



# Works Approval

## *Environmental Protection Act 1986, Part V*

**Works Approval Holder:** Northern Minerals Limited

**Works Approval Number:** W6007/2016/1

**Registered office:** Level 1, 675 Murray Street  
WEST PERTH WA 6872

**ACN:** 119 966 353

**Premises address:** Browns Range Rare Earths Pilot Plant  
Mining Tenement M80/627  
STURT CREEK WA 6770 as depicted in Schedule 1

**Issue date:** 13 March 2017

**Commencement date:** 14 March 2017

**Expiry date:** 13 March 2020

The following category/s from the *Environmental Protection Regulations 1987* cause this Premises to be a prescribed premises for the purposes of the *Environmental Protection Act 1986*:

Category number	Category description	Category production or design capacity	Approved premises production or design capacity
5	Processing or beneficiation of metallic or non-metallic ore: premises on which – (a) Metallic or non-metallic ore is crushed, ground, milled or otherwise processed; (b) Tailings from metallic or non-metallic ore are reprocessed; or (c) Tailings or residue from metallic or non-metallic ore are discharged into a containment cell or dam.	50,000 tonnes or more per year	80,000 tonnes per annual period

### Conditions

This Works Approval is subject to the conditions set out in the attached pages.

Date signed: 13 March 2017

**Danielle Eyre**  
**Senior Manager – Industry Regulation (Resource Industries)**  
Officer delegated under section 20  
of the *Environmental Protection Act 1986*



# Works Approval Conditions

## 1 General

### 1.1 Interpretation

1.1.1 In the Works Approval, definitions from the *Environmental Protection Act 1986* apply unless the contrary intention appears.

1.1.2 In the Works Approval, unless the contrary intention appears:

**'AS/NZS 5667.1'** means the Australian Standard AS/NZS 5667.1 *Water Quality – Sampling – Guidance of the Design of sampling programs, sampling techniques and the preservation and handling of samples*;

**'AS/NZS 5667.11'** means the Australian Standard AS/NZS 5667.11 *Water Quality – Sampling – Guidance on sampling of groundwaters*;

**'annual period'** means the inclusive period from 1 January until 31 December in the same year;

**'averaging period'** means the time over which a limit or target is measured or a monitoring result is obtained;

**'CEO'** means Chief Executive Officer of the Department of Environment Regulation;

**'CEO'** for the purpose of correspondence means;  
Chief Executive Officer  
Department Division 3, Part V of the EP Act  
Locked Bag 33, Cloisters Square  
PERTH WA 6850  
Email: [info@der.wa.gov.au](mailto:info@der.wa.gov.au);

**'Commissioning'** means the process of operation and testing that verifies the works and all relevant systems, plant, machinery and equipment have been installed and are performing in accordance with the design specification set out in the works approval application;

**'Department'** means the department established under section 35 of the *Public Sector Management Act 1994* and designated as responsible for the administration of Division 3 Part V of the EP Act;

**'EP Act'** means *Environmental Protection Act 1986*;

**'HDPE'** means high density polyethylene;

**'mbgl'** means metres below ground level;

**'NATA'** means the National Association of Testing Authorities, Australia;

**'NATA accredited'** means in relation to the analysis of a sample that the laboratory is NATA accredited for the specified analysis at the time of the analysis;

**'Premises'** means the area defined in the Premises Map in Schedule 1 and listed as the Premises address on page 1 of the Works Approval;

**'Schedule 1'** means Schedule 1 of this Works Approval unless otherwise stated;

**'spot sample'** means a discrete sample representative at the time and place at which the sample is taken;



**'Stage 1'** means construction of the Browns Range Rare Earths Pilot Plant (beneficiation and hydrometallurgical processing plants), tailings storage facility (embankment to elevation of RL450.2), evaporation pond, groundwater monitoring bores and ancillary infrastructure;

**'Stage 2'** means the final tailings storage facility embankment lift to elevation of RL453.0;

**'Works Approval'** means this Works Approval numbered W6007/2016/1 and issued under the Act; and

**'Works Approval Holder'** means the person or organisation named as the Works Approval Holder on page 1 of the Works Approval.

1.1.3 Any reference to an Australian or other standard in the Works Approval means the relevant parts of the standard in force from time to time during the term of this Works Approval.

1.1.4 Any reference to a guideline or code of practice in the Works Approval means the current version of the guideline or code of practice in force from time to time, and shall include any amendments or replacements to that guidelines or code of practice made during the term of this Works Approval.

## 1.2 General conditions

1.2.1 The Works Approval Holder must ensure that the Works specified in Column 1 of Table 1.2.1 meet or exceed the specifications in Column 2 of Table 1.2.1 for the infrastructure in each row of Table 1.2.1.

1.2.2 The Works Approval Holder must not depart from the specifications in Column 1 and 2 for the infrastructure in each row of Table 1.2.1 except:

- a) where such departure is minor in nature and does not materially change or affect the infrastructure; or
- b) where such departure improves the functionality of the infrastructure and does not increase risks to public health, public amenity or the environment;
- c) and all other Conditions in this Works Approval are still satisfied.

Table 1.2.1 Infrastructure to be constructed	
Infrastructure	Specifications (design and construction)
Stormwater infrastructure: General	<ul style="list-style-type: none"> <li>Stormwater diversion channels and bunds around process plant, tailings storage facility, evaporation pond</li> <li>Sediment retention pond downstream of the tailings storage facility, 90 metres length, 35 metres wide, overall storage capacity of 755 m<sup>3</sup>, with a rock filter of coarse rock for discharge and emergency spillway situated 0.5 metres from ground level</li> <li>Stormwater infrastructure installed in accordance with the design and construction specifications detailed in the report Golder Associates (2017) <i>Northern Minerals Limited – Browns Range Project – Updated Surface Water Management Plan</i> (1667882-001-R-Rev0) Pages 9 to 17</li> </ul>
Tailings Storage Facility: General	<ul style="list-style-type: none"> <li>Single cell paddock facility located above the 100 year annual recurrence interval flood level</li> <li>Stage 1: embankment constructed to RL450.2</li> <li>Stage 2: embankment constructed to final elevation of RL453.0</li> <li>Maximum embankment height of 6 metres</li> <li>6 metre wide crest embankment</li> <li>4 metre wide cut off trench</li> <li>Spillway installed</li> <li>Tailings pipeline - 63 mm HDPE pipe (SDR11 PE100 PN16)</li> <li>Return water pipeline – 43 mm HDPE pipe (SDR11 PE80 PN12.5)</li> <li>Tailings and return water pipelines fitted with automatic pressure drop cut</li> </ul>



	<p>out</p> <ul style="list-style-type: none"><li>• Sediment detention pond to capture surface water runoff from the external embankment</li><li>• Tailings storage facility constructed in accordance with the construction and design specifications detailed in sections 7.1-7.9 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li></ul>
Tailings Storage Facility: Discharge Points	<ul style="list-style-type: none"><li>• Discharge points spaced at approximately 28 metre intervals along embankment crest</li></ul>
Tailings Storage Facility: Liner	<ul style="list-style-type: none"><li>• 300 mm thick compacted soil subgrade</li><li>• 1.5 mm smooth HDPE liner installed to achieve permeability of <math>1 \times 10^{-9}</math> m/s</li><li>• Installed in accordance with the construction and design specifications detailed in the sections 7.1-7.9 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li></ul>
Tailings Storage Facility: Decant tower	<ul style="list-style-type: none"><li>• Access causeway</li><li>• Decant tower consisting of 1.8 metre diameter slotted concrete pipe surrounded by clean waste rock</li><li>• Submersible pump and pipework to convey return water to the processing plant</li><li>• Decant tower and associated infrastructure installed in accordance with the construction and design specifications detailed in sections 7.1-7.9 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li></ul>
Tailings Storage Facility: Underdrainage system	<ul style="list-style-type: none"><li>• Branch drains: 100 mm draincoil pipe surrounded by 400 mm of sand wrapped in geotextile (continuously seamed or heat welded)</li><li>• Finger drains: 63 mm draincoil pipe surrounded by 400 mm of sand wrapped in geotextile (continuously seamed or heat welded)</li><li>• HDPE lined collection sump to accept water from branch and finger drains, equipped with pipelines and pump to divert water to decant tower</li><li>• Underdrainage system installed in accordance with the construction and design specifications detailed in sections 7.1-7.9 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li></ul>
Tailings Storage Facility: Groundwater monitoring bores	<ul style="list-style-type: none"><li>• Construction of monitoring bores MB-01, MB-02 and MB-03, each comprising of a shallow bore (5-10 mbgl) and a deep bore (5 metres below groundwater table), installed in accordance with the construction and design specifications detailed in sections 10.1-10.3 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li></ul>
Evaporation pond: General	<ul style="list-style-type: none"><li>• 0.84 hectare in top area</li><li>• External embankment height of 3.8 metres, crest width 4 metres,</li><li>• Designed and constructed to store runoff from a 1 in 100 year 72 hour storm event</li><li>• 1.5 mm smooth HDPE liner installed to achieve permeability of <math>1 \times 10^{-9}</math> m/s (to be verified by a suitably qualified engineer)</li><li>• Spillway installed</li><li>• Raffinate pipeline from processing plant to evaporation pond fitted with automatic pressure drop cut out</li><li>• Raffinate pipeline - 40mm HDPE pipe (SDR11, PE100 PN10)</li><li>• All components installed in accordance with the construction and design</li></ul>



	specifications detailed in sections 8.1-8.4 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)
Evaporation pond: Groundwater monitoring bores	<ul style="list-style-type: none"> <li>Construction of monitoring bores MB-04 and MB-05, each comprising of a shallow bore (5-10 mbgl) and a deep bore (5 metres below groundwater table), installed in accordance with the construction and design specifications detailed in sections 10.1-10.3 of the report <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)</li> </ul>
Processing Plant (beneficiation and hydrometallurgical): Stormwater management	<ul style="list-style-type: none"> <li>HDPE lined stormwater event ponds, designed to contain a 1:20 year return period, 24 hour rainfall event</li> </ul>
Beneficiation plant: General	<ul style="list-style-type: none"> <li>Primary crushing unit</li> <li>Semi-autogenous grinding mill and a ball mill</li> <li>Two stage wet high gradient magnetic separation plant</li> <li>Flotation circuit</li> <li>Thickener</li> <li>Each wet processing unit described above contained within an impermeable bund (concrete bunding or processing units fitted with an integral spill tray, sump and spillage pump)</li> <li>Each bund to be constructed with an overflow to an HDPE lined event pond to capture spillage within the beneficiation plant, designed to contain 110% of the largest volume or a 1:20 year return period, 24 hour storm event</li> </ul>
Hydrometallurgical plant: General	<ul style="list-style-type: none"> <li>Dryer with a screw for conveyance of mineral concentrate</li> <li>Acid mixer</li> <li>Sulfation bake kiln</li> <li>Water leach facility</li> <li>Pregnant leach solution purification facility</li> <li>Pregnant leach solution filtration facility</li> <li>Ion exchange column</li> <li>Rare earth carbonate precipitation facility</li> <li>Mixed rare earth thickener, filtration unit and drier</li> <li>Each processing unit described above fitted with spill tray, sump and spillage pump with an overflow to a HDPE lined event pond designed to contain 110% of the largest volume or a 1:20 year return period, 24 hour storm event</li> <li>Pipe rack to be constructed above the concrete lined central drain</li> </ul>
Hydrocarbon and chemical storage areas	<ul style="list-style-type: none"> <li>20 foot sea container for the storage of quick lime, sodium carbonate, magnesium oxide and ferric sulfate</li> <li>20 foot sea container for the storage of flocculant and ion exchange resin</li> <li>Bunded compound designed to contain 110% of the largest volume stored and fitted with an impermeable liner for the storage of caustic soda, sodium silicate and fatty acid collector</li> <li>Bunded compound designed to contain 110% of the largest volume stored and fitted with an impermeable liner for the storage of five 21,000 litre sulfuric acid isotainer storage tanks</li> </ul>

1.2.3 The Works Approval Holder shall commission the Browns Range Rare Earths Project Pilot Plant for a period not exceeding 3 months.



## 2 Monitoring

2.1.1 The Works Approval Holder shall ensure that:

- (a) all water samples are collected and preserved in accordance with AS/NZS 5667.1;
- (b) all groundwater sampling is conducted in accordance with AS/NZS 5667.11; and
- (c) all laboratory samples are submitted to and tested by a laboratory with current NATA accreditation for the parameters being measured unless indicated otherwise in relevant table.

2.1.2 The Works Approval Holder shall undertake the monitoring specified in Table 2.1.1 following construction of the monitoring bores specified in Table 2.1.1, prior to the deposition of tailings into the tailings storage facility and hydrometallurgical plant raffinate into the evaporation pond.

