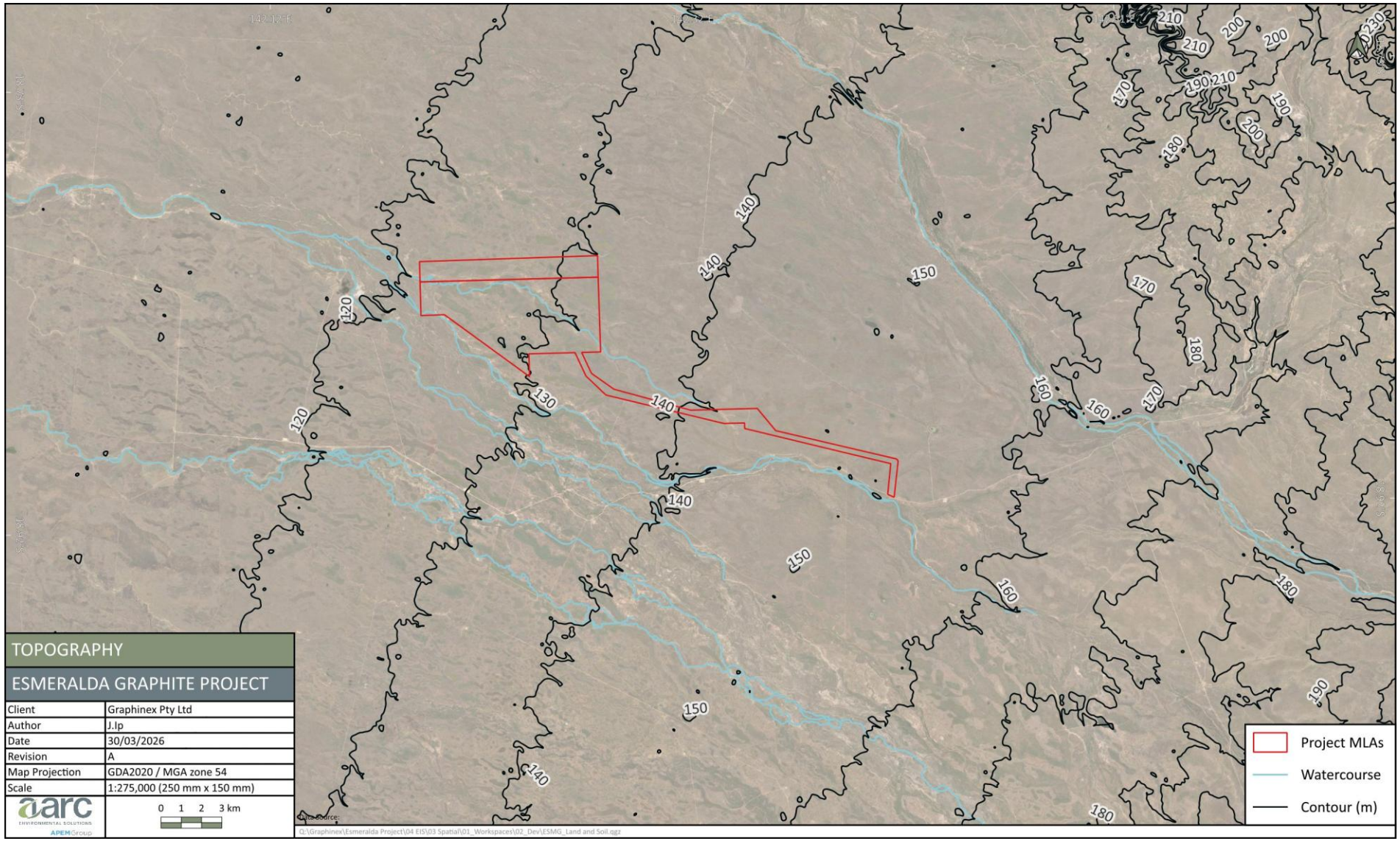


Figure 10-1: Regional topography

10.2.3 Geology

10.2.3.1 Regional geology

The Carpentaria and Karumba Basins cover parts of northern Queensland and the Northern Territory, extending over an area of 560,000 km^2. The Carpentaria Basin is Middle Jurassic to Late Cretaceous in age and is constrained to the east by the Palaeozoic and Proterozoic Coen, Yambo and Georgetown Inliers.

Sediments overlie a cratonic basement of Proterozoic and Palaeozoic rocks of the inliers outcropping on edges of the basin. The central part of the onshore Carpentaria Basin is unconformably overlain by the Cainozoic Karumba Basin.

A sequence of Mesoproterozoic S-type volcanic rocks and related granites in the Croydon area in the western part of the Georgetown Inlier is assigned to the Croydon Province. Outcropping rocks of the Croydon Province are rhyolitic to dacitic ignimbrite, rhyolite and rare andesite of the Croydon Volcanic Group, granites of the Esmeralda Supersuite and shallow water quartzose, mainly arenaceous sedimentary rocks of the Inorunie Group, which unconformably overlie the Croydon Volcanic Group. The Croydon Volcanic Group and Esmeralda Supersuite are contained within a cauldron subsidence structure that is likely to have been emplaced at approximately 1,550 mega-annum (Ma), at the close of the main deformation event in the Forsayth Subprovince.

The Esmeralda Granite is a coarse-grained biotite granite containing inclusions of graphite and xenoliths of graphitic meta-sedimentary rocks. Mackenzie (1988) noted that “parts of the granite are extremely rich in graphite”, observing in the Croydon Goldfield tabular zones up to 120 m thick and several kilometres long, packed with graphitic metasedimentary enclaves and masses of almost pure graphite set in a matrix of intensely hydrothermally altered granite.

10.2.3.2 Local geology

The Project is located within an area of Cainozoic and Mesozoic cover sequences. Cainozoic sediments are underlain by the Mesozoic sediments of the Carpentaria Basin consisting of sandstone, siltstones, and shales of the Gilbert River Formation. A major unconformity exists between the Mesozoic sediments and Proterozoic basement. The basement is interpreted to be the Esmeralda Supersuite granites.

Previous drilling in the area suggests that the cover sequence consists of flat laying laminated and cross bedded siltstone, claystone and coarse sandstones. These sediments appear to have alternating porous and non-porous horizons and differing strengths. According to historic drill holes, this sequence is approximately 50 - 70 m thick across the Project area.

Below this cover lies the target unit, a granitic pluton of unknown size, which has been interpreted to be the Esmeralda Granite, a member of the Esmeralda Supersuite of the Croydon Province. The pluton is assumed to be unaffected by any major structures at the local scale.

Exploration drilling has identified a number of local scale joints and fractures, with associated observations of slickensides and clay gouge. These joints and fractures have been identified in drill core samples and are associated with local scale deformation with minimal displacement. These localised joints and fractures are discontinuous and cannot be traced between nearby drillholes. The joints and fractures are not expected to influence groundwater conditions at a larger (pit) scale.

Hydrology

The Project is located in Northern Queensland within the Norman River Catchment area, which drains north to the Gulf of Carpentaria.

An unnamed non-perennial 3rd stream order watercourse is recorded within the Project’s MLA boundary. This watercourse tracks north-westerly through the central line of the MLA. Water, when present, would eventually

branch off to either join the Borer River, approximately 12 km downstream, or the Yappar River, approximately 50 km downstream.

Stratigraphic sequence

The typical stratigraphic sequence encountered in the Project area is illustrated in Table 10-1. Non-Proterozoic units are considered the cover sequence, or overburden. This may be unconformable and varies greatly in depth (up to 90 m). The Project geology is well understood and is at Measured Joint Ore Reserves Committee (JORC) Resource stage.

Table 10-1: Typical stratigraphic sequence at the Project area

Material Type	Unit	Age	Lithology
Soil		Quaternary	Sand, gravel, silt, and mud - alluvial and channel deposits
Overburden		Tertiary - Quaternary	Residual and alluvial sands, gravels, silt, and soil
		Tertiary - Quaternary	Ferricrete, alluvium, and colluvium
	Wallumbilla Formation	Cretaceous	Sandstone and mudstone
	Gilbert River Formation	Jurassic - Cretaceous	Dominantly sandstones, lesser finer clastics
	Eulo Queen Group	Jurassic	Sandstones, siltstones, and minor conglomerates
		Permian	Rhyolites, local andesites, and grandiorites
Ore body	Inorunie Group	Mid to Late Proterozoic	Dominantly sandstones and orthoquartzites, minor siltstones and mudstones
	Esmeralda Granite (& minor granites)	Middle Proterozoic	Dominantly biotite granites, some with muscovite and/or garnet
	Croydon Volcanic Group	Middle Proterozoic	Dominantly rhyolites and dacites, minor sediments and andesites
	Forest Home Trondhjemite	Middle Proterozoic	Biotite trondhjemite
	Langlovale Group	Middle Proterozoic	Sandstone overlain by finer clastics
	Etheridge Group	Middle Proterozoic	Dominantly fine clastics including carbonaceous shales

Overburden

The overburden is comprised of several sedimentary lithologies – claystone, sandstone, and siltstone, and may be bedded or massive. The materials are expected to be slightly alkaline and have low salinity. The total sulfur content of these materials is typically negligible, and higher concentrations are likely to be in an oxidised form as gypsum ($CaSO_4$). Acid neutralising capacity is generally low to moderate, and all but one overburden sample analysed by RGS was classified as NAF-Barren. Soluble fluoride concentrations are high in overburden compared to other material types. In alkaline pH conditions, some overburden materials can produce elevated concentrations of aluminium, molybdenum, and selenium, which can persist over the long-term as neutral mine drainage (NMD). Overburden materials are highly weathered and may be unconsolidated.

10.2.3.3 Mineralogy

RGS (2026) has conducted X-Ray Diffraction (XRD) for the mine material and tailing composites via a certified mineralogy laboratory (X-Ray Vision). Eleven mine materials and five Batch 1 tailing composite samples were tested. A summary of the minerals compositions is presented in Table 10-2. The full mineralogical results are available in Attachment H of Appendix U, Geochemistry assessment of mine materials and tailings (RGS 2026).

The ore reserve volume, including all ore passing the Mineral Resource classification of Measured and Indicated, mine design, modifying factors and economic testing, is presented in Table 10-3 (Wave International 2025). High Grade (HG) ore would be fed directly into the process plant while Low-Grade (LG) ore would be stockpiled and reclaimed to the process plant. A cross-section of the pit at year 30, relevant target resource, and adjacent geology is presented in Figure 10-2.

A composite granite breccia ore body sample was analysed by semi-quantitative XRD. The mineralogy of the composite sample is shown in Table 10-4.

Table 10-2: Summary of mineralogical results, adapted from RGS (2026)

Category	Minerals	Percentage range	Notes
Major minerals	Quartz	20 – 77	
	Muscovite	Trace to 19	
	Kaolinite	0 – 19	
	Chlorite	0 – 24	
	Plagioclase feldspar	0 – 14	
	Potassium feldspar	0 – 11	
	Amorphous material	2 – 44	
Mixed layer clays	Illite/smectite	7 – 27	Only in weathered overburden
Minor minerals	Graphite	14 – 26	Ore body (high and low grade ore)
	Pyrite	≤ 1	
	Clinozoisite	0 – 5	
	Magnesian calcite	0 – 2	
	Quantities of hematite and boehmite	Trace to 1	

Table 10-3: Graphinex Esmeralda Project reserve (as of 2024)

Ore Reserve (effective date: December 2024)	Reserve Kt (dry)	Grade (% TGC)
High Grade (HG) Ore		
Proven Reserve	-	-
Probable Reserve	129,028	6.05%
Total	**129,028**	**6.05%**

Ore Reserve (effective date: December 2024)	Reserve Kt (dry)	Grade (% TGC)
Low-Grade (LG) Ore		
Proven Reserve	-	-
Probable Reserve	34,741	3.36%
Total	**34,741**	**3.36%**
HG and LG ore		
Proven Reserve	-	-
Probable Reserve	163,769	5.48%
Total	**163,769**	**5.48%**

Note: Reserve strip ratio is 1.16 (waste/reserve tonnes)

Table 10-4: Composite graphitic granite breccia ore body sample (RGS 2026)

Phase Name/Formula	Weight %	Phase Name/Formula	Weight %
Quartz (SiO_2)	29	Graphite (C)	6
Microcline ($KAlSi_3O_8$)	22	Pyrrhotite (Fe_7S_8)	4
Albite ($NaAlSi_3O_8$)	17	Fluorapatite ($Ca_5(PO_4)_3F$)	1
Chamosite ($Fe^{2+},Mg)_5Al(AlSi_3O_{10})(OH)_8$	12	Calcite $CaCO_3$	1
Muscovite ($KAl_2(AlSi_3O_{10})(F,OH)_2$)	7	Sepiolite ($Mg_4Si_6O_{15}(OH)_2 \cdot 6H_2O$)	Trace

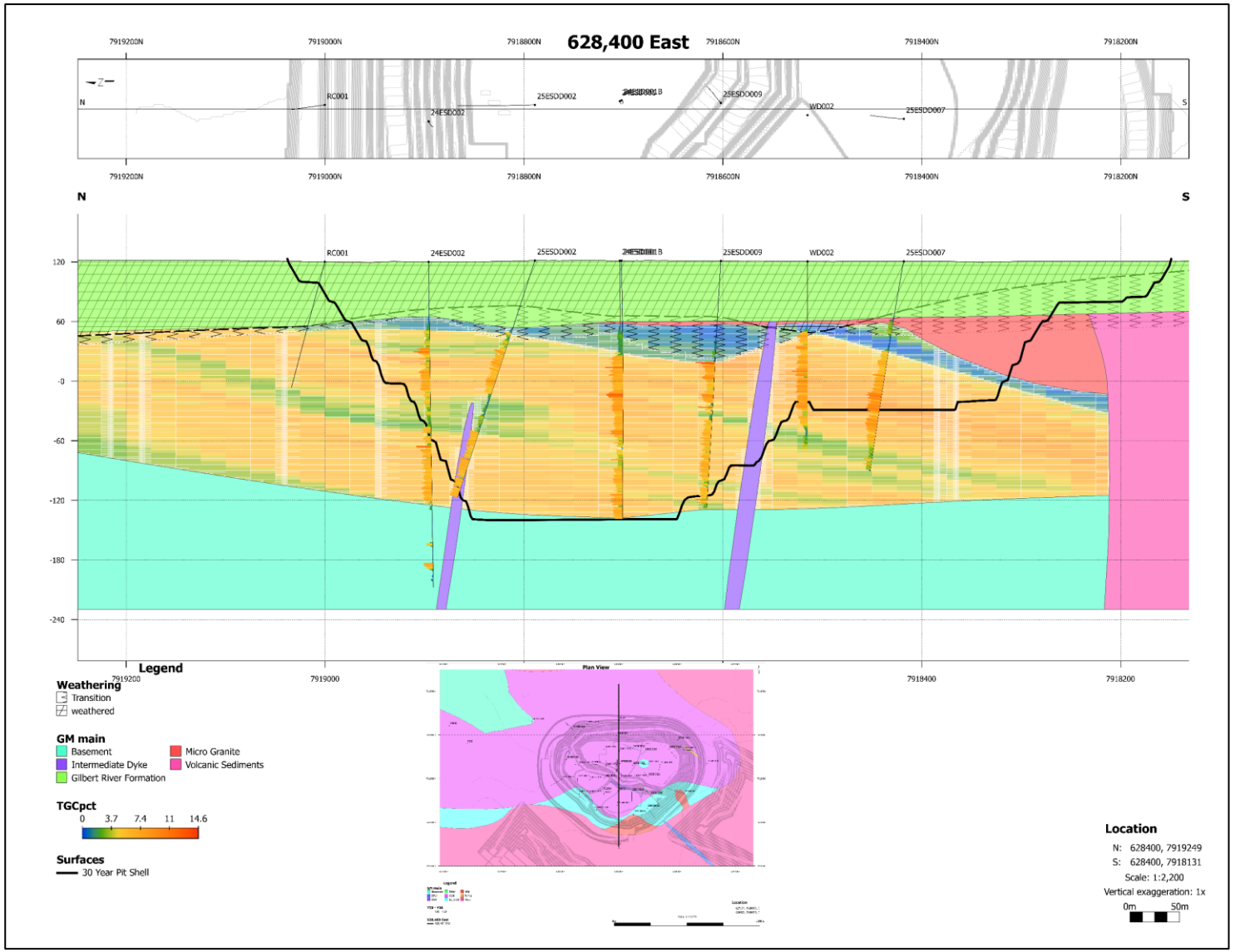


Figure 10-2: Stratigraphy and target resource

10.2.4 Soils

A soil and land suitability assessment (Appendix H) was conducted by GT Environmental. A desktop analysis was conducted prior to field survey efforts, comprising background research and evaluation of publicly available soils studies and satellite imageries relevant to the Project MLAs (the Study Area). Informed by the desktop analysis, field survey in 2025 was conducted with the following intensity:

- moderately high (detailed) intensity (1:25,000) within or adjacent to proposed mining pit disturbance area;
- medium (semi-detailed) intensity (1:50,000) within the proposed disturbance area; and
- low (semi-detailed) intensity (1:100,000) in areas not proposed to be disturbed.

In total, the survey consists of 14 detailed sites (Class I and II (a)), 8 analysed sites (Class II (b), III (a) and III (b)), and 35 brief mapping observation sites.

Seven soil profile classes (SPCs) and the associated Australian Soil Class (ASC) have been described within the Project area, illustrated in Table 10-5. Spatial distribution of the SPCs within the Project MLAs are shown in Figure 10-3.

