NORTHERN MINERALS

BROWNS RANGE RARE EARTHS PROJECT

CONCEPTUAL MINE CLOSURE AND REHABILITATION PLAN
Tenement Numbers M80/627, L80/76 and L80/77

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Q No.	Mine Closure Plan (MCP) Checklist	Y/N N/A	Page No.	Comments
1	Has the mine closure plan been endorsed by a senior representative within the tenement holder/operating company? (See bottom of checklist)			
2	How many copies of the plan were submitted to DMP?			Hard Copies= 3 Electronic = 1
Cover page, Table of contents				
3	Does the cover page include: • Project Title • Company Name • Contact Details (including telephone numbers and email addresses) • Document ID and version number • Date of submission (needs to match the date of this checklist)			
4	Has a table of contents been provided?			
Scope and project summary				
5	Why is the MCP submitted? (as part of a Mining Proposal or a reviewed MCP or to fulfil other legal requirements)			
6	Does the project summary include: • Land ownership details • Location of the project • Comprehensive site plan(s) • Background information on the history and status of the project.			
Legal obligations and commitments				
7	Has a consolidated summary or register of closure obligations and commitments been included?			
Data collection and analysis				
8	Has information relevant to mine closure been collected for each domain or feature (including pre-mining baseline studies, environmental and other data)?			
9	Has a gap analysis been conducted to determine if further information is required in relation to closure of each domain or feature?			
Stakeholder consultation				
10	Have all stakeholders involved in closure been identified?			
11	Has a summary or register of stakeholder consultation been provided, with details as to who has been consulted and the outcomes?			

Q No.	Mine Closure Plan (MCP) Checklist	Y/N N/A	Page No.	Comments
Final land uses(s) and closure objectives				
12	Does the MCP include agreed post-mining land uses(s), closure objectives and conceptual landform design diagram?			
13	Does the MCP identify all potential (or pre-existing) environmental legacies which may restrict the post mining land use (including contaminated sites)?			
Identification & management of closure issues				
14	Does the MCP identify all potential issues impacting mine closure objectives and outcomes?			
15	Does the MCP include proposed management of mitigation options to deal with these issues?			
16	Have the process, methodology and rationale been provided to justify identification and management of the issues?			
Closure criteria				
17	Does the MCP include a set of specific closure criteria and closure performance indicators?			
Closure financial provision				
18	Does the MCP include costing methodology, assumptions and financial provision to resource closure implementation and monitoring?			
19	Does the MCP include a process for regular review of the financial provision?			
Closure implementation				
20	Does the reviewed MCP include a summary of closure implementation strategies and activities for the proposed operations or for the site?			
21	Does the MCP include a closure work program for each domain or feature?			
22	Have site layout plans been provided to clearly show each type of disturbance?			
23	Does the MCP contain a schedule of research and trial activities?			
24	Does the MCP contain a schedule of progressive rehabilitation activities?			
25	Does the MCP include details of how unexpected closure (including care and maintenance) will be handled?			
26	Does the MCP contain a schedule of decommissioning activities?			

Q No.	Mine Closure Plan (MCP) Checklist	Y/N N/A	Page No.	Comments
27	Does the MCP contain a schedule of closure performance monitoring and maintenance activities?			
Closure monitoring and maintenance				
28	Does the MCP contain a framework, including methodology, quality control and remedial strategy for closure performance monitoring including post-closure monitoring and maintenance?			
Closure information and data management				
29	Does the mine closure plan contain a description of management strategies including systems, and processes for the retention of mine records?			

Corporate endorsement:

I hereby certify that to the best of my knowledge, the information within this Mine Closure Plan and checklist is true and correct and addresses all the requirements of the Guidelines for the Preparation of a Mine Closure Plan approved by the Director General of Mines.

Name: Signed:

Position: Date:

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1 INTRODUCTION

1.1 Purpose

This Conceptual Mine Rehabilitation and Closure Plan (MCP) has been prepared by Northern Mineral Limited (NML) as part of documentation supplied to the WA Environmental Protection Authority (EPA) for its assessment of the proposed Browns Range Rare Earths Project. In the Scoping Guideline prepared for its assessment of the Browns Range Project (OEPA, 2013), the EPA identified mine rehabilitation and closure as a 'preliminary key factor'. The Scoping Guideline stipulated that information presented in the Browns Range environmental review document should include:

- waste characterisation studies of tailings and waste rock material
- information regarding proposed management of final pit voids, waste rock landforms and tailing storage facilities at the conclusion of mining.

This Mine Rehabilitation and Closure Plan identifies key aspects of the Browns Range Project which could affect attainment of the EPA's objectives for mine rehabilitation and closure, which are:

> *'To ensure that premises can be closed, decommissioned and rehabilitated in an ecologically sustainable manner, consistent with agreed outcomes and land uses, and without unacceptable liability to the State'.*

The aims of this conceptual closure plan are to:

- identify key environmental and social risks associated with planned or unplanned closure of the Browns Range Project
- define a set of closure and rehabilitation objectives applicable during Northern Minerals' implementation of the Project
- describe the strategies that Northern Minerals will adopt to manage those aspects of its construction and operational activities which could compromise attainment of rehabilitation objectives
- propose a provisional set of measures that will be used by Northern Minerals to demonstrate attainment of its closure and rehabilitation targets
- identify key factors that influence closure and rehabilitation costs
- provide a basis for initiating discussions with stakeholders about rehabilitation and closure of the Browns Range Project.

This conceptual closure plan has been prepared in accordance with the *Guidelines for Preparing Mine Closure Plans* (DMP and EPA, 2011) and also reflects the approaches recommended in the following guidelines:

- *Mine Closure and Completion*, *Leading Practice Sustainable Development Program for the Mining Industry* (DITR, 2006a)
- *Mine Rehabilitation*, *Leading Practice Sustainable Development Program for the Mining Industry* (DITR, 2006b)
- Guidance Statement No 6 – *Rehabilitation of Terrestrial Ecosystems* (EPA, 2006)
- *Planning for Integrated Mine Closure: Toolkit* (International Council on Mining & Metals, 2008)
- *Mine Closure Guideline for Mineral Operations in Western Australia* (Chamber of Minerals and Energy WA Inc, 2000)
- *Strategic Framework for Mine Closure* (ANZMEC and MCA, 2000)
- *Guidelines for Mineral Exploration and Mining within Conservation Reserves and other Environmentally Sensitive Lands in Western Australia* (DMP, 1998)
- *Policy No. 10 Rehabilitation of Disturbed Land* (DEC, 1986).

1.2 Scope

This plan addresses closure and rehabilitation requirements on tenements M80/627, L80/76 and L80/77. The plan applies to Northern Minerals' activities during the construction, operation and eventual decommissioning and closure of the Browns Range Rare Earths Project. The plan does not specifically address exploration activities by Northern Minerals, as rehabilitation required in connection with Northern Minerals' exploration in the Browns Range Project Area are covered in various Programs of Work administered by the Department of Mines and Petroleum (DMP).

Northern Minerals is required to submit a mining proposal to the DMP as part of the permitting of the proposed Browns Range Project. The mining proposal will include an updated, more detailed version of this conceptual closure plan.

1.3 Key contact details

Northern Minerals Limited (ABN 61 119 966 353) is an Australian-based resource company and is listed on the Australian Securities Exchange. The key contact for Northern Minerals Limited is:

Mr Robin Jones
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PO Box 669
West Perth WA 6872
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Fax: +61 08 9481 5929
Email: rjones@northernminerals.com.au
Website: http://www.northernminerals.com.au/

No regional contact is provided as there is no permanent presence by senior Northern Minerals personnel on tenement M80/627.

2 PROJECT SUMMARY

2.1 Location

The Browns Range Rare Earths Project is a proposed greenfields mining and mineral processing operation. The Project area is located approximately 160 km south-east of Halls Creek, Western Australia, adjacent to the Western Australian/Northern Territory border (Figure 2-1). Access to the Browns Range Project site is from Halls Creek via Duncan Road (112 km) and the Gordon Downs Road to Ringer Soak (44 km), and then via an unformed track (58 km) to the Browns Range Project area. The Project lies within the Gordon Downs pastoral lease.

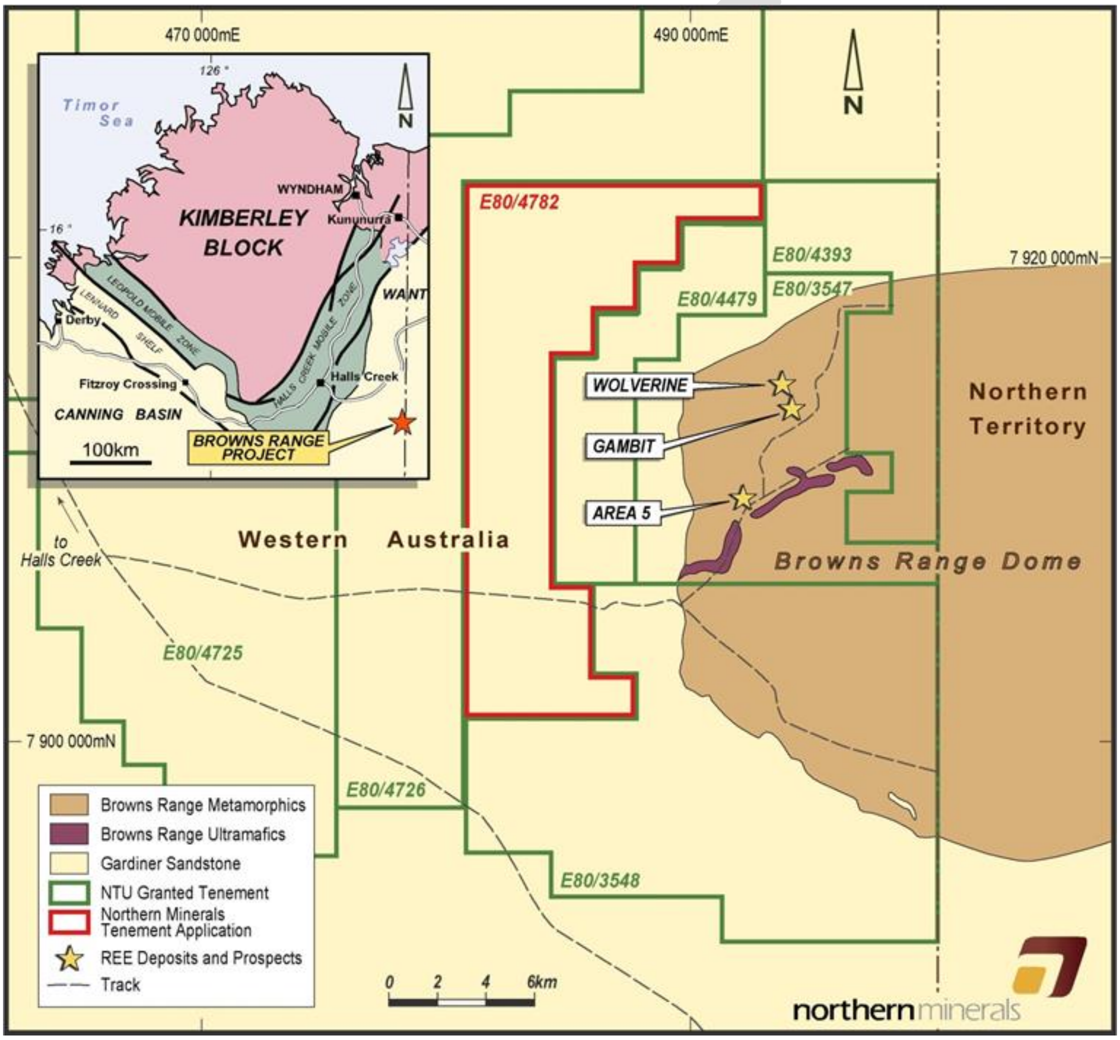

Figure 2-1: Regional location of the Browns Range Rare Earths Project

2.2 Tenure

The activities described in this conceptual closure plan would take place on one mining lease tenement (M80/627) and two miscellaneous licence tenements (L80/76 and L80/77). The miscellaneous licence tenements would generally be used for linear infrastructure (pipelines, roads, power transmission) and support facilities (water abstraction). Mining, ore processing and storage of mine waste would occur on the mining lease tenement. The mine accommodation village, airstrip and power generating plant would also be located on the mining lease tenement. Applications for grant of the mining lease and miscellaneous licence tenements were lodged with the DMP in November 2013 and January 2014, respectively. The locations and extents of the tenements included in this conceptual closure plan are shown in Figure 2-2. The tenement status is summarised in Table 2-1.

Table 2-1: Tenement summary for the Browns Range Project

Tenement ID	Application date	Grant date	Expiry date	Area (ha)
M80/627	26/11/2013	Pending	N/A	12,813
L80/76	14/01/2014	Pending	N/A	1431.79
L80/77	14/01/2014	Pending	N/A	181

If granted, all tenements would be held by Northern Minerals.

2.3 Existing disturbance

The existing disturbance in the Project area is associated with historic pastoral use of Gordon Downs pastoral station (established in 1887) and past exploration activity by Northern Minerals and others. Exploration disturbance and rehabilitation by Northern Minerals is reported annually to the DMP. The most recent annual environmental report for exploration related to the Browns Range Project was submitted to the DMP on 31 March 2014.

2.4 Native Title

Native Title has not been extinguished on either M80/627 or L80/77. Both tenements lie entirely within the registered Jaru Native Title Claim area (WAD45/2012). Native Title has been determined to exist on L80/76 under the Tjurabalan Native Title Claim (WC95/74; WAD160/97). Tenement L80/76 also lies partly within the registered Jaru Native Title Claim (WAD45/2012).

2.5 Current project status

The Browns Range Project is currently undergoing assessment by the EPA. The project is being assessed via the Assessment on Proponent Information (API) process.

Based upon investigations conducted as part of its assessment of potential environmental impacts of the Browns Range Project, Northern Minerals considers that the project does not constitute a ‘nuclear action’ and will not have a significant impact upon any Matter of National Environmental Significance. Nonetheless, Northern Minerals intends to refer the proposal to the Commonwealth Department of Environment for a determination under the *Environment Protection and Biodiversity Conservation Act 1999* shortly after a draft API is lodged with the WA EPA.

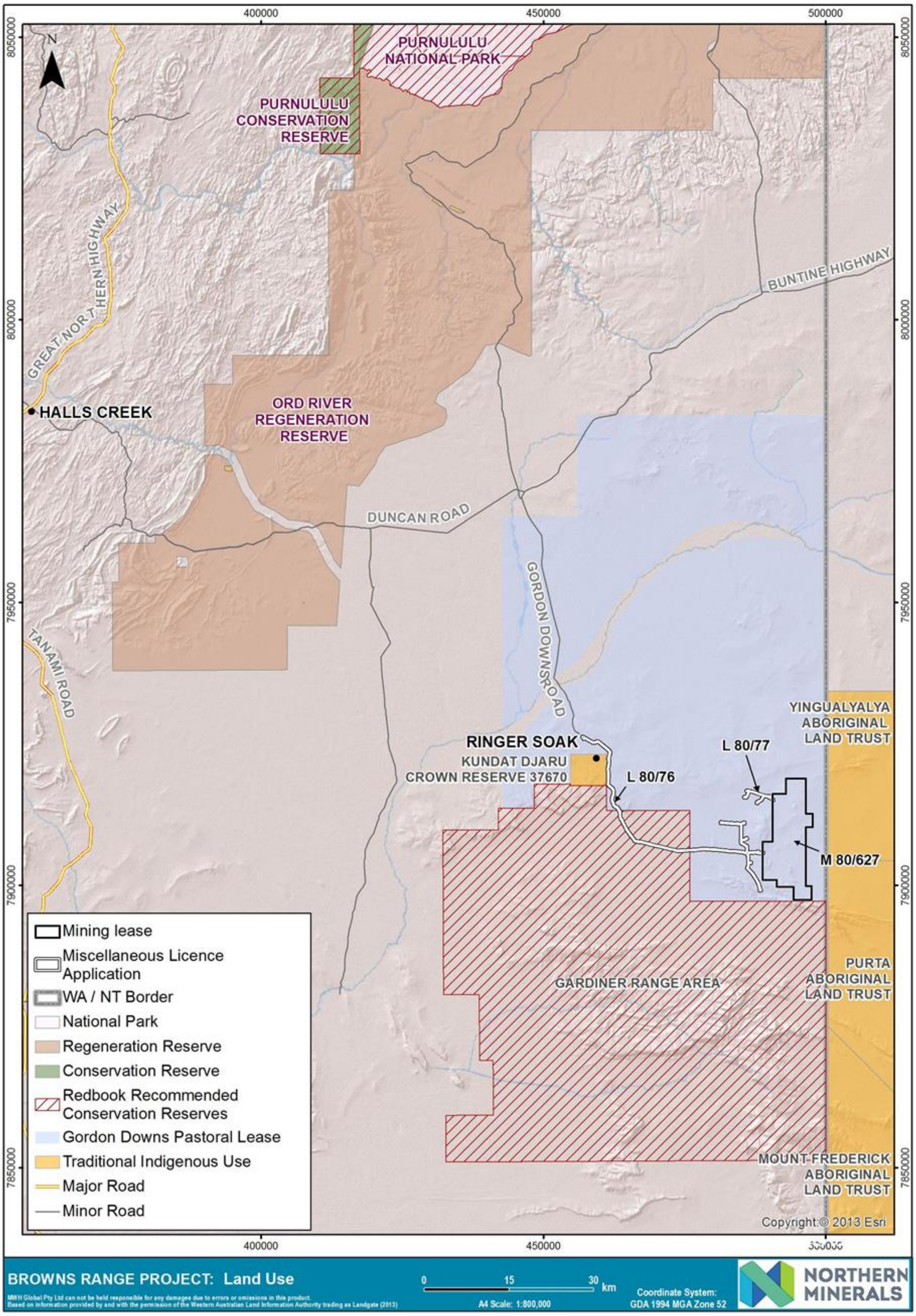

Figure 2-2: Browns Range Project tenements applied for

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3 IDENTIFICATION OF CLOSURE OBLIGATIONS AND COMMITMENTS

Closure and rehabilitation of the Browns Range Project must, as a minimum, satisfy general requirements set out in the following legislation:

- *Mining Act 1978*
- *Mines Safety and Inspection Act 1994*
- *Environmental Protection Act 1986*
- *Rights in Water and Irrigation Act 1914*
- *Contaminated Sites Act 2003*
- *Radiation Safety Act 1975*
- *Environment Protection and Biodiversity Conservation Act 1999* (Cwlth).

Currently, the key statutory conditions applicable to tenements within the Browns Range Project area are conditions imposed on Northern Minerals' exploration activities under a series of Programs of Work. If the proposed mining and mineral processing activities described in the Browns Range API are approved, obligations relevant to construction, operations and closure phases of the Project will be incorporated into the existing Company obligations register in the course of Project permitting. Commitments made to Traditional Owners, local government and other stakeholders will also be recorded and tracked through the project obligations register.

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4 COLLECTION, ANALYSIS AND MANAGEMENT OF CLOSURE DATA

4.1 Summary of baseline environmental information

The following summarises the key aspects of the biophysical environment relevant to mine closure design and implementation. More detailed information is provided in the Browns Range API (NML, 2014).