Table 2.1.1: Ambient groundwater monitoring				
Monitoring point reference	Parameter	Units	Averaging period	Frequency <sup>1</sup>
Tailings Storage Facility MB-01 MB-02 MB-03	Standing water level	mbgl	Spot sample	At least one monitoring event prior to tailings deposition
	pH <sup>1</sup>	-		
	Total Dissolved Solids	mg/L		
	Electrical Conductivity	S/m		
	Redox potential <sup>1</sup>	Volts		
	Total Acidity and Total Alkalinity <sup>1</sup>	mg/L		
	<b>Major cations and anions</b> Sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate <b>Metals, metalloids and non-metals</b> Aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, , iron, lead, manganese, molybdenum, mercury, nickel, thorium, selenium, tin, uranium, vanadium, zinc			
Evaporation Pond MB-04 MB-05	Standing water level	mbgl	Spot sample	At least one monitoring event prior to raffinate deposition
	pH <sup>1</sup>	-		
	Total Dissolved Solids	mg/L		
	<b>Major cations and anions</b> Sodium, potassium, calcium, magnesium, chloride, sulfate, bicarbonate <b>Metals, metalloids and non-metals</b> Aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, molybdenum, nickel, thorium, tin, uranium, vanadium, zinc			

Note 1. In-field non-NATA accredited analysis permitted.





### 3 Information

#### 3.1 Reporting

- 3.1.1 The Works Approval Holder shall submit a compliance document to the CEO, following the construction of the Browns Range Rare Earths Pilot Plant Stage 1 and Stage 2 and prior to commissioning of the same.
- 3.1.2 The compliance document shall:
- (a) certify that the works were constructed in accordance with the conditions of the Works Approval;
  - (b) be signed by a person authorised to represent the Works Approval Holder and contain the printed name and position of that person within the company; and
  - (c) If any departures to the specified works have occurred, the Works Approval Holder must provide the CEO with a list of the departures which are certified as complying with condition 1.2.2 at the same time, and from the same engineer, as the certification under condition 3.1.1.
- 3.1.3 The Works Approval Holder shall submit a commissioning report for the Browns Range Rare Earths Pilot Plant to the CEO one month prior to the completion of commissioning.
- 3.1.4 The Works Approval Holder shall ensure the commissioning report required under condition 3.1.3 includes:
- (a) a summary of the monitoring results recorded under condition 2.1.2;
  - (b) a list of any original monitoring reports submitted to the Works Approval Holder from third parties for the commissioning period;
  - (c) a summary of the environmental performance of the Browns Range Rare Earths Pilot Plant as installed, against the design specification set out in the works approval application;
  - (d) a review of performance against the works approval conditions; and
  - (e) where they have not been met, measures proposed to meet the design specification and/or works approval conditions, together with timescales for implementing the proposed measures.

#### 3.2 Notification

- 3.2.1 The Works Approval Holder shall ensure that the parameters listed in Table 3.2.1 are notified to the CEO and are in accordance with the notification requirements of the table.

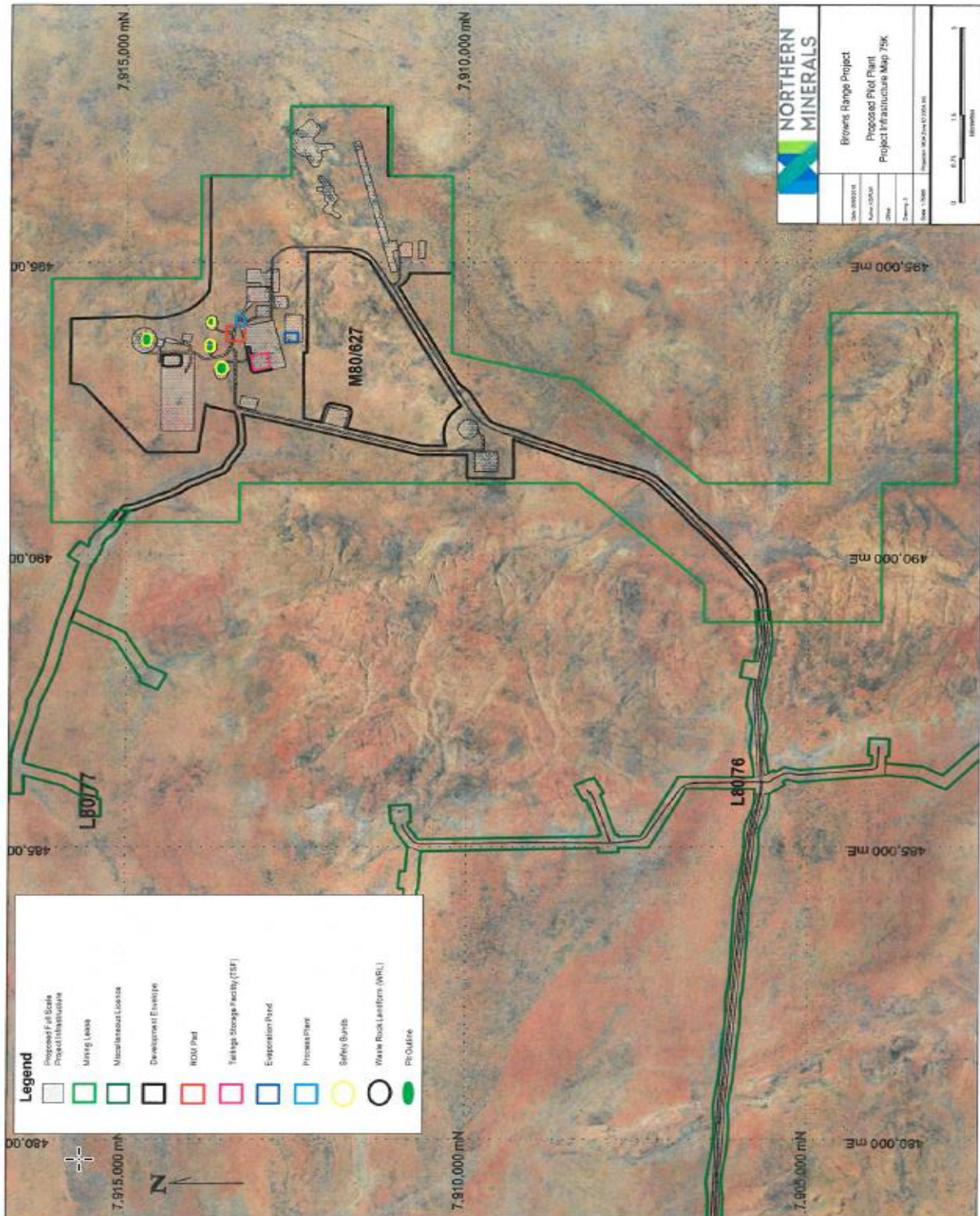
Table 3.2.1: Notification requirements			
Condition or table (if relevant)	Parameter	Notification requirement	Format or form
1.2.3	Commencement of commissioning	7 days prior to start	None specified
	Completion of commissioning	7 days after completion	



## Schedule 1: Maps

### Premises map

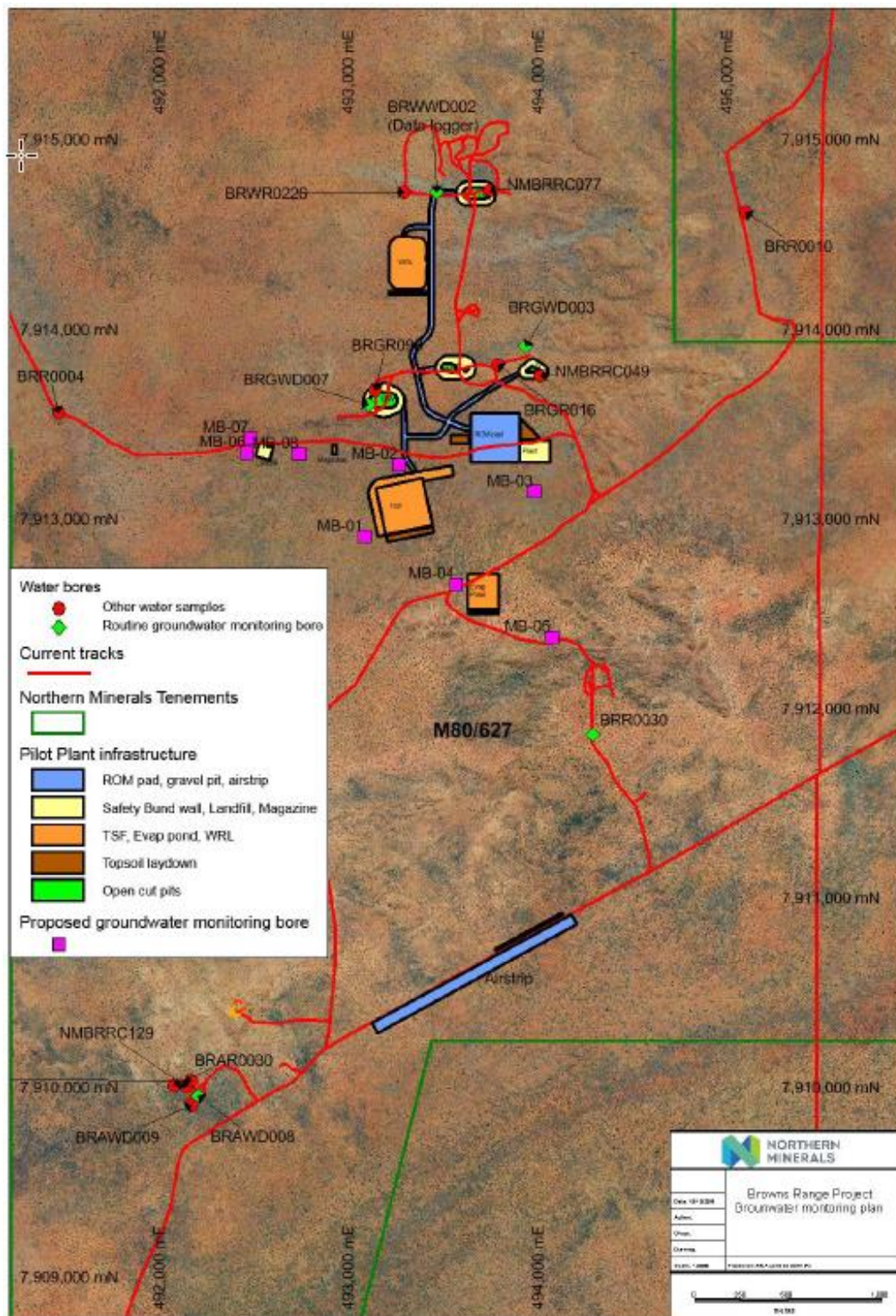
The Premises is shown in the map below. The green line depicts the Premises boundary.







The location of the monitoring locations defined in Table 2.1.1 are shown on the map below.





## ***Environmental Protection Act 1986, Part V***

**Works Approval: W6007/2016/1**

**Expiry date:** 13 March 2020

Decision Document authorised by: Alana Kidd  
Delegated Officer



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## 1 Purpose of this Document

This decision document explains how DER has assessed and determined the application and provides a record of DER's decision-making process and how relevant factors have been taken into account. Stakeholders should note that this document is limited to DER's assessment and decision making under Part V of the *Environmental Protection Act 1986*. Other approvals may be required for the proposal, and it is the proponent's responsibility to ensure they have all relevant approvals for their Premises.

## 2 Administrative summary

Administrative details		
Application type	Works Approval <input checked="" type="checkbox"/> New Licence <input type="checkbox"/> Licence amendment <input type="checkbox"/> Works Approval amendment <input type="checkbox"/>	
Activities that cause the premises to become prescribed premises	<b>Category number(s)</b> 5	<b>Assessed design capacity</b> 80,000 tonnes per annual period
Application verified	Date: 3 November 2016	
Application fee paid	Date: 10 November 2016	
Works Approval has been complied with	Yes <input type="checkbox"/> No <input type="checkbox"/> N/A <input checked="" type="checkbox"/>	
Compliance Certificate received	Yes <input type="checkbox"/> No <input type="checkbox"/> N/A <input checked="" type="checkbox"/>	
Commercial-in-confidence claim	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	
Commercial-in-confidence claim outcome	Accepted	
Is the proposal a Major Resource Project?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	
Was the proposal referred to the Environmental Protection Authority (EPA) under Part IV of the <i>Environmental Protection Act 1986</i> ?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Referral decision No: Managed under Part V <input type="checkbox"/> Assessed under Part IV <input checked="" type="checkbox"/>
Is the proposal subject to Ministerial Conditions?	Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>	Ministerial statement No: 986 EPA Report No: 1523





Does the proposal involve a discharge of waste into a designated area (as defined in section 57 of the <i>Environmental Protection Act 1986</i> )?	Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> Department of Water consulted Yes <input checked="" type="checkbox"/> No <input type="checkbox"/>
Is the Premises within an Environmental Protection Policy (EPP) Area Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> If Yes include details of which EPP(s) here.	
Is the Premises subject to any EPP requirements? Yes <input type="checkbox"/> No <input checked="" type="checkbox"/> If Yes, include details here, eg Site is subject to SO <sub>2</sub> requirements of Kwinana EPP.	