Table 10-5: Soil profile classes

Soil Profile Class	Australian Soil Class
1Cl(Ck)	Brown Tenosol
2Cl(Ck)	Brown Arenosol
3Cl(Ck)	Brown Tenosol
4Cl(Ck)	Brown Kandosol
5Cl(Nm)	Leptic Tenosol
6Cl(El)	Brown Dermosol
7Cl(Nm)	Leptic Rudosol

The properties and descriptions of each SPC are summarised in the following subsections. Further details on the physical and chemical analyses conducted on each SPC are provided in Appendix H, Soils and Land Suitability Assessment.

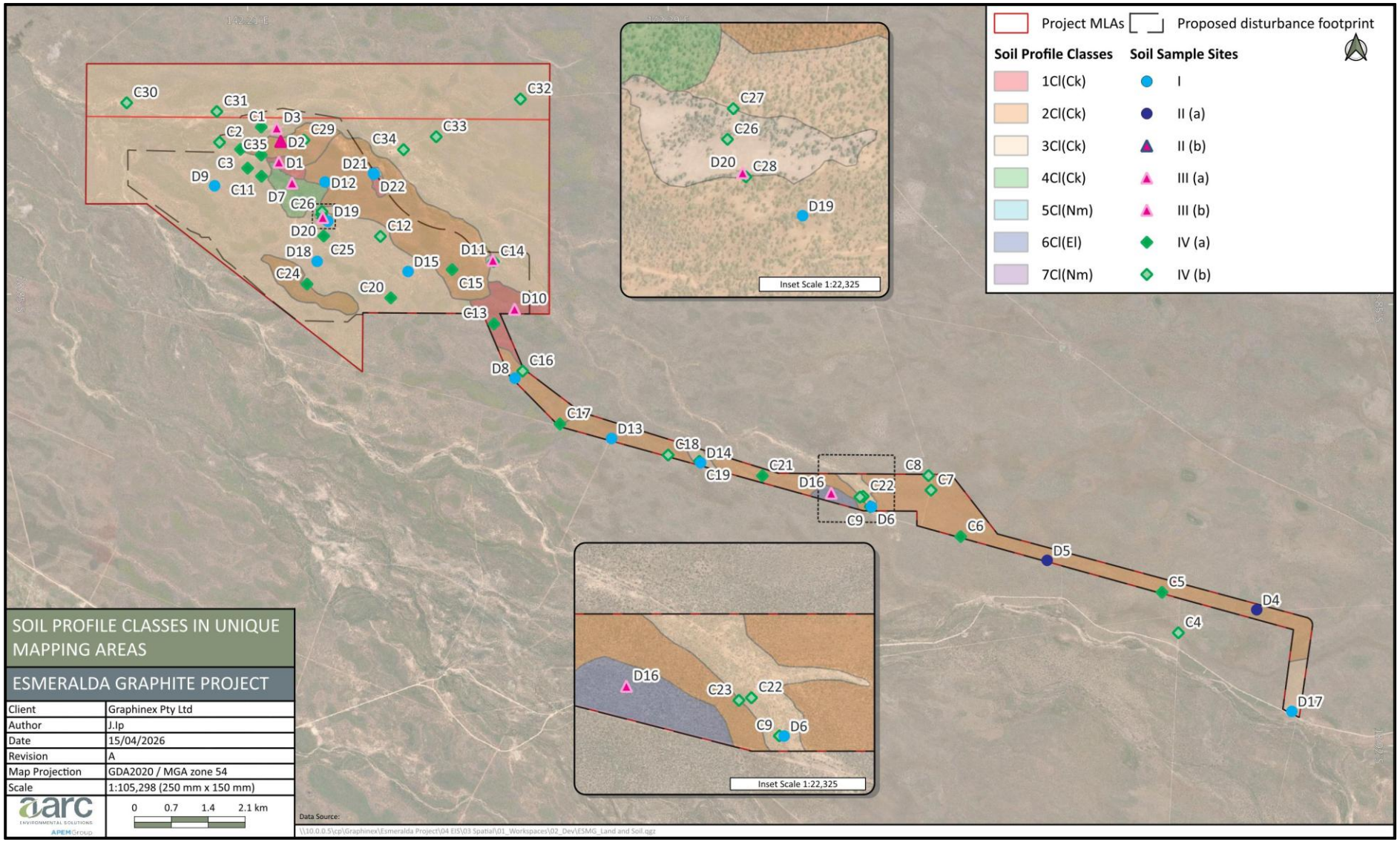


Figure 10-3: Soil profile classes and observation sites

10.2.4.1 Soil Profile Class 1Cl(Ck): Brown Tenosol

The slightly acidic to neutral pH in the topsoil of the 1Cl(Ck) is within a suitable range for plant growth and is not expected to limit the availability of essential nutrients within 0.7 m depth. Electrical conductivity (EC) values and chloride concentrations are considered very low and hence, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

Effective cation exchange capacity (ECEC) levels for this SPC are considered very low throughout the profile and declines from 1.18 cmol/kg in topsoil (0–0.1 m) to 0.61 cmol/kg in the subsoil (0.8–0.9 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The calcium to magnesium (Ca:Mg) ratio indicates that calcium is relatively high, approximately four times more dominant than magnesium in the topsoil, but decreasing through the profile, suggesting reduced calcium availability at depth. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), throughout the profile, reflecting a calcium deficiency below 0.5 m.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-6, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper and zinc levels.

Topsoil displays weak structure, due to a dominant sand fraction (approx. 80%) with less clay (6.6%), as per Table 10-7. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered moderate (56.7 mm/90 cm).

Non-sodic conditions occur in the top 0.6 m of the profile. Risk of dispersion and erosion in the surface layer is considered low. However, subsoil from 0.8 m is expected to display sodic properties. This is further indicated by an Emerson class number of 3 across the soil profile, where soil was observed to disperse after remoulding.

Topsoil and subsoil resources are considered suitable for use on all rehabilitation areas. In particular, the resource up to 0.7 m below ground level (mbgl) is suitable for use as a subsoil for rehabilitation use, supporting the subsequent placement of topsoil.

A summary, including the soil profile morphology, of SPC 1Cl(Ck) is provided in Table 10-8.

Table 10-6: Chemical fertility of topsoil (0 – 0.1 m) in SPC 1Cl(Ck), sampled at D1

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	1.6	<5.0	84	<2.5	6.1	0.15	0.16	32	2.8	0.12

Note: D1 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

Table 10-7: Physical properties of SPC 1Cl(Ck), sampled at D1

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	6.6	2.8	90.2	< 0.1	Sand	3.7	0.9	3
0.2–0.3	8.1	1.1	88.6	0.1	Sand	1.5	0.5	3
0.5–0.6	10.1	2.4	85.2	0.2	Sandy loam	0.8	1.2	3
0.8–0.9	12.6	1.1	63.4	8	Sandy loam	0.2	48	3

Note: D1 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-8: Land summary SPC 1Cl(Ck) – analysed site D1

Item	Description		
Unique Mapping Areas (UMAs)	3, 5, 9	Total area in MLAs (ha)	106.3
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top to bottom, 0.90 m)	
Location GDA2020 ZONE 54	628462 7918346		
Current Use	Grazing		
Geology (Dominant)	Tpc, Claraville		
Vegetation	Paperbark low woodland		
Disturbance	Limited clearing		
Landform pattern / element	Level plain, flat plain		
Microrelief / Rock outcrop	No microrelief / rock outcrop		
Drainage / Permeability	Rapid drainage / High permeability		
Slope (percent) / Erosion	<1.0 / <1.0		
Surface condition / Surface coarse fragments or segregations	Soft, no coarse fragments		
SPC ASC Order/Suborder	Brown Tenosol		
Site ASC Order (s) / Code	Basic, Paralithic, Brown Tenosol; moderately thick, non-gravelly, sandy, loamy, moderately deep (Confidence level 1)		
Land System / Soil	Claraville / Cockatoo		
Phases	None		

Soil Profile Morphology Summary							
Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abundance	Depth (m) / Field pH
A11 0.00-0.17 Clear 20-50mm	Loamy sand	Single grain	No inclusions or segregations	10YR3/4 Dark yellowish brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Common	0.10 / 6.0
A12 0.17-0.70 Abrupt 5-20mm	Loamy sand	Massive Weak Subangular blocky 20-50 mm No Slickensides	No inclusions or segregations	10YR5/6 Yellowish brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Common	0.40 / 5.5
BC 0.70-0.90 End of borehole (EOBH)	Loamy sand	Single grain	2-10% coarse fragments 20-60mm	10YR6/4 Light yellowish brown No mottles or bleaching	Dry Well drained	No roots	0.80 / 6.0
C Refusal on cemented pan							

10.2.4.2 Soil Profile Class 2Cl(Ck): Brown Arenosol

The moderately acidic topsoil and slightly acidic subsoils of the 2Cl(Ck) is within a suitable range for plant growth and is not expected to limit availability of essential nutrients at less than 2 m depth. EC values and chloride concentrations are considered very low throughout the profile and as such, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile and decline from 0.92 cmol/kg in topsoil (0–0.1 m) to 0.52 cmol/kg in the subsoil (1.7–1.8 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium is relatively high, approximately two times more dominant than magnesium in the upper 0.3 m, but decreases to moderate rating throughout the profile, suggesting reduced calcium availability throughout the profile. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), throughout the profile, reflecting a calcium deficiency below 0.2 m.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-9, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper and zinc levels.

Topsoil displays weak structure, due to dominant sand fraction (approx. 90%) with lesser clay (3.3%), and is consistent throughout the profile, as per Table 10-10. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered moderate (59 mm/100 cm).

Non-sodic conditions occur throughout the soil profile (0–1.8 m). Risk of dispersion and erosion in the surface layer and below is considered low. Emerson class results indicate class 3 near the surface, improving to class 4 lower in the soil profile. Soil was not observed to disperse, however may disperse after remoulding.

Topsoil and subsoils resources are suitable for use on all rehabilitation areas. In particular, subsoil resources between 0.5 and 2.2 mbgl are suitable as subsoils for rehabilitation use, supporting the placement of topsoil.

A land summary, including the soil profile morphology, of SPC 2Cl(Ck) is provided in Table 10-11.

Table 10-9: Chemical fertility of topsoil (0–0.1 m) in SPC 2Cl(Ck), sampled at D2

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	1.6	<5.0	86	<2.5	3.5	0.13	0.14	22	10	0.24

Note: D2 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

Table 10-10: Physical properties of SPC 2Cl(Ck), sampled at D2

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	3.3	2.8	93.2	0.2	Sand	2.7	0.6	3
0.2–0.3	5.2	1.1	93	0.4	Sand	2.2	1.1	3
0.5–0.6	5.3	0.5	93.7	< 0.1	Sand	0.5	0.6	3
0.8–0.9	3.6	2.4	93.3	< 0.1	Sand	0.7	<0.2	4
1.1-1.2	3.6	2.9	91	1.4	Sand	0.6	1.1	4
1.4-1.5	3.3	1.6	94	0.1	Sand	<0.1	1.7	4
1.7-1.8	4.9	1.1	93.4	< 0.1	Sand	0.7	0.3	3

Note: D2 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-11: Land summary SPC 2Cl(Ck) – analysed Site D2

Item	Description		
UMAs	2, 8, 11, 13, 16, 19	Total Area in MLAs (ha)	1,173.5
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top right to bottom left, 2.25 m)	
Location GDA2020 ZONE 54	628497 7918738		
Current Use	Cattle Grazing		
Geology	Tpc, Claraville		
Vegetation	Paperbark low woodland		
Disturbance	Limited clearing		
Landform pattern / pattern	Level plain, Plain flat		
Microrelief / Rock outcrop	No microrelief or rock outcrop		
Drainage / Permeability	Rapid drainage / High permeability		
Slope percent / Erosion	<1.0 / <1.0 No erosion observed		
Surface condition / Surface coarse fragments or segregations	Soft, no percent coarse fragments		
SPC ASC Order/Suborder	Brown Arenosol		
Site ASC Order (s) / Code	Basic, Tenic, Brown Arenosol, non-gravelly, sandy, sandy, very deep (Confidence level 1)		
Associated (Ass.) Land System / Soil	Claraville / Cockatoo		
Phases	Sites D8, D12, D13; deep phase		

Soil Profile Morphology Summary

Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abundance	Depth (m) / Field pH Dispersion Field Test
A11 0.00-0.20 Abrupt 5-20mm	Sand	Single grain Loose	No inclusions or segregations	10YR4/3 Brown No mottles or bleaching	Dry Rapidly drained	Very fine <1mm Few	0.10 / 6.5
A12 0.20-0.50 Gradual 50-100mm	Sand	Massive Loose	No inclusions or segregations	10YR4/6 Dark yellowish brown No mottles or bleaching	Moderately moist Rapidly drained	Very fine <1mm Few	0.35 / 5.5

Item		Description					
B21 0.50-1.80 Clear 20-50mm	Sand	Massive Loose	No inclusions or segregations	7.5YR5/6 Strong brown No mottles or bleaching	Moderately moist Well drained	No roots	1.20 / 6.0
B22 1.80-2.20 Abrupt 5-20mm	Sand	Massive Loose	No inclusions or segregations	7.5YR5/6 Strong brown Mottles: Pale Grey Many 20%-50% Coarse 15-30 mm	Moderately moist Imperfectly drained	No roots	2.00 / 6.0
BC 2.20-2.25 EOBH	Loamy sand Silty	Massive Loose	20-50% coarse fragments 2-6mm	10YR6/4 Light yellowish brown Mottles: Pale Grey Common 10%-20% Medium 5-15 mm	Moderately moist Imperfectly drained	No roots	2.22 / 6.0
C Refusal on cemented pan							

10.2.4.3 Soil Profile Class 3Cl(Ck): Brown Tenosol

The slightly acidic to neutral pH in the topsoil of the 3Cl(Ck) is within a suitable range for plant growth and is not expected to limit the availability of essential nutrients within 0.6 m depth. EC values are considered low within 0.3 m depth while chloride concentrations are considered very low. EC values and chloride concentrations increased to moderate and low, respectively, in the BC horizon (0.5–0.6 m). Hence, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile despite an increasing trend from 0.76 cmol/kg in topsoil (0–0.1 m) to 1.42 cmol/kg in the subsoil (0.5–0.6 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium and magnesium are co-dominant in topsoil, however, magnesium is more dominant than calcium below 0.2 m, suggesting reduced calcium availability throughout the profile. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), reflecting a calcium deficiency below 0.2 m.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-12, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper and zinc levels.

Topsoil displays weak structure, due to dominant sand fraction (approx. 80%) with lesser clay (8.4%), as per Table 10-13. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered moderate (48.5 mm/60 cm).

Non-sodic conditions occur in the top 0.3 m of the profile. Risk of dispersion and erosion in the surface layer is considered low. However, subsoil from 0.5 m is expected to display sodic properties. This is further supported by Emerson class 3 in top 0.3 m to class 2 below 0.5 m, where soil was observed to disperse after remoulding.

Topsoil and subsoil resources are suitable to use on all rehabilitation areas. In particular, subsoil resources between 0.45 and 0.65 mbgl are suitable as subsoils for rehabilitation use, supporting the subsequent placement of topsoil.

A land summary, including the soil profile morphology, of SPC 3Cl(Ck) is provided in Table 10-14.

Table 10-12: Chemical fertility of topsoil (0–0.1 m) in SPC 3Cl(Ck), sampled at D3

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	0.81	<5.0	89	<2.5	4.6	0.16	0.17	24	2.6	<0.08

Note: D3 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

Table 10-13: Physical properties of SPC 3Cl(Ck), sampled at D3

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	8.4	3.8	84.7	1.7	Loamy sand	1	1.8	3
0.2–0.3	11.7	1.1	85.6	< 0.1	Sandy loam	0.3	2	3
0.5–0.6	16.3	0.5	71.1	0.4	Sandy loam	0.4	37	2

Note: D3 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-14: Land Summary SPC 3Cl(Ck) – Analysed Site D3

Item	Description		
UMAs	1, 12, 15, 17	Total Area in MLAs (ha)	3,070.2
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top to bottom, 0.65 m)	
Location GDA2020 ZONE 54	628421 7918991		
Current Use	Cattle grazing		
Geology	Tpc, Claraville		
Vegetation	Paperbark low woodland		
Disturbance	Limited clearing		
Landform pattern / pattern	Level plain, stream channel		
Microrelief / Rock outcrop	No microrelief or rock outcrop		
Drainage / Permeability	Well drained / High permeability		
Slope percent / Erosion	<1.0 / 1.0, No erosion observed		

Item	Description						
Surface condition / Surface coarse fragments or segregations	Hard setting, no coarse fragments						
SPC ASC Order/Suborder	Brown Tenosol						
Site ASC Order (s) / Code	Basic, Paralithic, Brown Tenosol; moderately thick, non-gravelly, sandy, loamy, moderately deep (Confidence level 1)						
Ass. Land System / Soil	Claraville / Cockatoo						
Phases	D6 (Slope Phase)						
Soil Profile Morphology Summary							
Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abund-ance	Depth (m) / Field pH Dispersion Field Test
A11 0.00-0.10	Sandy loam	Massive Weak Subangular blocky 10-20 mm No Slickensides	No inclusions or segregations	10YR5/4 Yellowish brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Few	0.05 / 6.0
A12 0.10-0.45	Sandy loam	Massive Weak Subangular blocky 20-50 mm No Slickensides	<2% coarse fragments 2-6mm	10YR5/3 Brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Few	0.30 / 5.5
BC 0.45-0.65 EOBH	Clayey sand	Massive Weak Subangular blocky 10-20 mm No Slickensides	2-10% coarse fragments 6-20mm 2-10% coarse fragments 2-6mm	10YR6/4 Light yellowish brown No mottles or bleaching	Dry Well drained	No roots	0.55 / 9.0
C Refusal on cemented pan							

10.2.4.4 Soil Profile Class 4Cl(Ck): Brown Kandosol

The slightly acidic to neutral pH in the topsoil of the 4Cl(Ck) is within a suitable range for plant growth and is not expected to limit the availability of essential nutrients within 0.3 m depth. EC values and chloride concentrations are considered very low within 0.3 m. EC values and chloride concentrations increase to moderate and low, respectively, in the BC horizon (0.5–0.6 m). As such, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile ranging between 0.43 cmol/kg in topsoil (0–0.1 m) to 0.58 cmol/kg in the subsoil. The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium is relatively high, approximately three times more dominant than magnesium in the topsoil. However, calcium levels decrease across the profile to where magnesium is eight time more dominant than calcium below 0.65 m, suggesting reduced calcium availability throughout the profile. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011) throughout the profile, reflecting a calcium deficiency below 0.2 m.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-15, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper, manganese, and zinc levels.