4.1.1 Climate

The Project area has a semi-arid climate. Most of the rainfall occurs during the wet season (between November and March) and is associated with tropical monsoonal activity and the passage of cyclones. The absence of cyclones can lead to drought conditions. Climate data for the site has been gathered from the SILO database, which is hosted the Science Delivery Division of the Queensland Department of Science, Information Technology, Innovation and the Arts. SILO data are a synthetic dataset based on an interpolated grid derived from nearby Bureau of Meteorology (BOM) stations. Interpolated meteorological records from 1900 to 2013 show a distinct seasonal pattern with about 80% of the rainfall occurring from December to March (Table 4-1, Figure 4-1). Average annual evaporation is in the order of 3000 mm/year. Average monthly evaporation exceeds average rainfall throughout the entire year.

Rainfall in the project area is highly variable, both spatially and temporally. The highest monthly rainfalls can exceed 400 mm and daily rainfalls of over 100 mm can be expected to occur, on average, about once every 5 to 10 years. The highest daily rainfall total for the SILO record is 172.6 mm, which occurred on 20 January 1966. In mid-January 2014, the meteorological monitoring station at Browns Range recorded approximately 208 mm of rain within a 24 hour period. This is approximately the 1-in-100 year, 24 hour rainfall event. The annual rainfall for the 100 year average recurrence interval (ARI) is estimated to be 1052 mm.

4.1.2 Physiography and land use

The topography across the Project site is subdued, with a gentle gradient down towards the west. Surface elevation ranges between approximately 475 m Australian Height Datum (AHD) in the east to 445 mAHD in the west. The Gardiner Sandstone forms the most prominent topographic features in the locality, comprising low ridges and undulating terrain. Rocky outcrops of Browns Range Metamorphics are also present, rising to a maximum elevation of about 490 m RL AHD (or about 25-30 m above the surrounding plain).

The Project area is located in the upper Sturt Creek Basin, an area traditionally owned by people of the Jaru language group. The first non-Indigenous exploration of the region occurred in the mid-1800s. Traditional hunting and gathering continued into the late 19th century. Use of the land for cattle drives and other pastoral purposes increased from the 1880s to the 1920s. A pastoral station (Soakage Creek Station) was established at the site of the existing Gordon Downs pastoral lease in 1887. The Project lies within the Gordon Downs pastoral lease. Customary Aboriginal land uses and pastoral land use remain the dominant land uses in the Project area.

The settlement of Kundat Djaru (Ringer Soak) was established in the mid-1980s on land excised from the Gordon Downs pastoral station. The community is incorporated as the Kundat Djaru Aboriginal Corporation. The land on which the township lies and a parcel of land lying mainly to the south of it have been formally gazetted as Crown Reserve 37670 under the *Aboriginal Affairs Planning Authority Act 1972*.

Table 4-1: Average monthly rainfall and evaporation

Month	Rainfall[1] (mm)	Evaporation[2] (mm)
January	98.4	278.6
February	112.0	225.6
March	55.8	241.7
April	14.7	224.7
May	10.0	189.1
June	5.3	157.8
July	5.9	174.0
August	3.1	218.9
September	3.6	269.1
October	14.8	320.2
November	26.3	314.5
December	60.3	301.2
Annual	**409.3**	**2894.1**

Notes: 1. Measurement period: 1/1/1900–10/10/2013; 2. Measurement period: 1/1/1970–10/10/2013.

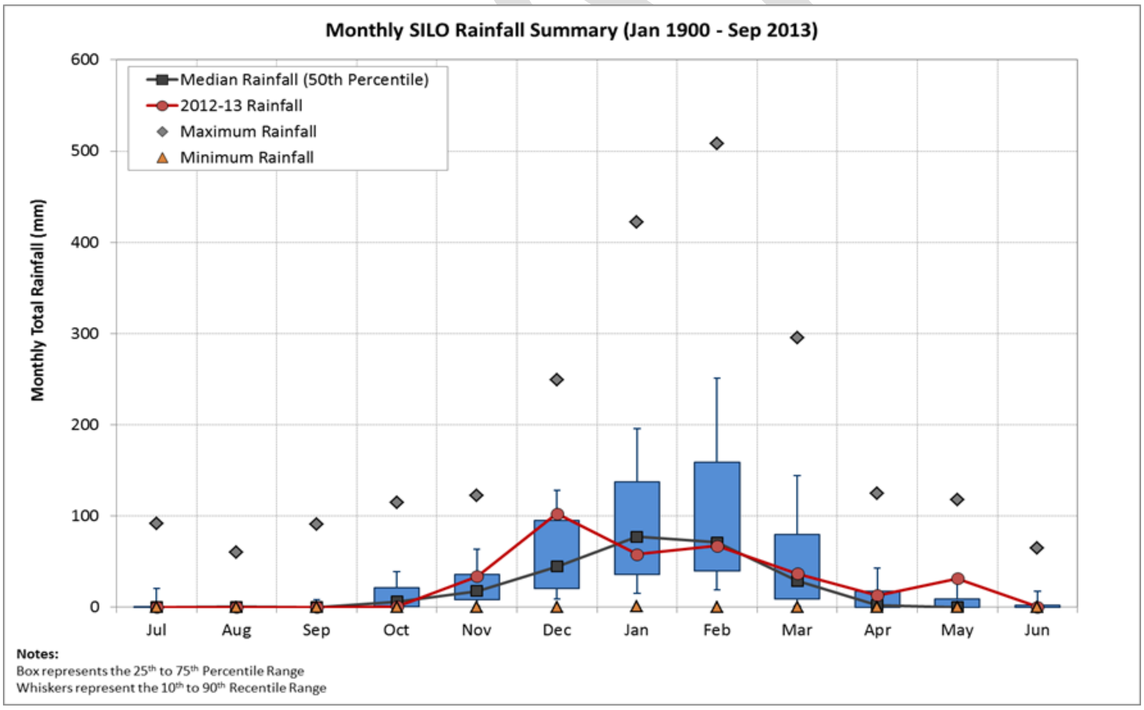

Figure 4-1: Monthly SILO rainfall totals for Browns Range

The closest Department of Parks and Wildlife (DPaW)-managed lands to the Project area include the Ord River Regeneration Reserve, located approximately 100 km north-west of the Project, and the Wolfe Creek Meteorite Crater National Park, located approximately 120 km to the west-southwest. The closest proposed protected area is the Gardiner Range proposed conservation area, located to the south and west of the Project. The proposed upgrade of the existing access track to Browns Range will occur within the northern part of the proposed Gardiner Range conservation area.

4.1.3 Geology and soils

The Project area is located on the western side of the Browns Range Dome, a Palaeoproterozoic dome formed by a granitic core intruding the Palaeoproterozoic Browns Range Metamorphics (meta-arkoses, feldspathic metasandstones and schists). The dome and its aureole of metamorphics are surrounded by the Palaeoproterozoic (1735–1640 Ma) Gardiner Sandstone (Birrindudu Group). Middle-Devonian to (likely) Ordovician sandstones from the Eastern Canning Basin margin (Billiluna Shelf) of uncertain age have also been interpreted to occur over the Gardiner Sandstone to the south-west of the dome (Das, 2012).

The dominant geological unit throughout the Project area consists of arkose and meta-arkose, mostly lying beneath a cover of transported alluvium, but with some outcrops. Other rock types include quartz mica schists, banded iron formation/quartz pebble conglomerate, dolerite and calc-silicate rocks (Figure 4-2). Minor occurrences of quartzite, silcrete, ferricrete and ironstone have also been identified. The Gardiner Sandstone flanks the western margins of the Project area and unconformably overlies the older Browns Range metamorphic rocks (Das, 2012). Mapping by Northern Minerals has identified both mineralised and non-mineralised occurrences of quartz veins and quartz breccia veins occurring as elongated discontinuous bodies, up to several metres wide and tens of metres long, and intruding along possible shears or faults.

The shallow regolith within the Project area chiefly comprises Quaternary or Tertiary sand deposits over broad plains. Colluvial deposits are present at the base of stony ridges of outcropping metamorphic rock outcrops (Figure 4-3). Recent alluvial deposits occur over limited extents, along ephemeral drainage lines. Details of baseline soil and landform studies of the Project area, including a topsoil inventory, are provided in Appendix A.

Numerous rangelands resource surveys conducted since the 1940s have contributed to a comprehensive description of biophysical resources present within the Kimberley region, including the condition of soil (Payne and Schoknecht, 2011). This information has been used to classify and map the land systems of the Kimberley region based on landforms, soils, vegetation, geology and geomorphology. In the Project area, two land systems occur: the Coolindie and Winnecke land systems.

The Coolindie land system occupies the majority of the Project area (Figure 4-4). The Coolindie land system is characterised by gently undulating red sandplains and dunes with acacia shrublands and spinifex. The soils are predominantly deep red sand with some lateritic gravel rises. The drainage floors are broad and shallow. Erosion is minimal.

The Winnecke land system is characterised by low linear or rounded stony hills and lowlands with eucalypt woodlands and spinifex. The soils are deep red sand with outcrops of sandstone. The gently sloping sandplains merge into mainly unchannelled valley floors. Widely spaced angular drainage lines occur on lower slopes and terminate at the base of the hills. Erosion is generally minimal, although some drainage floors are moderately susceptible to water erosion (Payne and Schoknecht, 2011).

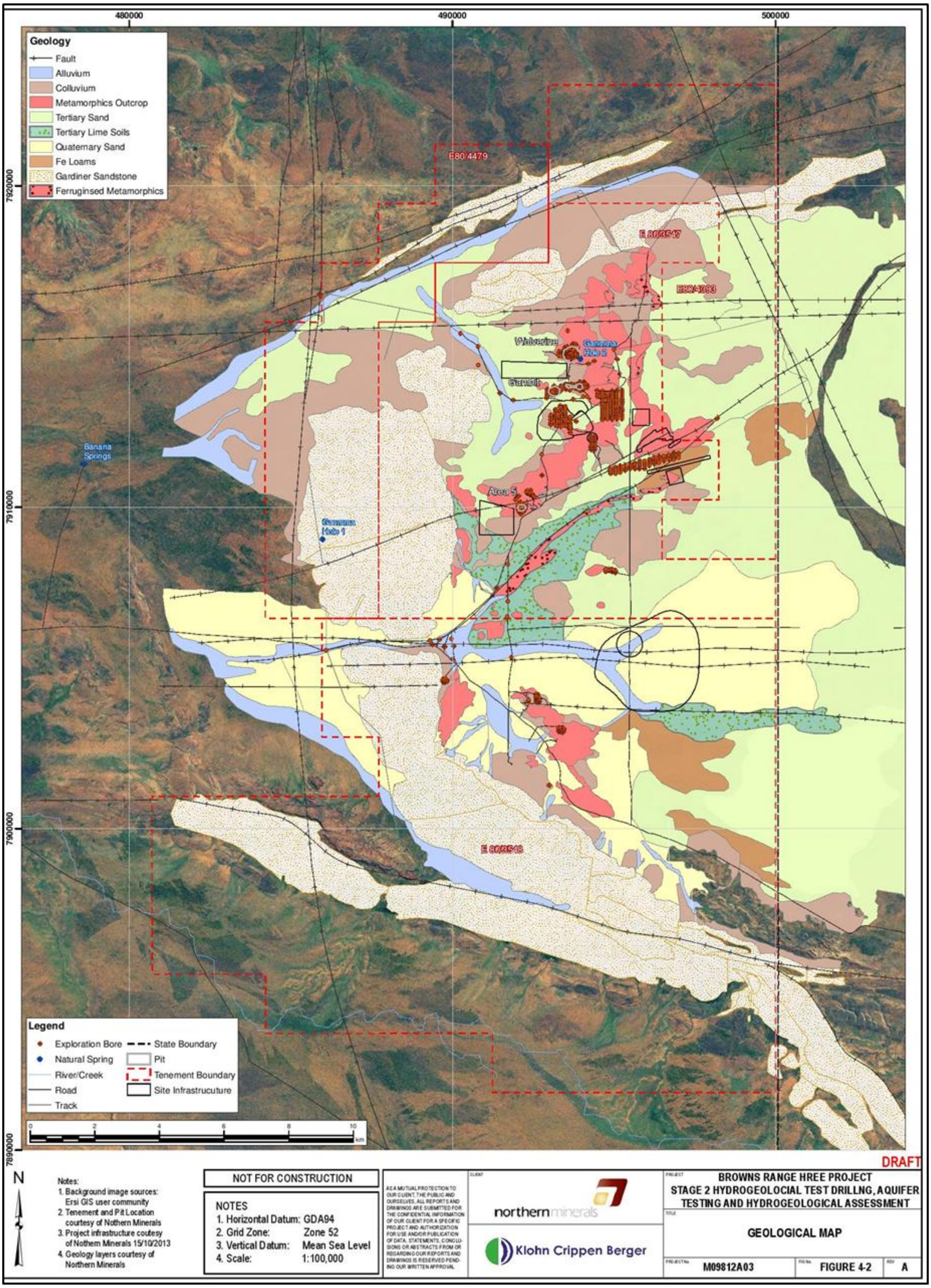

Figure 4-2: Surficial geology of the Browns Range Project area

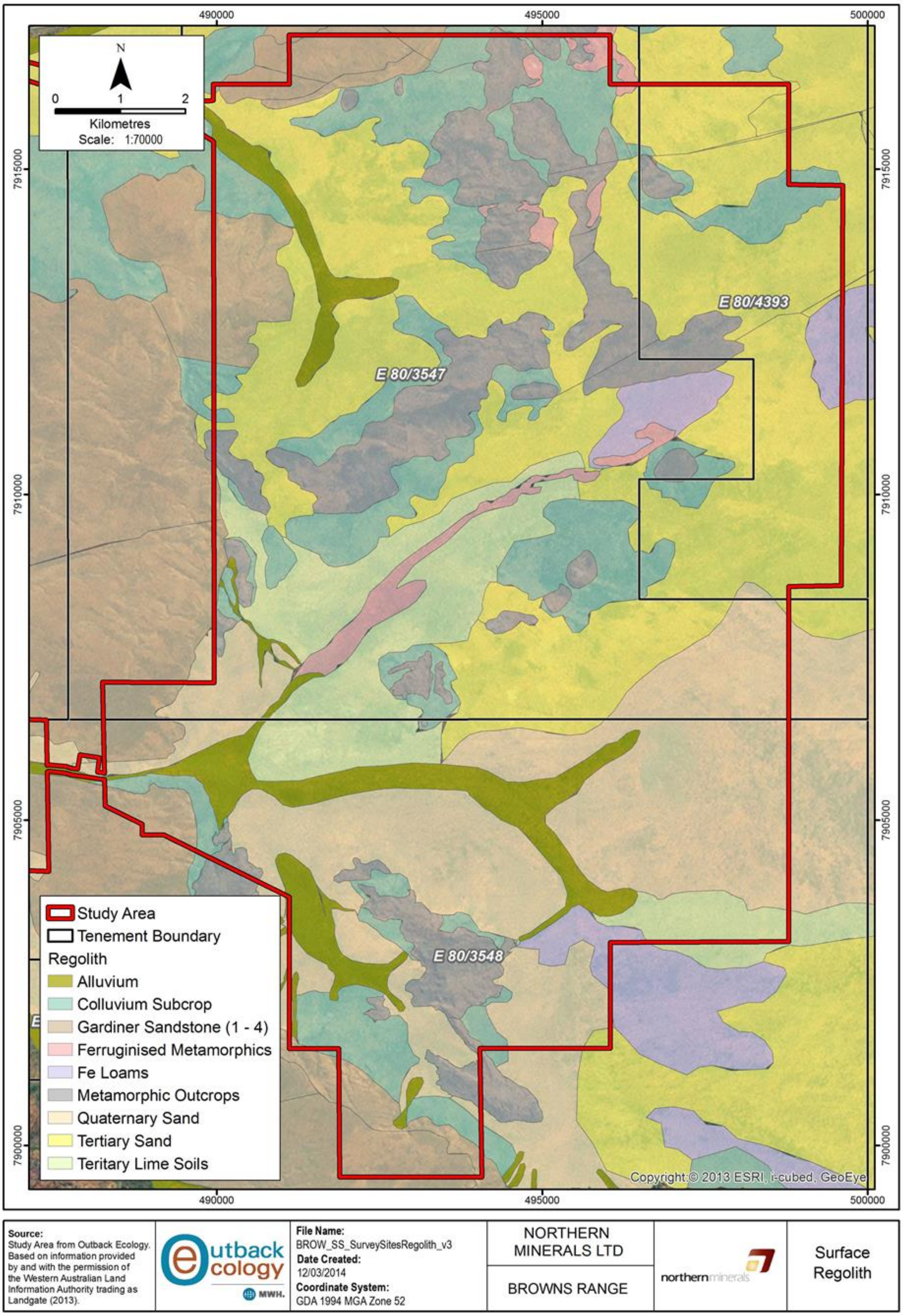

Figure 4-3: Regolith units

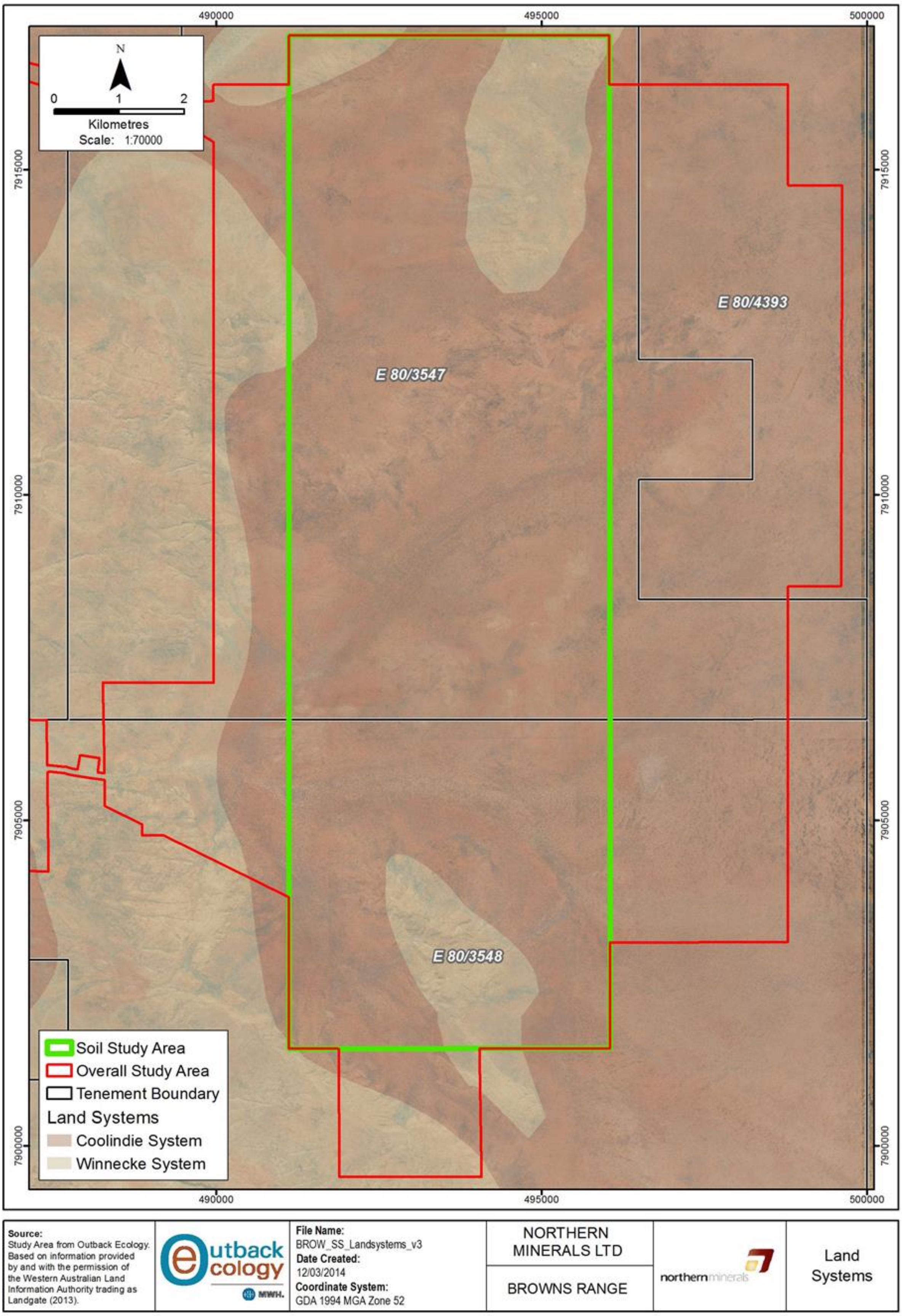

Figure 4-4: Land systems

4.1.4 Waste rock geochemistry and physical characteristics

Baseline geochemical studies of waste rock from the Project have shown that approximately 85% to 90% of the rock that will be stored in the waste rock landforms (WRLs) will consist of variably weathered arenites and arkoses (sedimentary rocks comprising mainly quartz, with some feldspar and mica). Other rock types, including conglomerate, quartz- or hematite-brecchias, siltstone and schist will be present in lesser proportions. The minor lithologies typically contribute less than 5% (per lithological group) to the overall waste rock mass. Geochemical testing has been carried out on waste rock (Table 4-2) to assess its potential for generation of saline, acidic, metalliferous or other potentially polluting seepage or runoff (Appendix B). The testing included static acid-base accounting, trace elements concentration determinations, radionuclide analysis and mineralogical characterisation. A series of complementary tests (including water and mild acid extraction to determine leachable metals and rapid peroxide oxidation to determine 'net acid generation') was also carried out to evaluate the potential environmental mobility of waste rock constituents.