### 3 Executive summary of proposal and assessment

A works approval application has been submitted by Northern Minerals Limited (Northern Minerals) for the construction of the Browns Range Rare Earths Pilot Plant (pilot plant). The pilot plant will be located on Mining Tenement M80/627, approximately 160 kilometres (km) south-east of Halls Creek, Western Australia (Figure 1). The Project area is adjacent to the Western Australian/Northern Territory border and will target heavy rare earth dominant xenotime mineralisation.



Figure 1. Regional location of the Browns Range Rare Earths Project

The Browns Range Rare Earths Project was assessed by the Environmental Protection Authority (EPA) under Part IV of the *Environmental Protection Act 1986* (EP Act). Ministerial approval for the project was via Ministerial Statement (MS) 986 issued 20 October 2014.

In 2015, Northern Minerals decided to adopt a staged approach to the implementation of the project. The first stage is proposed to be a three year pilot trial involving open cut mining and mineral processing to produce approximately 49,000 kilograms (kg) of dysprosium per year, in approximately 590,000 kg of Total Rare Earth Oxide (TREO). The TREO will be transported from site in shipping containers using public roads to either Darwin or the Port of Wyndham for export.

It is Northern Minerals objective to proceed with the full scale mining and processing facility once the pilot trial is complete (Northern Minerals, 2017b). This Works Approval relates solely to the construction of the pilot trial, being the first stage of works.





The pilot plant will be sized to about 10% of the full scale plant capacity assessed by the EPA under Part IV of the EP Act. Treatment of ore will occur for approximately 10 months each year depending on the wet season, for approximately three years. Northern Minerals aims to commence on-ground works for the pilot plant trial in Q2, 2017 (April 2017) and does not intend to operate the pilot plant trial during the wet season (December to March) due to the potential for road access to be restricted, which will limit the ability to bring in consumables and reagents.

The workforce for the Project will operate on a fly-in/fly-out basis and will be housed at the onsite accommodation village. Approximately 32 workers will be required for the construction phase. The estimated peak operational workforce will be 37 people.

The Project's disturbance footprint will encompass the following key infrastructure:

- open cut mine;
- mine dewatering infrastructure;
- beneficiation processing plant (crushing, grinding, magnetic separation and flotation);
- hydrometallurgical processing plant (sulfation baking, water leaching, ion exchange, precipitation, drying and bagging);
- tailings storage facility (TSF);
- lined evaporation pond for disposal of raffinate;
- power generation (gensets); and
- hydrocarbon and chemical storage areas.

A full description of the proposed prescribed and related activities is provided in Appendix A. The Delegated Officer has determined that the pilot plant triggers category 5 (processing or beneficiation of metallic or non-metallic ore) under Schedule 1 of the *Environmental Protection Regulations 1987* (EP Regs).

On 24 September 2015 Works Approval W5837/2015/1 was issued to Northern Minerals for the construction of a Category 64 landfill and Category 85 sewage facility, for full scale operations. Northern Minerals has advised that the quantity of septic waste generated during the proposed pilot plant trial will not trigger the threshold levels specified for sewage facilities under Schedule 1 of the EP Regs. Northern Minerals has also advised the operation of the pilot plant may trigger the 20 tonnes per annum threshold level for Category 64.

#### Other activities

Mine dewatering will be undertaken at a rate of approximately 130 cubic metres (m<sup>3</sup>) per day, which equates to approximately 24,000m<sup>3</sup> over the course of the three year trial; below the production capacity for Category 6 as described in Schedule 1 of the EP Regs. Water from mine dewater will be utilised on site for dust suppression.

Power generation will be supplied by a 1.5 MW generator; below the production capacity for Category 52 as described in Schedule 1 of the EP Regs.

Northern Minerals has advised that bulk storage of chemicals will not trigger Category 73 as the volume stored on site during the three year trial will not exceed 1,000 m<sup>3</sup> in aggregate.

#### **Location and siting**

The Project area is located at the northern edge of the Tanami Desert lying within the Tanami bioregion (Tanami 1 sub-bioregion). Tanami 1 consists of red desert sand plains that support mixed shrub steppes and hummock grasslands, as well as hills and ranges that support wattle scrub and hummock grasslands.



#### Sensitive land uses

The nearest settlement to the Project area is Kundat Djaru (Ringer Soak), approximately 34 km to the west/southwest. The Kundat Djaru community was established in the mid-1980s on land excised from the Gordon Downs pastoral station. The community is managed through the Kundat Djaru Aboriginal Corporation.

Northern Minerals has advised that the nearest Department of Water (DoW) registered bore is located 24 km north-west of the project area. Northern Minerals also commissioned a bores census to be undertaken. From this, six unregistered pastoral bores were identified within a nominal 30 km radius of the Project area as shown in Figure 2 (Northern Minerals, 2017a).

In identifying sensitive receptors, DER has excluded employees, visitors or contractors of Northern Minerals, as protection of these parties often involves different exposure risks and prevention strategies, provided for under other State legislation.

#### Specified ecosystems

The Project is not located within or close to a Public Drinking Water Source Area (PDWSA) or RAMSAR wetland.

The Project area is located in a region that supports a large land and waterbird assemblage. The nearest major waterbodies that support waterbirds are Lake Gregory (200 km south/west), Lake Argyle (250 km north) and Nongra Lake (120 km north/east). Seventy-five waterbird species, including 22 international migratory species have been identified at these water bodies (EPA, 2014).

Vegetation and flora surveys were conducted within and outside the development envelope in May 2012 and May 2013. No Threatened Ecological Communities (TEC) or Priority Ecological Communities (PEC) were recorded within the Project area. Vegetation was recorded to be in largely excellent condition. No Declared Rare Flora (DRF) has been identified within the Project area, although 21 species of conservation interest were identified, including 4 Priority-listed species, 2 species nominated for inclusion as Priority species, 6 species with 'medium' range extensions, 6 species with 'high' range extensions, 2 species not previously recorded in Western Australia and 1 undescribed species (Northern Minerals, 2014).

The Delegated Officer notes that Northern Minerals amended the development envelope to avoid and minimise impacts to conservation significant flora and vegetation associations (EPA, 2014).

A baseline fauna study was completed in May 2012 with a subsequent targeted survey carried out in December 2013. Six vertebrate fauna habitats were identified; none being restricted to the development envelope. A total of 16 species of conservation significance were identified by the baseline survey, with 7 of these species known to occur or have occurred in the development envelope:

- Greater Bilby (*Macrotis lagotis*) – Schedule 1 (*Wildlife Conservation Act 1950* (WC Act));
- Major Mitchell's Cockatoo (*Lophochroa leadbeateri*) – Schedule 4 (WC Act);
- Spectacled Hare-wallaby (mainland subspecies) (*Lagorchestes conspicillatus leichardti*) – Priority 3 (Department of Parks and Wildlife Priority Fauna List);
- Lakeland Downs Mouse (*Leggadina lakedownensis*) – Priority 4 (Department of Parks and Wildlife Priority Fauna List);
- Bush Stone-curlew (*Burhinus grallarius*) - Priority 4 (Department of Parks and Wildlife Priority Fauna List);
- Australian Bustard (*Ardeotis australis*) - Priority 4 (Department of Parks and Wildlife Priority Fauna List); and
- Oriental Plover (*Charadrius veredus*) – Schedule 3 (WC Act).



Short range endemic invertebrate fauna surveys were conducted and the Delegated Officer notes that the proponent amended the development envelope to also avoid impacting on habitat considered likely to contain short range endemic invertebrate fauna species.

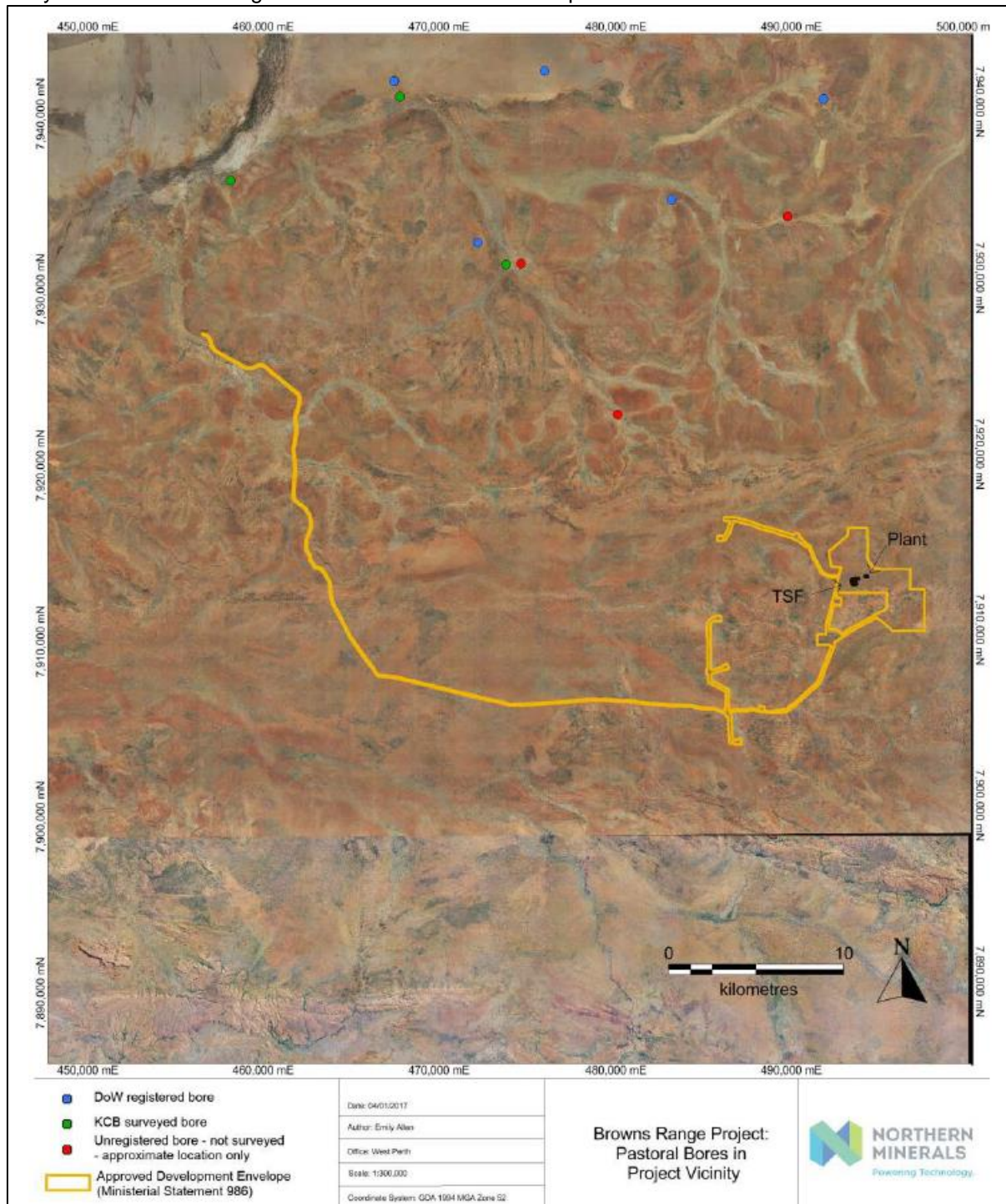


Figure 2. Pastoral bore locations





#### Topography

Topography at the Project area is generally subdued, with an average gradient of about 1%. The Gardiner Sandstone forms the most prominent topographic features in the area, comprising low ridges and undulating terrain. Rocky outcrops of Browns Range Metamorphics are also present, rising approximately 25-30 m above the surrounding land (Knight Piesold, 2016).

#### Groundwater and hydrology

The Project area lies within the Sturt Creek catchment, which flows to the southwest, ultimately discharging into Lake Gregory, approximately 220 km downstream of the site. Lake Gregory is recognised as a wetland of national importance under criteria 1, 2, 3, 4 and 6 of the *Directory of Important Wetlands in Australia* (DIWA).

The main water course of Sturt Creek is located approximately 45 km west/northwest of the site and is classified as an ephemeral system. Sturt Creek is classified by DoW as a 'wild river' (a river that is undammed and lies in a largely unmodified catchment with intact biological and hydrological processes).

Groundwater in the area is fresh to slightly brackish, with a near-neutral pH and very low concentrations of dissolved metals. The natural groundwater table is approximately 14 metres below ground level (mbgl) (Knight Piesold, 2016).