Topsoil displays weak structure, due to a dominant sand fraction (approx. 80%) with less clay (7.2%), as per Table 10-16. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered moderate (51.85 mm/75 cm).

Sodic conditions occur in the top 0.3 m of the profile. Risk of dispersion and erosion in the surface layer is considered moderate. Subsoil from 0.5 m is expected to display strongly sodic properties. This is further supported by an Emerson class 2 at depth, which indicates slaking with some dispersion of aggregates to complete dispersion with depth.

Topsoil and subsoil resources are suitable to use on all rehabilitation areas. In particular, subsoil resources between 0.35 and 0.60 mbgl are suitable as subsoils for rehabilitation use, supporting the placement of topsoil. Subsoils below 0.6 m are suitable as the first layer prior to suitable subsoil and topsoil for rehabilitation use.

A land summary, including the soil profile morphology, of SPC 4Cl(Ck) is provided in Table 10-17.

Table 10-15: Chemical fertility of topsoil (0 – 0.1 m) in SPC 4Cl(Ck), sampled at D7

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	0.63	<5.0	<25	<2.5	1.2	<0.10	0.11	30	0.4	<0.08

Note: D7 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

Table 10-16: Physical properties of SPC 4Cl(Ck), sampled at D7

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	7.2	0.5	91.4	0.1	Sand	2.8	8.2	3
0.2–0.3	10.1	4.6	83.8	0.3	Sandy loam	1.4	14	2
0.5–0.6	9.4	7.2	66.6	5.7	Sandy loam	0.5	44	2
0.65–0.75	15.9	1	54.9	10.4	Sandy loam	0.2	62	2

Note: D7 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-17: Land Summary SPC 4Cl(Ck) – Analysed Site D7

Item	Description		
UMAs	6	Total Area in MLAs (ha)	62.4
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top to bottom, 0.75 m)	
Location GDA2020 ZONE 54	628712 7917947		
Current Use	Beef cattle grazing		
Geology	Tpc, Claraville		
Vegetation	Paperbark low woodland		
Disturbance	No effective disturbance; hoofed animals		
Landform pattern / pattern	Plain flat, gently undulating plain		
Microrelief / Rock outcrop	No microrelief or rock outcrop		
Drainage / Permeability	Well drained / High permeability		
Slope percent / Erosion	1.0 / 1.0, No erosion observed		
Surface condition / Surface coarse fragments or segregations	Soft, no percent coarse fragments		
SPC ASC Order/Suborder	Brown Kandosol		
Site ASC Order (s) / Code	Haplic, Leptic, Brown Kandosol; moderately thick, non-gravelly, sand, loamy, moderately deep (Confidence level 1)		
Ass. Land System / Soil	Claraville / Cockatoo		
Phases	None		

Soil Profile Morphology Summary

Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abundance	Depth (m) / Field pH
A11 0.00-0.10	Loamy sand	Single grain	No inclusions or segregations	10YR3/3 Dark brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Few	6.5
A21 0.10-0.35	Loamy sand	Massive	No inclusions or segregations	10YR5/3 Brown No mottles or bleaching	Dry Rapidly drained	Very fine <1mm Few	6.0
A22 0.35-0.60	Sandy loam	Massive	No inclusions or segregations	10YR5/3 Brown No mottles or bleaching	Dry Well drained	Fine 1-2mm Few	6.0
B21 0.60-0.75 EOBH	Sandy clay loam	Weak Very weak Subangular blocky 10-20 mm No Slickensides	<2% coarse fragments 6-20mm	10YR6/3 Pale brown No mottles or bleaching	Moderately moist Well drained	Fine 1-2mm Few	7.5
C Refusal on rock outcrop EOBH							

10.2.4.5 Soil Profile Class 5Cl(Nm): Leptic Tenosol

The slightly acidic to neutral pH throughout the soil profile of the 5Cl(Nm) is within a suitable range for plant growth and is not expected to limit the availability of essential nutrients across the soil profile. EC values and chloride concentrations are considered very low throughout the profile (0–0.35 m), and hence, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile declining from 0.8 cmol/kg in topsoil (0–0.1 m) to 0.45 cmol/kg in the subsoil (0.25–0.35 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium is relatively high, approximately two times more dominant than magnesium in the topsoil but decreasing to a moderate rating throughout the profile, suggesting reduced calcium availability throughout the profile. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), reflecting a calcium deficiency below 0.2 m.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-18, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper, iron, and zinc levels.

Topsoil displays weak structure, due to a dominant sand fraction (approx. 85%) with less clay (11.6%), as per Table 10-19. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered low (34.9 mm/35 cm).

Non-sodic conditions occur across the profile. Risk of dispersion and erosion in the surface layer is considered low. This is further supported by an Emerson class 3 across the profile, where soil profile was observed to exhibit limited dispersion after remoulding.

Topsoil and subsoil resources are suitable for use on all rehabilitation areas. In particular, subsoil resources between 0.25 and 0.35 mbgl are suitable as subsoils for rehabilitation use, supporting the placement of topsoil.

A land summary, including the soil profile morphology, of SPC 5Cl(Nm) is provided in Table 10-20.

Table 10-18: Chemical fertility of topsoil (0-0.1m) in SPC 5Cl(Nm), sampled at D11

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	0.68	<5.0	50	<2.5	<1.0	0.14	0.11	4.1	2.4	<0.08

Note: D11 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

*Table 10-19: Physical properties of SPC 5Cl(Nm), sampled at D11**

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	11.6	1.7	84.6	0.6	Sandy loam	1.6	0.8	3
0.1–0.2	9.7	2.8	81.7	2.1	Sandy loam	0.5	0.6	3
0.25–0.35	4.4	2.2	59.8	22.6	Sand	0.4	2.2	3

Note: D11 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-20: Land Summary SPC 5Cl(Nm) – analysed Site D11

Item	Description		
UMAs	4, 7	Total Area in MLAs (ha)	4.2
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top to bottom, 0.35 m)	
Location GDA2020 ZONE 54	632521 7916481		
Current Use	Beef cattle grazing		
Geology	Tpc, Claraville		
Vegetation	Paperbark low woodland		
Disturbance	No effective disturbance; hoofed animals		
Landform pattern / pattern	Plain flat, gently undulating plain		
Microrelief / Rock outcrop	No microrelief or rock outcrop		
Drainage / Permeability	Rapidly drained / High permeability		
Slope percent / Erosion	1.0 / 1.0, Rill erosion observed		
Surface condition / Surface coarse fragments or segregations	Firm, <2% coarse fragments 6-20mm		
SPC ASC Order/Suborder	Leptic Tenosol		
Site ASC Order (s) / Code	Basic, Paralithic, Leptic Tenosol; moderately thick, gravelly, loamy, - , shallow (Confidence level 1)		
Ass. Land System / Soil	Claraville / Norman		
Phases	None		

Soil Profile Morphology Summary

Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abundance	Depth (m) / Field pH
A1 0.00-0.10 Abrupt 5-20mm	Loamy sand	Massive Loose	10-20% coarse fragments 6-20mm	7.5YR4/4 Brown No mottles or bleaching	Dry Rapidly drained	Very fine <1mm Few	0.05 / 7.0
A21 0.10-0.25 Abrupt 5-20mm	Loamy sand Silty	Massive Loose	2-10% coarse fragments 2-6mm	7.5YR5/4 Brown No mottles or bleaching	Moderately moist Well drained	Very fine <1mm Few	0.18 / 6.0
A22 0.25-0.35 EOBH	Loamy sand Silty	Massive Loose	50-90% coarse fragments 2-6mm 20-50% coarse fragments 2-6mm	7.5YR5/4 Brown No mottles or bleaching	Moderately moist Well drained	Very fine <1mm Few	0.30 / 6.0
C Coarse gravel layer							

10.2.4.6 Soil Profile Class 6Cl(El): Brown Dermosol

The slightly acidic to neutral pH in the topsoil and slightly acidic to moderately alkaline subsoil of 6Cl(El) are within a suitable range for plant growth and is not expected to limit the availability of essential nutrients across the soil profile (0–1.8 m). Chloride concentrations remain very low across the profile while EC values are considered very low in topsoil and subsoil to 1.2 m depth, then increasing to moderate below 1.4 m depth. Hence, this SPC is not affected by issues associated with toxic chloride concentrations or salinity (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile, with a slight decline from 1.4 cmol/kg in topsoil (0–0.1 m) to 1.02 cmol/kg in subsoil (1.7–1.8 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium is relatively high, at least two times more dominant than magnesium within the top 0.3 m before the ratio is balanced and declines to a calcium deficient level, suggesting reduced calcium availability throughout the profile. This is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), reflecting a calcium deficiency throughout the profile.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-21, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron, copper and zinc levels.

Topsoil displays a weak structure, due to a dominant sand fraction (approx. 87%) with less clay (9.7%), as per Table 10-22. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered moderate (66.4 mm/100 cm).

Non-sodic conditions occur in the top 1.5 m of the profile. The risk of dispersion and erosion in the surface layer is considered low. This is further supported by an Emerson class 3 for the topsoil where soil disperses after remoulding. However, subsoil from 2 m is expected to display extreme sodic properties.

Topsoil and subsoil resources are suitable for use on all rehabilitation areas. In particular, subsoil resources between 0.30 and 2 mbgl are suitable as subsoils for rehabilitation use, supporting the placement of topsoil. Subsoils below 2 m are suitable as the first layer prior to suitable subsoil and topsoil for rehabilitation use.

A land summary, including the soil profile morphology, of SPC 6Cl(El) is provided in Table 10-23.

Table 10-21: Chemical fertility of topsoil (0 – 0.1 m) in SPC 6Cl(El), sampled at D16

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	1.1	<5.0	64	<2.5	<1.0	0.11	0.18	14	7.4	0.09

Note: D16 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

*Table 10-22: Physical properties of SPC 6Cl(El), sampled at D16**

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	9.7	3.1	87.1	< 0.1	Sandy loam	5.4	<0.2	3
0.2–0.3	13.9	2.4	83.6	< 0.1	Sandy loam	2.1	0.4	4
0.5–0.6	20.3	3	76.6	< 0.1	Sandy clay loam	1.1	<0.2	2
0.8–0.9	25	1.7	73.1	< 0.1	Sandy clay loam	0.1	1.3	2
1.1–1.2	23.2	1	74.9	0.1	Sandy clay loam	<0.1	4.7	2
1.4–1.5	10	2.5	41.2	41.4	Sandy loam	1.3	1.8	4
1.7–1.8	22	2.8	63.8	6.1	Sandy clay loam	<0.1	32	2

Note: D16 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-23: Land Summary SPC 6Cl(El) – Analysed Site D16

Item	Description		
UMAs	14	Total Area in MLAs (ha)	19.1

Representative Landscape Photograph



Soil Profile Photograph



(Profile viewed top right to bottom left, 2.00 m)

Location GDA2020 ZONE 54	638936 7912063
Current Use	Beef cattle grazing
Geology	Tpc, Claraville
Vegetation	Paperbark low woodland
Disturbance	Limited clearing
Landform pattern / pattern	Plain flat, gently undulating plain
Microrelief / Rock outcrop	No microrelief or rock outcrop
Drainage / Permeability	Imperfectly drained / moderate permeability
Slope percent / Erosion	1.0 / 1.0, No erosion observed
Surface condition / Surface coarse fragments or segregations	Firm, 10-20% coarse fragments <2mm
SPC ASC Order/Suborder	Brown Dermosol
Site Dominant ASC Order (s) / Code	Haplic, Magnesic, Brown Dermosol, moderately thick, sandy, clay loamy, very deep (Confidence level 1)
Ass. Land System / Soil	Claraville / Elliot
Phases	None

Soil Profile Morphology Summary

Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abund-ance	Depth (m) / Field pH Dispersion Field Test
A11 0.00-0.10 Abrupt 5-20mm	Loamy sand	Single grain Loose	<2% coarse fragments <2mm	10YR4/2 Dark greyish brown No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Few	0.05 / 6.5
A12 0.10-0.30 Abrupt 5-20mm	Loamy sand	Single grain Loose	No inclusions or segregations	10YR6/1 Grey No mottles or bleaching	Dry Rapidly drained	Fine 1-2mm Few	0.20 / 6.5 No dispersion after 10 mins Complete slaking

Soil Profile Morphology Summary							
Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abund-ance	Depth (m) / Field pH Dispersion Field Test
A21 0.30-0.80 Gradual 50-100mm	Loam Sandy	Massive Loose	No inclusions or segregations	10YR6/3 Pale brown Mottles: Orange Very few <2% Medium 5-15 mm	Moderately moist Imperfectly drained	Medium 2-5mm Few	0.55 / 6.0 No dispersion after 10 mins Complete slaking
B21 0.80-1.00 Abrupt 5-20mm	Sandy clay loam	Weak / Very weak Subangular blocky 10-20 mm No Slickensides	No inclusions or segregations	10YR6/4 Light yellowish brown Mottles: Grey, Many 20%-50% Medium 5-15 mm	Moderately moist Imperfectly drained	Very fine <1mm Few	0.90 / 6.0 No dispersion after 10 mins Complete slaking
B22 1.00-1.30 Clear 20-50mm	Clay loam, sandy	Weak to moderate/ Very weak Subangular blocky 10-20 mm, No Slickensides	No inclusions or segregations	10YR6/4 Light yellowish brown Mottles: Grey, Many 20%-50% Coarse 15-30 mm	Moist Imperfectly drained	Coarse >5mm Few	1.15 / 6.5 No dispersion after 10 mins Complete slaking
B23 1.30-1.70 Clear 20-50mm	Clay loam, sandy	Moderate Weak Subangular blocky 10-20 mm	10-20% coarse fragments 6-20mm	7.5YR6/4 Light brown Mottles: Pale Grey & red (few) medium, Many 20%-50% Coarse 15-30 mm	Moist Imperfectly drained	Very fine <1mm Few	1.50 / 7.0 No dispersion after 10 mins Partial slaking
B24 1.70-2.00 EOBH	Sandy clay loam	Moderate Weak Subangular blocky 10-20 mm	10-20% coarse fragments 6-20mm	10YR7/3 Very pale brown Mottles: Pale brown red mott, few, medium Many 20%-50% Coarse 15-30 mm	Moist Imperfectly drained	Very fine <1mm Few	1.85 / 7.5 Slight Dispersion after 10 mins Partial slaking

10.2.4.7 Soil Profile Class 7Cl(Nm): Leptic Rudosol

The slightly alkaline pH in the topsoil of the 7Cl(Nm) is within a suitable range for plant growth and is not expected to limit the availability of essential nutrients across the profile. EC values are moderate in topsoil then decrease to low in A12 horizon (0.1–0.15 m) while chloride levels remain very low across the profile. Hence, this SPC is not affected by issues associated with salinity and toxic chloride concentrations (Rayment and Lyons 2011).

ECEC levels for this SPC are considered very low throughout the profile, decreasing from 1.96 cmol/kg in topsoil (0–0.1 m) to 0.61 cmol/kg in the A12 horizon (0.1–0.15 m). The very low ECEC levels indicate limited capacity to retain and supply exchangeable cations, which may constrain plant growth.

The Ca:Mg ratio indicates that calcium is relatively high in the topsoil, approximately five times more dominant than magnesium. However, calcium then decreases and becomes co-dominant with magnesium in the A12 horizon. This suggests reduced calcium availability throughout the profile and is further supported by a very low exchangeable calcium concentration, below desirable levels of exchangeable cations (> 5 cmol/kg) (Agriculture Victoria 2011), reflecting a calcium deficiency throughout the profile.

Organic matter is interpreted as low to very low in the topsoil, as shown in Table 10-24, with limited support to structural stability of the topsoil. Vegetation growth is potentially limited by boron and copper levels.

Topsoil displays a weak structure, due to a dominant sand fraction (approx. 80%) with less clay (7.5%), as per Table 10-25. Water holding capacity of this soil, estimated from SALFPREDICT PAWC, is considered low (18.65 mm/15 cm).

Non-sodic conditions occur through the profile. Risk of dispersion and erosion in the surface layer is considered low. This is further supported by an Emerson class 3 across the soil profile, where soil was observed to disperse after remoulding.

Topsoil and subsoil resources are suitable for use on all rehabilitation areas.

A land summary, including the soil profile morphology, of SPC 7Cl(Nm) is provided in Table 10-26.

Table 10-24: Chemical fertility of topsoil (0 – 0.1 m) in SPC 7Cl(Nm), sampled at D20

Depth (m)	Organic Matter (%)	Extractable Nutrients (mg/kg)*				Extractable Metals (mg/kg)**				
		P	K	S	NO_3	B	Cu	Fe	Mn	Zn
0–0.1	1.7	9.4	110	3.6	<1.0	0.14	0.22	51	12	0.64

Note: D20 is a nominated analysed site
* P = Phosphorus, K = Potassium, S = Sulphate, NO_3 = Nitrate
** B = Boron, Cu = Copper, Fe = Iron, Mn = Manganese, Zn = Zinc
Red text indicates potential deficiency for vegetation growth.