The results from geochemical testing of Browns Range waste rock indicate that waste rock arising from mining will not pose a significant risk of acidic, metalliferous or saline drainage.

Table 4-2: Lithological groupings used for geochemical characterisation

Lithological grouping	Sampled depth range (m)	Description
1	0.8–2.4	Transported material (including alluvial sand, colluvial sand and alluvial clay)
2	4.0–22.6	Weathered in-situ materials – including mottled saprolite
3	13.5–100.1	Weathered in-situ materials – predominantly moderately weathered sedimentary rocks (siltstones, arenites, arkoses)
4	109.9–145	Ore zone deposits (brecciation or alteration common)
5	117.2–173.5	Arkose footwall (comprising arkose or arenite – rarely brecciated)

Potential for acid mine drainage

The geochemical characterisation of the Project waste rock has shown that the majority (>99%) of the waste rock contains negligible sulphur (<0.1 wt% S). The median sulphur contents in all the deposits were less than the detection limit of 0.025 wt% S. Average sulphur contents were approximately 0.03 wt% S for most areas; the highest average was calculated for the Area 5 deposit (0.06 wt% S). Most of the waste rock tested meets the AMIRA definition of 'non-acid forming' (NAF) material (Figure 4-5, Table 4-3). A small number of mineralised waste rock samples from the ore zone and one sample of wall rock were classified as potentially acid-forming (PAF) material. In practice, the material would typically report to the processing plant and ultimately to the tailings storage facility (TSF) (Refer Section 4.1.5 for discussion on tailings geochemistry). Modelling conducted to assess the post-mining quality of water in pit lakes has taken account of possible contributions from reactive minerals in wall rock.

Additional information on the assessment of acid-generating properties of waste rock is provided in Appendix B.

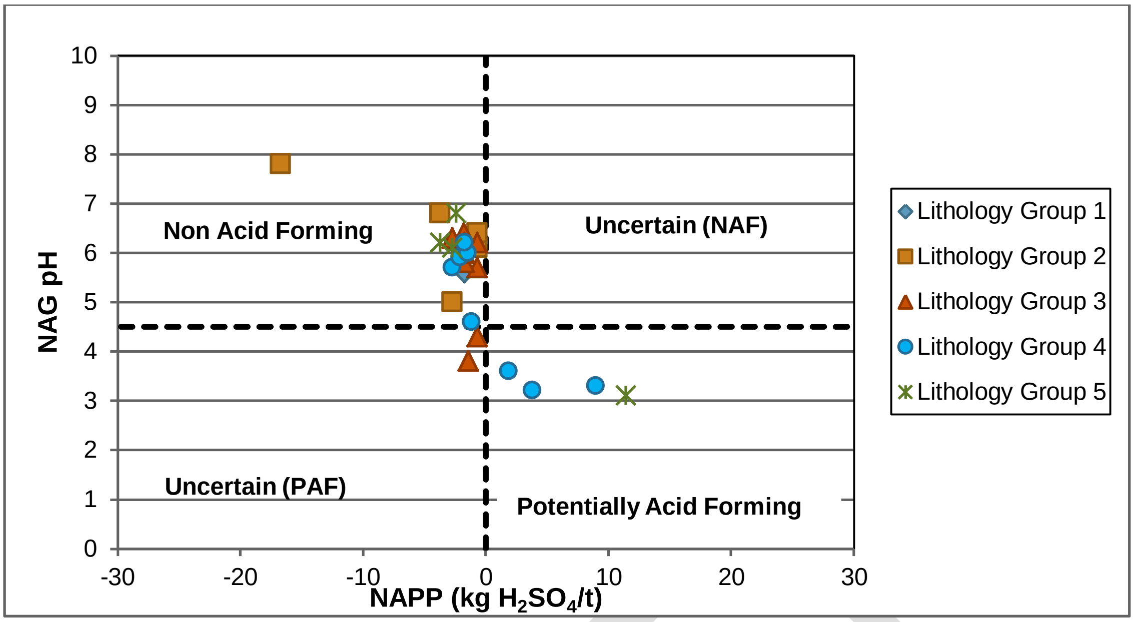

Figure 4-5: Static acid-base classification of Browns Range waste rock

Notes: Lithology Group 4 is mineralised material that would typically report to the processing plant. Strictly speaking, it is not 'waste rock'.

Table 4-3: AMIRA classification criteria

Class	Sub-class	Description
NAF	NAF	Samples with a negative NAPP value and a NAG pH of ≥4.5
	NAF-Barren	As above, and also a low ANC (≤5 kg H_2SO_4/t). Such samples have little value with respect to mitigating the effects of acid production in other mine waste materials
PAF	PAF	Samples with a positive NAPP value and a NAG pH of <4.5
	PAF-LC	PAF materials associated with low NAG acidities ($NAG_{pH4.5}$ < 5 kg H_2SO_4/t)
Uncertain	UC(PAF)	Samples with negative NAPP, but giving NAG pH values <4.5
	UC(NAF)	Samples with positive NAPP, but giving NAG pH values ≥4.5. Possibly some of the sulphur present in these samples is in non-pyritic forms

Notes: ANC – acid neutralising capacity; NAF – non-acid forming; NAG – net acid generation; NAPP – net acid producing potential; PAF – potentially acid forming; LC – low capacity (to produce acid); UC – uncertain acid potential.

Trace elements in waste rock

In samples collected from outside the ore zone, two trace elements (selenium and boron) were identified as 'enriched' in the Project waste rock on the basis that the total element concentration corresponded to a Global Abundance Index (GAI) equal to or greater than 3. The GAI is a tool which provides a measure of geochemical enrichment relative to average crustal abundance (Bowen, 1979). The GAI scale ranges from 0 to 6. A GAI of 0 indicates that the content of the element is less than, or similar to, the average crustal abundance. A GAI of 3 corresponds to a 12-fold enrichment above the average crustal abundance and is generally a level at which elements are considered to be 'enriched'.

Rock samples collected from within the ore zone contained enriched levels of the following trace elements: Ag, As, B, Bi, Ce, Dy, Er, Gd, Ho, La, Lu, Nd, Pr, S, Se, Sm, Tb, Te, Tm, Y and Yb. This material would typically report to the processing plant and ultimately to the tailings storage facility. Ore zone samples were included in the waste rock testing programme, as it is possible that a minor proportion of mineralised material may be exposed in the wall rock at completion of mining.

Typically, the Project waste rock material yielded neutral/mildly alkaline leachate solutions when leached with deionised water. The leachable trace metal concentrations of the waste rock samples (including samples taken from the ore zone) were generally low and often below detection limits. The leachable rare earth element concentrations from waste rock were predominantly below detection limit (<0.001 mg/L). Although selenium was identified as one of the two most enriched elements on the basis of the GAI assessment of the solid samples, no leachable selenium concentrations above detection level were obtained. Boron, the most commonly enriched element within the solid samples, was present in the leach extractions (Table 4-4). Additional information and laboratory reports for testing the Project waste rock are provided in Appendix B

Overall, the geochemical testing has shown that only a small proportion of the trace elements present in Project waste rock occurs in forms that are readily leachable under the geochemical conditions expected in the proposed waste rock landform: less than 1% under neutral pH conditions and less than 6% under acidic conditions (Appendix B). Neither acidic nor saline seepage is expected to occur at the waste rock landforms, as the waste rock stored there would be non-saline and have low acid-generating capacity.

Table 4-4: Typical trace elements concentrations in Browns Range waste rock

Element	LOD[1] (mg/kg)	Lithological Grouping					
		Transported material, including alluvial sand, colluvial sand and alluvial clay	Weathered in situ materials – including mottled saprolite	Moderately weathered siltstones, arenites, arkoses	Ore zone deposits (brecciation or alteration common)	Wallrock, comprising arkose or arenite – rarely brecciated	GAI=3
As	0.5	3.1	5.2	3.8	23.6	12.8	18
B	50	84	155	165	126	225	120
Ce	0.01	32.46	50.29	71.65	406.42	79.34	816
Cu	1	10	4	2	73	3	600
Dy	0.01	1.60	1.64	4.18	110.64	2.27	72
Er	0.01	0.92	1.01	2.68	72.11	1.53	45.6
Eu	0.01	0.41	0.38	0.53	7.56	0.50	25.2
Gd	0.01	1.85	1.78	3.27	70.02	2.00	92.4
Ho	0.01	0.33	0.34	0.87	24.00	0.47	16.8
La	0.01	17.24	28.41	37.56	167.38	52.47	384
Lu	0.005	0.14	0.17	0.37	8.85	0.24	6.12
Nd	0.01	12.57	18.09	28.01	246.20	27.89	456
Pr	0.005	3.59	5.40	8.16	57.06	8.67	114
Sb	0.05	0.39	0.38	0.33	0.66	0.63	2.4
Se	0.5	0.63	0.6	0.7	0.6	0.63	0.6
Sm	0.01	2.24	2.63	4.19	49.12	3.45	94.8
Tb	0.005	0.27	0.27	0.60	15.33	0.34	13.2
Th	0.01	10.7	20.2	31.0	18.4	30.2	144
Tm	0.01	0.14	0.16	0.40	10.60	0.23	5.76
U	0.01	1.11	1.26	2.01	7.95	1.72	28.8
Y	0.05	8.13	9.68	23.45	656.75	13.95	360
Yb	0.01	0.98	1.06	2.62	65.88	1.64	39.6

Notes: 1. LOD means the analytical limit of detection. All values are in mg/kg.

Radionuclides in waste rock

Barren overburden and non-mineralised waste rock will be excavated to expose the ore bodies and will be placed in waste rock landforms. The overburden is not classified as radioactive material, with average U and Th levels of up to 15 ppm and 2 ppm, respectively. Baseline radiological testing of representative waste rock samples has shown that neither the waste rock nor water that has come into contact with the waste rock will contain elevated concentrations of radionuclides (Table 4-5). No special controls are required for the purpose of managing radioactivity in waste rock.

Table 4-5: Radionuclide analysis of Browns Range waste rock

Composite lithological grouping sample	Radionuclide	Concentration in waste rock (Bq/g)			
		Th^{232} decay chain		U^{238} decay chain	
		Ra^{228}	Th^{228}	Ra^{226}	Pb^{210}
1	solid	0.048±0.003	0.055±0.006	0.023±0.002	0.019±0.003
2	solid	0.09±0.006	0.098±0.010	0.018±0.001	0.014±0.003
3	solid	0.132±0.008	0.145±0.014	0.028±0.002	0.029±0.005
4	solid	0.097±0.007	0.110±0.012	0.062±0.003	0.05±0.006
5	solid	0.118±0.007	0.129±0.129	0.021±0.002	0.018±0.005
NORM Investigation Level[1]		**0.2**	**-**	**0.5**	**-**
1	liquid	<0.12	<0.042	0.028±0.015	<0.15
2	liquid	<0.14	0.044±0.029	0.043±0.029	<0.16
3	liquid	<0.14	<0.049	0.026±0.02	<0.14
4	liquid	<0.14	<0.063	0.048±0.017	<0.14
5	liquid	0.126±0.034	<0.059	0.041±0.017	<0.21

Notes: 1. Radionuclides in water NORM Investigation Level (for surface and groundwater) – taken from Managing naturally occurring radioactive material (NORM) in mining and mineral processing- guideline, NORM-6, Reporting Requirements *(DMP, 2010).*

Physical properties of waste rock

Northern Minerals has commissioned studies to provide an initial assessment of the physical properties and potential erodibility of mine waste rock. Technical reports on these aspects of Browns Range waste rock are provided in Appendices C and D, respectively. The preliminary assessment of waste rock physical properties involved laboratory testing of rock strength, density, porosity and weathering characteristics ($MgSO_4$ soundness test), as well as review of drilling records and other geotechnical information to evaluate the likely size and shape of rocky waste from the mine pits. Testing of physical samples was carried out on samples to a maximum depth of approximately 120 m, and mostly on samples from depths from approximately 20 m to 50 m, and so is likely to reflect the properties of waste rock encountered during the earlier stages of mining. No suitable samples were available from greater depths at the time the testing was conducted.

The assessment of waste rock (SRK, 2013) confirmed that waste rock lithologies are similar across the Browns Range deposits, with sedimentary rocks (mainly arenite and arkose) making up more than 90% of the waste rock mass (Figure 4-6).

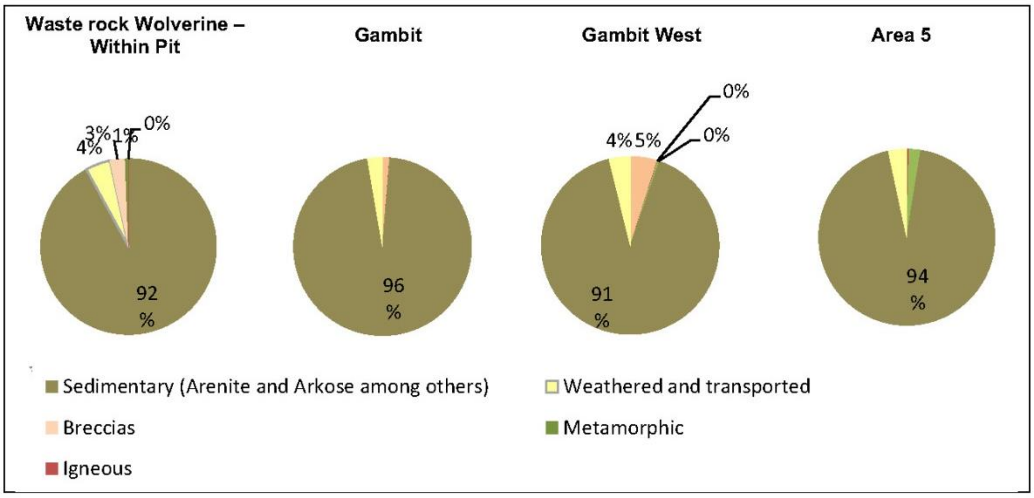

Figure 4-6: Waste rock lithology based in drilling records, weighted by length

Typically, less than 15% of the waste rock logged in over 60,000 m of drillhole data from Browns Range was described as extremely weathered or highly weathered. Between 13% and 49% of the rock was described as 'moderately weathered' and between 38% and 77% was described as 'slightly weathered' or 'fresh' (Figure 4-7). Again, these results generally relate to materials from depths of approximately 20 m to 50 m, and so may not fully describe deeper parts of the deposits. Deeper materials are likely to have a higher proportion of slightly weathered to fresh rock.

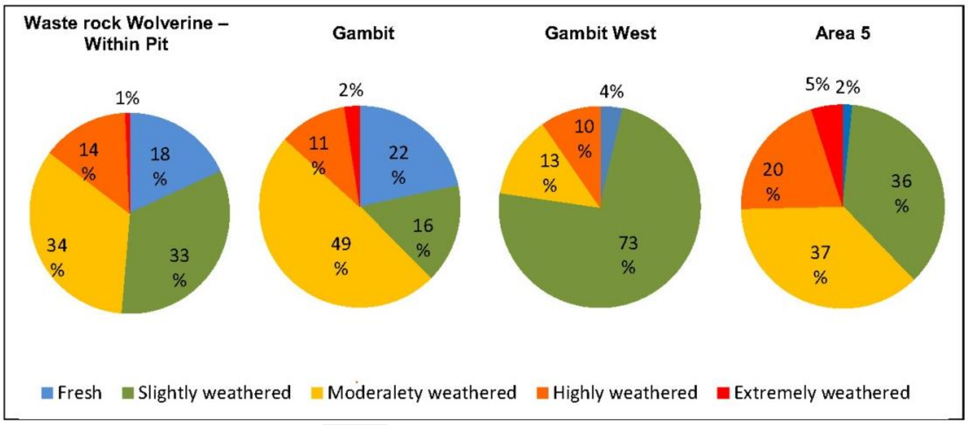

Figure 4-7: Waste rock weathering categories

The assessment of waste rock physical properties concluded that while the materials tested were not suitable for all engineering applications, they were suitable for uses including construction of embankments and general engineered backfill. Material suitable for specific applications such as rip-rap for erosion control structures will have to be selected for the purpose, as not all of the waste rock encountered during early stages of mining will be durable enough for such applications.

A preliminary erosion assessment has been conducted by Landloch (2014) to evaluate potential runoff and sediment mobilisation from the proposed Gambit integrated waste landform. The results of this work will be generally applicable to other proposed waste rock storages. The assessment focused on the Gambit IWL, as it is currently expected to be the highest of the three proposed waste rock landforms (maximum height of approximately 23 m). A copy of the preliminary erosion assessment is provided in Appendix D.

As the Project is not yet operational, no bulk samples were available for flume studies to determine project-specific erosion parameters. Accordingly, input to the erosion model made use of materials properties for comparable sedimentary rocks, including sandstones from the Ellendale diamond mine in the Kimberley (Figure 4-8). Modelling of runoff and potential erosion was carried out using the Water Erosion Prediction Project (WEPP) model and CLIGEN climate simulator software. Representative regional meteorological data were used to carry out runoff and erosion simulations for individual storm events as well as for a 100 year period. The preliminary erosion assessment generally predicted that the bulk of sediment (in the order of 75%) that could be mobilised from Browns Range waste landforms is likely to comprise sand-size or coarser material which can be readily settled out in detention basins. A smaller proportion of the sediment will comprise silt-sized or smaller particles.

The preliminary analysis predicted that potential erosion losses for slopes of up to approximately 16 m in height, with a gradient of 18.4° (33%) are likely to be low to moderate. The predicted sediment yield resulting from flows from a 1-in-100 year storm event were approximately 21 t/ha. Less intense storm flows resulted in commensurately lower sediment loss. For higher embankments, sediment yields increased markedly and this result will need to be taken into account in conducting detailed design of the integrated waste landform.