#### Meteorology

The region experiences an arid subtropical climate within a monsoonal influence. Most of the rainfall occurs during the relatively short wet season between November and March, associated with tropical monsoonal activity and cyclonic activity, occasionally as short term heavy downfalls. Average rainfall is approximately 410 mm and annual average evaporation is approximately 3,000 mm (Knight Piesold, 2016).

#### **Clearing**

The clearing of native vegetation is approved under MS986.

#### **Other approvals**

##### Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

The Browns Range Rare Earths Project (full scale) was referred to the Commonwealth Department of the Environment due to the potential presence of species listed as Threatened and/or Migratory under the EPBC Act. On 14 August 2014, the Department of Environment determined that the Project was not a Controlled Action and did not require further assessment.

##### Part IV of the Act

MS986 for the Browns Range Rare Earths Project was issued 20 October 2014. The EPA identified rehabilitation and closure, inland waters environmental quality, flora and vegetation and terrestrial fauna as key environmental factors. These factors were evaluated by the EPA in Report 1523 (August, 2014). The outcome of the EPA's assessment and recommendation to the Minister was the inclusion of condition 6 in MS986 relating to the development of a fauna management plan to reduce impacts to conservation significant fauna during construction and operation of the proposal.

The Delegated Officer has not considered potential impacts to terrestrial vertebrate fauna in the risk assessment for the pilot plant so as to avoid duplication with Part IV of the EP Act.

##### Rights in Water and Irrigation Act 1914 (RIWI Act)

Pursuant to section 5C of the RIWI Act, Northern Minerals has been issued GWL177452(3) authorising the abstraction of 790,000 kilolitres (kL) of groundwater for the purposes of earthworks and construction, and potable water supply. Northern Minerals has applied to DoW to amend GWL177452(3) to allow taking and use of water from pit dewatering.





#### Mining Act 1978

Northern Minerals has advised that the mining proposal for the pilot plant trial was submitted to the Department of Mines and Petroleum (DMP) on 6 July 2016; approval of the Mining Proposal (REG ID 59841) was granted on 28 November 2016.

#### Radiation Management

Mineralisation at Browns Range also hosts low levels of uranium and thorium. A Radiation Management Plan (RM/234-181589) has been developed for exploration activities associated with the Browns Range Project to address the requirements of the *Mines Safety Inspection Regulations 1995*, the *Radiation Safety Act 1975* and Regulations and the requirements of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. DMP approved the implementation of the plan on 19 May 2015.

The Delegated Officer understands radiation management in relation to the pilot plant was considered in the assessment of the Browns Range Project Management Plan, approved by the Resources Safety Division of DMP on 31 August 2016.

#### Radiological Council of Western Australia

Northern Minerals has registered the Project with the Radiological Council of Western Australian, as premises in which radioactive substances are to be used, stored or manufactured (registration number RS 73/2012 22222). Conditions of this registration include the development of a radiation management plan, and the appointment of a Radiation Safety Officer.

#### Local Government

Northern Minerals will seek relevant approvals from the Local Government authority and/or Department of Health for the operation of a septic system to dispose of septic waste from the ablutions on site.

DER's assessment and decision making with respect to the Browns Range Rare Earths Project pilot plant trial is detailed in the decision table below.



## 4 Decision table

All applications are assessed in line with the *Environmental Protection Act 1986*, the *Environmental Protection Regulations 1987* and DER's Operational Procedure on Assessing Emissions and Discharges from Prescribed Premises. Where other references have been used in making the decision they are detailed in the decision document.

DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
Interpretation	Works Approval conditions 1.1.1-1.1.4  Licence - Definitions	<b>Construction</b> Conditions 1.1.1 and 1.1.2 require that terminology used in the Works Approval is referenced to appropriate definitions where applicable. Conditions 1.1.3 and 1.1.4 requires that the relevant part of an Australian or other standard, and current version of a guideline or code of practice in force during the term of the Works Approval, is used.  <b>Operation</b> The operating licence for the pilot plant may refer to terminology and definitions within the EP Act and Australian Standards for water quality sampling.	General provisions of the <i>Environmental Protection Act 1986</i>
General conditions	Works Approval conditions 1.2.1 to 1.2.3	<b>Construction</b> Condition 1.2.1 requires the construction of infrastructure in accordance with the specifications detailed in Table 1.2.1 of the Works Approval. These specifications relate to the pilot plant (beneficiation and hydrometallurgical processing components), TSF, evaporation pond, stormwater infrastructure and chemical/hydrocarbon storage areas. This condition is considered necessary based on the potential risk to the environment from contaminated stormwater, TSF seepage, pipeline ruptures and overflow from the TSF and evaporation ponds (as detailed in Appendix B).  Condition 1.2.2 allows for minor deviations from the design and construction specifications where such departures improve the functionality of the infrastructure and does not increase the risk to public health, public amenity or the environment.	General provisions of the <i>Environmental Protection Act 1986</i>  Application supporting documentation  <i>Northern Minerals Limited Browns Range Project Pilot Plant – Tailings Storage Facility and Evaporation Pond Permitting Design Report</i> (Knight Piesold, 2016)



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
	N/A	<p>Northern Minerals has advised that commissioning of the pilot plant will be carried out in accordance with a commissioning plan which will be developed by Northern Minerals to bring the pilot plant up to steady state production over approximately 8 months. The Delegated Officer has determined that the commissioning activities can be conducted under the operating Licence. Condition 1.2.3 specifies a commissioning period of 3 months to allow initial testing of the pilot plant.</p> <p><b>Operation</b> The Delegated Officer has determined that a general licence condition relating to the immediate recovery or removal of spills of wastewater, process liquors, tailings, hydrocarbons or processing chemicals outside of engineered containment systems may be required (refer to stormwater management in Appendix B). A range of chemicals including sodium silicate, caustic soda (sodium hydroxide), flocculant, sulfuric acid, sodium carbonate, quick lime, ferric sulfate, magnesium oxide and ion exchange will be used in the beneficiation and hydrometallurgical processes.</p>	<p>East Perth, WA 6004</p> <p><i>Northern Minerals Limited – Browns Range Project – Updated Surface Water Management Plan</i> (Golder Associates, 2017, 1667882-001-R-Rev0)</p>
<b>Premises operation</b>	N/A  Licence conditions	<p><b>Construction</b> Approval to operate is not granted under the Works Approval.</p> <p><b>Operation</b> DER's assessment and decision making with respect to the operation of the TSF, evaporation pond and stormwater management is detailed in Appendix B.</p> <p>Conditions relating to the acceptance and management of waste may be included on the Licence if the landfill approved under Works Approval W5837/2015/1 triggers the threshold for the description of a category 64 landfill under the EP Regs. Alternatively, Northern Minerals may seek to operate the landfill under a registration.</p>	<p>General provisions of the <i>Environmental Protection Act 1986</i></p> <p><i>Northern Minerals Limited – Browns Range Project – Updated Surface Water Management Plan</i> (Golder Associates, March 2017)</p>



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
<b>Emissions general</b>	N/A	<p><b>Construction and Operation</b></p> <p>No approval to emit waste from any emission points at the Project have been granted under the Works Approval. The Delegated Officer notes that there will be no specified emission points on the Licence, therefore general emissions conditions will not be required on the licence.</p>	General provisions of the <i>Environmental Protection Act 1986</i>
<b>Point source emissions to air including monitoring</b>	<p>N/A</p> <p>N/A</p>	<p><b>Construction</b></p> <p>There will be no point source emissions to air during construction of the pilot plant. No specified conditions relating to point source air emissions are required on the Works Approval.</p> <p><b>Operation</b></p> <p>The Delegated Officer notes there are no sensitive receptors within 30 km of the project. The nearest settlement to the Project area is Kundat Djaru (Ringer Soak), approximately 34 km to the west/southwest. This distance is considered to be a sufficient separation distance for emissions generated by a category 5 premises.</p> <p>Point source air emissions of SO<sub>x</sub>, NO<sub>x</sub>, CO and particulates are expected from the burning of diesel fuel from the gensets. Emissions of SO<sub>x</sub>, NO<sub>x</sub>, CO, radon, thoron and particulates will occur during ore processing.</p> <p>The Delegated Officer acknowledges that radionuclides in airborne dust is regulated by DMP under the requirements of the Radiation Management Plan. Air emissions modelling for particulates (total suspended particles (TSP), PM<sub>10</sub> and PM<sub>2.5</sub>) for the full scale hydrometallurgical plant has been undertaken to assess potential worst case air quality impacts. The modelling demonstrates that the ambient air criteria are met at the site's accommodation village which is located a few kilometres from the sources of air emissions. As previously noted, the accommodation village is not considered a sensitive receptor.</p> <p>The Delegated Officer also notes that the modelling was undertaken for the full</p>	<p>Ambient Air Assessment Criteria, National Environmental Protection Measure (Ambient Air Quality)</p> <p>General provisions of the <i>Environmental Protection Act 1986</i></p> <p>Application supporting documentation</p> <p><i>Radiation Management Plan – Browns Range Project</i> (Northern Minerals Limited, 11 March 2015)</p> <p>Guidance Statement <i>Environmental Siting</i> (DER, November 2016)</p>





DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		<p>scale operations, which is considerably larger than the proposed pilot plant subject to this works approval. It can be reasonably assumed that the ambient air quality for the pilot plant, which will be operating at one tenth of the capacity of full operations, will meet the air quality criteria at sensitive receptors.</p> <p>The Delegated Officer has noted that Northern Minerals will be undertaking quarterly monitoring of radon and thoron in air, in accordance with the Radiation Management Plan approved by DMP. This plan also addresses the management of radionuclides in airborne dust. The Radiation Management Plan has been developed to address the requirements of the <i>Mines Safety Inspection Regulations 1995</i>, the relevant parts of the <i>WA Radiation Safety Act</i> and Regulations and the requirements of the ARPANSA Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing.</p> <p>A detailed risk assessment of point source air emissions has not been undertaken as there are no sensitive receptors at risk of being impacted by point source air emissions from the project.</p>	
Point source emissions to surface water including monitoring	N/A	<p><b>Construction and Operation</b></p> <p>There will be no point source emissions to surface water during the construction and operation of the pilot plant. No specified conditions relating to point source emissions to surface water are required for the Works Approval and licence.</p>	<p>General provisions of the <i>Environmental Protection Act 1986</i></p> <p><i>Environmental Protection (Unauthorised Discharges) Regulations 2004</i></p>
Point source emissions to groundwater including monitoring	N/A	<p><b>Construction and Operation</b></p> <p>There will be no point source emissions to groundwater during the construction and operation of the pilot plant. No specified conditions relating to point source emissions to groundwater are required for the Works Approval and licence.</p>	<p>General provisions of the <i>Environmental Protection Act 1986</i></p> <p><i>Environmental Protection</i></p>



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
			<i>(Unauthorised Discharges) Regulations 2004</i>
<b>Emissions to land including monitoring</b>	N/A	<b>Construction and Operation</b> There will be no point source emissions to land during the construction and operation of the pilot plant. No specified conditions relating to point source emissions to land are required for the Works Approval and licence.	General provisions of the <i>Environmental Protection Act 1986</i>  <i>Environmental Protection (Unauthorised Discharges) Regulations 2004</i>
<b>Fugitive emissions</b>	N/A	<b>Construction and Operation – Fugitive Dust</b> The Delegated Officer notes there are no sensitive receptors within 30 km of the project. The nearest settlement to the Project area is Kundat Djaru (Ringer Soak), approximately 34 km to the west/southwest. This distance is considered to be a sufficient separation distance for category 5 premises from sensitive land uses.  <u>Emission description</u> <i>Emission:</i> Dust emissions during construction earthworks. Dust emissions from the handling, storage and processing of ore.  <i>Impact:</i> Impacts to vegetation health from dust deposition, impacts to human health.  <i>Controls:</i> There are no human receptors within 30 km of the premises. Northern Minerals has advised the following measures will be implemented to manage dust: <ul style="list-style-type: none"><li>• water trucks and a sprinkler system will be used to suppress dust emissions from stockpiles;</li><li>• the dump hopper at the ROM pad will be equipped with motion activated water sprays and/or rubber curtains to limit dust emissions;</li></ul>	General provisions of the <i>Environmental Protection Act 1986</i>  <i>Radiation Management Plan – Browns Range Project</i> (Northern Minerals Limited, 11 March 2015)