Table 10-25: Physical properties of SPC 7Cl(Nm), sampled at D20

Depth (m)	Particle Size Analysis (%)				Laboratory Soil Texture	Ca/Mg Ratio	ESP (%)	Emerson test class
	Clay	Silt	Sand	Gravel				
0–0.1	7.5	3.5	87.8	0.3	Loamy sand	5.8	0.3	3
0.1–0.15	9.1	5.6	73.9	7.5	Loamy sand	1.1	2.9	3

Note: D20 is a nominated analysed site
Red text indicates potential deficiency for vegetation growth.

Table 10-26: Land Summary SPC 7Cl(Nm) – Analysed Site D20

Item	Description		
UMAs	10	Total Area in MLAs (ha)	4.1
Representative Landscape Photograph		**Soil Profile Photograph**	
		 (Profile viewed top to bottom, 0.70 m)	
Location GDA2020 ZONE 54	629294 7917294		
Current Use	Beef cattle grazing		
Geology (Dominant)	Tpc, Claraville		
Vegetation	Patchy grasslands		
Disturbance	No effective disturbance; hoofed animals		
Landform pattern / pattern	Plain flat, gently undulating plain		
Microrelief / Rock outcrop	No microrelief or rock outcrop		
Drainage / Permeability	Rapid drained / high permeability		
Slope percent / Erosion	<1.0 / <1.0, No erosion observed		
Surface condition / Surface coarse fragments or segregations	Firm, 10-20% coarse fragments <2mm		
SPC ASC Order/Suborder	Brown Dermosol		
Site ASC Order (s) / Code	(Confidence level 1)		
Ass. Land System / Soil	Claraville / Norman		
Phases	None		

Soil Profile Morphology Summary

Horizon / Depth (m) / Boundary	Field Texture	Structure / Strength / Pedality / Slickensides	Coarse fragments / Segregations	Colour / Mottle / Bleaching	Soil water status / Drainage	Roots Size / Abund-ance	Depth (m) / Field pH Dispersion Field Test
A11 0.00-0.10 Abrupt 5-20mm	Loamy sand	Massive	10-20% coarse fragments 2-6mm 10-20% coarse fragments 6-20mm	10YR4/3 Brown No mottles or bleaching	Dry Well drained	Very fine <1mm Few	0.05 / 7.0 Not conducted (n/c)
A12 0.10-0.15 EOBH	Loamy sand	Massive	10-20% coarse fragments 2-6mm 10-20% coarse fragments 6-20mm	7.5YR4/3 Brown No mottles or bleaching	Dry Well drained	Very fine <1mm Few	0.15 / 6.0 n/c

C Refusal on cemented pan

10.2.5 Land suitability assessment

The Land Suitability Class (LSC) was assessed in accordance with the Guidelines for Agricultural Land Evaluation (GALE) (DSITI and DNRM 2015). The GALE defines five LSC for use in Queensland in which the land suitability for agriculture decreases progressively from Class 1 to Class 5, based on the severity of the land use limitations (Table 10-27).

Table 10-27: Land suitability classes

Land Suitability Class	Suitability	Limitations	Definition[1]
1	Suitable	Negligible	Highly productive land requiring only simple management practices to maintain economic production.
2	Suitable	Minor	Land with limitations that either constrain production or require more than the simple management practices of class 1 land to maintain economic production.
3	Suitable	Moderate	Land with limitations that either further constrain production or require more than those management practices of class 2 land to maintain economic production.
4	Unsuitable	Severe	Currently unsuitable land. The limitations are so severe that the sustainable use of the land in the proposed manner is precluded. In some circumstances, the limitations may be surmountable with changes to knowledge, economics or technology.
5	Unsuitable	Extreme	Land with extreme limitations that preclude any possibility of successful sustained use of the land in the proposed manner.

[1] Definitions from GALE (DSITI and DNRM 2015)

The assessment was informed by the cropping examples outlined in the Suitability Framework for the Gulf Plains area. Of the 41 crops identified within the framework, 24 crops were selected for the assessment, representing a range of land use categories, including wet, dry and perennial season crops.

The assessed categories of LSCs for each crop land use and associated SPC are summarised in Table 10-28 and illustrated in Figure 10-5. A summary for pasture and grazing land use is provided in Table 10-29 and illustrated in Figure 10-6.

Table 10-28: Summary of crop land use suitability for each SPC

Regional Frameworks Cropping Assessment	SPCs and specific UMAs	Area within the Study Area (ha)	Area within the disturbance area (ha)
Capsicum, Cucurbit, Millet (Class 2), Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Sweet corn, Tomato, Sugarcane, Mangoes, Eggplant, Rice, Sorghum, Sunflower, Cashew, African Mahogany (Class 3), Bananas, Peanuts, Grape, Citrus (Class 4)	6Cl(El)	19.2	19.1
Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Capsicum, Cucurbit, Sweet corn, Tomato, Sugarcane, Mangoes, Bananas, Eggplant, Peanuts, Rice, Sorghum, Millet, Sunflower, Cashew, African mahogany, Grape, Citrus (Class 3)	1Cl(Ck), 2Cl(Ck) 3Cl(Ck) (UMAs 1, 12, 17) 4Cl(Ck)	4,467.6	2364.4
Lucerne, Capsicum, Cucurbit, Sweet corn, Tomato, Sugarcane, Mangoes, Bananas, Eggplant, Peanuts, Sorghum, Cashew, African Mahogany, Grape, Citrus (Class 3), Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Rice, Millet, Sunflower (Class 4)	3Cl(Ck) (UMA 15)	23.8	23.7
Sweet corn (Class 3), Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Capsicum, Cucurbit, Tomato, Sugarcane, Mangoes, Bananas, Eggplant, Peanuts, Rice, Sorghum, Millet, Sunflower, Cashew, African Mahogany, Grape, Citrus (Class 4)	5Cl(Nm)	4.2	2.4
Cotton, Chickpea, Lucerne, Capsicum, Cucurbit, Sweet corn, Tomato, Sugarcane, Eggplant, Millet (Class 4), Maize, Mungbean, Soybean, Lablab, Mangoes, Bananas, Peanuts, Rice, Sorghum, Sunflower, Cashew, African Mahogany, Grape, Citrus (Class 5)	7Cl(Nm)	4.1	4.1

Table 10-29: Summary of pasture and grazing land use suitability for each SPC

Regional Frameworks Cropping Assessment	SPCs and specific UMAs	Area within the Study Area (ha)	Area within the disturbance area (ha)
Millet (Class 2), Lablab, Lucerne, Sorghum (Class 3)	6Cl(El)	19.2	19.1
Millet, Lablab, Lucerne, Sorghum (Class 3)	1Cl(Ck), 2Cl(Ck), 3Cl(Ck) – UMA 1, 12, 17, 4Cl(Ck)	4,467.6	2364.4
Lucerne, Sorghum (Class 3), Lab Lab, Millet (Class 4)	3Cl(Ck) – UMA 15	23.8	23.7
Millet, Lablab, Lucerne, Sorghum (Class 4)	5Cl(Nm)	4.2	2.4
Lucerne, Sorghum (Class 4), Lablab, Millet (Class 5)	7Cl(Nm)	4.1	4.1

10.2.6 Agricultural land classification

The agricultural land classification (ALC) is a hierarchical scheme based on interpreted land evaluation information (DSITI and DNRM 2015). There are four classes, ranging from Class A to D, implying a decreasing range of land use choice and an increase in the severity of land use limitations and/or land degradation. The ALC is used to inform government planning schemes and regional plans as required for agricultural state interest provisions of the State Planning Policy. The description of each ALC is illustrated in Table 10-30.

The land suitability assessment identified five of the seven SPCs as having high versatility, being suitable for a broad range of existing and potential broadacre and horticultural crops, with nil to moderate production limitation, and therefore accorded an ALC Class of A1, comprising 2,407.3 ha of the Project's proposed disturbance footprint.

The land suitability assessment identified SPC 5Cl(Nm) as being suitable for a limited range of crops, with such severe production limitations that the sustainable use of the land for those crops is precluded; and therefore an ALC Class of B is appropriate. Similarly, SPC 7Cl(Nm) was identified as having extreme production limitations that preclude any possibility of successful sustained use of the land in the proposed manner and was therefore accorded an ALC Class of C.

A summary of the ALC for all SPCs is outlined in Table 10-31, noting the areas may not exactly equate the Project disturbance footprint due to rounding, and illustrated in Figure *10-4*.

Table 10-30: ALC description

Agricultural Land Class	Description
A	Land that is suitable for a wide range of current and potential crops with nil to moderate limitations to production.
A1	Suitable for a wide range of current and potential broadacre and horticultural crops.
A2	Suitable for a wide range of current and potential horticultural crops only.
B	Land that is suitable for a narrow range of crops. The land is suitable for sown pastures and may be suitable for a wider range of crops with changes to knowledge, economics or technology including the availability of water for spray or furrow irrigation.
C	Land that is suitable only for improved or native pastures due to limitations that preclude continuous cultivation for crop production. Some areas may tolerate a short period of ground disturbance for pasture establishment.
C1	Suitable for grazing sown pastures requiring ground disturbance for establishment or native pastures on higher fertility soils.
C2	Suitable for grazing native pastures, with or without the introduction of pasture species, and with lower fertility soils than C1.
C3	Suitable for light grazing of native pastures in accessible areas and includes steep land more suited to forestry or catchment protection.
D	Land not suitable for agricultural use, including land alienated from agricultural use.

Table 10-31: Summary of ALC for each SPC

ALC	SPC	Land Suitability Class	Land Uses	Total Area in MLAs (ha)	Total Area in Disturbance Footprint (ha)
A1	1Cl(Ck)	Class 3	Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Capsicum, Cucurbit, Sweet corn, Tomato, Sugarcane, Mangoes, Bananas, Eggplant, Peanuts, Rice, Sorghum, Millet, Sunflower, Cashew, African mahogany, Grape, Citrus	106.3	93.8
	2Cl(Ck)			1173.4	1072.4
	3Cl(Ck)			3070.2	1159.6
	4Cl(Ck)			62.4	62.4
	6Cl(El)	Class 2	Capsicum, Cucurbit, Millet	19.1	19.1
		Class 3	Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Sweet corn, Tomato, Sugarcane, Mangoes, Eggplant, Rice, Sorghum, Sunflower, Cashew, African Mahogany		
		Class 4	Bananas, Peanuts, Grape, Citrus		
B	5Cl(Nm)	Class 3	Sweet corn	4.2	2.4
		Class 4	Cotton, Maize, Mungbean, Soybean, Chickpea, Lablab, Lucerne, Capsicum, Cucurbit, Tomato, Sugarcane, Mangoes, Bananas, Eggplant, Peanuts, Rice, Sorghum, Millet, Sunflower, Cashew, African Mahogany, Grape, Citrus		
C2	7Cl(Nm)	Class 4	Cotton, Chickpea, Lucerne, Capsicum, Cucurbit, Sweet corn, Tomato, Sugarcane, Eggplant, Millet	4.1	4.1
		Class 5	Maize, Mungbean, Soybean, Lablab, Mangoes, Bananas, Peanuts, Rice, Sorghum, Sunflower, Cashew, African Mahogany, Grape, Citrus		