Figure 4-8: Blasted sandstone at Ellendale mine (boulders in foreground ~1m diameter)

4.1.5 Tailings geochemistry

Baseline studies of the geochemical and radiological properties of beneficiation tailings and hydrometallurgical tailings have been carried out as part of the Browns Range environmental impact assessment. The test programme included testing of process waters and evaluation of the leachability of trace elements in tailings. Results of this work are presented in Appendices E and F.

Potential for acid generation

Tailings from the beneficiation plant will contribute in the order of 90% of the total mass of material reporting to the tailings storage facility. Rejects from the hydrometallurgical plant will account for the remaining 10% of material reporting to the tailings storage facility. The beneficiation tailings did not contain measureable concentrations of sulphur (<0.01% total S), while the hydrometallurgical tailings were reported to contain approximately 4.27% total sulphur. Chromium-reducible sulphur (sulphide-sulphur) content was not determined on the hydrometallurgical tailings, so the static acid-base assessment has conservatively assumed that all sulphur is present as sulphide. Neither tailings stream contains appreciable acid neutralising capacity.

When co-disposed in the tailings storage facility, the combined tailings are unlikely to pose a significant risk of acid generation, due to the low overall concentration of sulphur (Table 4-6, Figure 4-9). The addition of process reagents as part of mineral extraction will result in a strongly alkaline tailings stream (pH of approximately 10), which will further reduce the likelihood of acid seepage and associated mobilisation of trace metals.

Table 4-6: Static acid-base test results – Browns Range tailings

	NAG pH (pH units)	Estimated sulphide-S (%)	MPA (kg H_2SO_4/t)	ANC (kg H_2SO_4/t)	NAPP (kg H_2SO_4/t)
Beneficiation tails	6.1	<0.01	0.153	<0.5	-0.10
Hydromet tails	6.3	2.03	131	3	128
Combined tails (calculated as 90:10 mix)	--	0.21	6.3	1	6

Note: MPA means 'Maximum Potential Acidity'. It has been estimated by multiplying the measured total sulphur concentration by 30.6. ANC means 'Acid Neutralising Capacity'. NAPP means net acid producing potential.

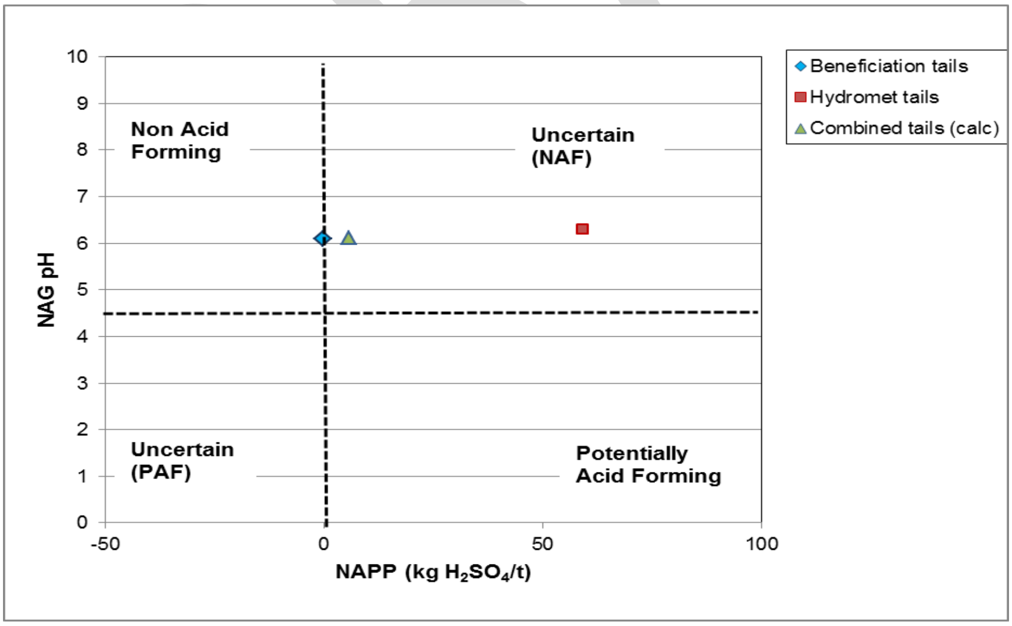

Figure 4-9: Static acid-base classification of Browns Range tailings

Trace elements in tailings

Total concentrations of trace metals in tailings are summarised in Table 4-7. In the combined tailings stream (90% beneficiation solids and 10% hydrometallurgical solids), only molybdenum and selenium are predicted to be present at elevated concentrations (relative to average global crustal abundance values).

The tailings liquid reporting to the tailings storage facility would comprise approximately 75% beneficiation tailings liquid and approximately 25% hydrometallurgical tailings liquid. The results of testing carried out on the tailings liquids are summarised in Table 4-8. The results are shown in the context of ANZECC and ARMCANZ guideline (2000) values for water used for watering of livestock. Of the salts and metals present in the combined tailings liquid, only sulphate exceeded the ANZECC and ARMCANZ guideline values. Additional information on the geochemistry of tailings solids and liquid, and results of leachability testing for the tailings samples, is presented in Appendix C.

The tailings liquid test results show that while the trace element concentrations in the liquid waste stream are generally low, the salt composition of tailings liquid is very different to local groundwater and much higher in both magnesium and sulphate. Accordingly seepage control will be required to prevent the formation of a localised plume of high salinity, high sulphate groundwater.

Table 4-7: Trace metal concentrations in tailings solids

Element	LOD	Units	Beneficiation tails	Hydrometallurgical tails	Combined tails (90:10)	GAI=3
As	0.1	mg/kg	1.9	**76.8**	9.39	18
B	50	mg/kg	<50	<50	<50	120
Cd	0.1	mg/kg	<0.1	<0.1	<0.1	1.32
Co	0.1	mg/kg	2.3	14	3.47	240
Cr	0.1	mg/kg	118	725	178.7	1200
Cu	0.1	mg/kg	43.9	61.3	45.6	600
Fe	50	mg/kg	41,200	18,200	38,900	492,000
Hg	0.1	mg/kg	<0.1	<0.1	<0.1	0.6
Mn	0.1	mg/kg	26.5	23.2	26.17	11,400
Mo	0.1	mg/kg	16.2	144	**28.98**	18
Ni	0.1	mg/kg	97.8	404	128.42	960
Pb	0.1	mg/kg	5.6	37.5	8.79	168
Sb	0.1	mg/kg	0.2	2	0.38	2.4
Se	0.5	mg/kg	2	**363**	**38.1**	6
Th	0.01	mg/kg	3	145	17.2	144
U	0.01	mg/kg	2.3	**141**	16.17	28.8
Z	0.5	mg/kg	10.9	15.1	11.32	900

Table 4-8: Trace metals and major cations/anions in tailings liquid

Parameter	LOD	Units	Beneficiation liquid	Hydrometallurgical tails liquor	Combined tails liquid (75:25)	Guideline[1]: livestock water
TDS[2]		mg/L	787.2	8640	2750	5000 (beef cattle)
Ca	1	mg/L	4	511	131	1000
Mg	1	mg/L	3	3460	867	(~2000)
Na	1	mg/L	256	221	247	–
K	1	mg/L	16	211	65	–
Cl	1	mg/L	215	169	204	–
SO_4	1	mg/L	68	13,800	**3501**	1000
HCO_3	1	mg/L	248	101	211	–
CO_3	1	mg/L	<1	<1	<1	–
Al	0.01	mg/L	2.38	0.03	1.79	5
As	0.001	mg/L	0.012	0.164	0.050	0.5
B	0.05	mg/L	0.13	1.2	0.40	5
Cd	0.0001	mg/L	0.0001	0.0003	0.000	0.01
Co	0.001	mg/L	0.005	0.008	0.006	1
Cr	0.001	mg/L	0.018	0.038	0.023	1
Cu	0.001	mg/L	0.334	0.012	0.254	1
Fe	0.05	mg/L	3.2	<0.05	2.406	–
Mn	0.001	mg/L	0.433	0.192	0.373	–
Mo	0.001	mg/L	0.061	0.092	0.069	0.15
Ni	0.001	mg/L	0.071	0.212	0.106	1
Pb	0.001	mg/L	0.03	<0.001	0.023	0.1
Sb	0.001	mg/L	0.002	<0.001	0.002	–
Se	0.01	mg/L	<0.01	<0.01	0.005	0.02
Th	0.001	mg/L	0.002	0.0005	0.002	–
U	0.001	mg/L	0.007	<0.001	0.005	0.2
Z	0.005	mg/L	0.104	0.006	0.080	20

Notes: 1. ANZECC and ARMCANZ (2000), a dash (–) means no guideline value is available; 2. TDS values for tailings liquor are approximate, they were calculated from laboratory values for EC (µS/cm), using a conversion factor of 0.64.

Radiological properties of tailings

The metallurgical testwork has shown that some radionuclides concentrate through the processing plant as the ore undergoes a range of chemical and metallurgical processes. Australian Nuclear Science and Technology Organisation (ANSTO) conducted a radionuclide deportment study and additional testwork has been undertaken by Northern Minerals to determine radionuclide distribution through the mineral extraction process.

The tailings from the hydrometallurgical process contain some radionuclides that exceed the threshold values for classification as a radioactive material. However, it is intended that the beneficiation tailings and the hydrometallurgical tailings are recombined for final disposal in a purpose-built, engineered tailings storage facility. The concentration of radionuclides in the final combined tailings is practically identical to that of the ore, which is not a radioactive material. Table 4-9 estimates of the radionuclide content of the combined tailings solids and liquids.

Additional information on the radiological properties of Browns Range tailings is provided in Appendix D.

Table 4-9: Predicted radionuclide concentrations in processing plant streams

	Feed to plant (solids) (Bq/g)	Combined Tailings	
		Solids (Bq/g)	Liquids (Bq/L)
U^{238}	0.6	0.3	41
Th^{230}	0.5	0.4	0.5
Ra^{226}	0.6	0.6	0.2
Pb^{210}	0.6	0.6	0.5
Th^{232}	0.1	0.1	0.1
Ra^{228}	0.1	0.1	0.1
Th^{228}	0.1	0.1	0.1
U^{235}	0.03	0.02	2.0

Notes: 1. the difference between radionuclide concentrations in ore and tailings is due to mass gain from reagents addition in the neutralisation of the waste liquid streams.

4.1.6 Surface water and groundwater

Surface hydrology

There are no permanent water bodies in the Project area. Intermittent seasonal flow in the ephemeral drainage lines that traverse the Project area generally travels in a westerly direction. Topography in the Project area is generally subdued, with an average gradient of about 1%. The Project site lies within the Sturt Creek catchment, which flows to the south-west, ultimately discharging into Lake Gregory (Paruku), 280 km downstream of the Project area. The main water course of Sturt Creek is located approximately 45 km west-northwest of the Project site and is classified as an ephemeral system. Sturt Creek is classified as a 'wild river' (a river that is undammed and lies in a largely unmodified catchment with intact biological and hydrological processes). Lake Gregory is recognised as an important wetland and a significant site for waterbirds.

The Lake Gregory system is one of the most important arid wetlands in Australia (Timms, 2001). It is currently identified as a wetland of national importance under several criteria of the Directory of

Important Wetlands in Australia. The system is a significant site for both domestic and migratory waterbird species, some of which are recognised as being of conservation significance at a national and international level.

The Lake Gregory system is of high importance to local Aboriginal people. It is part of the Paruku Indigenous Protected Area, which was declared in 2001 (DEC, 2009).

Surface water quality

Northern Minerals has conducted two campaigns of surface water sampling, during the 2012–2013 and the 2013–2014 wet seasons. Water samples were recovered at two locations each wet season by means of rising stage samplers deployed in ephemeral creek lines. As would be expected, the water recovered during seasonal flow events has very low salinity (Figure 4-10). The water has a near-neutral pH and variable suspended solid concentrations. The water has low sulphate concentrations. Concentrations of dissolved metals are low (Table 4-10, Figure 4-11). The dominant anion in surface water is bicarbonate (Figure 4-12).

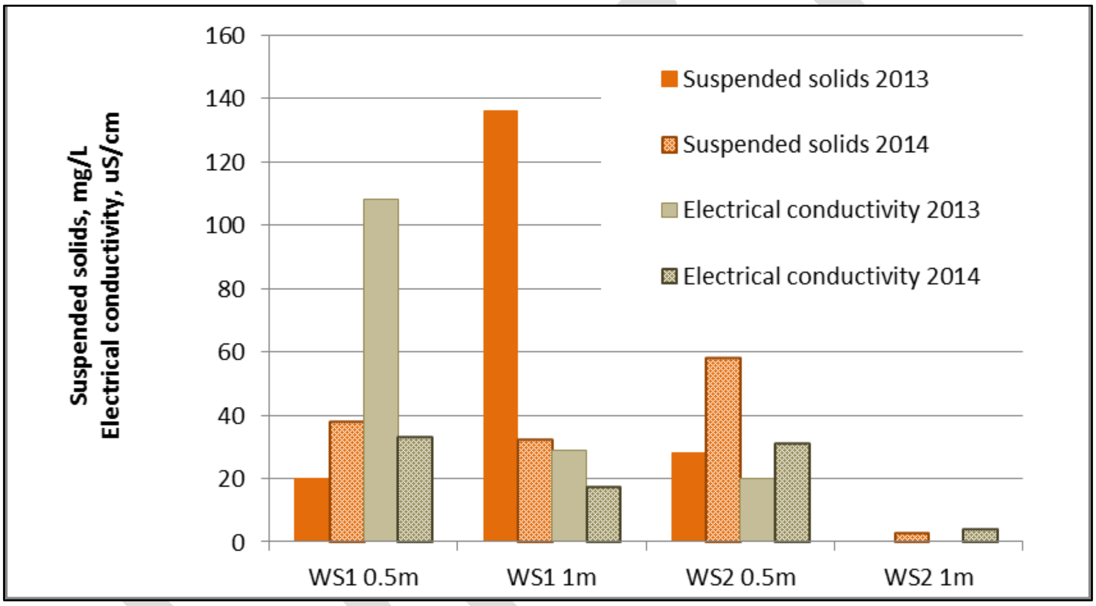

Figure 4-10: Physical parameters in surface water (Nov 2013 and Feb 2014)

Table 4-10: Dissolved trace metals in surface water

	WS1 0.5 m (mg/L)	WS1 1 m (mg/L)	WS2 0.5 m (mg/L)	WS1 0.5 m (mg/L)	WS1 1 m (mg/L)	WS2 0.5 m (mg/L)	WS2 1 m (mg/L)
Antimony	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Barium	0.032	0.013	0.011	0.022	0.006	0.016	<0.001
Chromium	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001
Nickel	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc	<0.005	<0.005	0.005	0.025	<0.005	0.075	<0.005

Note: No sample was recovered at WS2 – 1 m in 2013, as the depth of water flow was too shallow.

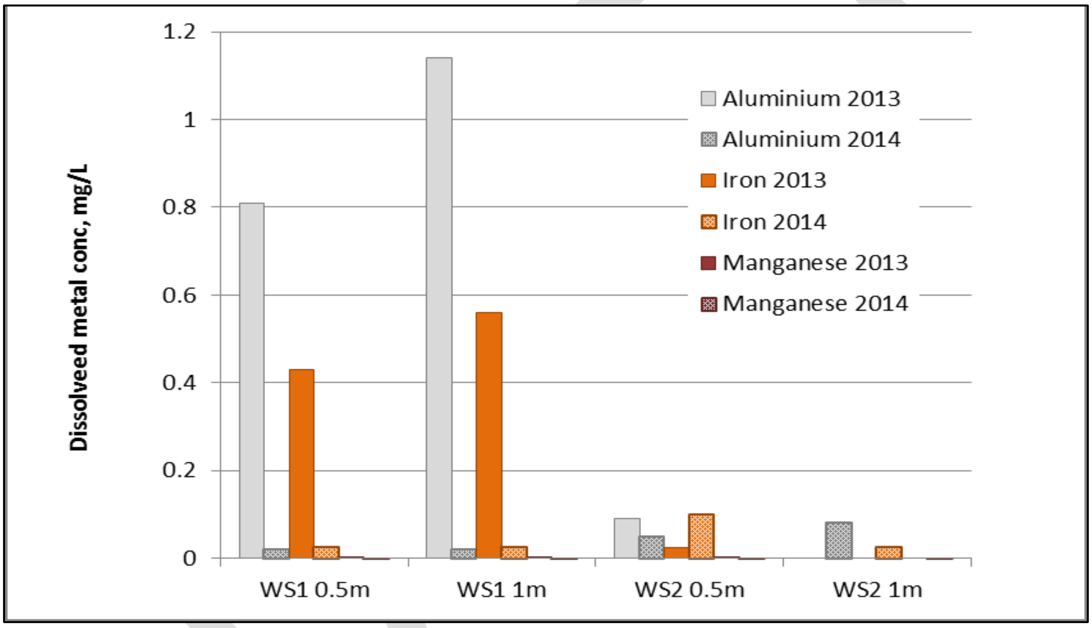

Figure 4-11: Aluminium, iron and manganese in surface water (Nov 2013 and Feb 2014)

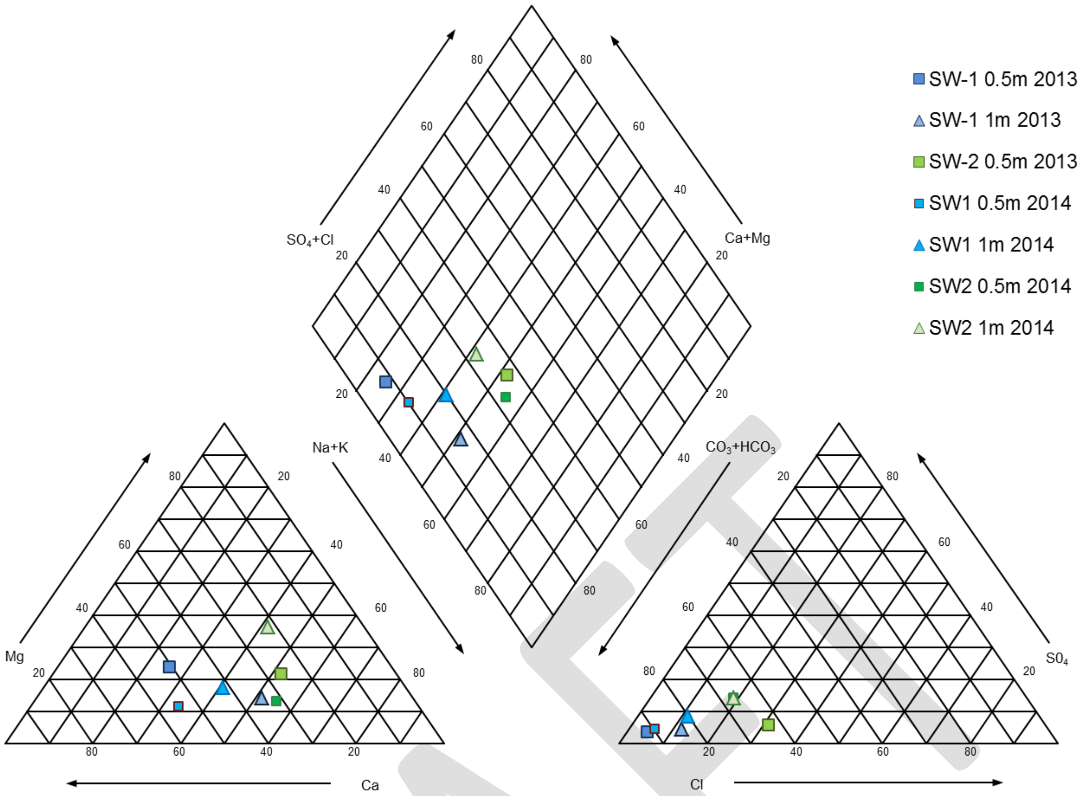

Figure 4-12: Trilinear plot showing surface water chemistry

Groundwater flow systems

Baseline studies conducted for the Browns Range Project have identified three water-bearing stratigraphic units in the Project area. The shallow stratigraphy of the area is shown in Figure 4-2. The main water bearing zones at Browns Range are:

- **Browns Range Metamorphics fractured rock aquifer:** A thick sequence of metamorphosed sediments with limited primary porosity. The unit is confined to semi-confined by overlying transported sediment and in situ weathered materials. Localised zones of high hydraulic conductivity are associated with secondary structures (e.g. faults, shears, joints). A shear zone trending in a general NW-SE direction has been identified at the Area 5 deposit.
- **Gardiner Sandstone fractured rock aquifer:** The Gardiner Sandstone outcrops at the western margin of the Project area and extends westward from the outcrop. East of the outcrop, this unit is largely absent from the Project area. The sandstone comprises medium-grained quartz and lithic arenites. The unit is deep and regionally extensive. Some recharge occurs via outcropping zones of the Gardiner Sandstone unit.
- **Unconfined alluvial aquifer:** This unit is mainly localised along drainage lines and saturated conditions in this layer are present only during and immediately following the wet season. Some seasonal leakage is likely from the alluvial aquifers to underlying fractured rock aquifers.