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		<ul style="list-style-type: none"><li>a dust suppression system using raw water and compressed air (to provide suppression mist) will be located at the ROM hopper loading point, jaw feed and discharge, grizzly screen undersize discharge as well as the mill re-load hopper discharge;</li><li>sensors will be installed to ensure the suppression system only activates during loading and crushing;</li><li>dryers will have dedicated baghouses complete with cyclones; and</li><li>water trucks will be used to water the haul roads and access roads.</li></ul> <p>The Delegated Officer notes that the management of radionuclides in dust has been addressed in the Radiation Management Plan for Browns Range, which has been developed to address the requirements of the <i>Mines Safety Inspection Regulations 1995</i>, the relevant parts of the <i>WA Radiation Safety Act</i> and Regulations and the requirements of the ARPANSA Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing.</p> <p>The Delegated Officer understands radiation management in relation to the pilot plant was considered in the assessment of the Browns Range Project Management Plan, approved by the Resources Safety Division of DMP on 31 August 2016.</p> <p><u>Risk Assessment</u></p> <p><i>Consequence:</i> The Delegated Officer considers that fugitive dust will have minimal onsite impacts. Even in areas most impacted by dust it is likely that the natural dust tolerance of vegetation in the project area will prevent widespread vegetation impacts. Therefore, the Delegated Officer considers the consequence to be slight.</p> <p><i>Likelihood:</i> The Delegated Officer has considered the relatively short timeframe of construction and operation of the pilot plant, and determined that adverse impacts to vegetation health from fugitive dust emissions will not occur in most</p>	



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		<p>circumstances. Therefore, the Delegated Officer considers the likelihood of the consequence to be unlikely.</p> <p><i>Risk Rating:</i> The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for dust emissions to be low.</p> <p><u>Regulatory Controls</u> Fugitive dust emissions are considered a low risk for the project given the location of the premises (nearest sensitive human receptor over 30 km away) and there are no PEC, TEC or DRF within the project area.</p> <p>Fugitive dust emissions can be sufficiently regulated under section 49 of the EP Act.</p> <p>The regulation of radionuclides in airborne dust and potential impacts to onsite personnel is regulated by DMP under the <i>Mines Safety and Inspection Regulations 1995</i>.</p> <p><u>Residual Risk Assessment</u> <i>Consequence:</i> Slight <i>Likelihood:</i> Unlikely <i>Risk rating:</i> Rare</p>	
Odour	N/A	<p><b>Construction and Operation</b> Odour emissions are not expected during construction of the pilot plant and ancillary infrastructure.</p> <p>Minor odour emissions may be generated from the operation of the landfill. The Delegated Officer notes the nearest settlement to the Project area is Kundat Djaru (Ringer Soak), approximately 34 km to the west/southwest.</p>	General provisions of the <i>Environmental Protection Act 1986</i>





DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		The Delegated Officer considers the separation distance sufficient and no specified conditions relating to odour emissions are required for the Works Approval and licence.	
Noise	N/A	<p><b>Construction and Operation</b></p> <p>During construction and operation, noise will be generated from the operation of mobile equipment (haul trucks, water trucks and dozers), power generation facilities and ore handling and processing facilities.</p> <p>The Delegated Officer notes the nearest settlement to the Project area is Kundat Djaru (Ringer Soak), approximately 34 km to the west/southwest. The Delegated Officer considers the separation distance sufficient for category 5 premises.</p> <p>A detailed risk assessment of noise emissions has not been undertaken as there are no sensitive receptors at risk of being impacted by noise emissions from the project.</p> <p>The Delegated Officer notes that the <i>Environmental Protection (Noise) Regulations 1997</i> will apply to the operation of the project.</p>	<p>General provisions of the <i>Environmental Protection Act 1986</i></p> <p><i>Environmental Protection (Noise) Regulations 1997</i></p>
Monitoring general	<p>Works Approval condition 2.1.1 and 2.1.2</p> <p>Licence conditions</p>	<p>The Delegated Officer has specified ambient groundwater monitoring requirements under condition 2.1.2 of the Works Approval to ensure that baseline groundwater quality is obtained for the TSF and evaporation pond vicinity prior to the deposition of waste into these facilities. This will allow for the comparison of groundwater quality prior to, and following operation of these facilities to determine any impacts to groundwater from seepage.</p> <p>Condition 2.1.1 specifies the Australian Standards relevant to the collection of groundwater samples and that laboratory analysis is to be undertaken by a NATA accredited laboratory.</p> <p>Following the risk assessment for the pilot plant, the Delegated Officer has</p>	<p>Australian Standard AS/NZS 5667.1 – Water Quality – Sampling – Guidance on the Design of sampling programs, sampling techniques and the preservation and handling of samples</p> <p>Australian Standard AS/NZS 5667.11 – Water Quality – Sampling –</p>



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		determined that appropriate regulatory controls will include licence conditions requiring ambient groundwater monitoring at the TSF and evaporation pond (refer to Appendix B for risk assessment). Conditions on the licence will therefore include general monitoring conditions relating to applicable Australian Standards for the collection of samples, use of a NATA accredited laboratory to assess samples, and calibration and maintenance of monitoring equipment.	Guidance on the sampling of groundwaters
<b>Monitoring of inputs and outputs</b>	N/A	<b>Construction and Operation</b> The monitoring of inputs and outputs are not required for the construction or operational phases of the project.	N/A
<b>Process monitoring</b>	N/A  Licence condition	<b>Construction</b> Conditions requiring the monitoring of processes associated with the construction of the pilot plant will not be required on the Works Approval.  <b>Operation</b> The Delegated Officer will include the requirement to monitor the cumulative monthly volume of tailings deposited into the TSF and raffinate discharged to the evaporation pond as a process monitoring requirement of the operating licence.	N/A
<b>Ambient quality monitoring</b>	Works Approval condition 2.1.2  Licence conditions	<b>Construction</b> The Delegated Officer has specified ambient groundwater monitoring requirements under condition 2.1.2 of the Works Approval to ensure that baseline groundwater quality is obtained from the site of the TSF and evaporation pond prior to the deposition of waste into these facilities. This will allow for the comparison of groundwater quality prior to, and following operation of these facilities to determine impacts to groundwater from seepage, should it occur.  <b>Operation</b> Following the risk assessment for potential seepage from the TSF and	Australian Standard AS/NZS 5667.1 – Water Quality – Sampling – Guidance on the Design of sampling programs, sampling techniques and the preservation and handling of samples  Australian Standard AS/NZS 5667.11 – Water



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
		evaporation pond, the Delegated Officer has determined that appropriate regulatory controls will include licence conditions requiring ambient groundwater monitoring at the TSF and evaporation pond (refer to Appendix B for risk assessment).	Quality – Sampling – Guidance on the sampling of groundwaters
Meteorological monitoring	N/A	<b>Construction and Operation</b> Conditions relating to the monitoring of meteorological conditions at the premises are not required to be applied to the Works Approval or licence.	N/A
Improvements	N/A	<b>Construction and Operation</b> Conditions relating to improvements are not being applied to the Works Approval. The Delegated Officer will not be applying any improvement conditions to the operating Licence.	N/A
Information	Works Approval conditions 3.1.1 to 3.1.4  Works Approval condition 3.2.1	<b>Construction</b> The Delegated Officer has applied condition 3.1.1 to ensure that Northern Minerals submits a compliance document following the completion of construction of the pilot plant. Two construction stages have been specified to allow for the proposed TSF embankment lift. Condition 3.1.2 specifies the requirements that the compliance document must meet.  The Delegated Officer has applied condition 3.1.3, requiring the submission of a commissioning report one month prior to the completion of the three month commissioning period. Submission of the report prior to completion of the commissioning timeframe will allow DER to review the report and finalise the licence and associated decision document while the pilot plant continues to function under the Works Approval.  The Delegated Officer has applied condition 3.2.1, requiring Northern Minerals to notify the CEO of DER seven days prior to the commencement of commissioning, and within 7 days of the completion of commissioning.	N/A



DECISION TABLE			
Works Approval / Licence section	Condition number	Justification (including risk description & decision methodology where relevant)	Reference documents
	Licence conditions	<b>Operation</b> The Delegated Officer will apply conditions to the Licence relating to the submission of an Annual Audit Compliance Report to the CEO of DER, the calibration of monitoring equipment in accordance with manufacturer specifications and submission of an Annual Environmental Report containing the information collected from the monitoring conducted under the Licence.	
<b>Licence Duration</b>	Works Approval	The works approval will be issued for a period of three years, which is considered adequate as Northern Minerals has advised that construction of the pilot plant is anticipated to commence in April 2017. Construction should take approximately 12 months (Northern Minerals, 2017b).	Guidance Statement <i>Licence duration</i> (DER, August 2016)
	Licence	In accordance with the Guidance Statement <i>Licence duration</i> (DER, August 2016), the Delegated Officer will consider issuing the pilot plant operating licence for a period of 20 years.	





## 5 Advertisement and consultation table

Date	Event	Comments received/Notes	How comments were taken into consideration
17 November 2016	Application referred to interested parties <ul style="list-style-type: none"><li>Department of Water;</li><li>Department of Mines and Petroleum; and</li><li>Radiological Council of Western Australia</li></ul>	<b>Department of Water comments</b> Comments regarding potential impacts from drawdown and additional monitoring requirements to determine interconnection between the Browns Range Metamorphic and impacts to the hydrology of Banana Springs.  <b>Department of Mines and Petroleum</b> Advice that the Mining Proposal and Mine Closure Plan for the pilot plant were approved by DMP on 28 November 2016.  Radiation management in relation to the pilot plant was considered in the assessment of the Browns Range Project Management Plan, approved by the Resources Safety Division of DMP on 31 August 2016.	Comments noted. Drawdown impacts will be regulated by Department of Water under the Groundwater Operating Strategy, implemented under Northern Mineral's section 5C of the RIWI Act groundwater licence.  Comments noted.
21 November 2016	Application advertised in West Australian (or other relevant newspaper)	No comments received	N/A
21 November 2016	Application referred to Shire of Halls Creek	No comments received	N/A
20 January 2017	Proponent sent a copy of draft instrument	Refer to Appendix C – Northern Minerals comments	Refer to Appendix C



## 6 Risk Assessment

*Note: This matrix is taken from the DER Guidance Statement Risk Assessments (DER, November 2016)*

**Table 1: Emissions Risk Matrix**

Likelihood	Consequence				
	Slight	Minor	Moderate	Major	Severe
Almost Certain	Medium	High	High	Extreme	Extreme
Likely	Medium	Medium	High	High	Extreme
Possible	Low	Medium	Medium	High	Extreme
Unlikely	Low	Medium	Medium	Medium	High
Rare	Low	Low	Medium	Medium	High



## Appendix A

### Proposed activities

The Browns Range pilot plant will include both a beneficiation and hydrometallurgical process. The primary purpose of the beneficiation plant is to remove gangue (mainly silica) materials and increase the rare earth concentration prior to treatment in the hydrometallurgical plant. The beneficiation plant will process (on average) 60,000 tpa of ore at 1.19% TREO grade to produce approximately 3,200 tpa of mineral concentration at 20% TREO. This mineral concentrate will be further processed at the hydrometallurgical plant.

Northern Minerals has advised that mining is anticipated to commence in April 2017. The trial mine has a production period of about six months to provide the ore stockpile for the pilot processing plant and also material for construction of the TSF.

The general site layout, including the location of proposed groundwater monitoring bores is shown in Figure 3.