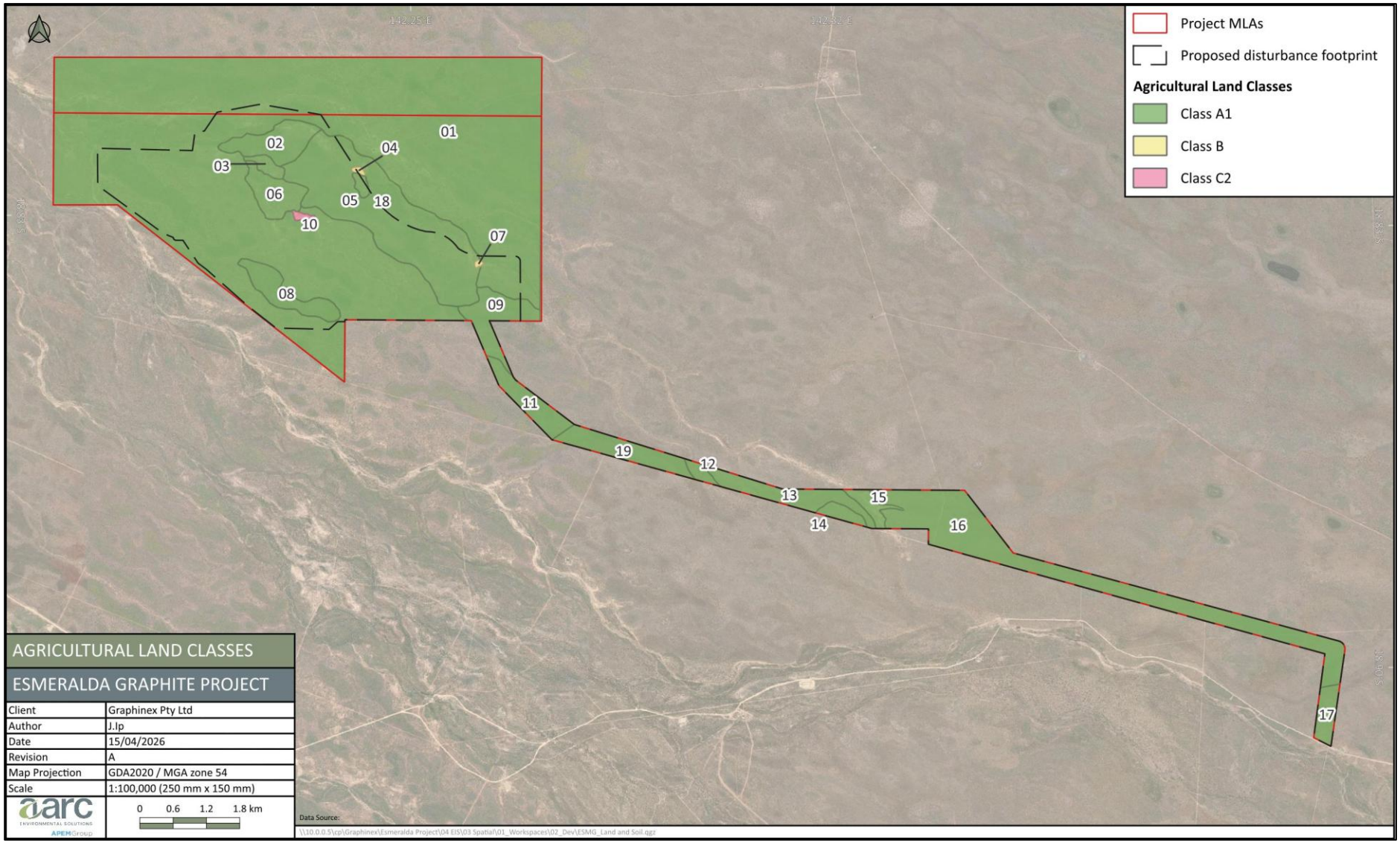


Figure 10-4: *Assessed Agricultural Land Classification*

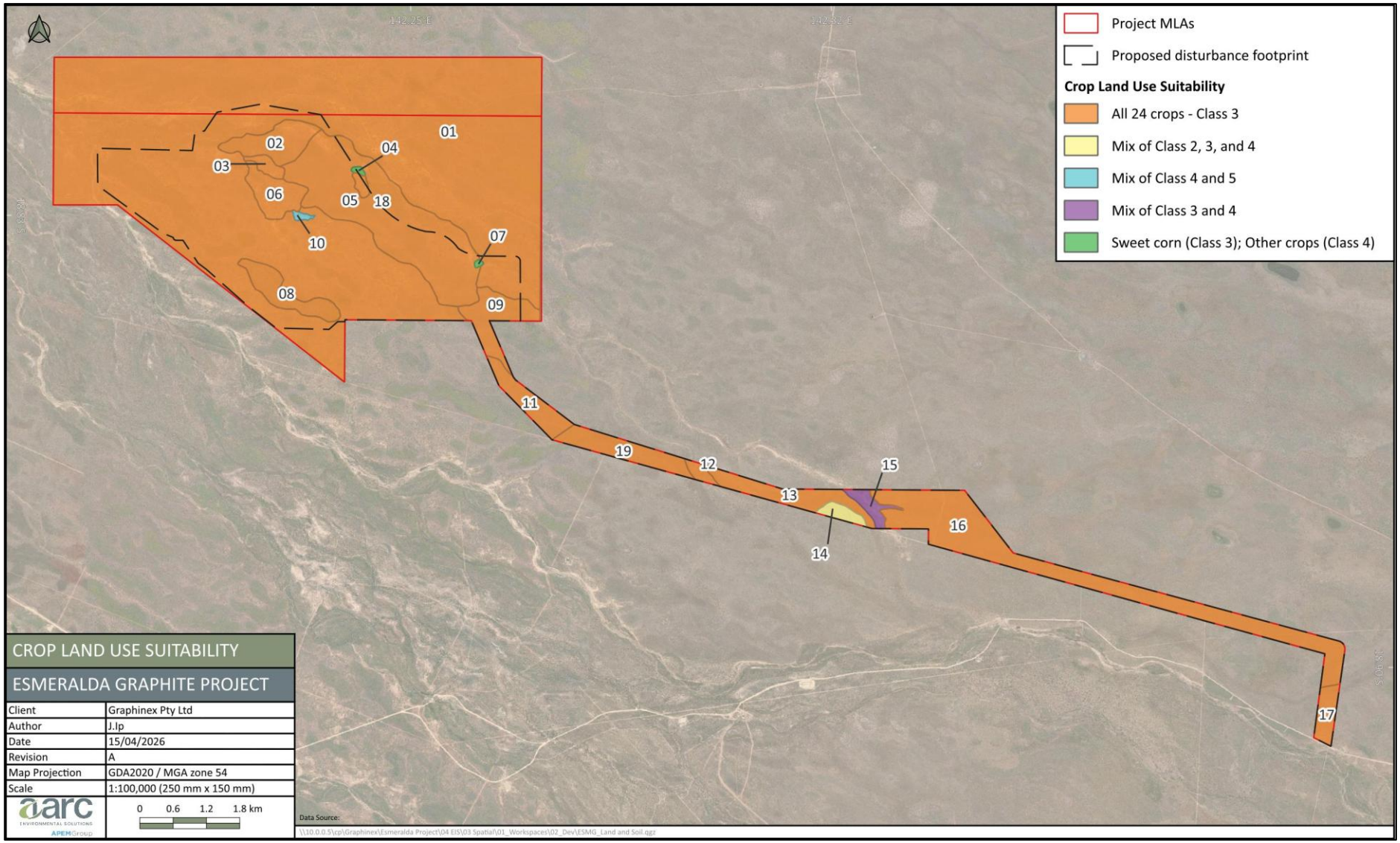


Figure 10-5: Assessed crop land use suitability

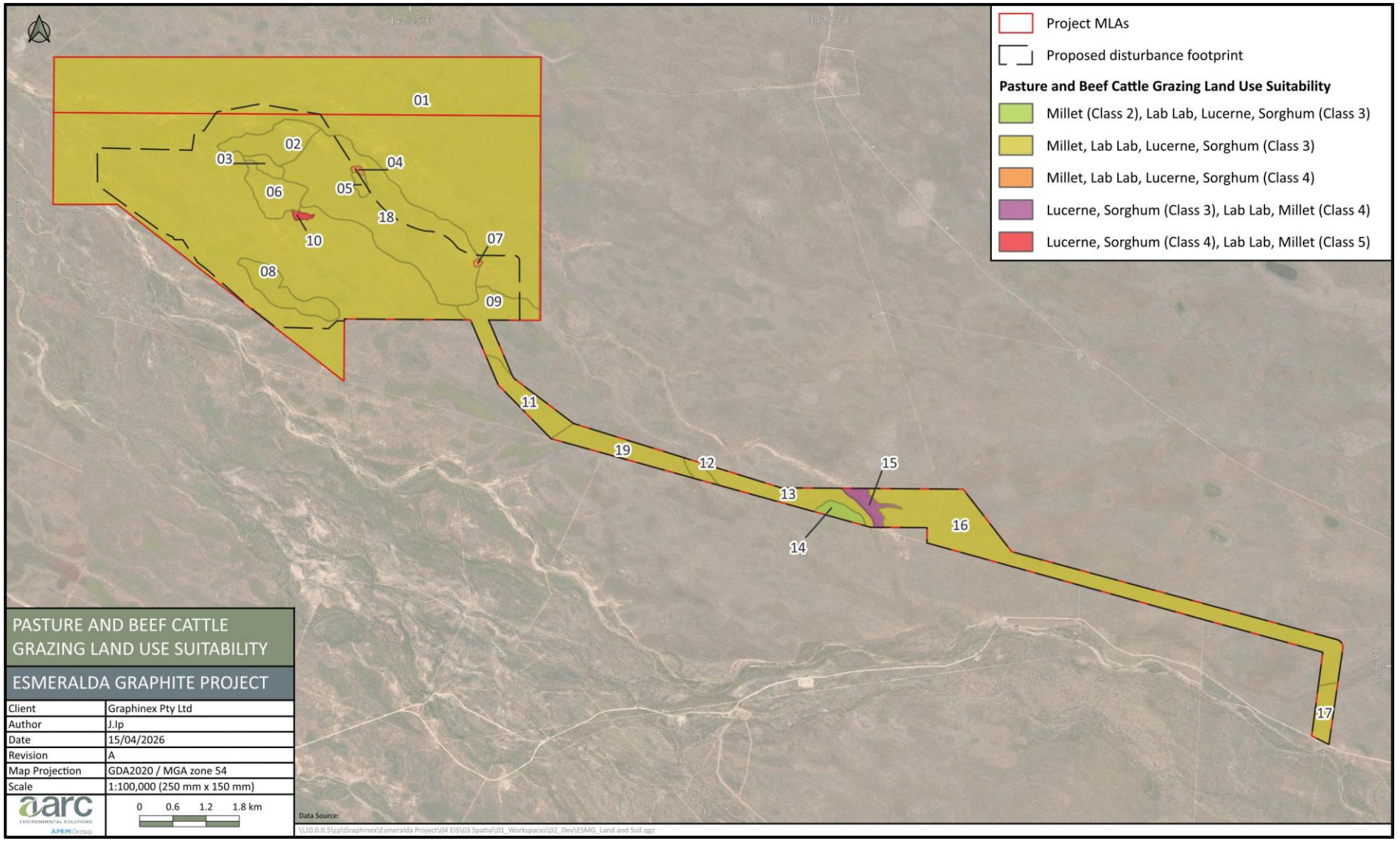


Figure 10-6: Assessed pasture and beef cattle grazing land use suitability

10.2.7 Acid sulphate soils

An acid sulphate soils assessment was undertaken by GT Environmental (2026), consisting of:

- a review of the Australian Soil Resource Information System (ASRIS);
- assessment of Actual Acid Sulphate Soils (AASS); and
- assessment of Potential Acid Sulphate Soils (PASS).

The desktop review of the ASRIS indicated the Project MLAs are located within an area having an "extremely low probability of occurrence" (GT Environmental 2026).

Field pH was initially conducted using a pH indicator kit and meter. Laboratory pH analysis results were also reviewed. All other indicators were visually inspected within the soil profile and field as part of the SLSA assessment.

All SPCs reported pH levels at or below neutral levels within the soil profile. Other acid sulphate soil indicators (including corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils) were not observed. The assessment therefore indicates a very low field indication of PASS within the Project MLAs, if not very unlikely.

In conclusion, it is highly unlikely the Project MLAs include AASS and/or PASS.

A summary of the acid sulphate soils assessment is shown in Table 10-32.

Table 10-32: Acid Sulphate Soil Assessment

SPC	AASS / PASS Assessment	Assessment
1Cl(Ck)	The pH is moderately acidic to slightly alkaline, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
2Cl(Ck)	The pH is strongly acidic to neutral, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
3Cl(Ck)	The pH is moderately acidic to moderately alkaline, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
4Cl(Ck)	The pH is slightly acidic to slightly alkaline, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
5Cl(Nm)	The pH is slightly acidic to neutral, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
6Cl(El)	The pH is slightly acidic to moderately alkaline, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.
7Cl(Nm)	The pH is slightly acidic to slightly alkaline, no observation of shells, corroded shell, jarosite horizons, iron oxide mottling, sulphurous smell or waterlogged soils.	Very low field indication of PASS, very unlikely. No field indicators of AASS.

10.3 Potential impacts

10.3.1 Topography

The Project would alter the topography and landform within parts of the Project area. Some changes would be temporary, with mining infrastructure and certain landforms being rehabilitated upon mine closure, while others would be permanent, including where infrastructure is retained post-closure. The retained infrastructure proposed includes:

- cattle exclusion fencing around the area of tailings storage facility Cell 4 and the south-western waste rock dump;
- sealed roads, access tracks and haul roads;
- airstrip;
- helipad;
- accommodation camp;
- solar array;
- diesel station;
- high-voltage substation;
- raw water dam;
- clean water sump; and
- sediment dams.

The maximum area proposed to be disturbed within the Project footprint is 2,413.7 ha. Disturbance associated with supporting infrastructure located outside of the MLAs is described in Chapter 4, Project Description.

In the operational phase, waste rock would be placed in the external waste rock dumps (WRDs) adjacent to the mine pit. The mine pit is proposed to be backfilled over the last 16 years of the mine operations.

At closure, the backfilled pit would have a final landform similar to the existing landform, sitting slightly proud of the existing surface to allow for settlement. The retention of a single remaining TSF cell and waste rock dump post-closure would alter the existing topography, however the revegetation and sloping of these landforms would not create a significant landform impact. The permanent diversion would also alter the final topography, however it would have a maximum depth of approximately 1 m, with the design criteria of mimicking the functionality of the existing watercourse, and therefore would not result in significant impacts.

The predicted regional topography in Year 63 is illustrated in Figure 10-7.

10.3.2 Hydrology

The pit will intersect the stream order 3 watercourse in approximately year 4 of operations. A permanent diversion will be developed in year 3 to ensure the suitable establishment of the diversion prior to extending the pit and flood protection levee into this area.

10.3.3 Land use

The land use of the disturbance area would be temporary altered from low-intensity cattle grazing of native vegetation (Section 10.2.2) to mining activities. However, the changes in land use would be temporary and would not significantly alter the land use permanently. The disturbance footprint would be largely rehabilitated and would be able to sustain the pre-existing land use (i.e. grazing) as part of the Progressive Rehabilitation and Closure Plan (PRCP). Retained infrastructure would further support agricultural operations, by providing quality access tracks and infrastructure to the landholder. Small areas associated with the retained WRD and

TSF (approximately 199.9 ha cumulatively) would be fenced to support cattle exclusion and the long-term stability of the landform. At a run rate of approximately 20 ha/head of cattle, this would see a herd reduction of approximately 10 head.

10.3.4 Geology

The Project location and design considered the geological properties of the site, as discussed in Section 10.2.3.

The proposed open cut mine would target the Esmeralda Granite, hosted by basement rocks within the Permian and Mesoproterozoic basement, below the Gilbert River Formation. The basement rocks are estimated at a depth of 50 m below ground level, and ore would be mined to an approximate maximum depth of 250 mbgl. Open pit mining has been identified as the optimal mining method for the type of hosted ore body, with backfilling of the pit at closure.

Along the stratigraphic profile at the Project site, the geological units intersected by mining operations would be:

a) Tertiary Claraville Beds (Tertiary sediments): Consisting of clayey quartzose sand, sandy mud and gravel, it would be backfilled into the mine void as waste.

b) Sandstone: The Gilbert River Formation, within the Cretaceous/Jurassic Carpentaria Basin strata, comprises fine to medium grained sandstone and a thin basal siltstone. It would be considered as an overburden waste material and used as backfill.

c) Basement: The Proterozoic basement rocks host the orebody proposed to be mined and processed as part of the Project.

10.3.4.1 Overburden

Overburden materials were subject to kinetic leach column testing to assess NMD potential and risk. It was determined that it can produce concentrations of molybdenum (Mo) and selenium (Se) that are above livestock drinking water criteria of 0.15 mg/L and 0.02 mg/L, respectively. These trace metal/metalloids are typically associated with neutral metalliferous drainage (NMD), rather than AMD. Concentrations peak in the third leach event and then diminish and are unlikely to persist long-term.

10.3.4.2 Geomorphology

As outlined at Section 10.3.1, the landform at closure is intended to be similar to that existing prior to mining.

The Project proposes stripping of soils within the disturbance footprint, which would result in removal of pre-existing landform features. However, the Project area is characterised by generally flat terrain, as such, soil stripping activities are not expected to result in significant alterations to the existing topography.

The Project proposes to develop an open cut pit with a maximum excavation depth of approximate 250 mbgl. There is no known regional fault structures present within the proposed pit area or within the Project MLAs. Additionally, no microrelief features or rock outcrop were observed within the MLAs. Therefore, the Project would not have an impact on fault, microrelief or rock outcrop.

The TSF cells, including the final cell retained post-closure, would be engineered structures with battered slopes ensuring geotechnical and erosive stability. This would include the revegetation of the slopes with suitable grass species which would enhance the structural stability of the form. The underlying soil type is considered highly permeable, and therefore the TSFs would be lined with an impermeable HDPE liner. TSFs and regulated structures are detailed further in Chapter 16, Flooding and Regulated Structures.

A permanent watercourse diversion would be developed where the unnamed 3rd stream order watercourse intersects the proposed open cut pit. The diversion is expected to modify the local floodplain. Further assessment of the diversion impacts is provided in Chapter 14, Water Resources.

Given the geomorphologically-aged, largely flat, gently undulating existing landform, the minimal topographical changes associated with the closure landform, and the progressive rehabilitation of disturbed areas, geomorphological impacts associated with the Project are expected to be minimal.

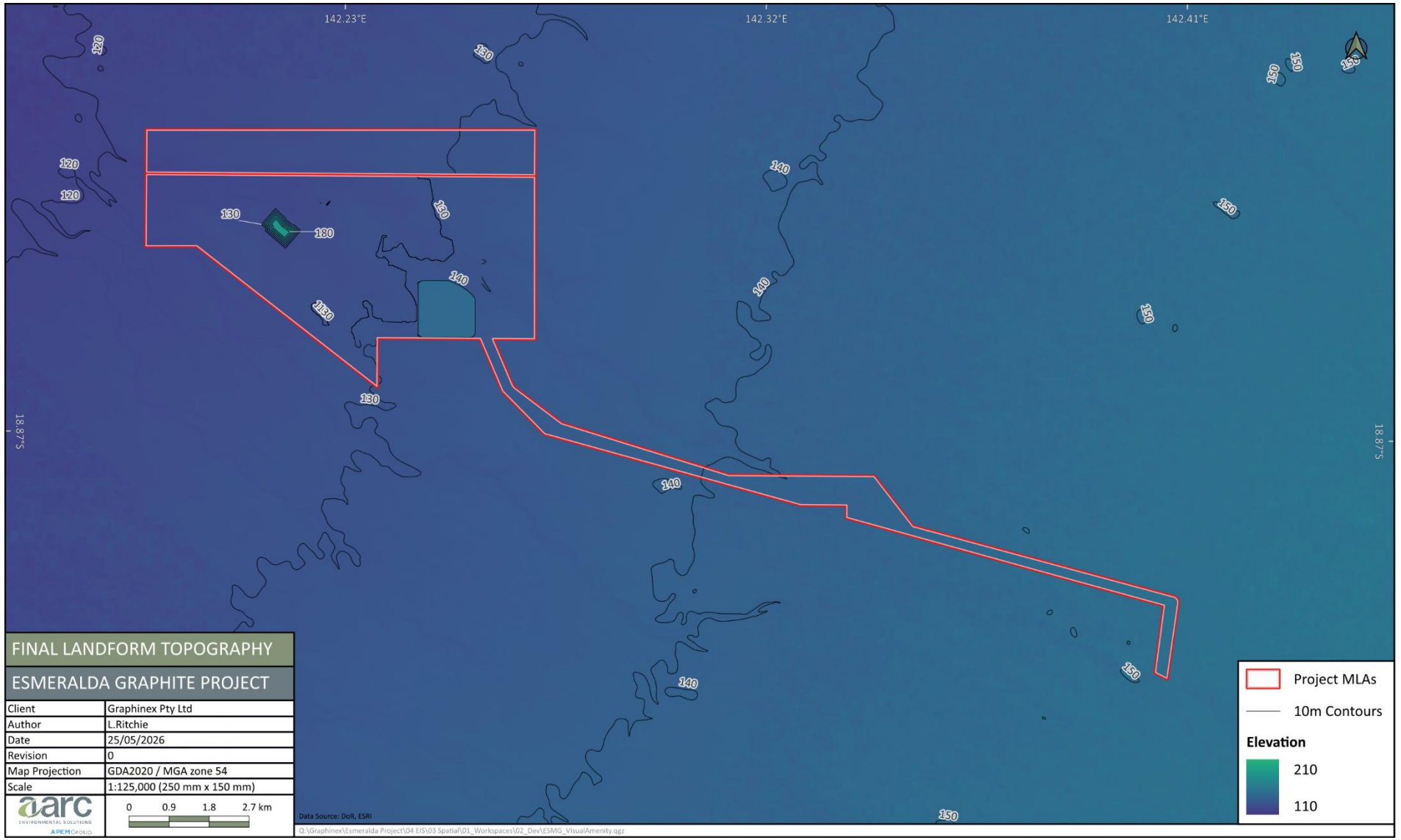


Figure 10-7: Predicted regional topography in Year 63

10.3.5 Land contamination

Activities that are ancillary to the Project have the potential to contaminate land. These activities are referred to as 'notifiable activities' and are listed in Schedule 3 of the EP Act. The Project would involve the notifiable activities presented in Table 10-35.

The inappropriate storage and handling of chemicals and waste presents a potential risk of land contamination. Soil contamination, which is an aspect of land contamination, is discussed further in Section 10.3.5.1.

Further information on the hazardous materials and activities with risk to land contamination, as well as mitigation measures, are discussed in Chapter 22, Hazards, Health and Safety. Information on potential water impacts due to the Project's land uses are discussed in Chapter 15, Water Quality.

Table 10-33: Notifiable activities for the Project

Notifiable activity	Notifiable activity description
Schedule 3 of the EP Act	
7 Chemical storage	Storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.
24 Mine wastes	a) Storing hazardous mine or exploration wastes, including, for example, tailing dams, waste rock or waste rock dumps containing hazardous contaminants; or b) Exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
29 Petroleum product or oil storage	Storing petroleum products or oil: c) In above ground tanks: a. for petroleum products or oil in class 3 in packaging groups 1 and 2 of the dangerous goods code – more than 2,500 L capacity; or b. for petroleum products or oil in class 3 in packaging groups 3 of the dangerous goods code – more than 5,000 L capacity; or c. for petroleum products that are combustible liquids in class C1 or C2 in Australian Standard AS 1940, 'The storage and handling of flammable and combustible liquids' published by Standards Australia – more than 25,000 L capacity.
37 Waste storage, treatment of disposal	Storing, treating, reprocessing or disposing regulated waste including operating a sewage treatment facility with onsite disposal facilities.

10.3.5.1 Land contamination

The Project activities have the potential to contaminate land by spills or leakage from several sources and activities as follows:

a) mineral processing, tailings and process water operations;

b) mine-affected water storages and drainage;

c) the storage and use of chemicals or fuel;

d) the waste collection area; and

e) sewage treatment plant (STP) effluent.