Overall, annual recharge to the fractured rock aquifers is expected to be low: in the order of 1% to 3% of annual precipitation.

The depth to groundwater in the Project area is variable, ranging from about 7 m to more than 25 m below ground surface, and reflects (in a subdued way) surface topography of the area. Static water levels in boreholes were observed to be shallower than the depths of water strike during drilling, which is an indication that the fractured aquifers are confined or semi-confined. The regional groundwater flow direction is from east to west, at an estimated hydraulic gradient of 0.001.

Groundwater quality

Groundwater quality in the Project area is generally fresh to brackish, with an average total dissolved solids concentration of about 2000 mg/L (Table 4-11). There is one part of the mining tenement area (remote from any proposed mining or water abstraction activities) which is known to have much higher salinity in the order of 20,000 mg/L. Groundwater pH ranges from slightly acidic to slightly alkaline.

Dissolved metals concentrations are generally low and, with the exceptions of localised areas where the groundwater is naturally saline, the water is suitable for watering of livestock. The nearest Department of Water (DoW) registered bore is located approximately 17 km north-west of the proposed Wolverine pit.

Table 4-11: Groundwater quality

Parameter	Units	No of Results	No of Detects	Min Conc	Max Conc	Average Conc	Median Conc
Alkalinity as CaCO3	mg/L	43	43	3	500	196	173
Aluminium	mg/L	42	27	<0.01	3.97	0.61	0.105
Aluminium (Filtered)	mg/L	44	19	<0.01	0.78	0.071	0.01
Ammonia as N	µg/L	43	36	<10	2710	115	30
Antimony	mg/L	42	0	<0.001	<0.005	0.00069	0.0005
Arsenic	mg/L	44	16	<0.001	0.022	0.0023	0.0005
Barium	mg/L	44	44	0.005	0.785	0.087	0.051
Beryllium	mg/L	44	0	<0.001	<0.005	0.00068	0.0005
Bicarbonate	mg/L	43	43	3	500	196	173
Boron	mg/L	28	23	<0.05	1.5	0.39	0.255
Cadmium	mg/L	44	0	<0.0001	<0.0005	0.000068	0.00005
Calcium	mg/L	43	42	<1	725	93	33
Carbonate	mg/L	43	0	<1	<1	0.5	0.5
Chloride	mg/L	43	43	12	12,300	1263	198
Chromium (III+VI)	mg/L	44	10	<0.001	0.005	0.0011	0.0005
Cobalt	mg/L	44	13	<0.001	0.029	0.0018	0.0005
Copper	mg/L	44	31	<0.001	0.02	0.0036	0.002
Electrical conductivity *(lab)	µS/cm	43	43	60	33,200	4085	1270
Fluoride	mg/L	41	35	<0.1	1.2	0.55	0.6
Hardness as CaCO3	mg/L	41	40	<1	9720	1149	276
Iron	mg/L	43	21	<0.05	3.65	0.33	0.06
Kjeldahl Nitrogen Total	mg/L	16	11	<0.1	1.1	0.25	0.2
Lead	mg/L	44	2	<0.001	<0.005	0.0007	0.0005
Magnesium	mg/L	43	42	<1	1920	211	40
Manganese	mg/L	44	41	<0.001	1.29	0.11	0.0195
Mercury	mg/L	44	0	<0.0001	<0.0001	0.00005	0.00005

Parameter	Units	No of Results	No of Detects	Min Conc	Max Conc	Average Conc	Median Conc
Molybdenum	mg/L	42	10	<0.001	0.01	0.0012	0.0005
Nickel	mg/L	44	29	<0.001	0.035	0.0027	0.002
pH (Lab)	pH units	43	43	5.56	8.17		
Phosphorus	mg/L	16	12	<0.01	0.12	0.038	0.0275
Potassium	mg/L	43	43	3	374	56	27
Reactive Phosphorus	mg/L	42	19	<0.01	0.18	0.018	0.0075
Selenium	mg/L	42	2	<0.01	0.06	0.0086	0.005
Sodium	mg/L	43	43	6	4640	562	163
Sulphate	mg/L	43	43	1	3180	367	79
TDS	mg/L	28	28	39	20,100	2130	789.5
Thorium	µg/L	42	2	<1	<5	0.71	0.5
Tin	mg/L	42	2	<0.001	<0.005	0.00071	0.0005
Uranium	µg/L	42	25	<1	120	23	2.5
Vanadium	mg/L	44	2	<0.01	<0.05	0.007	0.005
Zinc	mg/L	44	40	<0.005	1.35	0.18	0.017

4.1.7 Final pit voids

Preliminary studies have been carried out to identify the key factors affecting the likely geochemical and hydrological behaviour of pit voids following cessation of mining at Browns Range. The studies conducted to date include preliminary modelling of pit lake hydrology and geochemistry (Appendix G) and reviews of ecotoxicological and ecological aspects of pit lakes (Appendix H and I).

These studies have identified the following key considerations in the long term management of final mine voids:

- Climatic factors have a dominant influence on pit lake hydrology and geochemistry. Because the project lies in an area of very high evaporative demand, concentration of dissolved salts and metals by evaporation is the key factor that influences pit lake water quality.
- Chemical reactions of pit lake water with wall rock may be a contributing source of salts or metals, but are not a dominant factor.
- In the absence of contributions of freshwater runoff from areas surrounding the pit voids, the pit lakes will necessarily become saline over the very long term, as evaporation in the Browns Range area typically exceeds rainfall by an order of magnitude. The rate at which concentration effects occur will be influenced by pit geometry, with wider, shallow pits being more affected by evaporative concentration.
- The hydrological behaviour of the pit voids varies from deposit to deposit and is influenced both by pit geometry and by local hydrogeological conditions (characteristics of surrounding rock). Pit lakes are expected to form in each of the Browns Range pit voids. Most of the water levels in pit lakes will stabilise at levels below the pre-mining water levels (Figure 4-12). This is a reflection of the climatic regime and the generally low rates of groundwater inflow to the pits. The Area 5 pit is the only pit lake predicted to stabilise at a level near to the pre-mining water table level.
- The rate of recovery of water levels in the pit lakes varies from deposit to deposit, with the time to reach steady-state conditions ranging from less than a year to approximately 50 years.

- All pit lakes are predicted to function primarily as sinks in the centuries following cessation of mining. At times of extreme wet conditions, Area 5 may occasionally and temporarily function as a throughflow system.

Table 4-12: Summary of final pit lake water elevations

Deposit	Predicted steady-state lake surface elevation (mAHD)	Time to reach steady-state water level	Lake water level compared to pre-mining water table (m)
Wolverine	~404	50 years	~40 m below
Gambit West	~334	20 years	~95 m below
Gambit Central	~428	5 years	~12 m below
Gambit	~4342	15 years	~12 m below
Area 5	~413	<1 year	~1 m below

A necessary corollary of the long term evaporative concentration of water in the pit voids is that both metals and salts will eventually exceed a range of ANZECC water quality criteria in the long term. Concentrations cannot increase without limit due to mineral solubility constraints. There is some uncertainty about the rate at which chemical reactions of rainwater or pit lake water with pit wall rock would contribute salt or metals to the pit lake water, and therefore the preliminary modelling included sensitivity analysis to test the effect of different contributions from pit wall rock. While the assumptions about wall rock contributions incorporated in the preliminary modelling made some difference to the predicted long term concentration of some trace elements, the ultimate salinization of the lakes occurred in all cases.

Whether or not the long term evaporative concentration of water in pit lakes (in the absence of any external fresh water contributions, other that direct rainfall over the pit void) would constitute a threat to wildlife depends upon a great many factors. Preliminary reviews of ecological aspects of final pits lakes at Browns Range have identified that most of the pits (with the possible exception of Gambit Central) would be deep and steep-sided with water levels more than 30 m below natural ground level, and accordingly would not provide hospitable habitat to support waders and shorebirds. Moreover, it is not certain that the lake voids would support the aquatic flora and fauna upon which water birds rely for their diet. A preliminary ecotoxicological assessment (Appendix H) has identified that dietary sources, rather than drinking water or dermal contact are likely to dominate toxicity effects for water birds.

It is possible that migratory birds or terrestrial fauna would seek to access water in the pit voids, especially during the dry season. Acute adverse effects on migratory birds or terrestrial fauna are unlikely, even if the worst case water quality predictions were to be realised. However, there is some potential for chronic exposures to elevated trace elements concentrations. It is important to recall that the driver for increased trace element concentration is evaporation and as the trace elements become more concentrated, so do dissolved salts. At the maximum predicted salinity concentrations (in the order of 5000 mg/L to 50,000 mg/L), the lake would be less attractive as a drinking water source for wildlife or livestock.

4.1.8 Flora and vegetation

The Project occurs within the Tanami 1 sub-region as defined within the Interim Bioregions of Australia (IBRA) classification system. Within the study area, 19 vegetation associations were identified across the study area (Figure 4-13 and Figure 4-14). Three vegetation associations—*Eucalyptus brevifolia* (rocky hills), *E. brevifolia* (plains) and *E. chlorophylla* (plains)—comprise more than 70% of the study area. None of the vegetation associations identified represents a Threatened Ecological Community (TEC) or a Priority Ecological Community (PEC).

The drainage lines in the Project area support characteristic vegetation assemblages, but no groundwater-dependent ecosystem (GDE) was recorded within the study area. The nearest known GDE is Sturt Creek, to the north and west of the study area. However, five vegetation associations are associated with broad floodplain and drainage areas. While these are believed to be dependent on surface water flows rather than groundwater, some contain *Eucalyptus victrix* which is known to be a facultative phreatophyte, i.e. it may use groundwater when available.

Vegetation was recorded to be in largely excellent condition. Some populations of weed species occur near existing roads and tracks (including the access road from Ringer Soak), and in laydown areas associated with mineral exploration activities.

No species protected under either the *Wildlife Conservation Act 1950* (WA) or the *Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth) were recorded during surveys. However, some species that are listed as Western Australian Priority Flora and a range of other species of conservation significance were recorded (Table 4-13). Overall, these comprise:

- four Priority-listed species
- two species nominated for inclusion as Priority species
- six species with 'medium' range extensions (see Table 4-13 for definition)
- six species with 'high' range extensions
- two species not previously recorded in Western Australia
- one undescribed species.

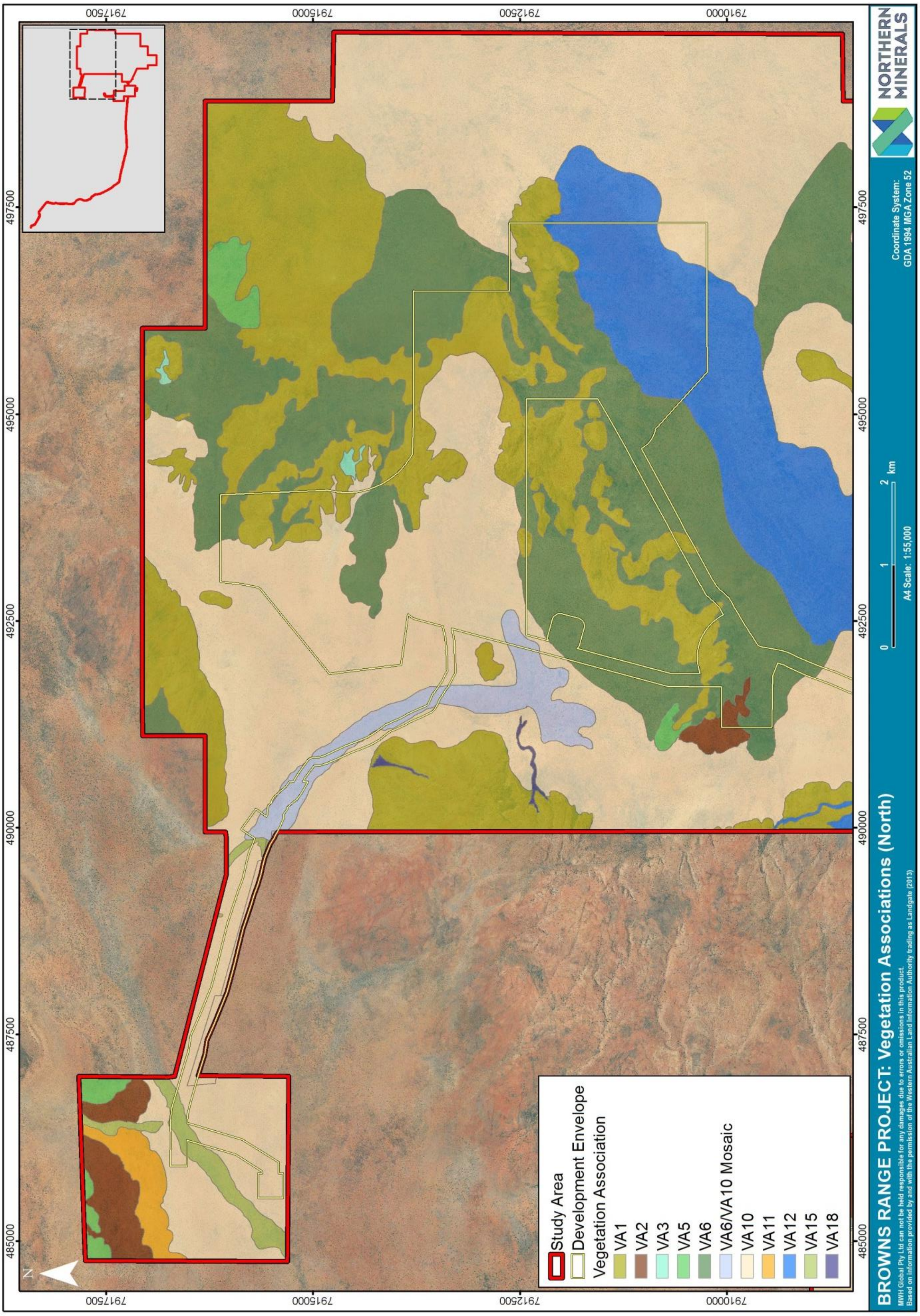

Figure 4-13: Vegetation associations occurring within proposed Project area (north)

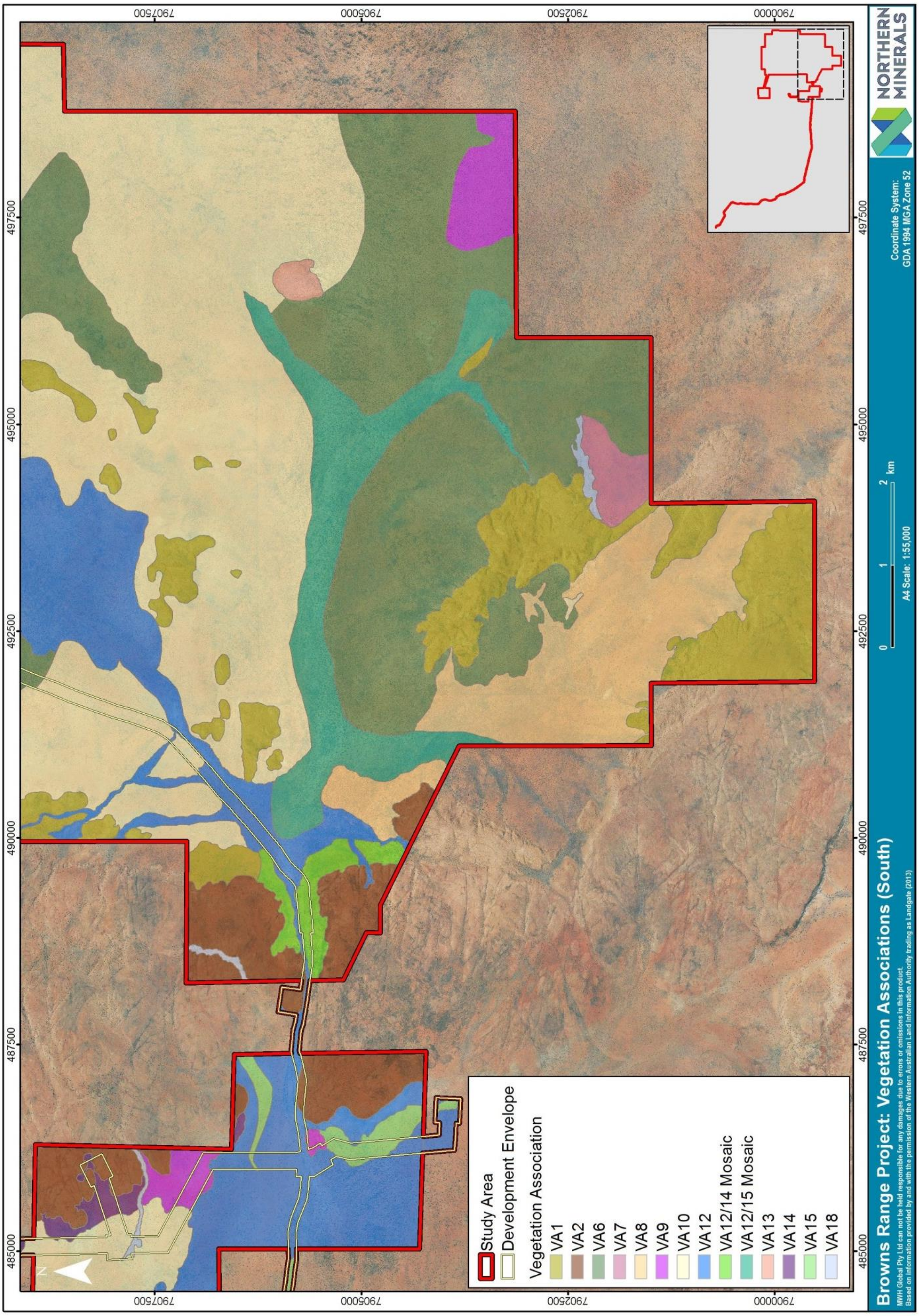

Figure 4-14: Vegetation associations occurring within proposed Project area (south)

Table 4-13: Priority Flora and other species of conservation significance

Species	Ranking	Comment
Brachychiton multicaulis	Nom	53 populations of 266 plants
Corynotheca micrantha var. *gracilis*	M	5 populations recorded
Cyperus haspans subsp. *?juncoides*	H	1 population recorded (location unknown)
Eleocharis ochrostachys	P3	1 population of six plants on *E. victrix* floodplain
Euphorbia ?inappendiculata	M	1 population recorded
Euphorbia armstrongiana var. *?distans*	H	1 population recorded.
Exocarpos latifolius	M	1 population recorded
Fimbristylis pauciflora (s.l.)	H	1 population recorded
Gomphrena flaccida	M	1 population recorded
Goodenia arachnoidea	H	1 population recorded
Goodenia crenata	P3	51 populations of approximately 6200 plants
Goodenia goodeniacea	N	12 populations of 265 plants on floodplain
Goodenia sp. nov.	U	1 population of 1 plant
Heliotropium uniflorum	P1	1 population of 1 plant on a rocky ridge
Polymeria lanata (s.l.)	H	3 populations recorded
Sesbania muelleri	N	2 populations of 60 plants on rocky ridge
Stemodia sp, Tanami (PK Latz 8218)	Nom	5 populations of 20 plants
Swainsona formosa	M	1 population recorded
Trachymene villosa	P1	10 populations of 46 plants on foothills
Vigna vexillata var. *angustifolia*	H	1 population recorded
Whiteochloa airoides	M	1 population recorded

Notes on rankings:
H – Taxa not listed or nominated as a Priority species but local populations represent a 'high' range extension over previously known specimens. A 'high' range extension occurs where the nearest other record is 100 km away and the taxa has not been recorded in an adjacent bioregion (Ord Victoria Plain, Great Sandy Desert).
M – Taxa not listed or nominated as a Priority species but local populations represent a 'medium' range extension over previously known specimens. A 'medium' range extension occurs where the nearest other record is 200–500 km away but the taxa has been recorded in an adjacent bioregion (Ord Victoria Plain, Great Sandy Desert).
N – Taxa not previously known to occur in Western Australia.
Nom – nominated for Priority status.
P1 – Taxa with few, poorly known populations on threatened lands.
P3 – Taxa with several, poorly known populations, some on conservation lands.
U – Taxon is undescribed.