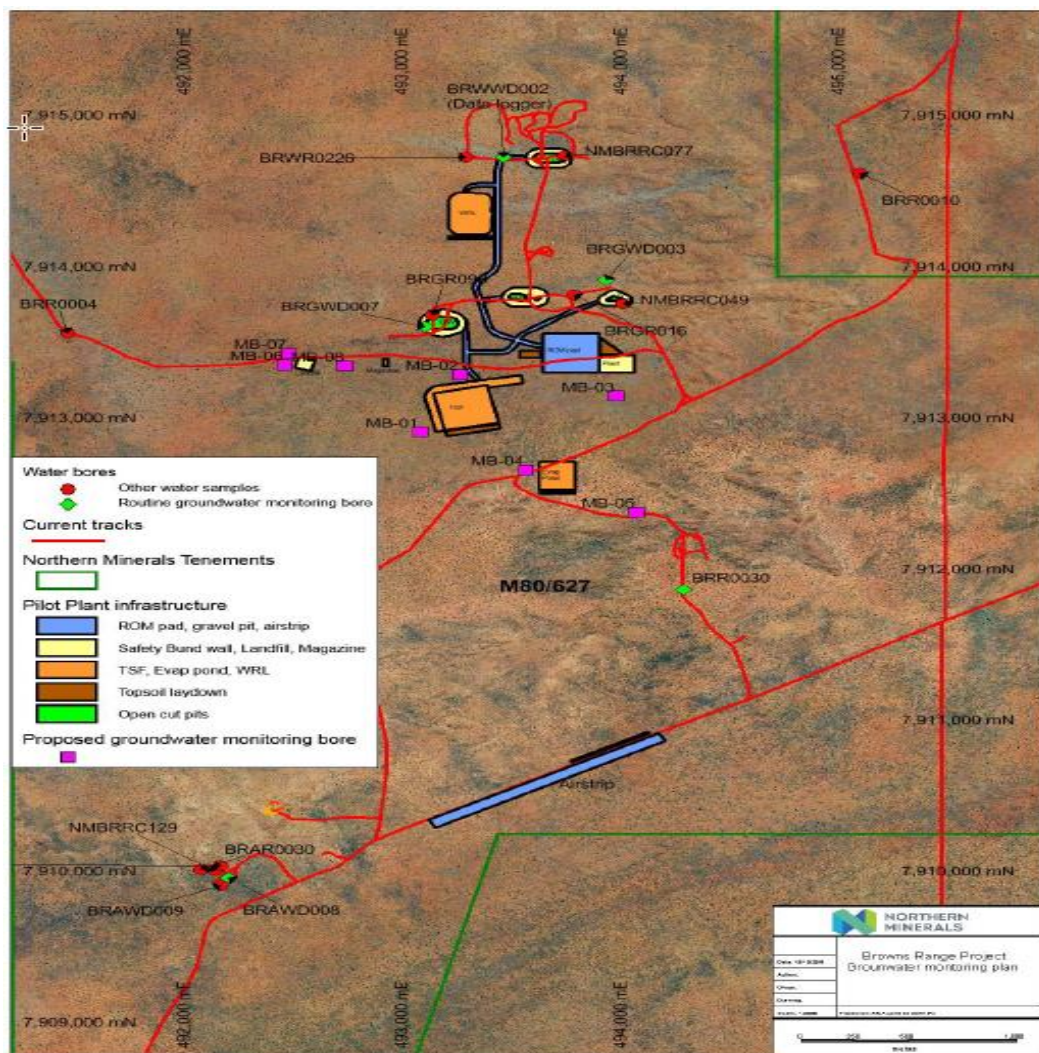


Figure 3. Proposed site layout



#### Beneficiation plant

ROM ore will be transported to the ROM pad where it will be stockpiled and blended to the desired grade. Ore stored at the ROM will be placed on a compacted engineered base. A front end loader will be used to reclaim the ore from the stockpile and transfer it to the ROM bin.

The beneficiation plant will comprise of:

- a primary crushing unit;
- semi-autogenous grinding (SAG) mill and a ball mill to reduce the particle size of the ore to 80% passing 63 µm;
- two stage wet high gradient magnetic separation process to produce magnetic concentrate rick in xenotime, and a non-magnetic stream containing largely silica and mica which is rejected as tailings;
- flotation circuit to produce a 20% TREO mineral concentrate; and
- thickening of the residue stream from the magnetic separation and flotation circuits, prior to combining with hydrometallurgical tailings for disposal in the TSF.

Flotation reagents (fatty acid), sodium silicate, caustic soda (sodium hydroxide) and flocculant will be used in the beneficiation process.

#### Hydrometallurgical plant

The hydrometallurgical plant will further process the 20% TREO mineral concentrate to extract rare earths and remove contaminants such as iron, phosphate and aluminium; and small amounts of thorium and uranium.

The hydrometallurgical plant process is described below:

- Mineral concentrate produced at the beneficiation plant will be reclaimed from bunkers with a bobcat, fed into a live bottom bin and screw conveyed into a dryer;
- The dry concentrate is then fed into an acid mixer to be mixed with 98% H<sub>2</sub>SO<sub>4</sub> and then to the kiln (the "sulfation bake" step). The sulfation bake is undertaken at a nominal 275 degrees Celsius, which cracks the xenotime mineral to allow the rare earths to be readily leached in water;
- Following the water leach step, the leach residue is washed, filtered and separated from the pregnant leach solution (PLS);
- The PLS undergoes a series of purification steps where the pH of the solution is steadily increased with lime and magnesium oxide to reject impurities such as phosphate, iron, aluminium, thorium and uranium;
- The solid purification residue is separated from the PLS by thickening and filtering, and the PLS is passed through an ion exchange column to remove any residual uranium. The purification residue is repulped and mixed with the repulped water leach residue before being combined with the beneficiation tailings and pumped to the TSF;
- Following purification and ion exchange, the PLS is contacted with sodium carbonate to precipitate the rare earths. The mixed rare earth carbonate is thickened, filtered, washed and dried before being bagged for export.

An estimated 1,200 tpa of mixed rare earth carbonate product containing around 52% TREO will be produced.

Sulfuric acid, sodium carbonate, quick lime, ferric sulfate, magnesium oxide, ion exchange resin, caustic soda (sodium hydroxide) and flocculant will be used in the hydrometallurgical process.

Surplus raffinate water produced at the hydrometallurgical plant is discharged to a high density polyethylene (HDPE) lined evaporation pond for disposal.



Rare earth concentrate product will be put into 1 tonne bulk bags for transport off site. There will be sufficient space in the hardstand container yard to provide for two months' storage of product.

#### Ore processing waste generation and storage

The main wastes resulting from the beneficiation and hydrometallurgical processing are:

- Solid, non-magnetic particulate residue from the magnetic separator, consisting mainly of silica and mica;
- Rejected gangue materials from the beneficiation plant flotation circuit;
- Water leach residues generated following the sulfation bake process;
- Purification residues generated following the purification process;
- Acidic waste water from the hydrometallurgical plant;
- Precipitates from the neutralisation of acid waste water; and
- Off gases from the waste gas scrubber.

In Attachment 3A of the works approval application Northern Minerals has advised:

*"The hydrometallurgical waste streams that undergo neutralisation include the sulphation bake waste gas scrubber bleed, precipitation barren solution, ion exchange waste solutions, purification effluent and potable water plant effluent. The solid precipitates generated from the neutralisation step are combined with the purification and water leach residues from the hydrometallurgical plant. This combined waste stream will be co-mingled with the beneficiation tails (comprising flotation tailings and WHGMS circuit tailings). The co-mingled beneficiation and hydrometallurgical tailings will be pumped to the TSF."*

#### Tailings Storage Facility

Waste and residue streams from the beneficiation and hydrometallurgical processes are combined in a mixing tank (there is no separate waste storages for the streams prior to the mixing tank) prior to being sent to the above ground TSF for disposal and storage. Mixing of the two streams will also occur in the pump and pipeline to the TSF.

Northern Minerals has stated (Northern Minerals, 2017a) that potential loss of containment of tailings streams in the processing plant will be minimised through the incorporation of the following controls:

- High level detectors in the mixing tank, which will be linked to a supervisory control and data acquisition (SCADA) control system;
- Automatic, variable speed pumps to maintain flow of material from the mixing tank to the TSF;
- Tailings pipework will be equipped with density and pressure detectors (also linked to the SCADA control system) to alert plant operators to blockages or loss of containment; and
- Concrete bunding to contain any spillages from the mixing tank or associated pipework.

As some components of the hydrometallurgical tailings are classified as radioactive material they will be managed under the Radiation Management Plan approved by DMP. The combined beneficiation and hydrometallurgical tailings is classified as non-radioactive. Over the course of the three year trial, approximately 198,000 tonnes of combined tailings will be produced and disposed of in the TSF. The characteristics of the tailings from each process is summarised Table 2 below.



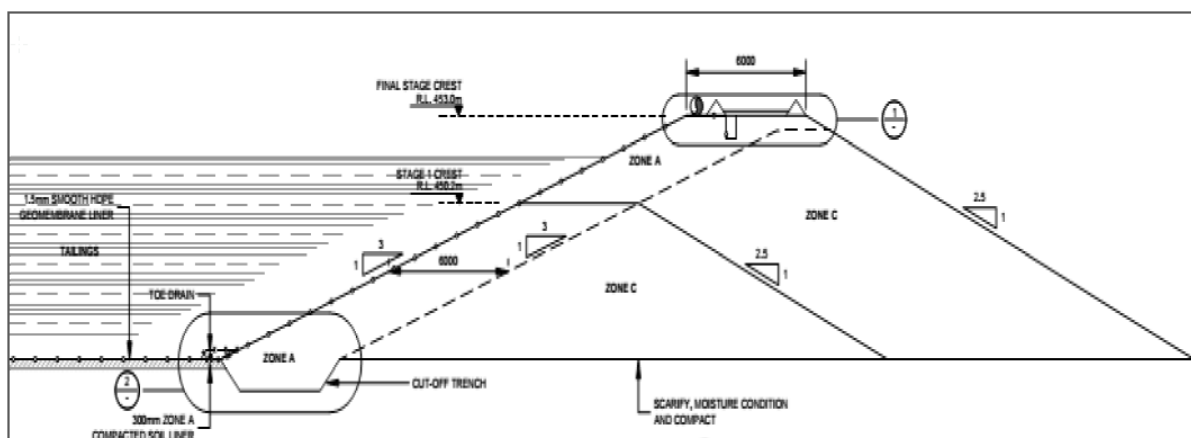
**Table 2. Tailings characteristics**

Source	Rate of deposition (tonnes/hour)	Characteristics
Beneficiation plant (90% of tailings mass)		
WHGMS circuit	10	Crushed and milled ore, no chemical processes
Flotation circuit		Crushed and milled ore, trace amounts of flocculation reagents
Hydrometallurgical plant (10% of tailings)		
Leach residue	1	Traces of sulfuric acid, some uranium and thorium and other elements
Purification residue		Contains iron, aluminium, thorium hydroxides and some uranium
Ion exchange (IX) residue		Contains low level uranium and thorium
Waste water treatment plant residue		Gypsum and remaining metals as hydroxides
Total	11	

The TSF will comprise of a single cell paddock storage, constructed as a multi-zoned earth and rockfill dam. It will be an integrated waste landform, using non-reactive waste rock from the Gambit open pits to construct the main embankment. Embankment raises will be undertaken using a downstream construction method. The first stage will be constructed to RL450.2 using mine waste and/or local borrow, providing for 12 months storage capacity. It is anticipated that in Year 2 of the trial the embankment will be raised to the final elevation of RL453.0, corresponding to a maximum embankment height of approximately 6 m.

Tailings will be deposited into the facility by sub-aerial deposition methods, via discharge points located at regular intervals along the embankment crest.

The TSF will be lined with a 1.5 mm thick HDPE geomembrane, underlain by a seepage collection system and a prepared, low permeability earthen base. The permeability of the proposed geomembrane will be less than  $1 \times 10^{-9}$  m/s. Figure 4 shows the typical TSF embankment cross section.

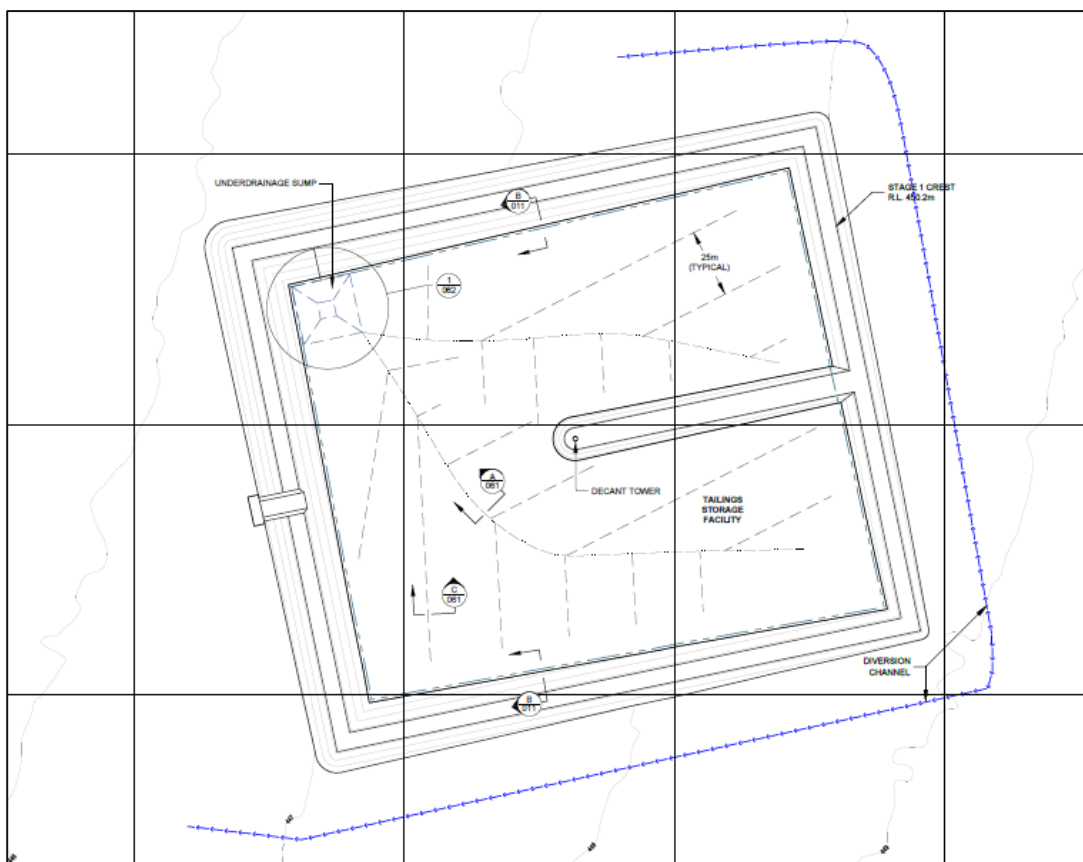


**Figure 4. TSF embankment cross section**



A single decant tower will be used to pump supernatant water from the TSF back to the processing plant for reuse.