Each of the potential sources of land contamination has been subject to a risk analysis as part of the Hazards, Health and Safety assessment (Chapter 22, Hazards, Health and Safety). Mitigation and management controls have beem developed through a structured, evidence-based process following identification and assessment of the specific risk and by applying the hierarchy of controls. The hierarchy of controls prioritises the most effective measures such as elimination or substitution rather than lower level controls such as administration.

The potential sources of land contamination that have identified are common to the mining industry and well-established controls exist to manage the contributing activity, and in case of an emergency.

10.3.5.2 Potential Acid Forming materials

An assessment of the geochemistry of mine materials was undertaken by RGS Environmental Consultants (2026) (Appendix U, Geochemistry Assessment of Mine Materials and Tailings). It was identified that potential acid forming (PAF) materials may be present in low grade ore, ore body, and tailings materials (Table 10-34).

The risk of acid mine drainage (AMD) increases with depth along the stratigraphic profile. While the soil, overburden and waste rock are expected to be non-acid forming (NAF), low grade (LG) ore is also typically classified as NAF. In contrast, high grade (HG) ores were found to contain PAF materials. Ore body materials with > 3% total carbon are typically classified as PAF – low capacity or PAF, with only approximately 10% of these materials being NAF. Tailings generated from ore body materials are also expected to be typically PAF. Material identified as PAF would be processed at the end of the mine life to extract economic value (RGS 2026).

A detailed summary of the geochemical properties of mine materials is provided in Chapter 17, Waste.

Table 10-34: Summary of geochemical characteristics for mine materials

Mine materials	$pH_{1:5}$	Geochemical classification*	Proportion of samples containing PAF (%)^	Metal/ metalloids
Soil	5 to 6	NAF-B	0	Al, Cd, Cu, Pb, Zn
Overburden	7 to 8	NAF-B	0	Al, Mo, Se, CaSO4
Waste rock	Alkaline	NAF-B	0	F, Al, Cu
Ore body	Slightly alkaline and low pH value	NAF/NAF-B to PAF-LC/PAF	78	S content increases with depth
Low grade ore	Low pH	NAF/NAF-B and PAF	12.5	Higher C content
Tailings	6 to 9	PAF	87.5	Al, Cr, Cu, Mn, Ni, and Zn Minor Cu, Mo, Re, S and Te

*NAF = Non-acidic forming; NAF-B = Non-acidic forming – Barren; PAF-LC = Potential acid forming – Low capacity
^includes PAF-LC and PAF

10.3.6 Soils

10.3.6.1 Soil disturbance

Disturbance of land associated with Project activities may impact soils and degrade land, as described in Table 10-35.

Table 10-35: Potential impacts from soil disturbance and relevant management measures

Land degradation	Impact and management description
Erosion	Susceptibility to water erosion depends on several factors including climate, slope, runoff, soil erodibility and land use. Erosion contributes to a reduced ability of the soil to store water/nutrients, the exposure of subsoils with poor physical properties, high rates of runoff causing a loss of moisture and nutrients and loss of juvenile plants. The topsoil of all SPCs were assessed as Emerson Class 3. Materials of Emerson Class 3 are preferred for most construction work and these soils are expected to be generally stable (RGS 2026). However, the subsoils of SPC 3Cl(Ck), 4Cl(Ck) and 6Cl(El) were assessed as generally being of Emerson Class 2, indicating a higher risk of erosion. Appropriate erosion and sediment control measures can effectively mitigate the risk of erosion. **Erosion and sediment controls would be implemented during the construction, operation and rehabilitation phases of the Project**, including: • topsoiled areas would be deep ripped to reduce compaction from heavy machinery, encourage infiltration of water and prevent erosion. Areas would be ripped along the contour to reduce the velocity of runoff water down the slope and encourage infiltration; • revegetation of disturbed areas would be carried out as soon as practicable following completion of works, subject to weather forecasts; • placement of topsoil stockpiles would be away from drainage areas, roads, machinery, transport corridors and stock grazing areas; • design and management of drainage control measures to prevent erosion from concentrated flows and manage the flow of clean and sediment runoff; • design and management of sediment dams including dewatering and desilting requirements to meet IECA standards; • upslope diversions would be used to reduce clean water interaction with disturbed areas; • downslope collection drains would be used to divert sediment laden water to sediment dams, designed to capture sediment from disturbed areas; and • sediment fences and filters would be used to retain and filter suspended solids. An Erosion and Sediment Control Plan would be developed for the Project to ensure the effective and appropriate implementation of erosion control measures; including monitoring and maintenance of control systems.
Salinity	Soil salinity refers to the accumulation of water-soluble salts, mainly sodium, calcium, and magnesium. These can severely affect plant growth and land use and increase soil erosion. **No salinity impacts are expected as a result of soil disturbance by the Project**, as soil properties of SPCs within the Project MLAs are typically non-saline.
Acidity	Soil acidity refers to the concentration of hydrogen ions in the soil. A suitable soil pH range indicates essential nutrients are available and supports plant growth. **No acidity impacts are expected as a result of soil disturbance by the Project**, as the soil properties of SPCs within the Project MLAs range from moderately acid (pH 5.33) to moderately alkaline (pH 8.76); i.e. within the range most suitable for plant growth.
Rehabilitation	Soil for rehabilitation use would be stripped and stockpiled which may create additional erosion risk. Erosion impacts and mitigation measures are described in Section 10.4.2.2. Soil amelioration is proposed to be undertaken where required to support the desired PMLU outcome. This is discussed in detail in Section 10.4.2.1. The rehabilitation and final landform are discussed in detail in Chapter 13, Rehabilitation and Closure.

Land degradation	Impact and management description
Stability	Soil testing would be conducted prior to any construction of infrastructure to verify that the in-situ soil properties can provide the required structural stability. Where testing identifies soils that are unsuitable to support development, appropriate structural reinforcement measures would be implemented to ensure stability and safety. As discussed above under 'Erosion', the erosion potential across the Project area is generally moderate, except for three SPCs which comprise only a relatively small proportion of the disturbance area. Where these SPCs are required as a rehabilitation resource, they would be managed appropriately. The PRCP would ensure the final landform achieves a stable landform in all rehabilitated areas and the retained WRD and single tailings storage facility (TSF). Further details are provided in Chapter 13, Rehabilitation and closure.
Loss of organic matter, fertility and soil structure decline	Mining disturbance leads to the loss of litter layer and organic matter, causing a drastic reduction in nutrient-holding capacity. Loss of organic matter limits the binding of soil aggregates and leads to soil structure decline. Therefore, a soil with low organic matter readily collapses when wetted, reducing infiltration of rain and increasing runoff and subsequent erosion. Topsoil management and amelioration measures are recommended in Section 10.3.6.2 to improve topsoil quality and rehabilitation success upon mine closure.

10.3.6.2 Soil stripping, stockpiling, placement, and amelioration

The Project would require soil stripping, stockpiling, and placement. Appropriate practices are necessary to prevent impacts such as land degradation, soil contamination, erosion, excess salinity and toxic chloride concentrations, and loss of critical nutrients for plant growth, during these processes. Stripping and stockpiling of soil would supply the growth medium used in rehabilitation of the Project site.

A summary of the potential stripping depths and estimated volumes is shown in Table 10-36.

Table 10-36: Potential growth medium stripping depth and estimated volumes

SPC	Topsoil Depth Interval (mbgl)	Subsoil Depth (mbgl)[1]	Area within disturbance (ha)	Available Topsoil Volume within disturbance (m³)	Available Subsoil Volume within disturbance (m³)
1Cl(Ck)	0.00–0.70		93.8	657,090	
2Cl(Ck)	0.00-0.50	UMAs 2, 8, 13, 16: 0.50 – 2.20 UMA 11: 0.50 – 1.15 UMA 18: 0.50 – 1.40 UMA 19: 0.50 – 1.70	1,072.4	5,362,000	UMAs 2, 8, 13, 16: 10,327,500 UMA 11: 407,550 UMA 18: 2,893,500 UMA 19: 968,400
3Cl(Ck)	0.00-0.45	0.45 – 0.65	1,159.6	5,218,400	2,319,300
4Cl(Ck)	0.00-0.60	0.60-0.75	62.4	374,160	93,540
5Cl(Nm)	0.00-0.35	-	2.4	8,400	
6Cl(El)	0.00-0.30	0.30-2.0	19.1	57,720	327,080
7Cl(Nm)	0.00-0.15	-	4.1	6,150	0
Total				**11,683,720**	**17,336,770**

[1] Where UMAs of sufficient size and topsoil/subsoil depth exist, UMAs have been calculated separately.

Erosion

Disturbance of vegetation and topsoil layer can lead to soil erosion, such as water erosion from heavy rainfall or overland flow, and wind erosion on the dry, sandier soils and self-mulching clays. The following Project activities are expected to increase the risk of soil erosion:

a) clearing of vegetation;

b) topsoil stripping and stockpiling;

c) construction of infrastructure; and

d) exposure of slopes.

10.3.6.3 Acid sulphate soils

As discussed in Section 10.2.7, the presence of AASS and/or PASS is highly unlikely, therefore, no impacts are expected to arise from the Project.

10.3.7 STP effluent disposal

The Project proposes a package sewage treatment plant (STP) to be constructed at the on-site accommodation facility located near the eastern boundary of the Project MLA. The STP is designed to treat 100% of potable water throughput of the accommodation camp for the Project. Treated effluent generated by the STP would be managed via land application through irrigation.

To manage potential impacts associated with treated effluent and to assess the long-term sustainability of the proposed treated wastewater irrigation scheme, a Model for Effluent Disposal using Land Irrigation (MEDLI) has been undertaken (Appendix M - Land-based Effluent Disposal Assessment Report).

Considering local climate factors, MEDLI modelling identified that a 3 ha irrigation area located 50 m southeast of the accommodation camp (Figure 10-8) would be of sufficient size and a suitable location. The irrigation system would be operated using a simple fixed daily design irrigation rate of no more than 3.5 mm/day to dispose a conservative volume of 40 m^3 per day of secondary treated effluent. MEDLI model outputs are summarised in Table 10-37. Full details regarding sewage and irrigation management are provided in Chapter 17, Waste.

The STP and effluent irrigation system represents a balanced, conservative, and efficient design with the following objectives:

- achieve all performance objectives for effluent reuse, soil protection, and water balance;
- be robust to site vegetation and soils as demonstrated by irrigation scheduling sensitivity analysis; and
- avoid unnecessary expansion of the land application footprint.

The irrigation area is relatively level, at an elevation of approximately 130 m AHD, and does not contain any drainage lines of significance. The nearest mapped watercourse is an unnamed non-perennial 3rd stream order watercourse, approximately 400 m northeast of the irrigation area.

The underlying soil type is 1Cl(Ck), a brown tenosol. This soil type is characterised by moderately deep loamy sand soil with a soft surface and single grain to massive structured subsoils, associated with flat to gently undulating plains with paperbark low woodland.

The effluent irrigation area is located within the broader Project footprint and overlies the same regional hydrogeological setting assessed for the mine (AARC 2026-MEDLI). The mine pit is located down-gradient of the irrigation area, in the direction of the regional groundwater flow path. Therefore, any groundwater recharge or downward flux originating beneath the irrigation area would migrate toward the mine pit.

The proposed irrigation area is located within Least Concern *Corymbia polycarpa* woodland (RE 2.5.28a, Figure 10-9) and does not contain any Regional Ecosystems classed as Endangered or Of Concern.

It is not proposed to harvest or remove the above-ground biomass of the irrigation area as part of the irrigation area management.

Table 10-37: MEDLI output summary

Parameter	Units	Design Irrigation Rate of 3.5 mm/day over a 3-ha area
Irrigation Area	ha	3
Wet Weather Storage Volume	kL	2,400
Irrigation Control		Every 1 day to 3.5 mm (Excl. rainfall days)
Pond Inflow	kL/year	15,704
Irrigation Volume	kL/year	15,685
Overflow Volume	kL/10 years	5.54
No. of Days Overflow	Days/10 years	0.2
Overall Reuse	%	100
Rainfall	mm/year	775
Irrigation Applied	mm/year	523
Soil Evaporation	mm/year	353
Transpiration	mm/year	704
Rain Runoff	mm/year	26.4
Irrigation Runoff	mm/year	0
Drainage	mm/year	213
Plant Species		Monthly Green Covers – Deciduous Forest Cover
Salinity of Soil Solution at Base of Rootzone	dS/m	4.17
Nitrogen Irrigated	kg/ha/year	146
Phosphorus Irrigated	kg/ha/year	49

10.3.7.1 Effluent quality

The quality of treated wastewater used as the MEDLI input parameter for effluent is presented in Table 10-38. This data is based on the long-term limits established in the *Eligibility Criteria and Standard Conditions for Sewage Treatment Works (ERA 63) – Version 2* (Department of Environment and Heritage Protection 2015). These limits also align with the quality which would be expected from a basic sewage treatment plant as per the *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1)* (Natural Resource Management Ministerial Council, Environment Protection and Heritage Council, & Australian Health Ministers' Conference. 2006).

Table 10-38: Effluent quality

Parameter	Units	Effluent Quality
pH	-	5.0 – 8.5
Conductivity	µs/cm	1,600
Total Nitrogen	mg/L	30
Total Phosphorous	mg/L	10
Total Residual Chlorine (if used for disinfection)	mg/L	1
Total Suspended Solids	mg/L	20 – 25
Biochemical Oxygen Demand	mg/L	30
E.coli	Cfu/100 mL	<1,000

10.3.7.2 Nutrient leaching

MEDLI outputs indicate the applied nutrient and salt loads presented in Table 10-39.

Table 10-39: Nutrient Loading

Effluent constituent	Approximate total applied load (kg/year)	Approximate applied load (kg/ha/year)
Total Nitrogen (TN)	437	146
Total Phosphorus (TP)	146	49
Total Dissolved Salts	14,900	5,000

Nitrogen (N)

A Rhodes grass pasture scenario was used to assess nitrogen leaching under the proposed irrigation and effluent conditions. Results for a 3 ha area show very low nitrogen losses, approximately 146 kg/ha/year applied, with only about 0.10 kg/ha/year leached (<0.1% of applied N). This indicates nitrogen loss to leaching is negligible with most nitrogen applied to the irrigation area remaining in the soil or taken by plants. Average deep drainage nitrate concentrations are extremely low (0.01–0.03 mg/L long-term), with temporary short-term peaks (<1 mg/L) only in early years or after wet season drainage.

Flow-weighted nitrate-N concentrations in deep drainage are presented in Table 10-40.

Table 10-40: Flow weighted nitrate concentration

Metric	Modelled value (mg/L)
Average nitrate-N concentration (all years)	0.03
Average nitrate-N concentration (excluding first year)	0.01
Maximum annual nitrate-N concentration	0.94

Phosphorus (P)

MEDLI modelled an average load of 49 kg/ha/year of phosphorus added to the soil, with the majority of the applied phosphorus retained within the soil profile through adsorption and incorporation into soil phosphorus pools. No progressive increase in dissolved or mobile phosphorus is evident over the simulation period. On average, approximately 0.0036 kg/ha/year of phosphorus would be lost via leaching, which corresponds to less than 0.1% of the applied phosphorus. These values confirm that phosphorus leaching is negligible and that soil adsorption capacity effectively immobilises applied phosphorus. The absence of increasing leached mass over time indicates that phosphorus retention mechanisms remain effective at steady state.

Salinity

Salinity modelling shows that salt behaviour is characterised by effective leaching sufficient to prevent accumulation in the rootzone, while maintaining stable long-term conditions.

Quantitative salt leaching behaviour is consistent across vegetation scenarios. MEDLI outputs indicate an average annual salt added and leached at steady state by approximately 5,110 kg/ha/year, resulting in an average rootzone salinity (ECe) of approximately 0.63 dS/m.

This demonstrates that rootzone salinity remains well below crop tolerance thresholds. The leaching fractions are considered to be sufficient to prevent salt accumulation within the soil profile. There is no upward trend in soil salinity observed over the simulation period, indicating that the irrigation scheme would be well within acceptable salinity limits and does not present an environmental risk.

10.3.7.3 Wet weather storage and flooding

Wet weather effluent storage has been provided with a usable capacity equivalent to approximately 60 days of Average Dry Weather Flow (ADWF). This storage duration has been adopted to account for the monsoonal rainfall regime of north-west Queensland, where prolonged wet season conditions can significantly restrict irrigation opportunities and result in extended periods during which land application is not practicable. A 60-day storage allowance represents a conservative and commonly applied design assumption for mine accommodation facilities in remote northern Queensland and is considered appropriate to ensure continuous operation of the sewage treatment system without uncontrolled releases during sustained wet weather.

A review of the 0.1% AEP flood model result (Appendix K, Surface Water Impact Assessment), indicates that the proposed irrigation area is located outside the mapped 0.1% flood extents. Surrounding areas are predicted to experience shallow inundation (≤ 0.30 m depth) under the 0.1% AEP flood event.