4.1.9 Terrestrial fauna and fauna habitats

A baseline fauna survey was conducted in May 2012 with a subsequent targeted survey undertaken in December 2013. Across the Project Area, six vertebrate fauna habitats have been identified. Of these, Open Shrubland over Mixed Grassland on Sandy Plain is by far the most widespread. None of the habitats that will be disturbed by Project implementation have special attributes that would cause them to be considered significant habitat required to support fauna of conservation significance or distinct faunal assemblages.

The vertebrate fauna assemblages found in the Project development envelope and the general Project locality are consistent with those known to occur in the region. No vertebrate fauna assemblages are believed to be restricted to the study area.

In the Project area, five invertebrate habitat types were identified. These habitats were categorised as having a high, medium or low potential to support short-range endemic (SRE) species based on the presence of sheltered micro-habitats or their propensity to form habitat isolates. A Development Exclusion Zone has been established around Internal Drainage habitat within the study area as it was considered to have a high potential of supporting SRE species. No significant impacts on SRE fauna are expected, as none of the SRE species recorded in the Project area are restricted to the proposed disturbance footprint.

4.2 Other closure related information

A preliminary tailings design report, including conceptual design for rehabilitation and closure has been prepared (Appendix J).

The results of preliminary modelling of alternative tailings cover systems are presented in Appendix K.

Preliminary modelling of final pit lake hydrology and geochemistry has also been completed (Appendix G).

4.3 Data analysis and review

As Northern Minerals' activities on the Browns Range tenements are currently limited to exploration, limited routine environmental monitoring, data analysis and review is carried out. The closure-related information that is currently collected includes:

- documenting the location, extent and rehabilitation status of exploration disturbance
- quarterly groundwater quality monitoring
- opportunistic sampling of surface water during the wet season
- opportunistic observations of weed occurrence.

The information collected is used in annual compliance reporting to the DMP and for budgeting purposes.

4.4 Closure information gap analysis

Northern Minerals has conducted a gap analysis to determine what, if any, additional information is required to enable the effective implementation of mine rehabilitation/closure activities for the Browns Range Project. A domain-by-domain summary is presented in Table 4-14. Information on the planned programme of additional rehabilitation studies is provided in Section 8.2.

Table 4-14: Gap analysis: mine rehabilitation and closure

Domain	Information gap	Explanation
Waste rock landforms	Erodibility of waste rock	Preliminary testing has been completed on waste rock to a nominal depth of approximately 180 m to assess the strength, porosity and weathering characteristics of waste rock (SRK Consulting, 2013). Further testing is required to characterise waste rock from deeper in the proposed pits and to provide a more direct measure of the erodibility of material reporting to the waste landforms.
Tailings storage facility	Seepage characteristics of in situ materials	Preliminary engineering design for the TSF has assumed that it will be necessary to provide a seepage barrier constructed of imported clay and/or a geofabric (HDPE liner). Further testing of in-situ materals within the footprint of the proposed integrated waste landform for use in constructing seepage control layers and/or cover systems for the TSF will be required if geosynthetic materials are not adopted in the containment design.
	Detailed water balance	A detailed water balance will be required to enable design of an appropriate final cover system for the TSF. A store and release cover, possibly with a basal capillary break layer, has provisionally been assumed in the current TSF design.
Evaporation ponds	Geochemistry of evaporites	A geochemical assessment is required to determine how evaporites contained within evaporation ponds should be disposed of at mine closure.
Pit lakes	Stratification of pit lakes	Preliminary modelling of pit lakes has been completed, but the modelling did not include assessment of possible stratification. In the first instance, as the factors determining the frequency and severity of stratification will depend on final pit configurations (which are still being refined) and other factors (such as the closure drainage design). NML proposes to make observations on the Area 5 pit lake, which is predicted to fill within 1 year of cessation of mining, and potentially on other existing pit lakes and permanent water bodies within 150 km of the Project area as a means of evaluating stratification effects.
All domains	Closure criteria	Final closure criteria have not yet been defined in consultation with relevant stakeholders. A set of agreed completion criteria is required as the basis for demonstrating that disturbed land within the Project area is safe, non-polluting, stable and self-sustaining.

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5 STAKEHOLDER INFORMATION

Planned or unplanned mine closure may interest a range of stakeholders, depending upon when and how the Project is completed and decommissioned. As the Browns Range Project, the main stakeholders include Traditional Owners, the pastoral lease holder, the Shire of Halls Creek and the DMP. Other stakeholders include the Department of Environmental Regulation (DER), the DPaW and the DoW.

Northern Minerals has conducted regular consultation with Traditional Owners and the Shire of Halls Creek, and has provided targeted briefings to key stakeholders since 2012. To date, most consultation has focussed on the construction and operational phases of the Project, although a briefing session with regulators to discuss post-closure pit lakes was held in Perth on 11 February 2014. A further meeting was held with the Office of the EPA on 28 May, 2014. Much of the discussion at that meeting related to closure issues, including matters relating to the design and management of final pit voids. A briefing with regulators on tailings management (including closure strategies) was held on 14 February 2014.

Further consultation with stakeholders will be carried out as part of the development of the Browns Range mining proposal, which will include a more detailed closure plan.

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6 POST-MINING LAND USE AND CLOSURE OBJECTIVES

6.1 Post-closure land uses

The current uses of land within the Browns Range Project area include customary uses by Traditional Owners and pastoral uses. It is Northern Minerals' expectation that the land will revert to these uses at project completion. The post-mining land uses assumed in developing this conceptual closure plan are:

- customary uses
- cattle grazing
- ecosystem services.

It is conceivable that the land may one day support some additional use, such as tourism or primary production other than cattle grazing. The Project area is within 150 km of other existing tourism destinations, including the Purnululu National Park and the Wolfe Creek Meteorite Crater National Park (Figure 6-1). The environmental quality objectives targeted in Northern Minerals' closure strategy do not specifically target these alternative uses, but would not be incompatible with them.

6.2 Closure goals and objectives

Northern Minerals' overall goals in relation to mine closure and rehabilitation are to ensure that land disturbed by implementation of the Browns Range Project is:

- safe to both humans and wildlife
- non-polluting
- geotechnically and erosionally stable
- self-sustaining, with minimal maintenance required
- ecologically similar to the pre-mining environment, incorporating local native plant taxa and fauna habitat to the extent practicable
- visually compatible with the surrounding natural landscape
- suitable for agreed post-mining land uses.

6.3 Closure criteria

Northern Minerals will develop a set of closure criteria in consultation with key stakeholders. A provisional list of closure criteria is presented in Table 6-1.

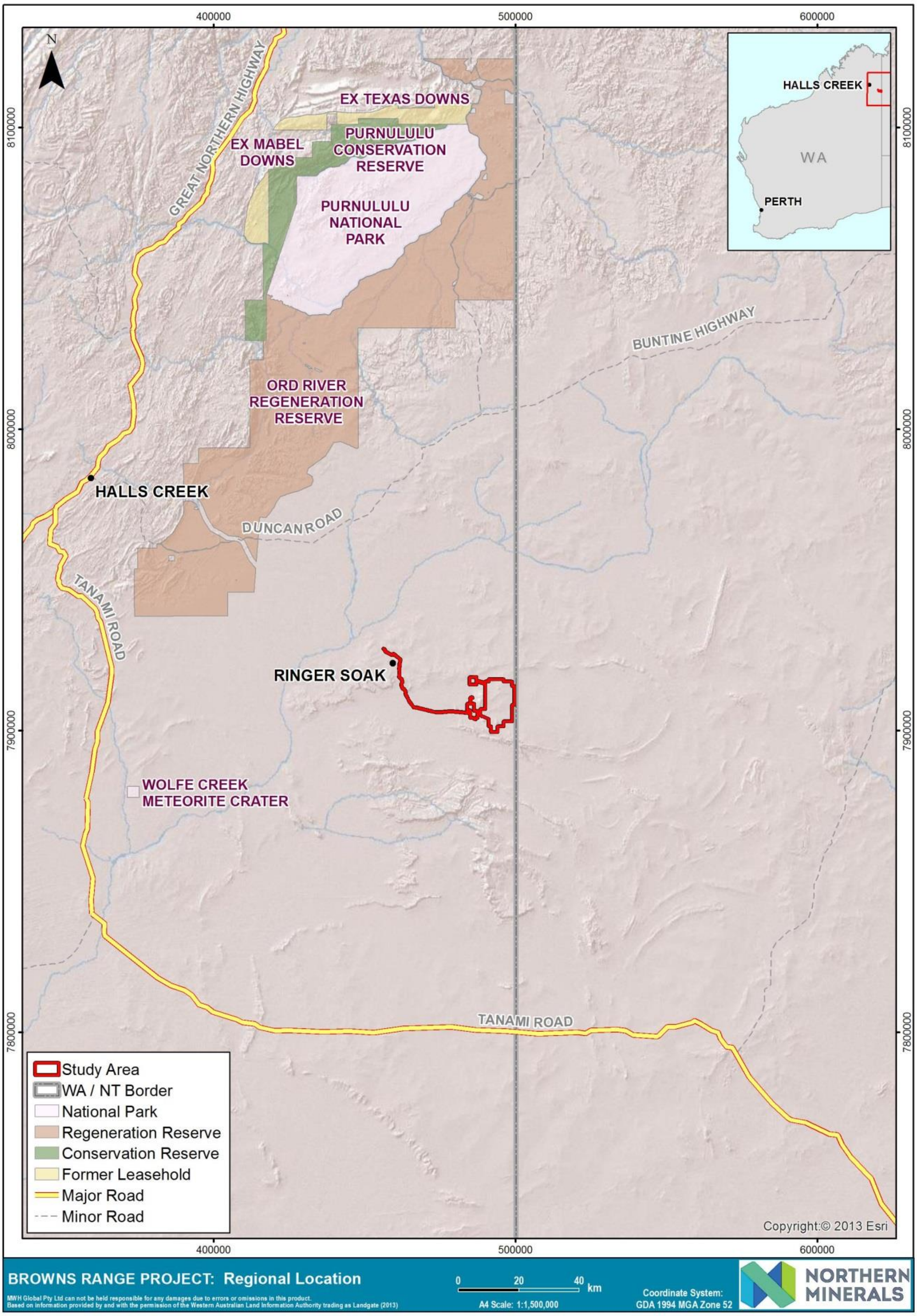

Figure 6-1: Existing conservation areas in proximity to Browns Range

Table 6-1: Rehabilitation criteria (provisional)

Objectives	Completion criteria	Measurement tools
Final landforms		
Safe, structurally & chemically stable without ongoing maintenance Landforms conform to agreed post-closure land use	Safety and abandonment bunds are in place Geotechnical stability of pit and dump slopes has an acceptable factor of safety under worst case conditions Erosion of built landforms is similar to naturally occurring colluvial slopes in the Project area	Audits of bund integrity Results of pre-closure geotechnical review Observation of erosion response of built landforms at established monitoring points
Vegetation and biodiversity		
Disturbed areas are returned to self-sustaining vegetation communities similar to naturally occurring vegetation assemblages in the Project locality	Similarity of vegetation in rehabilitation areas to pre-mining vegetation (cover, density, species diversity, weed occurrence)	Weed surveys and vegetation health assessments Comparison of vegetation density and diversity with agreed reference communities
Inland waters		
Quantity and quality of groundwater and surface water has been maintained, so that existing environmental values are protected	Groundwater monitoring indicates no significant impairment of pre-mining beneficial uses of groundwater No discernible changes in flows or water quality at Banana Springs as a result of Project activities Water quality in pit lakes does not exceed ANZECC and ARMCANZ (2000) water quality guideline values for water used for livestock	6-monthly monitoring of groundwater levels and salinity
Soil quality		
No pollution of environment (including soil, surface and groundwater) Any known contaminated sites are recorded, reported and remediated as per legislation	Soil chemical concentrations do not exceed DER environmental investigation levels or local average background concentrations, whichever is the greater Chemical and physical condition of surface soils does not impede plant growth	Pre-closure contamination survey of plant area and other locations used for fuel or chemicals storage (e.g. explosives magazine) Soil quality assessments in rehabilitation areas
Decommissioning		
Project infrastructure not required for post-closure land use has been removed and appropriately disposed of	Infrastructure removed and/or does not constrain use of the site for agreed post-closure purposes All wastes removed from site and disposed of appropriately	Site inspection/audit before final demobilisation

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7 IDENTIFICATION OF CLOSURE ISSUES

Northern Minerals has systematically considered closure issues potentially arising from implementation of the Browns Range Project through a qualitative risk assessment. The risk assessment was carried out in accordance with guidelines contained in AS/NZS ISO 3100:2009 and specifically reflected the definition of risk ('effect of uncertainty on objectives') in the current risk standard. Risk events that have the potential to occur during or following mine closure were included (for example, exposure of demolition workers to radioactive hazards; social impacts arising from loss of jobs or business opportunities as a result of planned or unplanned mine closure). Also included were risk events that are mostly associated with activities that would be carried out during the operational phase of the Project, but which have the potential to affect the attainment of closure objectives (for example, spillage of fuels or reagents; introduction or spread of weeds on mobile equipment).

Both likelihood and consequence ratings were determined on the basis of professional judgement and using information contained in technical reports used in the preparation of the Browns Range API. The 'likelihood' column in the risk assessment table represents Northern Minerals' assessment of how likely it is that a particular risk event could occur during the whole of the Project life. The 'consequence' column provides a description of the plausible worst case outcome that would result if the risk event were to occur. Detailed consequence and likelihood definitions are provided in Appendix L. A risk score was calculated as the product of the consequence rating and the likelihood rating, described qualitatively in Table 7-1.

Table 7-1: Qualitative risk scores

Risk score	Description of risk
1–4	Very low
5–11	Low
12–16	Medium
17–25	High

A summary of the risk assessment findings is provided in Table 7-2. No hazard event was classified as having 'high' inherent risk. This reflects the generally benign geochemical and radiological properties of the waste materials that will be generated by the Project, and the relatively small disturbance footprint, compared to the extent of intact vegetation communities and fauna habitat types within the Project area and wider region.

Of the 89 risk events considered, 17 (19%) were considered to have a 'medium' inherent risk. The medium inherent risk elements form the main focus of Northern Minerals' proposed rehabilitation and closure management actions. Other risk elements will also be addressed in closure design and planning, but generally can be addressed through routine operational controls and surveillance and are unlikely to require additional studies or trials.

The 17 medium risks can be grouped as follows:

- **Weed, feral animal and pathogen risks**: need to implement effective controls
- **Control of clearing**: need to implement effective systems for salvaging topsoil and ensuring all clearing is within approved areas

- **Rehabilitation practices**: need to implement progressively and conduct trials; further assessment of erodibility of wastes stored in waste landforms; planning for collection and storage of local provenance seed
- **Management of process wastes and effluents**: engineering design and subsequent monitoring to ensure effectiveness of containment systems and water management systems
- **Prevention, assessment and clean up of contamination** in ore processing areas, especially in areas used for storage of fuels, reagents and mineralised materials
- **Groundwater monitoring** to verify groundwater modelling predictions (quality and drawdown)
- **Control of occupational exposures to radiation** during site decommissioning
- **Managing social and economic impacts** of planned and unplanned closure, especially at local scale.

A number of the key closure risks lend themselves to 'Caring for Country' management initiatives. Subject to endorsement by the Traditional Owners of the land within the Project area, Northern Minerals proposes to incorporate healthy country initiatives in its operational management and mine rehabilitation approach. Additional information on key closure strategies is presented in Section 8.3.