Northern Minerals will be implementing an underdrainage system beneath the TSF to reduce seepage and an upstream toe drain to lower the potential phreatic surface adjacent to the embankment. The upstream toe drain and underdrainage system, drain by gravity to a collection sump located at the north-west corner of the TSF. Water recovered from the underdrainage and toe drain system will be pumped directly to the decant tower, from where it will go to the process plant for reuse (Knight Piesold, 2016). The underdrainage system is shown in more detail below (Figure 5).



**Figure 5. TSF underdrainage system and sump**

#### Evaporation pond

Northern Minerals is proposing to construct an HDPE lined evaporation pond facility, designed to evaporate surplus raffinate (liquid containing impurities from the waste water treatment plant) water produced at the hydrometallurgical plant. The embankment of the evaporation pond will be formed by constructing embankments to a height of 3.8 m, with a crest width of 4 m. The evaporation pond will have a top area of 0.84 hectares (ha) and an overall footprint of 1.52 ha.

Waste water will be discharged at a rate of approximately 3 m<sup>3</sup> per hour (approximately 18,000 m<sup>3</sup> per year) and the maximum operating water depth under average climatic conditions will be approximately 1.9 m. The embankment has been designed for average conditions plus an allowance of 300 mm depth below the spillway invert to store runoff from a 1 in 100 year 72 hour storm event, or the height to store a 1 in 100 wet year annual sequence to determine the spillway invert level. Based



on the maximum operating level for average climatic conditions, at most times the pond will have storage capacity available to contain all direct incident rainfall without the need for removing accumulated salts / sediments or de-sludging.

The raffinate will contain approximately 48,429.68 mg/L of dissolved solids; with more than 97% comprising of sodium sulfate, potassium sulfate and magnesium sulfate. Other minor constituents are listed in Table 3 below.

**Table 3. Typical raffinate composition**

Constituent	mg/L	% of solids	Constituent	mg/L	% of solids
Na <sub>2</sub> SO <sub>4</sub>	45717.89	94.40%	Ce <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	3.67	0.01%
K <sub>2</sub> SO <sub>4</sub>	828.05	1.71%	Sr(SO <sub>4</sub> )	2.73	0.01%
MgSO <sub>4</sub>	737.51	1.52%	Nd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	2.61	0.01%
Al <sub>2</sub> SiO <sub>3</sub>	335.36	0.69%	Sm <sub>2</sub> (SO <sub>4</sub> ) <sub>4</sub>	2.23	0.00%
Na <sub>2</sub> SiO <sub>3</sub>	184.56	0.38%	Ho <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	1.97	0.00%
Floc	144.31	0.30%	CuSO <sub>4</sub>	1.41	0.00%
MnSO <sub>4</sub>	116.91	0.24%	La <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	1.37	0.00%
Y <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	73.53	0.15%	Tb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	1.26	0.00%
NaOH	62.84	0.13%	Zr(SO <sub>4</sub> ) <sub>2</sub>	0.94	0.00%
NaCl	49.37	0.10%	Tm <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.81	0.00%
CoSO <sub>4</sub>	48.2	0.10%	K <sub>2</sub> SO <sub>3</sub>	0.72	0.00%
NiSO <sub>4</sub>	28.03	0.06%	Lu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.6	0.00%
Fe <sub>2</sub> SO <sub>4</sub>	24	0.05%	Pr <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.5	0.00%
Na <sub>3</sub> PO <sub>4</sub>	20.43	0.04%	Eu <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	0.39	0.00%
Na <sub>2</sub> SO <sub>3</sub>	9.52	0.02%	UO <sub>2</sub> SO	0.25	0.00%
Dy <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	9.18	0.02%	Ti(SO <sub>4</sub> ) <sub>2</sub>	0.23	0.00%
H <sub>2</sub> SiF <sub>6</sub>	8.28	0.02%	Sb <sub>2</sub> (SO <sub>4</sub> )	0.14	0.00%
MgCl <sub>2</sub>	7.57	0.02%	CaSO <sub>4</sub>	0.12	0.00%
Gd <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	5.54	0.01%	Th <sub>2</sub> SO <sub>8</sub>	0.11	0.00%
Er <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	5.46	0.01%	ZnSO <sub>4</sub>	0.1	0.00%
KHCO <sub>3</sub>	4.65	0.01%	PbSO <sub>4</sub>	0.01	0.00%
Mg(HCO <sub>3</sub> )	4.27	0.01%	BaSO <sub>4</sub>	0	0.00%
Yb <sub>2</sub> (SO <sub>4</sub> ) <sub>3</sub>	4.22	0.01%	Sn(SO <sub>4</sub> ) <sub>2</sub>	0	0.00%

#### Naturally occurring uranium and thorium

Northern Minerals appointed JRHC Enterprises Pty Ltd to develop a radiation technical report for the Browns Range Rare Earths Project. The primary guidance for radioactive materials is provided in national standards by the ARPANSA. ARPANSA guidance notes that material containing naturally occurring radionuclides in secular equilibrium, with head-of-chain uranium or thorium activity concentrations less than 1 Becquerel per gram (Bq/g) would generally be considered inherently safe and therefore exempt from regulation. 1Bq/g equates to 81 parts per million (ppm) uranium or 245 ppm thorium, and also applies to the combined activity if both decay chains are present (JRHC Enterprises Pty Ltd, 2014).

In Western Australia the primary legislation relating to radiation management is the *Radiation Safety Act 1975* and subsidiary legislation. Radiation is also subject to regulation under the *Mines Safety and Inspection Act 1994*. DMP has issued the NORM guidelines which provide detailed advice on radiation protection in mines.

Testing carried out by the Australian Science and Technology Organisation (ANSTO) has found that the Browns Range ore deposits contain naturally occurring uranium and thorium as oxides, at



concentrations of approximately 40 ppm and 30 ppm respectively. These concentrations are below the ARPANSA classification for radioactive material. Table 4 compares the radionuclide concentrations of material at Browns Range with the classification levels for radioactive material specified by ARPANSA and illustrates that the ore is below the classification for radioactive material.

**Table 4. Uranium and Thorium concentrations compared to guideline**

Material	Uranium		Thorium	
	(ppm)	(Bq/g)	(ppm)	(Bq/g)
Soils (above ore body)	1.2	0.02	11	0.05
Ore bodies (average)	40	0.05	30	0.12
Threshold of Classification as Radioactive	81	1.0	245	1.0

While ore is below the classification for radioactive material, Northern Minerals has advised that during the hydrometallurgical process some radionuclides are concentrated and therefore exceed the trigger for classification as 'radioactive material'. Concentrations of uranium and thorium in the hydrometallurgical tailings waste stream expected to reach 620 ppm and 240 ppm respectively (JRHC Enterprises Pty Ltd, June 2014). The beneficiation plant tailings are not classified as radioactive.

The Delegated Officer notes that the various residue streams from the hydrometallurgical plant will be combined into a single residue stream that will then be combined with the beneficiation tailings and directed to the TSF. Concentrations of uranium and thorium in the combined tailings will be similar to the ore (approximately 40 ppm uranium and 30 ppm thorium), meaning the combined tailings material will not be classified as a radioactive material (JRHC Enterprises Pty Ltd, June 2014).



## Appendix B – Premises operation

### Stormwater management – general

#### Emission Description

*Emission:* Stormwater from cleared/disturbed areas, stockpiled earthen materials and operational areas containing high sediment loads.

Stormwater contaminated by chemicals used in processing (flotation reagents (fatty acid), sodium silicate, caustic soda (sodium hydroxide), flocculent, sulfuric acid, sodium carbonate, quick lime, ferric sulfate, magnesium oxide and ion exchange resin), and hydrocarbons.

Stormwater from the hydrometallurgical plant potentially containing elevated concentrations of radionuclides.

*Impact:* Stormwater with high sediment loads discharging to surface drainage leading to downstream sedimentation, disrupting aquatic ecosystems through reduced primary production and/or direct impacts through the smothering of organisms and benthic habitats. Stormwater contaminated by chemicals/hydrocarbons causing soil, groundwater and surface water contamination; leading to ecosystem disruption.

The Project area lies within the Sturt Creek catchment, which flows to the southwest, ultimately discharging into Lake Gregory, approximately 220 km downstream of the site. Lake Gregory is recognised as a wetland of national importance under the *Directory of Important Wetlands in Australia* (DIWA).

*Controls:* Northern Minerals commissioned Golder Associates to develop a surface water management plan for Browns Range and has advised that surface water will be managed to reduce sediment in accordance with the design principles in this plan, specifically:

- Infrastructure is located above the 100 year annual recurrence interval (ARI) flood level, or appropriate protection is required;
- Runoff from undisturbed catchments upstream of the operational areas will be diverted away from operational areas into existing drainage lines;
- Diversion channels and bunds around mine infrastructure, including the process plant, TSF and waste rock landforms will be sized to withstand an event with a probability of exceedance of 20% over the life of the mine. For a nominal 4.5 year trial (3 year operating phase, plus and 18 month allowance for construction and rehabilitation), an exceedance probability of 20% corresponds to approximately a 1 in 20 year storm event; and
- Surface water runoff from waste rock landforms, ROM pad and external faces of the TSF will be directed to sediment detention ponds (Golder Associates, 2017).

Northern Minerals has advised of a number of controls to manage stormwater and/or prevent stormwater contamination:

- bunds will be used to divert stormwater away from operational and chemical storage areas;
- infrastructure located above the 100 year ARI flood level;
- quick lime, sodium carbonate, magnesium oxide and ferric sulfate will be delivered to the site as dry solids in 1 tonne bulka bags; and subsequently stored in a 20 foot sea container. Flocculant and ion exchange resin will be brought to site in 25 kg bags and also stored in a 20 foot sea container;
- caustic soda, sodium silicate and fatty acid collector will be delivered in 1,000 litre intermediate bulk containers (IBC) and stored in separate bunded areas;





- 3,200 tonnes per annum of sulfuric acid will be delivered to site via bulk road tanker and discharged into five dedicated 21,000 litre isotainer storage tanks, located in a separate bunded area;
- Diesel will be managed in accordance with Australian Standard 1940-2004. Hydrocarbon and reagent spills will be managed in accordance with site procedures; and
- Operations may cease or be reduced in the wet season, during which very limited stocks of fuels and reagents will be stored onsite. Sumps and bunds will be emptied prior to the wet season and the site will be manned at all times.

Stormwater in the process area and surrounding infrastructure will be managed by a combination of elevated terraces, stormwater cut-off drains and drainage channels. Clean water external to the processing areas will be diverted to natural drainage lines.

Stormwater within the plant area will be collected on raised terraces through an interconnected network of drainage channels that gravity flow into HDPE lined event ponds, designed to contain a 1 in 20 year return period, 24 hour rainfall event. Water in the event ponds will be evaporated or reused in the processing circuit. Water remaining in the event pond would be recovered prior to plant shut down at the onset of the wet season (Northern Minerals, 2016).

Spillage within the beneficiation plant will be controlled within the bunded area of each process building. Bunds will be equipped with pumps to return spillage back into the process; and will be provided with an overflow into a dedicated HDPE lined event-pond located adjacent to the area that will be sized to hold 110% of the largest volume or a 1 in 20 year return period, 24 hour storm event.

The hydrometallurgical plant will consist of a number of processing units each fitted with an integral spill tray, sump and spillage sump for spillage containment and the prevention of cross-contamination between adjacent process facilities. The individual spill trays and sumps will overflow into a dedicated HDPE lined event pond located adjacent to the area and sized to hold 110% of the largest volume or a 1 in 20 year return period, 24 hour storm event. The main pipe rack connecting individual components of the hydrometallurgical plant will be located above the concrete lined central drain that connects the units to the event pond.

Surface runoff or through flow at the ROM pad, the Wolverine waste dump and the external TSF embankments will be captured in detention ponds to remove sediment. Detention ponds will be designed to contain a 1 in 20 year rainfall event. Leachability testing carried out on representative samples of waste rock and ore has generally found that trace element concentrations in samples subjected to leaching by water are low and none of the leachable concentrations exceeded the ANZECC water quality guideline values for water used for watering livestock.