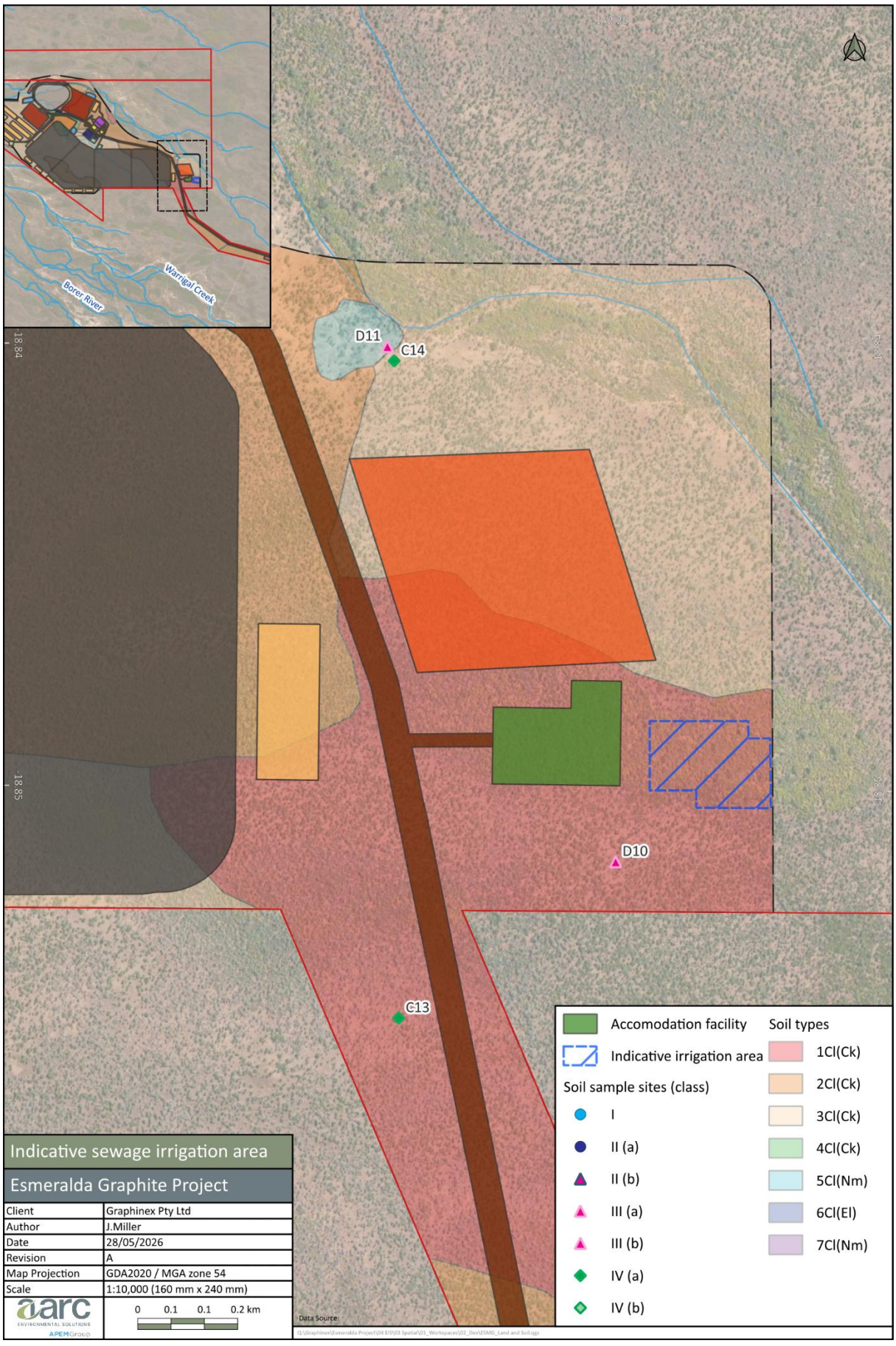


Figure 10-8: Proposed irrigation area

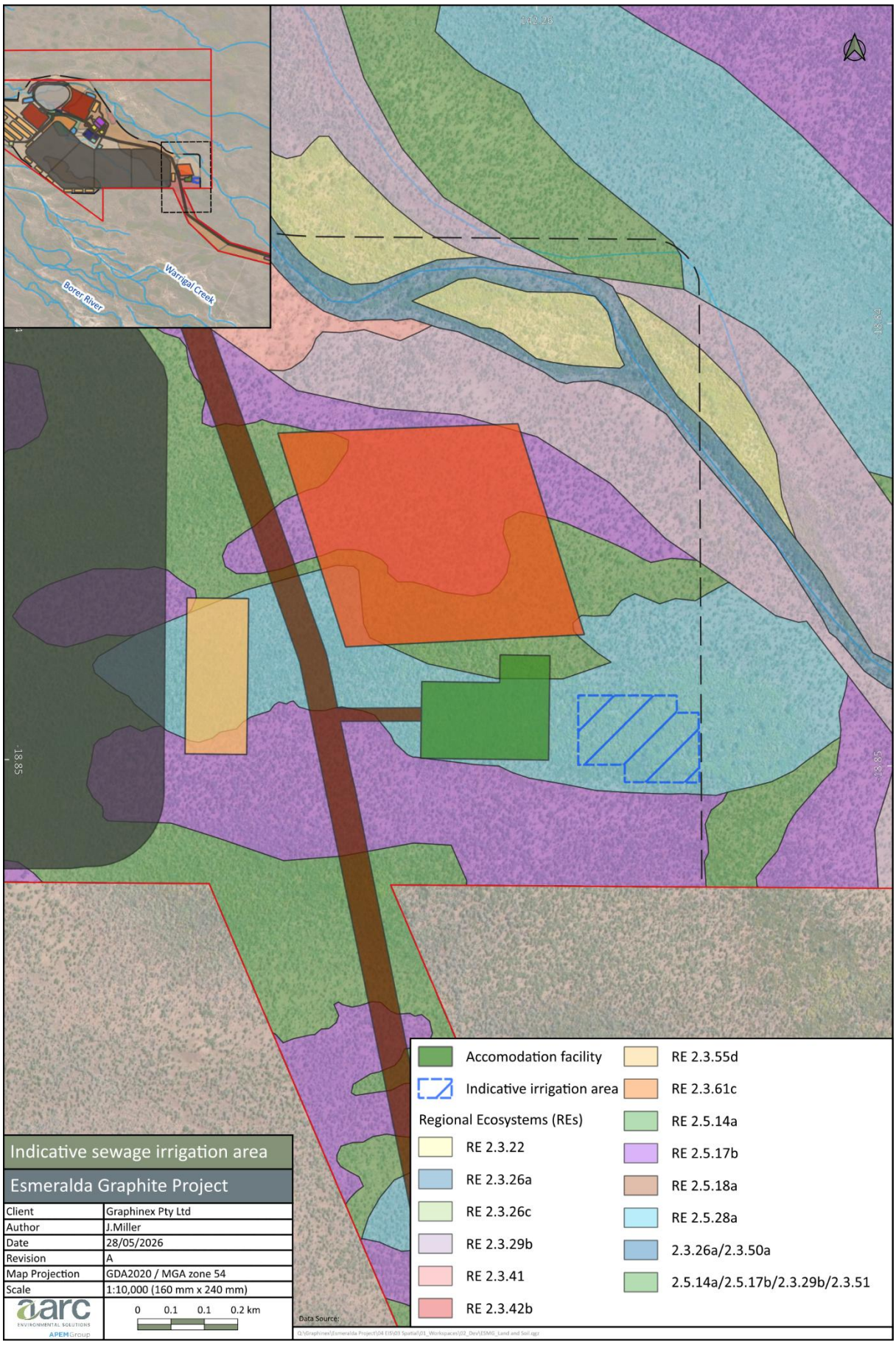


Figure 10-9: Sewage irrigation area with regional ecosystem context

10.4 Mitigation and management measures

10.4.1 Land

The Project would ensure that disturbed land, soils, subsoils, and landforms would be managed in a way that prevents or minimises adverse effects on the environmental values of land. This includes that areas disturbed by the Project's activities would be rehabilitated or restored to ensure that the site is safe and stable.

The open-cut pit would be backfilled to at or slightly above surface level, with the top surface rehabilitated to a PMLU of grazing native vegetation. Backfilling is scheduled to commence during the late stages of mine operation, starting with the transport of tailings from the first three tailings storage facilities to the base of the pit in approximately year 35, before capping with an engineered capping layer that hydraulically disconnects the tailings from the waste rock from the waste rock dumps (WRDs) as an upper backfill and capping material to surface. By backfilling the pit and ensuring no final void in the landscape, the Project would also reduce the impact of the WRD on overall topography by entirely removing the eastern WRD, and the upper half of the western WRD. A layer of growth medium, comprising stripped or stored topsoil and subsoil would be applied to the surface of rehabilitated landforms to encourage vegetation growth and water retention.

The remaining material in the western WRD would be retained, and have an elevation up to approximately 180 mAHD. The rehabilitated landform would be revegetated and designed in a manner that ensures a safe and stable landform, which complements the gently undulated topography of the surrounding landform, as shown in Figure 10-7. Further details on rehabilitation are provided in Chapter 13, Rehabilitation and Closure.

The topographical changes that may occur with the construction of dams and access roads/tracks would be minor.

A signed agreement has been received by Graphinex, indicating that the landholder:

- consents to the identified infrastructure remaining on the land after the cessation of mining activities for the Project; and
- undertakes to accept responsibility, liability and ongoing maintenance obligations for the permanent infrastructure following the surrender of the MLAs.

The proposed permanent diversion would be purposefully designed in consideration of the structure, composition, and criteria of establishing a functional watercourse in lieu of the disturbed watercourse. As such, it would support longevity and stability as a landform and riparian or aquatic ecosystem during Project operations and post-closure.

10.4.1.1 Geomorphology

As described in Section 10.3.4.2, the impacts to the local geomorphology are mostly temporary, as the PRCP aims to rehabilitate the disturbed areas to achieve a topography and landform similar to the existing condition. The Project proposes to retain one WRD and one TSF, which would be rehabilitated to ensure a safe, stable, and self-sustaining landform. Rehabilitation details are provided in Chapter 13, Rehabilitation and closure.

Table 10-41 details a summary of the management measures that would be undertaken at the Project site for mine materials in each geology units.

Table 10-41: Summary of application or management measures on mine materials (adapted from RGS 2026)

Units	Mine materials	$pH_{1:5}$	Geochemical classification*	Application or management
Wallumbilla Formation / Gilbert River Formation / Eulo Queen Group	Overburden	7 to 8	NAF-B	• Likely to be suitable as a bulk fill or cover material. • No AMD management required if used as backfill or placed into out-of-pit dumps. • May produce neutral metalliferous drainage (NMD) in oxidising conditions, resulting in slightly elevated concentrations of F, Mo, and Se. Unlikely to persist long-term, but would be included in the water monitoring program.
	Waste rock	Alkaline	NAF-B	• Likely to be suitable as a bulk fill or cover material. • No AMD management required if used as backfill or placed into out-of-pit dumps. • Potential to be used as competent rock for rehabilitation purposes.
Inorunie Group / Esmeralda Granite / Croydon Volcanic Group / Forest Home Trondhjemite / Langlovale Group / Etheridge Group	Ore body	Slightly alkaline and low pH value	NAF/NAF-B to PAF-LC/PAF	• Likely to be processed as ore to generate a graphite concentrate and tailings that would be disposed as backfill. • Water management at ROM ore stockpiles required. Unsuitable as a bulk fill material or surface layer.
	Low grade ore	Low pH	NAF/NAF-B and PAF	• If not processed, low grade ore may be suitable as backfill or for placement in the central core of a backfilled void.
	Tailings	6 to 9	PAF	• Disposal into the backfilled void with a waste rock cover and soil capping is the recommended AMD management strategy. • Preferably inundated with groundwater. • Tailings are unsuitable as a bulk fill material or surface layer without treatment.

*NAF = Non-acidic forming; NAF-B = Non-acidic forming – Barren; PAF-LC = Potential acid forming – Low capacity

10.4.2 Soils

10.4.2.1 Soil stripping, stockpiling, placement and amelioration

Stripping, stockpiling, and placement practices, as well as relevant management and mitigation measures for possible detrimental impacts on soil and land, are based on expert recommendations by GT Environmental (2026). The expert recommendations were tailored to the Project site in accordance with the relevant soil and land guidelines and assessments (Appendix H, Soils and Land Suitability Assessment). Good topsoil management practices would enable mitigation of impacts from mining activities.

Topsoil stripping is required when planning mine disturbance areas to recover valuable topsoil resource for rehabilitation purposes, ensuring the removal of the maximum volume of viable topsoil and waste reduction. The depth of topsoil suitable to be stripped and stockpiled would vary by soil type, as outlined in Table 10-36, to ensure the retention of valuable vegetative organic matters, seedstock, and nutrients. Where possible, topsoil would be stripped with its existing ground cover vegetation and, if subject to stockpiling, relocated with its cover crop vegetation. Similarly, subsoil suitable to be stripped and stockpiled would also vary by soil type

(refer to Table 10-36) and would be stockpiled separately from topsoils and other subsoils according to the soil properties.

In general, SPCs within the MLAs displayed similar properties, including:

- sandy to sandy loam dominant texture;
- high sand content (> 70%) with low clay content (3 – 15%) in topsoil and subsoils (except for SPC 6Cl(El) where subsoil has > 20% clay content);
- high permeability and well to rapid drained (except SPC 6Cl(El): moderate permeability and imperfectly drained);
- very low ECEC across soil profile;
- low organic matter in topsoils;
- no sodicity concerns in topsoil;
- no salinity or chloride toxicity concerns in topsoils and subsoils;
- deficient in at least 3 types of extractable nutrients and 2 types of extractable metals in topsoils; and
- a low surface K-factor (except SPC 5Cl(Nm): moderate K-factor).

Topsoils of all SPCs are considered suitable materials for rehabilitation use. However, given the subsoil depth differs across different areas of the same SPCs, the stripping depth of subsoil has been adjusted based on observations, described in Table 10-36.

Where possible, topsoil would be directly placed in prepared rehabilitation areas, rather than stockpiled, to assist in maintaining a viable seedbank and promote timely revegetation (Figure 10-10). Stockpiling of topsoil for extended periods can lead to physiochemical and biological deterioration in the soil and affect the viability of the soil seed bank.

However, when stockpiling is necessary, the following recommendations by GT Environmental (2026) would be implemented for soil stockpile management to reduce the risk of soil degradation and improve the chances of rehabilitation success:

a) stockpile locations should be placed in areas outside the mining activities, as close to the area to be rehabilitated where possible and away from watercourse and tributaries;

b) any known overland flow, watercourse and tributaries around the stockpiles should be diverted or have appropriate measures in place to prevent erosion;

c) locations are to be designated off limits by remaining grazing stock, machinery, and vehicles;

d) stockpile locations should be placed against existing vegetated areas to function as a buffer, or adjacent to any rise in landscape to provide protection from wind erosion, where possible;

e) ripping, seeding and/or adding amelioration treatments should occur during operation to minimise compaction and surface structure degradation;

f) the surface of the stockpile should be flat;

g) adequate erosion and sediment control including but not limited to sediment fencing, shall be placed on the down slope area of stockpiles;

h) the installation of plastic lined catch drains or runoff areas along the surface edge of waste or elevated landforms may assist in minimising surface runoff on batter slopes;

i) stockpiles should have a maximum height of 3.0 m, preferably 2.0 m with a batter recommended no steeper than 3 h : 1 v (horizontal run to vertical rise). Stockpiles required to be more than 3.0 m in height shall require additional erosion and sediment controls and ideally be temporary stored;

j) covering of the stockpiles with grasses or groundcover species appropriate to the nominated PMLU would minimise erosion and soil loss, minimise the establishment of weeds, assist in maintaining organic matter, nutrients and microbial activity and rejuvenate native vegetation through existing seedbank;

k) stockpiles which are scheduled to be stored over a long-term period i.e. not utilised within a short term period of stripping to replacement of soil resources, shall be reviewed and soil turned and mixed, in order to engage deeper stockpile soils, spread biological aspects of existing growth medium and existing vegetation (now organic matter). This would reduce the situation of stockpile soil being unbalanced with surface soils retaining their health (biological, physical and chemical) with deeper soils becoming weathered and transitioning to less healthy, potentially subsoil resources; and

l) an inspection of the stockpiles should occur once they are completed with scheduled ongoing maintenance either as required, or recommended every six months if no scheduling has been considered.

Before topsoil placement, topsoil sampling and analysis would be undertaken to determine any deficiencies in the chemical composition of the soil for vegetation health. The results of the topsoil analysis would decide the amelioration measures required to mitigate soil deficiencies to promote revegetation.

GT Environmental (2026) recommended a topsoil placement depth of 0.15 m and a minimum depth of 0.10 m pending the requirements of the PMLUs. Subsoil placed underneath to support topsoil is recommended to be between 0.20 m and 0.30 m, to allow sufficient depth for shallow scarifying and ripping of topsoils and vegetation establishment.

To optimise the topsoil conditions for revegetation, the following amelioration methods are considered:

a) gypsum application;

b) fertiliser application; and

c) organic matter application.

Gypsum may be applied to improve sodicity and enhance the structural stability of SPC 6Cl(El) subsoil (1.70 – 1.85 mbgl), where extreme sodicity was identified. Where practical, the stockpiling of this SPC's subsoil would be kept separated from the remaining SPC's subsoil. Fine grade gypsum would be applied to the sodic subsoil at a rate of 2.5 t/ha or more if erosion is observed. This would improve soil structure, thereby enhance infiltration and reduce dispersion. In the absence of adequate vegetation cover, this may assist in minimise runoff and rill erosion.

In general, all SPCs exhibit very low fertility, with limited macronutrient and micronutrient availability. However, native vegetation and some introduced pasture species are adapted to very low nutrient levels and may not require fertiliser application. Accordingly, fertilisers would only be applied where the desired PMLU outcomes have not been achieved with all other amelioration measures undertaken.

Fertiliser application, if required, would be undertaken during final soil replacement and seed bed preparation. The application rate would be determined through rehabilitation trials prior to the commencement of full-scale rehabilitation. Detailed application rates and fertiliser types are provided in Appendix H, Soil and Land Suitability Assessment.