Table 7-2: Summary of closure risk assessment for tenements M80/627, L80/76 and L80/77

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
1	Air quality: excessive dust deposition	Wheel-generated dust from haulage, earthmoving plant and other vehicular movements	Impact on vegetation	Possible	Minor	Low
2	Air quality: high ambient radon	Emissions from stockpiled materials; off-gases from ore processing; emissions from mineralised materials in wall of pit; emissions from tailings	Exceedance of air quality criteria	Unlikely	Minor	Very low
3	Air pollution: airborne radionuclides	Dust lift off from evaporation pond	Dust concentrations in environment above modelled levels	Possible	Moderate	Low
4	Radioactivity: higher than predicted public doses	Emissions of radionuclides in dust higher than predicted	Dust concentrations in local communities above modelled levels, impacting bush tucker	Rare	Moderate	Very low
5	Soil contamination	Spillage or loss of containment from bulk storages (fuel, explosives, reagents)	Reduction in land capability	Possible	Moderate	Low
6		Seepage or runoff from stockpiled materials (ore, concentrate)	Reduction in land capability	Possible	Moderate	Low
7		Spillage or loss of containment as a result of transport incident (fuels, reagents, product)	Reduction in land capability	Possible	Moderate	Low
8		Seepage, runoff or airborne dust from TSF	Reduction in land capability	Possible	Moderate	Low
9	Soil contamination	Airborne dust from mining and processing operations	Reduction in land capability	Possible	Moderate	Low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
10	Loss of topsoil: land clearing	Failure to salvage or properly store topsoil during land clearing operations	Reduction in land capability	Possible	Major	Medium
11	Soil compaction	Traffic, earthworks	Reduction in land capability	Almost certain	Minor	Low
12	Surface water quality: discharge of turbid water	Concentration of flow; excessively steep slopes; erodible materials	Increased turbidity in surface waters	Possible	Moderate	Low
13	Slope stability: erosion of built landforms, drainage lines	Concentration of flow; excessively steep slopes; erodible materials	Slope or cover failure/loss of containment, increased maintenance costs, failure to meet closure objectives	Likely	Moderate	Medium
14	Water quality: discharge of saline or other poor quality water	Seepage or runoff from WRLs	Surface/groundwater water contamination	Possible	Moderate	Low
15		Seepage or runoff from stockpiled materials (ore, concentrate)	Surface/groundwater water contamination	Possible	Moderate	Low
16		Overtopping, failure or discharge of supernatant water from TSF spillway	Surface/groundwater water contamination	Unlikely	Major	Low
17		Seepage through TSF embankment or base	Surface/groundwater water contamination	Possible	Major	Medium
18	Water quality: discharge of saline or other poor quality water	Overtopping of evaporation pond	Surface/groundwater water contamination	Possible	Major	Medium
19		Seepage through base of evaporation pond	Surface/groundwater water contamination	Possible	Major	Medium
20		Water quality in pit lakes gives rise to density-driven groundwater pollution plumes	Groundwater contamination	Rare	Moderate	Very low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
21	Water quality: loss of containment - tailings/return water	Failure of tailings pipeline or return water pipeline	Surface/groundwater water contamination	Possible	Major	Medium
22	Water quality: reagent or fuel spillage	Spillage during filling/dispensing	Surface/groundwater water contamination	Likely	Moderate	Medium
23		Spillage during transport	Surface/groundwater water contamination	Possible	Moderate	Low
24		Major loss of containment from storage vessel	Surface/groundwater water contamination	Unlikely	Moderate	Low
25	Water quality: entrainment of stored materials	Flooding/significant rain event	Surface/groundwater water contamination	Possible	Moderate	Low
26	Water quality: septic contamination	Seepage from sewage treatment facility or effluent disposal area	Surface/groundwater water contamination	Possible	Minor	Low
27		Runoff from effluent disposal area	Surface/groundwater water contamination	Possible	Moderate	Low
28	Water quality: acid mine drainage/neutral mine drainage	Release of acids metals or salts from wall rock	Groundwater contamination	Unlikely	Major	Low
29	Groundwater quality: contamination by explosives residues (nutrients/hydrocarbons)	Blasting	Groundwater contamination	Possible	Minor	Low
30	Water quality: contamination by nutrients, BOD, pathogens, hydrocarbons, salinity, other contaminants	Poor design, siting or operational practices at landfill	Groundwater contamination	Possible	Moderate	Low
31	Vegetation impacts: dust/sediment released from built landforms	Indirect effects: dust or sediment from waste landforms	Change in abundance or distribution of conservation significant species or ecosystems	Likely	Minor	Low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
32	Altered hydrology: vegetation impacts	Construction of linear infrastructure results in changed frequency, magnitude, extent or duration of flooding	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
33		Construction of engineered landforms results in changed frequency, magnitude, extent or duration of flooding	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
34		Development of mine pits results in changed frequency, magnitude, extent or duration of flooding	Change in abundance or distribution of conservation significant species or ecosystems	Unlikely	Moderate	Low
35		Construction of processing plant results in changed frequency, magnitude, extent or duration of flooding	Change in abundance or distribution of conservation significant species or ecosystems	Unlikely	Moderate	Low
36		Construction of support infrastructure (village, airstrip, etc.) results in changed frequency, magnitude, extent or duration of flooding	Change in abundance or distribution of conservation significant species or ecosystems	Unlikely	Moderate	Low
37		Modified drainage results in reduction of water available to water-dependent species or communities	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
38	Vegetation/habitat impacts: unauthorised vegetation clearing	Poor control of clearing results in clearing beyond approved footprint or in a location not approved for clearing	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Major	Medium

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
39	Vegetation impacts: weed introduction/spread	Introduction or spread of weeds on mobile plant	Change in abundance or distribution of conservation significant species or ecosystems	Likely	Major	Medium
40		Introduction or spread of weeds in imported materials (borrow)	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Major	Medium
41	Vegetation impacts: fire	Modification of fire regimes as a result of Project activities (e.g. hot work)	Change in abundance or distribution of conservation significant species or ecosystems	Rare	Moderate	Very low
42	Vegetation impacts: herbivory	Establishment of permanent water bodies attracts herbivores in localised areas	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
43	Vegetation impacts: soil contamination	Increased salinity or altered soil pH, runoff from haul roads	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
44		Increased salinity or altered soil pH, runoff from processing plant	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
45		Altered soil quality, seepage or runoff from mineralised stockpiles	Change in abundance or distribution of conservation significant species or ecosystems	Unlikely	Minor	Low
46		Altered soil quality, seepage or runoff from waste landforms	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
47		Altered soil quality, seepage or runoff from evaporation pond	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
48	Fauna impacts: fauna-traffic interaction	Fauna killed by mine traffic	Change in abundance or distribution of conservation significant species	Almost certain	Insignificant	Low
49	Fauna impacts: entrapment	Fauna trapped in uncapped boreholes	Change in abundance or distribution of conservation significant species	Possible	Minor	Low
50		Fauna trapped in water storages or TSF	Change in abundance or distribution of conservation significant species	Possible	Insignificant	Very low
51		Fauna trapped in mine pit	Change in abundance or distribution of conservation significant species	Possible	Insignificant	Very low
52	Fauna impacts: toxicity	Ingestion of spilled reagents or fuel or of water contaminated by these	Change in abundance or distribution of conservation significant species	Unlikely	Insignificant	Very low
53		Ingestion of water contaminated by metals or radionuclides	Change in abundance or distribution of conservation significant species	Possible	Minor	Low
54		Ingestion of vegetation or soil contaminated by metals or radionuclides	Change in abundance or distribution of conservation significant species	Unlikely	Minor	Very low
55		Water quality in pit lakes becomes toxic to fauna	Change in abundance or distribution of conservation significant species	Unlikely	Moderate	Low
56	Altered hydrology: fauna impacts	Formation of permanent pit lakes results in attraction of fauna, resulting in increased predation	Change in abundance or distribution of conservation significant species or ecosystems	Possible	Moderate	Low
57	Fauna impacts: habitat loss resulting from planned vegetation clearing	Reduction in available habitat as a result of approved clearing	Change in abundance or distribution of conservation significant species	Almost certain	Minor	Low
58	Fauna impacts: habitat loss resulting from unauthorised vegetation clearing	Reduction in available habitat as a result of accidental over clearing or clearing in wrong location	Change in abundance or distribution of conservation significant species	Unlikely	Major	Low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
59	Habitat impacts: fire impacts	Reduction in available habitat as a result of fires initiated by project activities	Change in abundance or distribution of conservation significant species	Unlikely	Moderate	Low
60	Fauna injury or death impacts: fire impacts	Fauna death or injury arising from fires initiated by Project activities	Change in abundance or distribution of conservation significant species	Unlikely	Moderate	Low
61	Authorised habitat clearing leads to increased predation, altered behaviours, reduced population viability	Habitat fragmentation as a result of approved disturbance	Change in abundance or distribution of conservation significant species	Likely	Minor	Low
62	Unauthorised habitat clearing leads to increased predation, altered behaviours, reduced population viability	Habitat fragmentation as a result of accidental over clearing or clearing in wrong location	Change in abundance or distribution of conservation significant species	Possible	Moderate	Low
63	Noise/vibration: Disruption to breeding, foraging or other behaviours	Noise/vibration from Project	Change in abundance or distribution of conservation significant species	Almost certain	Insignificant	Low
64	Light: Increased predation, disruption to breeding, foraging or other behaviours	Light emissions from Project	Change in abundance or distribution of conservation significant species	Almost certain	Insignificant	Low
65	Non-process wastes: Increased predation	Feral animals attracted to landfill or waste bins	Conservation significant fauna, biodiversity loss (feral animals)	Possible	Major	Medium
66	Introduced predators, competitors	Introduction of pest animals on mobile plant, equipment or materials imported to site	Conservation significant fauna, biodiversity loss (feral animals)	Possible	Major	Medium

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
67	Permanent water storage: fauna impacts	Planned development and use of water storages	Behavioural change: Fauna impacts: migratory birds are attracted to water storages (TSF, evaporation pond, other process water storages; pit voids)	Possible	Moderate	Low
68	Soil quality: reduction in viable soil seedbank	Poor soil storage practices	Poor rehabilitation outcome (revegetation)	Possible	Major	Medium
69	Groundwater hydrology: reduction in groundwater level	Mine dewatering	Reduction in habitat for stygal communities	Almost certain	Moderate	Medium
70		Mine dewatering	Impact on health of water-dependent vegetation	Possible	Minor	Low
71		Mine dewatering	Impact on culturally significant feature	Rare	Major	Very low
72		Abstraction from borefield	Reduction in habitat for stygal communities	Possible	Moderate	Low
73		Abstraction from borefield	Impact on health of water-dependent vegetation	Unlikely	Minor	Very low
74	Altered flow at Banana Springs	Abstraction from borefield	Impact on culturally significant feature	Unlikely	Major	Low
75	Mine rehabilitation: vegetation fails to emerge	Insufficient seed bank storage in topsoil	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
76		Poor handling/storing of viable topsoil, mixing of good/poor quality topsoil	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
77		Soil crusting, compaction	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
78		Drought	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
79	Mine rehabilitation: regrowth fails to survive	Poor handling/storing of viable topsoil, mixing of good/poor quality topsoil	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
80		Loss of key soil properties (nutrients, soil water etc.)	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
81		Drought	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
82		Grazing by herbivores	Poor rehabilitation outcome (revegetation)	Possible	Moderate	Low
83	Mine rehabilitation: unsatisfactory vegetation abundance/diversity	Insufficient seed collection/distribution during rehabilitation	Restored site not returned to previous levels of habitat complexity/health	Likely	Moderate	Medium
84	Fauna impacts: animal interaction with mine pit voids	Improper/inadequate bunding or delineating of mine pit voids	Accidental injury/death to fauna	Possible	Minor	Low
85	Safety: human interaction with mine pit voids	Improper/inadequate bunding or delineating of mine pit voids	Accidental injury/death to humans	Unlikely	Extreme	Low
86	Stability: instability of pit wall	Inappropriate batter angles; inadequate water control	Wall collapse	Unlikely	Major	Low
87	Safety: demolition workers exposed to radiation levels above the level predicted	Unforseen build up of radionculides in processing circuit	Areas of processing plant have higher gamma radiation levels or process materials have higher radionuclide concentrations	Possible	Major	Medium

ID	Risk event	Initiating event	Outcome	Inherent Risk		
				Likelihood	Consequence	Risk rating
88	Social impact: mine closure	Planned or unplanned mine closure results in job losses, other reduced funding	Sudden downturn in local economy	Likely	Moderate	Medium
89	Social impact: cultural change	Availability of mine-related business or employment	Focus on mine-related activities results in loss of traditional knowledge, connection to culture	Possible	Moderate	Low

8 CLOSURE IMPLEMENTATION

The programme for mine closure and rehabilitation described in this conceptual closure plan will be developed around a framework comprising six closure domains:

1. Stockpiles and built landforms (waste rock landforms; tailings storage facility; run of mine (ROM) pad; mineralised waste/low grade ore stockpiles; topsoil stockpiles)
2. Mine pits and underground workings
3. Water storages and drainage infrastructure
4. Industrial plant areas, including bulk fuel and reagent storage areas
5. Access/haul roads and other linear infrastructure (power transmission, telecommunications, pipelines
6. Support infrastructure (accommodation village, airstrip, landfill, clay pit, gravel pit, borefield).

Table 8-1 provides a summary of rehabilitation and closure treatments for each domain.

Table 8-1: Summary of rehabilitation treatments

Description	General closure concept
1. Stockpiles and built landforms	
Wolverine waste rock dump	Rocky ridge, with armoured lower slopes
Area 5 waste rock dump	Rocky ridge, with armoured lower slopes
TSF and integrated waste land form	Rocky ridge surrounding central store and release cover over tailings cells; rocky drainage line to safely convey large flow events to Gambit pit(s)
ROM pad	Recontour, topsoil, revegetate
Mineralised waste stockpiles	Remove, if necessary dispose of mineralised wastes underground
Topsoil stockpiles	Use for mine rehabilitation
2. Mine pits and underground workings	
Wolverine pit and underground	Flood and seal underground; permanent pit lake
Gambit West pit and underground	
Gambit pits	Permanent pit lake or backfill
Area 5 pit	Permanent pit lake
3. Water storages and drainage infrastructure	
Evaporation pond	Backfill, recontour, cap if required; revegetate; consider disposal of evaporite to TSF or underground workings
Process facility run off pond	Empty, decommission, backfill, recontour, revegetate
Raw water pond	
Water storage dam	

Description	General closure concept
4. Industrial plant areas	
Beneficiation plant	Decommission/remove above ground structures; remove footings to 1 m nominal depth, assess contamination and clean up if required, recontour, topsoil, revegetate.
Hydrometallurgical plant	
Bulk fuel store	
Power station	
Offices, laboratory, ablutions	
Laydown areas	
Workshops/maintenance areas	
5. Roads and other linear infrastructure	
Haul roads	Recontour, topsoil, rip, revegetate
Access roads	Retain, subject to discussions with Shire and other stakeholders
Power transmission	Remove above ground structures; abandon buried structures in situ, recontour, topsoil, rip, revegetate
Water pipelines	Remove above ground structures; plug and abandon buried structures in situ, recontour, topsoil, rip, revegetate
6. Support infrastructure	
Accommodation village	Decommission and remove, recontour, topsoil, rip, revegetate
Sewage treatment infrastructure	Decommission and remove, recontour, topsoil, rip, revegetate
Landfill	Construct final cover, topsoil, revegetate
Water supply borefield	Consult with stakeholders, possible retention of production bores
Airstrip	Consult with stakeholders, possible retention of airstrip
Telecommunications infrastructure	Decommission and remove, recontour, topsoil, rip, revegetate
Gravel pit	Recontour, topsoil and revegetate or use as landfill; cap, contour, topsoil, revegetate

8.1 Conceptual closure design concepts

8.1.1 Pits

As at the date of preparing this conceptual closure plan, all deposits remain ‘open’ at depth, meaning that the extent of mineralisation below the current planned open pits and underground mine designs is unknown and that further exploration at depth may result in underground mining or deepening of the current proposed pits. Accordingly, it is Northern Minerals preference not to propose backfilling of pits at the completion of the 10 year Browns Range mining operation. Moreover, the amount of waste rock required for construction of the tailings containment cells south of the Gambit, Gambit Central and Gambit West pits will consume virtually all of the waste rock generated by mining of those deposits, so that there would not be any local surplus for backfilling of the pits. It may be feasible to rehandle a proportion of waste rock to backfill the

Gambit Central pit, which is the smallest of the planned open pits and the pit which has been predicted to have the poorest long term water quality.

Baseline hydrogeological assessments for the Browns Range Project have identified that following closure, permanent pit lakes are likely to form in each of the mine pits (Klohn Crippen Berger, 2014). Preliminary modelling has shown that the pit lakes will predominantly operate as sinks, rather than as flow-through systems. Once a quasi-steady state water elevation has been achieved, the predicted average level of water in the pit lakes is expected to stabilise at approximately 1 m below the pre-mining water level at Area 5 and up to 95 m below pre-mining levels at Gambit West. It is unlikely that groundwater levels in the pit will ever fully recover to pre-mining levels, because of the high evaporative regime in the Project area. Seasonally, the levels of the pit lakes will vary by between 1 m (Area 5) and 5m (Gambit West).

As part of its detailed closure design, Northern Minerals proposes to investigate the possible benefits of directing a proportion of waste landform runoff to the final pit voids. On the basis of studies completed to date, a design which allows periodic inflows of fresh runoff to the mine pits may help maintain water quality in the pit voids. This work will be carried out as part of detailed design.

The development of final pit lakes could result in fauna being attracted to the area, which in turn could create pressures on local vegetation (through increase herbivory) or on local fauna (through increased predation and/or competition). This is not an effect that can be readily addressed in the short term. A 'Caring for Country' management approach involving Traditional Owners to help manage fauna has shown promise in other remote areas and may be applicable to the Browns Range area. This is one aspect of mine rehabilitation and closure that will be discussed with stakeholders as part of the further development of closure strategies for Browns Range.

At closure, access to pits will be prevented by ensuring that an adequate perimeter bund is in place. A pre-closure safety audit will be conducted to identify any significant geotechnical risks requiring modification of pit walls or surroundings to ensure that the pit can be safely abandoned.

8.1.2 Wolverine and Area 5 waste rock landforms

The Wolverine and Area 5 waste rock landforms will be constructed as freestanding landforms, with a maximum height of approximately 15 m. The landform configurations will be designed to be erosionally and geotechnically stable and to blend with the surrounding natural terrain.

8.1.3 Tailings storage facility, incorporating Gambit and Gambit West waste rock landform – Integrated Waste Landform (IWL)

At the end of the operation of the tailings storage facility, the downstream faces of the tailings storage facility perimeter embankment will have a maximum slope of 3H:1V (18°). The adopted downstream profile will be geotechnically stable under both normal and seismic loading conditions, will provide a stable drainage system and will allow for re-vegetation.

Depending upon the results of further pit lake modelling, it is likely that the final surface of the IWL will be designed to allow periodic runoff of fresh rainwater towards the Gambit West pit. It is envisaged that the cover over the tailings storage cells will comprise a store and release cover, underlain by a capillary break, if required. Preliminary modelling of a range of possible cover systems (Appendix K) have shown that the climate in the Browns Range area and the inherently low tailings permeability mean that there is little risk of seepage of meteoric water (rain) into or through the tailings mass. There is a modest risk of upward migration of salts from the tailings into the store and release cover. Modelling to date has shown that even a relatively thin cover system (0.5 m of water storage, plus 0.15 m of topsoil) should provide adequate storage of incident rain. This quantity of material is readily available from non-mineralised surficial alluvial material stripped off as part of pre-mining activities. Adequate space has been allowed in the proposed disturbance footprint for separate stripping and storage of topsoil and other overburden required for rehabilitation of the integrated waste landform.

The proposed capping configuration will be reviewed during the operational phase of the Project, to take into account the in situ tailings characteristics and available materials on site.

The nominal design of the final cover is as follows:

- A base layer is placed to facilitate access to the surface. For the bulk of the tailings surface, it is anticipated that when fully dried the tailings will have sufficient strength to support equipment over this cushion layer. A nominal allowance of 500 mm of clayey sand material has been assumed.
- A capillary break layer of coarse gravel/rockfill material would block migration of any salts from the tailings into the upper layer of the cover.
- A store and release layer; based on the low rainfall and high evaporation a relatively thin store and release layer will be required. Thus an allowance of 500–1000 mm is considered suitable. Suitable mine waste will be selected which is both erosion resistant and provides suitable storage characteristics.
- A growth medium surface layer. The upper 150 mm would be lightly ripped topsoil and non-reactive material reclaimed from stockpiles to form a rock mulch and promote vegetation growth.

Additional information and drawings to illustrate the tailings cover system are provided in the Preliminary Tailings Design Report (Appendix J).

8.1.4 Water storage and distribution

Water storage and distribution infrastructure would be decommissioned at Project completion. It is not proposed to backfill the production bores. The well heads will be secured to prevent vandalism or contamination of the bores, and the bores will be abandoned in situ.

8.1.5 Former ore processing area, chemical storage areas, fuel storage and dispensing

Under the *Contaminated Sites Act 2003*, a site is considered to be contaminated if it has a substance present at above background concentrations and presents, or has the potential to present, a risk of harm to human health, the environment or any environmental value.

The potential exists for contamination to be present from previous mining operations at the Browns Range site due to the handling and storage of hydrocarbons and chemicals. A pre-closure survey of areas used for storage or dispensing of fuels and chemicals would be carried out in accordance with relevant DER guidelines. Any contamination inconsistent with post-closure land uses would be cleaned up to meet environmental investigation guideline values (or other appropriate standards as agreed with stakeholders).

8.1.6 Camp and airstrip

At cessation of Northern Minerals' operations at Browns Range, all accommodation facilities and support infrastructure (sewage treatment facilities, for example) will be removed and sold or disposed of appropriately. It is possible that the airstrip may be retained; however, this would be subject to consultation with stakeholders and with the land manager.

8.2 Revegetation

Northern Minerals will seek to establish self-sustaining vegetation assemblages similar to pre-mining vegetation. Local provenance propagules will be used in mine revegetation. Necessarily, the distribution of vegetation types will differ to the pre-mining vegetation distribution as the substrate conditions and soil-water relations of post-mining landforms will not be the same as in the pre-mining environment. Table 8-2 provides an initial concept of the vegetation assemblages that would be used as the basis for closure planning.

Table 8-2: Analog vegetation associations for mine rehabilitation

Analog vegetation association	Domain	Typical vegetation
VA 4: Perched damplands. *Themeda avenacea, Aristida holathera and Acrachne racemosa (Eriachne obtusa)* closed tussock grassland	Backfilled water storages, possibly including evaporation pond and TSF cells	
VA 3: Closed tussock grassland in drainage basins amongst rocky hills. *Chrysopogon fallax (Themeda avenacea)*	Integrated waste landform cover (above tailings storage cells)	
VA 10: *Eucalyptus chlorophylla* undulating plains with *Acacia lysiphloia* scrub. *Eucalyptus chlorophylla* scattered low trees over *Acacia lysiphloia* tall open scrub over *Aristida holathera* and *Eriachne obtusa* open tussock grassland and *Triodia epactia* very open hummock grassland	Haul roads, lay down areas, base of Wolverine waste landform	

Analog vegetation association	Domain	Typical vegetation
VA 6: *Eucalyptus brevifolia* plains. Scattered low trees to low open woodland over a variable mid-storey (when present) of either *Acacia sericophylla* or *A. lysiphloia* scattered tall shrubs to tall open shrubland over *Acacia adoxa* var. *adoxa* and *A. hilliana* low shrubland over either *Triodia epactia (T. wiseana)* hummock grassland or *Themeda avenacea* tussock grassland.	Base of Area 5 waste landform; gravel borrow pit	
VA 12: *Eucalyptus flavescens* broad drainage. *Corymbia flavescens* scattered low trees to low open woodland over combinations of *Hakea macrocarpa, H. arborescens, Acacia sericophylla* or *Dolichandrone heterophylla* tall open to tall shrubland over *Aristida holathera, Eragrostis eriopoda, Eulalia aurea, Chrysopogon fallax, Cymbopogon obtectus, Themeda avenacea* and *T. triandra* tussock grassland	Airstrip, accommodation village	
VA 1: Eucalyptus brevifolia on rocky low hills. Scattered low trees with occasional *Corymbia pachycarpa, C. aspera* or *Eucalyptus odontocarpa* over scattered shrubs to a low open shrubland (*Acacia colei, A. gonoclada, A. hilliana, A. lysiphloia, A. monticola, A. retivenea* subsp. *retivenea* and *Grevillea wickhamii*) over either *Scaevola browniana*, *Acacia adoxa* var. *adoxa* or *A. orthocarpa* scattered low shrubs over *Triodia schinzii, T. wiseana, T. pungens* and *T. basedowii* hummock grassland and variable densities	Sides and top of Wolverine and Area 5 waste landforms	

Analog vegetation association	Domain	Typical vegetation
VA 16:*Triodia basedowii* hummock grassland	IWL embankments	

8.3 Key strategies

This section presents a summary of preliminary closure implementation strategies. A closure task register will be provided in the updated closure plan submitted as part of the Browns Range mining proposal. The proposed post-closure land uses and agreed rehabilitation outcomes for the Browns Range Project have led Northern Minerals to adopt the following key closure and rehabilitation strategies:

- During construction and operations, control disturbance through a well-defined permitting system for ground disturbance
- Progressively rehabilitate waste landforms and other disturbance (such as borrow pits)
- Implement stringent weed hygiene practices
- Consult with Traditional Owners about the suitability of implementing a ‘Caring for Country’ approach to the long-term management of pit lakes and associated biodiversity issues.

8.4 Management accountabilities

Management accountabilities for mine closure and rehabilitation are summarised in Table 8-3.

Table 8-3: Mine closure and rehabilitation accountabilities

Role	Responsibility
Northern Minerals Managing Director	Promotes a high level of environmental commitment through visible leadership and Project direction
	Provides adequate resources and supports the establishment, implementation, maintenance and ongoing improvement of the exploration management system
	Manages emergency response situations
Mine Manager	Accountable to the Managing Director
	Manages and plans operational activities in a manner consistent with Northern Minerals' environmental policy, statutory requirements and regulatory approvals
	Manages work area personnel and contractors
	Responsible for site safety and environmental performance.
	Receives and forwards external communications to the HSE Manager
	Provides emergency assistance
	Addresses non-conformances and corrective or preventative actions as requested
HSE Manager	Accountable to the Mine Manager
	Ensures projects are adequately resourced to fulfil environmental requirements
	Oversees environmental performance and compliance
	Ensures processes are in place to meet legal and other requirements including the implementation of the exploration management system
	Undertakes management review of the environmental management system, including setting environmental objectives, targets and performance indicators
	Responsible for the environmental performance of Northern Minerals projects
	Communicates relevant environmental issues to personnel, including contractors
	Resolves issues pertaining to public complaints and legal non-conformances
	Responds to external communications
	Schedules periodic monitoring and compliance activities

8.5 Investigations and monitoring

A preliminary gap analysis conducted by Northern Minerals has identified some information gaps that must be addressed in order to reduce uncertainty about how to achieve closure objectives (thereby reducing risk). The following information gaps will be addressed through targeted investigations and monitoring:

- Further water balance studies will be required as part of detailed design of the tailings storage facility cover system and post-mining drainage.
- Additional physical characterisation of waste rock will be required to establish appropriate waste landform slope configurations.
- Revegetation trials will be required to evaluate the feasibility of establishing target analogue vegetation assemblages identified in this conceptual closure plan.

- Further groundwater quality testing and modelling will be required to update the preliminary pit lake geochemical assessment.

The implementation schedule for key components of the research will be provided in the updated closure plan submitted as part of the Browns Range mining proposal.

8.6 Planned closure sequence

The general sequence of mine rehabilitation and closure activities for Northern Minerals' operations at Browns Range will be:

- progressive rehabilitation of land disturbance in accordance with DMP and other licence requirements
- submit final closure plan to DMP 12 months prior to cessation of operations
- remove any residual structures or pavements and other fixed or demountable structures no longer required for operations
- conduct contamination survey and clean up contaminated areas as required
- recontour (if required), rip, topsoil and seed former haul roads, laydown areas, water storages, plant and waste landforms
- review access requirements: decommission roads no longer required
- conduct a safety audit of pit bunds, above-ground tailings storage facility and existing waste landforms
- consult regulators and other stakeholders concerning post-mining monitoring and maintenance.

8.7 Post-closure monitoring and maintenance

A post-closure monitoring and maintenance programme will be presented in the updated closure plan supplied with the Browns Range mining proposal. In addition to post-closure tailings management stipulated under the Australian National Committee on Large Dams (ANCOLD) guidelines (2012), as a minimum the post-closure programme during the first five years after completion of mining is likely to include the following:

- annual observations of weed occurrence
- six monthly monitoring of selected groundwater monitoring bores near the tailings storage facility
- six monthly testing of pit water quality
- two-yearly observations of vegetation condition and erosion at established photopoints.

8.8 Unexpected or temporary closure

In the event of a temporary suspension of exploration activities, the *Mines Safety and Inspection Regulations 1995* will be used to guide development of a suspension plan. The DMP will be notified of the nature of the suspension and measures in place that will limit impact to the environment and ensure health and safety requirements are met. The suspension plan will not consist of a full rehabilitation and closure strategy, but will incorporate interim measures. As a minimum, the suspension plan would include:

- provision of adequate signage, physical barriers and security to ensure no unauthorized access to the mine site
- removal of domestic and industrial wastes
- removal of chemicals, hydrocarbons and other hazardous substances
- provision of adequate on-site facilities for any staff remaining at the site (for example, a caretaker)

- revision of statutory reporting arrangements, in consultation with regulators.

In the event of sudden (unplanned) permanent cessation of Northern Minerals' operations, a final closure report will be immediately prepared, using the framework provided in the updated Closure and Rehabilitation Plan submitted as part of the Browns Range mining proposal. A review of the closure cost liability will be carried out and funds for closure will be sourced from Northern Minerals closure provision accounts. If necessary, a post-closure monitoring schedule will be developed for use following cessation of operations (in consultation with DER, DMP and other stakeholders).

9 FINANCIAL PROVISION FOR CLOSURE

The Browns Range closure cost provisioning will take into account the following cost elements:

- reshaping and revegetation of the waste landforms
- construction of a final cover over tailings storage cells
- drainage works and seepage management at the tailings storage facility and other waste landforms
- maintenance (reseeding and erosion control works) of waste landforms
- rehabilitation (ripping, topsoiling, revegetation) of disturbed areas around mine pits
- plugging of underground portals and other access points to underground workings
- removal of the ROM pad
- backfilling and rehabilitation of water storage ponds
- decommissioning and removal of tankage, buildings and other facilities within the processing plant area
- contamination assessment and rehabilitation of the former plant area
- removal of the accommodation camp and rehabilitation of associated disturbance
- removal and/or rehabilitation of the airstrip
- removal or decommissioning of existing groundwater production bores
- rehabilitation of access/haul roads
- maintenance/upgrading of pit safety bunds
- post-closure monitoring, maintenance (including weed control) and compliance reporting for up to 5 years following cessation of Northern Minerals' operations.

The following items are excluded from the estimated closure costs:

- removal of existing access road from Ringer Soak
- backfilling of mine pits.

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10 GLOSSARY, ACRONYMS AND ABBREVIATIONS

Term	Definition
Care and maintenance	Period following temporary cessation of operations when infrastructure remains largely intact and the site continues to be managed.
Closure	The point at which operations cease and plant and infrastructure are removed. It includes decommissioning, rehabilitation and monitoring and typically culminates in tenement relinquishment.
Closure planning	A process that extends over the mine life cycle and continues until final tenement relinquishment.
Completion criteria	Qualitative or quantitative standards of performance used to measure the success or otherwise of rehabilitation actions required for closure of a site.
Decommissioning	The process that begins near or at the cessation of mineral production and ends with the removal of all unwanted infrastructure and services.
Disturbance	Any process resulting in substantial damage to the biotic and abiotic properties of ecosystems. Disturbance results in reduction in biodiversity and alteration to soils, landforms and hydrology.
Domain	A group of landform(s) or infrastructure that has similar rehabilitation and closure requirements and objectives.
Environment	Means living things, their physical, biological and social surroundings, and interactions between all of these. The social component of the environment includes the aesthetic, cultural, economic and social aspects that may directly affect or be affected by changes to the physical or biological environment.
Facultative phreatophyte	A species that may be groundwater dependent in some environments, but not in others.
In situ	In the natural or original position or place
Keystone species	Species with a major role supporting other species by providing food, shelter or habitat. These often are canopy of dominant species in ecosystems.
Local provenance	Material used to propagate plants (most often seed) collected from a narrowly defined geographic area, which closely matches the plant community types and physical environment where it is to be used (see provenance).
Rehabilitation	In restoration ecology rehabilitation (reclamation) is normally defined as a process where disturbed land is returned to a stable, productive and self-sustaining condition, taking future land use into account. This process differs from the narrower definition of restoration by not aspiring to fully replace all of the original components of an ecosystem.
Remediation	To clean up or manage the effects of contamination of soil or water.
Stakeholder	A person, group or organisation with the potential to affect or be affected by the process or outcome of mine closure.

Abbreviation	Description
AHD	Australian Height Datum
ANC	Acid neutralising capacity
ANCOLD	Australian National Committee on Large Dams
ANSTO	Australian Nuclear Science and Technology Organisation
ANZECC	Australian and New Zealand Environment Conservation Council
ANZMEC	Australian and New Zealand Minerals and Energy Council
API	Assessment on Proponent Information
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BOD	Biological oxygen demand
Bq/g	Becquerels per gram, a measure of radioactivity
DEC	Department of Environment and Conservation
DER	Department of Environmental Regulation
DAA	Department of Aboriginal Affairs
DMP	Department of Mines and Petroleum
DoW	Department of Water
DPaW	Department of Parks and Wildlife
DRF	Declared Rare Flora
EMS	Environmental Management System
EC	Electrical conductivity
EPA	Environmental Protection Authority
EP Act	*Environmental Protection Act 1986*
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FCTs	Floristic community types
GAI	Global Abundance Index
GDA	Geocentric Datum of Australia
GDE	Groundwater dependent ecosystem
H:V	Horizontal to vertical ratio
HDPE	High density polyethylene
HSE	Health, Safety and Environment
IBRA	Interim Biogeographic Regionalism for Australia
IPA	Indigenous Protected Area
IWL	Integrated waste landform
LC	Low capacity (to produce acid)
LOD	Limit of detection
LOM	Life of Mine
MCA	Minerals Council of Australia MCA
MCP	Mine Closure Plan
MPA	Maximum potential acidity
Mt	Million tonnes
µm	Micrometres (or microns)
NAF	Non-acid forming
NAG	Net acid generation
NAPP	Net acid producing potential

Abbreviation	Description
NML	Northern Minerals Limited
NORM	Naturally occurring radioactive material
NT	Northern Territory
OEPA	Office of the Environmental Protection Authority
PAF	Potentially acid forming
PEC	Priority Ecological Community
pH	Degree of alkalinity/acidity
RIWI Act	*Rights in Water and Irrigation Act 1914*
ROM	Run-of-mine
TDS	Total dissolved solids
TEC	Threatened Ecological Community
SRE	Short-range endemic
TSF	Tailings storage facility
TSP	Total Suspended Particulates
TSS	Total Suspended Solids
UC	Uncertain acid potential
WA	Western Australia
WRL	Waste rock landform

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11 REFERENCES

Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC and ARMCANZ) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*.

Australian and New Zealand Minerals and Energy Council (ANZMEC) and Minerals Council of Australia (MCA) (2000). *Strategic Framework for Mine Closure*. Canberra.

Australian National Committee on Large Dams Incorporated (ANCOLD) (2012). *Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure.*

Bowen HJM (1979). *Environmental Chemistry of the Elements*, Academic Press, New York

Chamber of Minerals and Energy WA Inc. (2000). *Mine Closure Guideline for Mineral Operations in Western Australia*.

Department of Environment and Conservation (DEC) (1986). *Policy No. 10 Rehabilitation of Disturbed Land.*

Department of Environment and Conservation (DEC) (2009), *Resource Condition Report for Significant Western Australian Wetland: Lake Gregory*. Prepared for Resource Condition Monitoring Project, Department of Environment and Conservation. Perth, Australia.

Department of Mines and Petroleum (DMP) (1998). *Guidelines for Mineral Exploration and Mining within Conservation Reserves and other Environmentally Sensitive Lands in Western Australia.*

DMP (2001). *Environmental Notes on Mining Waste Rock Dumps*, Environment Branch, Perth.

DMP (2006). *Environmental Notes on Mining Acid Rock Drainage*, Perth.

DMP (2010). *Managing naturally occurring radioactive material (NORM) in mining and mineral processing- guideline, NORM-6, Reporting Requirements.* Resources Safety, Government of Western Australia.

DMP and EPA (2011). *Guidelines for Preparing Mine Closure Plans*. June 2011.

Department of Industry Tourism and Resources (DITR) (2006a). *Mine Closure and Completion, Leading Practice Sustainable Development Program for the Mining Industry*, Commonwealth of Australia 2006.

DITR (2006b). *Mine Rehabilitation, Leading Practice Sustainable Development Program for the Mining Industry*, Commonwealth of Australia 2006.

Ecology Matters Pty Ltd, Bamford Consulting Ecologists and Dalcon Environmental (2014). Review of Impact of Pit Lakes upon Fauna – Browns Range Project, unpublished report prepared for Northern Minerals Limited, June 2014.

Environmental Protection Authority (EPA) (2003) *Guidance Statement No. 51: Guidance for the Assessment of Environmental Factors: Terrestrial flora and Vegetation Surveys for Environmental Impact Assessment in Western Australia*.

EPA (2006). *Guidance for the Assessment of Environmental Factors, EPA Guidance Statement No. 6 – Rehabilitation of Terrestrial Ecosystems* (GS6).

Golder Associates Pty Ltd (2014). Browns Range Brief Ecotoxicological Assessment on Pit Lake Water, unpublished report prepared for Northern Minerals Limited, June 2014.

International Council on Mining & Metals (2008). *Planning for Integrated Mine Closure: Toolkit*.

Johnson SL and Wright AH (2003). *Mine void water resource issues in Western Australia*, Water and Rivers Commission Resource Science Division, Hydrogeological Record Series, Report HG 9, 93p.

Klohn Crippen Berger (2014a). Browns Range Project: TSF Cover Assessment, unpublished letter report to Northern Minerals Limited, June 2014.

Klohn Crippen Berger (2014b). Browns Range Rare Earth Elements (REE) Project: Pit Lake Water Quality Assessment, unpublished report to Northern Minerals Limited, June 2014.

Landloch Pty Ltd (2014) Memorandum: results of runoff sediment study, Browns Range Rare Earth Project, unpublished memo to Northern Minerals Limited, June 2014.

Northern Minerals Limited (2014). *Browns Range Rare Earths Project – Assessment on Proponent Information*.

Office of the Environmental Protection Authority (OEPA) (2013). EPA Prepared Scoping Guideline – Browns Range Project, EPA Assessment No. 1973, 26 July 2013.

Payne, A. and Schoknecht, N. (2011) Land Systems of the Kimberley Region, Western Australia:

Technical Bulletin No. 98. Department of Agriculture and Food (WA), Perth, W.A

SRK Consulting (2013). Physical Properties of Browns Range Waste Rock, unpublished report prepared for Northern Minerals Limited, December 2013.

Standards Australia (2009). AS/NZS ISO 31000:2009 Risk management – principles and guidelines.

Timms, B V (2001). Large freshwater lakes in arid Australia: a review of their limnology and threats to their future, Lakes & Reservoirs: Research and Management 2001 6: 183–196.

Appendix A: Baseline Soil and Landform Studies

Appendix B: Geochemical Characterisation of Waste Rock

Appendix C: Physical Properties of Waste Rock

Appendix D: Preliminary Erosion Assessment

Appendix E: Geochemical Characterisation of Tailings

Appendix F: Radiological Characterisation of Tailings

Appendix G: Preliminary Pit Lake Assessment

Appendix H: Ecotoxicological Assessment of Pit Lakes

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Appendix I: Review of Pit Lake Impacts on Fauna

Appendix J: Preliminary Tailings Design Report

Appendix K: Preliminary TSF Cover System Modelling

Appendix L: Environmental Consequence Definitions for Closure Risk