Similar to fertiliser application, organic matter application should be undertaken where the desired PMLU outcomes have not been achieved. Organic matter may be incorporated into the topsoil to improve organic levels, soil structure, increase CEC, reduce erosion, and increase water holding capacity, thereby supporting vegetation establishment. The establishment of sufficient vegetation cover is important to mitigate erosion risk, especially as rehabilitated slopes increase. Where practical, organic matters generated from land clearing or stripped vegetation would be prioritised for use, provided they are suitable for the intended PMLU and are available in proximity to the rehabilitation area. SPCs which may benefit from amelioration with organic matter are generally sandier, firm setting soils with low CEC and PAWC such as SPCs 3Cl(Ck), 5Cl(Nm), 6Cl(El) and 7Cl(Nm).

The Project would implement an overarching Topsoil Management Plan, informed by the International Erosion Control Association (IECA) (2008) and further refined by the findings and recommendations of the Soils and Land Suitability Assessment (GT Environmental 2026), to mitigate and monitor topsoil impacts. The Plan would include the following management practices:

a) minimising topsoil handling;

b) current weather forecast should be checked prior to stripping of soils to reduce exposure of bare sodic, erosive soils and sediment runoff;

c) vegetation clearing should occur immediately prior to stripping;

d) suitable machinery shall comply with onsite procedures including, but not limited to, weed and feral animal management;

e) areas of land upgradient and downgradient of soil stripping activities, low-lying areas or areas of observed runoff should have suitable erosion and sediment control measures in place such as clean water diversion bunds, sediment-affected water diversion bunds and/or sediment fencing prior to construction commencing;

f) revegetating stockpiles if stockpiles are to remain for substantial periods;

g) SPCs that are potentially dispersive or erosive would be placed on flat plains to slopes up to 10%, if possible;

h) application of gypsum is recommended for placement of potential dispersive or erosive soil materials, with ≥ 20% clay, on steeper slope or where pre-strip observations indicate erosive characteristics (e.g. hard-setting surface);

i) topsoil should be placed in even layers at the recommended depths to ensure enough coverage and soil to re-establish vegetation;

j) additional seeding should be applied to assist with encouraging suitable vegetation regrowth;

k) subsoil resource material should be recovered from the subsoil stockpiles and placed initially prior to topsoil resource material;

l) sediment and erosion controls are to be utilised to ensure that loss of soil resources are minimal and product can be recovered;

m) inspection and maintenance of rehabilitation areas are to be undertaken to ensure erosion and sediment control measures are performing as constructed. Measures are to be outlined within the Projects Erosion and Sediment Control Plan (ESCP) as detailed in Section 10.4.2.2;

n) topsoil suspected of being mixed with subsoils should be either resampled and analysed as the current stockpile or separated from topsoil and placed with the appropriate subsoil stockpile; and

o) topsoil should be inspected prior to reinstatement for invasive vegetation (plants and weeds). Invasive vegetation should be controlled.

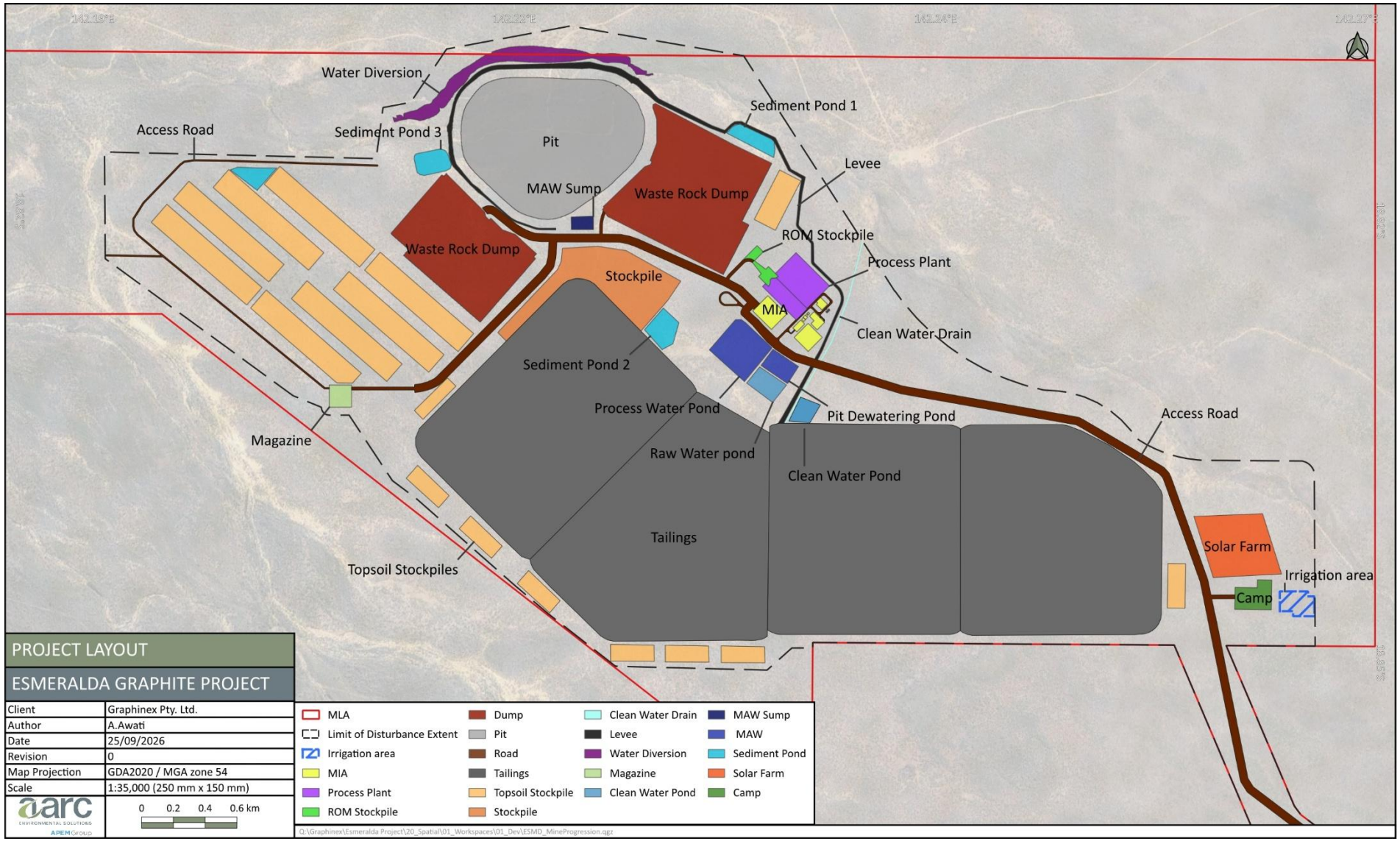


Figure 10-10: Indicative locations for soil stockpiles

10.4.2.2 Soil erosion

The majority of the SPCs exhibit low inherent erodibility, as indicated by low surface K-factors, predominantly sandy textures (i.e. generally >70% sand and <15% clay content), and high permeability with well to rapid drainage. These characteristics reduce the likelihood of runoff-driven erosion but may increase susceptibility to localised wind erosion and surface instability where groundcover is absent. Localised exceptions are SPC 6Cl(El) where moderate erodibility may occur due to higher clay content in subsoil (>20% below 0.5 m) and has a moderate permeability and imperfect drainage. Subsoil of SPC 6Cl(El) at depth greater than approximately 2 m present a risk of extreme sodicity and dispersive behaviour (Emerson Class 2), therefore subsoil stripping in SPC 6Cl(El) would only be undertaken within the top 2 m to prevent exposure and placement of sodic soil at surface.

To mitigate erosion risks, topsoil and subsoil would be managed in accordance with the measures described in Section 10.4.2.1.

An Erosion and Sediment Control Plan (ESCP) would be prepared by suitable certified personnel and developed in accordance with the *Best Practice Erosion and Sediment Control* (IECA 2008).

The ESCP would be prepared prior to commencement of construction works, and would ensure the Project achieves:

- no worsening of the existing levels of soil loss from the land in or downslope of the Project area;
- no increased risk of erosion, or other land degradation, on land or in waterways downslope of the Project area; and
- no net increase in the sediment load leaving the Project area and entering waterways and/or watercourses.

WEPP modelling has been undertaken as part of proposed rehabilitation landforms to ensure minimal erosive risk of proposed slopes. This modelling is detailed further in Chapter 13, Rehabilitation and Closure, and Appendix T, Progressive Rehabilitation and Closure Plan.

The Project would also establish water management infrastructure including sediment dams and drainage, such that any mobilised sediment-laden water would report to the dams and deposit sediment in-situ. This would ensure that any erosion has minimal impacts off-site on the receiving environment. Water management infrastructure is detailed further in Chapter 14, Water Resources.

10.4.2.3 Soil contamination

Potential land contamination would be mitigated and managed by implementing the following:

a) An Erosion and Sediment Control Plan (ESCP) for all stages of mining activities on site to minimise erosion and release of sediment to receiving waters and contamination of stormwater.

b) Ensuring all hazardous chemicals, corrosive substances, toxic substances, gases and dangerous goods are stored and handled in accordance with the current Australian standard, where such is applicable.

c) Minimising the potential for contamination of land and waters by diverting stormwater around contaminated areas and facilities used for the storage of chemicals and flammable or combustible liquids.

d) Transporting paints and miscellaneous chemicals off-site by a licensed regulated waste contractor and treated at a licensed waste facility before disposal.

e) Treating and disposing hydrocarbon contaminated material off-site by licenced waste transport operators at an appropriately licensed waste disposal facility. Cleanaway provides contaminated soil remediation services delivering safe, compliant, and environmentally responsible solutions.

f) Treating sewage effluent on-site, within a STP at the on-site accommodation facility towards the eastern boundary of the Project MLAs. Treatment would comprise standard primary, secondary removal of solids alongside nutrient removal and disinfection. Treated effluent would be released for irrigation and accordance with conditions.

g) Irrigation water would be applied to land as a means of disposing of STP effluent. During Project operation, a conservative volume of 40 m^3 per day of secondary treated effluent would be applied to an area of 3 ha, at no more than 3.5 mm/day. MEDLI modelling (AARC 2026-MEDLI) indicates that the rate and area of irrigation would result in negligible nutrient leaching, waterlogging, runoff or overflow issues arising.

h) If any unexpected contamination due to prior land uses is identified, work would cease in that area and appropriate actions taken to delineate the contaminated area. If required, further investigation and/or remediation works would be undertaken.

Further details on the proposed mitigation and management measures for hazardous materials and activities are discussed in Chapter 22, Hazards, Health and Safety.

As described in Section 10.3.5, the ore body and tailings material are typically classified as PAF and would be processed at the end of the mine life to extract economic value (RGS 2026). An Excavated Material Management Plan (EMMP) would be developed by suitably qualified professionals in accordance with the *Managing Acid and Metalliferous Drainage Leading Practice Sustainable Development Program for the Mining Industry* (Australia Government 2016) and *Global Acid Rock Drainage Guide* (International Network on Acid Prevention 2024), to mitigate, manage and monitor the impact of PAF materials. The Plan would include the following management practices:

- geochemically characterise waste rocks, ore body, and tailing materials;
- maintain an inventory of waste rock and tailing materials;
- regular testing of waste rocks and tailing materials;
- assess and consider ASS/PAF, and whether ASS specific management strategies are required to be incorporated into the EMMP is required; and
- monitor and evaluate environmental risks associated with the excavated materials.

10.4.3 Irrigation water and effluent

10.4.3.1 Irrigation scheduling and application rate

A spray irrigation system would be adopted for the site. A fixed daily design irrigation rate of approximately 3.5 mm/day, consistent with AS/NZS 1547:2012 for the site soil category would be adopted. Irrigation would not occur on days with measurable rainfall (>0 mm).

10.4.3.2 Irrigation system design specifications

60-days of wet weather effluent storage based on Average Dry Weather Flow would be used to manage prolonged wet seasons and prevent uncontrolled discharges when irrigation is not practicable.

The spray irrigation system would be operated to ensure:

- distribution of effluent evenly across the designated area;
- minimise aerosol formation and spray drift through appropriate sprinkler selection, operating pressures, and inward throw design;
- compliance with signage and public safety requirements in accordance with AS 1319 / AS/NZS 1319; and
- ensure runoff beyond the designated irrigation area does not occur.

10.4.3.3 Monitoring program

An Irrigation Management Plan (IMP) would be developed, consistent with the DETSI *Technical Guideline for Disposal of Effluent Using Irrigation*.

The monitoring program would include where practicable:

- periodic soil and groundwater monitoring for nutrients, salinity and sodicity;
- reviews of irrigation performance, monitoring results, and operational practices; and
- updates where necessary to relevant management measures to ensure ongoing compliance with licensing requirements and environmental objectives.

10.5 TOR Reconciliation table

Terms of reference - Content requirements of the EIS		EIS Section
Section 10 - Land – geology, geomorphology, topography and soils		
10.1	The following guidance is relevant for the assessment of land, including geology, geomorphology, topography and soils: (a) Queensland Government, Land – EIS information guideline, ESR/2020/5303 (b) Queensland Government, Rehabilitation – EIS information guideline, ESR/2020/5308 (c) Queensland Government, Contaminated land – EIS information guideline, ESR/2020/5300 (d) Queensland Government, Quarry material – EIS information guideline, ESR/2020/5306 (e) Queensland Government, Application requirements for activities with impacts to land, ESR/2015/1839 (f) Queensland Government, Queensland Land Resource Assessment Guidelines – Volume 1: Soil and land resource assessment, 2021 (g) Queensland Government, Queensland Land Resource Assessment Guidelines – Volume 1: Field tests, 2020 (h) Queensland Government, Queensland Soil and Land Resource Survey Information Guideline, VEG/2018/4460 (i) Soil Science Australia, Guideline for soil survey along linear features, 2015 (j) International Erosion Control Association, Best Practice Erosion and Sediment Control, 2008.	Section 10.1
Land – geology, geomorphology, topography and soils - Existing environment		
10.2	Describe, map and illustrate the topography and geomorphology of the project footprint and surrounding area.	Section 10.2.1 Section 10.2.3.2
10.3	Describe and map the geology and mineralogy of the project footprint and surrounding area, with reference to the physical and chemical properties of surface and sub-surface materials within the proposed areas of disturbance. This should include information regarding the presence of any naturally occurring hazardous materials (e.g. radioactive material or asbestos).	Section 10.2.3 Section 10.2.3.3
10.4	Describe and map geological structures and properties that could affect ground stability and influence the nature and location of project activities.	Section 10.2.3
10.5	Describe and map soil types, soil profiles and unique map areas within the project footprint at a detailed property level scale relevant to project disturbance.	Section 10.2.4
10.6	Describe physical and chemical soil properties relevant to erosion, stability, salinity, acidity, rehabilitation and agricultural suitability and productivity supported by site-specific soil data.	Section 10.2.4
10.7	Where excavated rock or spoil is to be used or placed within the project footprint, analyse the potential for acid generation, or generation of other potential pollutants of air, land or waters, supported by site-specific geochemical data.	Section 10.2.7

Terms of reference - Content requirements of the EIS		EIS Section
10.8	Discuss how geology, geomorphology, topography, soils and relevant environmental values have informed the project design (e.g. constraints).	Section 10.2.1 Section 10.2.3 Section 10.2.4 Section 10.2.5
Land – geology, geomorphology, topography and soils - Impact assessment		
10.9	Identify and assess the impacts of project activities and disturbance on geology and geomorphology. Analyse and describe the significance of these impacts on the structural stability of affected strata and landforms and their ability to support environmental values.	Section 10.3.3
10.10	Identify and assess the impacts of project activities and disturbance on soils during each project phase and identify soil types requiring particular management. Analyse and describe the significance of these impacts on environmental values, current and future land use and management requirements, including consideration of erosion, stability, salinity, acidity, rehabilitation and agricultural productivity.	Section 10.3.5
10.11	Assess the risks of project activities resulting in land contamination.	Section 10.3.5
10.12	Where irrigation water or effluent is proposed to be applied to land: (a) identify the irrigation area (b) describe irrigation water or effluent quality (including pH, salinity, biological oxygen demand, total solids, nutrients, and microbiology) (c) provide design irrigation rates (d) identify contingency storage (e) demonstrate the avoidance of soil and land degradation (e.g. soil structure decline, secondary salinisation, erosion), and protection of soil composition and condition and associated environmental values, supported by irrigation modelling (e.g. MEDLI (model for effluent disposal using land irrigation)).	Section 10.3.7 Section 10.3.7.3
Land – geology, geomorphology, topography and soils - Mitigation measures		
10.13	Describe proposed measures to avoid and minimise predicted impacts to land or soils, and the environmental values they support. Demonstrate how proposed measures are consistent with best practice environmental management.	Section 10.4.2
10.14	Demonstrate how the proposed project would meet the environmental objectives and performance outcomes for land in Schedule 8 of the EP Regulation.	Section 10.4
10.15	Demonstrate that the disposal to land of any liquid wastes from onsite sewage treatment would meet the environmental objectives and performance outcomes in Table 1 (Operational assessment), Part 3, Schedule 8 of the EP Regulation.	Chapter 17 Waste: Section 17.5.3.3
10.16	Describe how unplanned impacts to land would be managed, including measures to avoid, identify, remediate and manage land that is contaminated or may become contaminated.	Section 10.4.2.3
10.17	Describe how the achievement of environmental objectives and associated performance outcomes would be monitored, audited and reported, and how corrective/preventative actions and continual improvement would be managed.	Section 10.4.2 Section 10.4.3
10.18	Where actual or potential acid sulfate soils would be disturbed by the project, prepare an acid sulfate soil management plan in accordance with accepted industry guidelines to avoid or minimise adverse effects on environmental values.	N/A – no actual or potential sulphate soils present within the Project site. (See Section 10.2.7)

Terms of reference - Content requirements of the EIS		EIS Section
10.19	Where excavated material is potentially acid-forming or otherwise potentially polluting, prepare an excavated material management plan in accordance with accepted industry guidelines to avoid or minimise adverse effects on environmental values.	Section 10.4.2.3