The closest ephemeral drainage line is 2 km from the project area and there are no permanent water bodies within the proposed project area. The main water course of Sturt Creek is located approximately 45 km west/northwest of the site and is also classified as an ephemeral system. Groundwater is located approximately 14 mbgl. Groundwater in the area is fresh to slightly brackish, with a near-neutral pH and very low concentrations of dissolved metals.

#### Risk Assessment

*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively), depth to groundwater (14 mbgl) and the potential stormwater contaminants, and determined that stormwater runoff will have low-level onsite impacts and minimal offsite impacts. Therefore, the Delegated Officer considers the consequence to be minor.



*Likelihood:* The Delegated Officer has considered the proponent controls (diversion channels/bunds, sediment detention ponds, individual bunding of processing units, processing spillage containment in HDPE event ponds, infrastructure above the 100 ARI flood level, appropriate chemical/diesel storage) and determined that adverse impacts to the environment from stormwater runoff will not occur in most circumstances.

With respect to stormwater from the hydrometallurgical plant, the Delegated Officer considers the proposed operator controls (spill trays, concreted lined central drain and the lined event ponds etc.) are appropriate to prevent stormwater containing radionuclides from discharging to the environment. Therefore, the Delegated Officer considers the consequence to be unlikely.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for stormwater runoff during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with stormwater runoff is acceptable, subject to appropriate operational regulatory control. Regulatory controls may include licence conditions for the siting of stormwater infrastructure and/or infrastructure operating requirements; including maintenance of the external drainage infrastructure, freeboard and liner requirements for the event ponds and infrastructure inspection requirements.

A condition requiring the stormwater event ponds at the beneficiation and hydrometallurgical plants to be emptied prior to the commencement of the wet season will also be applied to the licence.

The Delegated Officer has determined that a general licence condition relating to the immediate recovery or removal of spills outside of containment areas may be applied to the licence, minimising the likelihood of stormwater contamination.

#### Residual Risk

*Consequence:* Minor

*Likelihood:* Unlikely

*Risk Rating:* Medium

#### **Tailings storage facility – abnormal operation (seepage)**

##### Emission Description

*Emission:* Seepage of tailings leachate in event of liner breach.

*Impact:* Groundwater contamination, impacts to ecosystems receiving groundwater in the area. Deterioration of water quality impacting on stock health.

*Controls:* Northern Minerals has advised that the TSF will be constructed with a compacted soil base and a HDPE geomembrane liner on the base and embankments to achieve a permeability of  $1 \times 10^{-9}$  m/s. The soil base will comprise primarily in-situ soils, scarified and re-compacted through the TSF basin to form a 300 mm thick soil subgrade. The 1.5 mm smooth HDPE geomembrane liner is expected to achieve overfall seepage performance of less than 4kL per hectare per day (Knight Piesold, 2016).

An underdrainage collection system, designed to reduce the phreatic surface on the tailings basin, will be constructed. This drainage system will minimise seepage, and increase the density of tailings to maximise storage potential. The underdrainage system will be constructed above the HDPE liner and will consist of two drainage networks, branch drains and finger drains. The finger drains will be



spaced at approximately 25 m and will connect to the branch drains. The branch drains will feed directly into the underdrainage collection sump located at the upstream toe of the embankment. The branch and finger drains will be corrugated, perforated tubing surrounded by sand and wrapped in geotextile which will be continuously seamed or heat welded (Knight Piesold, 2016).

A toe drain will be constructed along the upstream toe of the embankment to increase the stability of the embankment by providing drainage at the embankment. It will also act as an underdrainage collection pipe.

The underdrainage collection sump will collect seepage from the toe drains and underdrainage system (finger and branch drains). It will comprise an excavated sump, filled with clean gravel wrapped in geotextile, located on top of the HDPE geomembrane liner against the upstream toe of the embankment (Knight Piesold, 2016). A pump will be used to direct water from the collection sump to the decant tower, from where it will be sent to the process plant waste water treatment plant. The treated water from the waste water treatment plant will then be sent to the beneficiation plant water tank for reuse throughout the plant (Northern Minerals, 2017a).

Deposition will occur from multiple discharge points and deposition locations will be moved progressively along the line to control the location of the supernatant pond. After initial establishment of the tailings beaches, a suitable cycle time will be determined to ensure even deposition of tailings around the facility, thereby maintaining the supernatant pond at the decant tower and maintaining the formation of tailings beaches. Sub-aerial tailings deposition allows for maximum amount of water removal through the formation of a large beach for drying and draining (Knight Piesold, 2016).

Groundwater is located approximately 14 mbgl at the location of the proposed TSF. The nearest ephemeral creek is located approximately 2 km from the TSF and Sturt Creek is located approximately 45 km from the premises.

During the beneficiation process some radionuclides will concentrate and may exceed the trigger for classification as 'radioactive material', with concentrations of uranium and thorium in the beneficiation concentrate expected to reach 620 ppm and 240 ppm respectively (JRHC Enterprises Pty Ltd, June 2014).

The hydrometallurgical plant will produce tailings with low level radiation levels. Beneficiation tailings are not classified as radioactive. Northern Minerals has advised that the overall activity of the co-mingled tailings will not exceed an overall average radioactivity concentration of 1 Becquerel per gram, the level at which materials are considered to warrant some form of radiological assessment and control (ARPANSA, 2005).

The Delegated Officer notes that the various residue streams from the hydrometallurgical plant will be combined into a single residue stream that will then be combined with the beneficiation tailings and directed to the TSF. Concentrations of uranium and thorium in the combined tailings will be similar to the ore (approximately 40 ppm uranium and 30 ppm thorium), meaning the combined tailings material will not be classified as a radioactive material (JRHC Enterprises Pty Ltd, June 2014).

Leachability testing carried out on representative samples of waste rock and ore has generally found that trace element concentrations in samples subjected to leaching by water are low and none of the leachable concentrations exceeded the ANZECC water quality guideline values for water used for watering livestock. Ecotoxicological testing was carried out on the tailings materials to evaluate the risk of environmental hazard associated with loss of containment, for example from a pipeline or embankment cell failure. Results from this assessment demonstrated that the highest concentrations of tailings constituents generated in acute aquatic toxicity tests did not exceed the selected aquatic toxicity benchmarks (Golder Associates, 2015), which for the purposes of this assessment were the



ANZECC (2000) 95% species protection trigger values for freshwater. This means that the tailings are “not classifiable as an environmentally hazardous substance”.

The Delegated Officer notes that waste rock samples from the area were subjected to chemical analysis to compare their chemical composition to the Global Abundance Index (GAI) for elements in the earth's crust. Samples were also subjected to static testing to determine the risk of acid drainage being produced, and to short-term leaching tests with deionised water to determine the risk of potentially toxic chemical constituents being leached into groundwater.

Testing of representative samples of waste rock found that only boron and possibly selenium are present in the waste rock at concentrations exceeding a GAI value of 3, which is commonly taken to represent significant enrichment (compared to average crustal abundances). The static testing suggested that although total sulfur levels in rocks at the site were generally very low, the acid neutralising capacity of the rocks was also low. Consequently, some samples were shown to be potentially acid forming. Additionally, although many samples were considered to be “non-acid forming” they plotted very close to the boundary between “acid forming” and non-acid forming” on a NAG pH versus NAPP plot (SRK Consulting, 2013). The Delegated Officer notes that there is a significant degree of uncertainty about how these materials will behave after a prolonged period of weathering. Further, longer term kinetic testing is required to determine the leaching characteristics of waste rocks after the materials have been subjected to a prolonged period of weathering.

Data from the geochemical testing indicate that mercury, thallium and gadolinium have the potential to reach levels that may adversely affect the suitability of groundwater for livestock (and wildlife) water supply if leachate from waste rock and tailings were to percolate to groundwater.

With respect to longer term kinetic testing, the Delegated Officer notes that in the Report and recommendations of the EPA Report 1523 for the Browns Range Rare Earths Project, the EPA provided advice to DMP that further geochemical testing will need to be undertaken at the site, including longer term kinetic humidifier tests, for example, 48 month tests. These tests will determine what the long-term leachate will likely contain and will be particularly useful for modelling post-closure scenarios for the pit lakes and waste landform (EPA, 2014). Northern Minerals has advised DER that longer term kinetic testing will commence once bulk samples are obtained at the commencement of mining (Northern Minerals, 2016).

Northern Minerals has indicated that monitoring bores upstream and downstream of the TSF will be installed to identify if seepage from the TSF is occurring. Monthly monitoring of groundwater levels will be undertaken, while groundwater chemistry (major component analysis – pH, total dissolved solids, major cations and anions, aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, lead, thorium, tin, uranium, vanadium and zinc) will be undertaken quarterly.

Monitoring bores will comprise one shallow bore (5-10 m of the near surface horizon) to detect any seepage from the TSF within the surface sediment and a deep bore to monitor any changes in the chemical composition of the groundwater. Each borehole will be cased and screened over an interval set in the field during installation and sealed back to surface with low permeability grout. Monitoring boreholes will be constructed prior to commissioning of the TSF to accumulate background data specific to the storage location.

Northern Minerals has advised in their application that daily inspections of the drainage blanket outflow, tailings and water levels, size and location of decant pond, outflow from decant, tailings quantity discharged and tailings density will be undertaken, including during the wet season.

#### Risk Assessment



*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively), depth to groundwater (14 mbgl), and the extended timeframe that the TSF will be in existence, and determined that potential seepage from the TSF could have mid-level onsite impacts and low level offsite impacts at a local scale with minimal off-site impacts at a wider scale. Therefore, the Delegated Officer considers the consequence to be moderate.

*Likelihood:* The Delegated Officer has considered the proponent controls (compacted soil base, HDPE liner, underdrainage system, decant tower for removal of supernatant water, daily inspections) and determined that adverse impacts to the environment from TSF seepage will not occur in most circumstances. Therefore, the Delegated Officer considers the consequence to be unlikely.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for TSF seepage during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with potential seepage from the TSF is acceptable, subject to appropriate operational regulatory controls. Regulatory controls applied to the operating licence may include infrastructure requirements relating to TSF freeboard, and infrastructure inspections (tailings delivery lines, return water lines, tailings deposition, TSF ponding, internal embankment freeboard). These controls are consistent with the proposed operator controls, considered by the Delegated Officer in the risk assessment for TSF seepage.

Background water quality is required to be established prior to tailing deposition.

The Delegated Officer has imposed monthly ambient groundwater monitoring for the field parameters below onto the licence to detect if seepage is occurring. Potential impacts on groundwater which has potential to be used for stock watering will then require the analysis of the following major ions, metals and radiological constituents on a 6 monthly basis (or immediately should field parameters be detected to have increased from established levels):

- Field parameters: pH, electrical conductivity, redox potential, total acidity, total alkalinity;
- Major ions: sodium, potassium, calcium, magnesium, chloride, sulfate and bicarbonate; and
- Metals: cadmium, zinc, cobalt, mercury, nickel, selenium, thallium and gadolinium.

#### Residual Risk

*Consequence:* Minor

*Likelihood:* Unlikely

*Risk Rating:* Medium

#### **Tailings storage facility – emergency situation (overtopping/embankment failure)**

##### Emission Description

*Emission:* Overtopping of TSF, embankment failure resulting in discharge of tailings material and supernatant water into the environment.

*Impact:* Groundwater contamination, impacts to ecosystems receiving groundwater in the area. Deterioration of water quality impacting on stock health. Surface discharge to drainage lines, impacts to aquatic ecosystems and biota. Impacts to vegetation.

*Controls:* Northern Minerals has advised that a 300 mm freeboard will be maintained on the TSF. The TSF has been designed to contain storm events during operation up to and including an annual exceedance probability (AEP) of 1:100, on top of the predicted maximum pond level under average





climatic conditions. In the event that the storage capacity during operation of the facility is exceeded, water will be discharged via an engineered spillway. The emergency spillway is designed to convey runoff from a 1:100,000 AEP critical duration storm, assuming that the decant pond level is at the spillway invert level at commencement of the storm event (Knight Piesold, 2016).

The TSF has been designed in accordance with the Australian National Committee on Large Dams (ANCOLD) guidelines and geotechnical stability analysis of the proposed design demonstrate an acceptable factor of safety for both static and dynamic loading.

As previously described, ecotoxicological testing was carried out on the tailings materials to evaluate the risk of environmental hazard associated with loss of containment. The outcome of this assessment was tailings at Browns Range are “not classifiable as an environmentally hazardous substance”.

Groundwater is located approximately 14 mbgl at the location of the proposed TSF. The nearest ephemeral creek is located approximately 2 km from the TSF and Sturt Creek is located approximately 45 km from the premises.

Northern Minerals has advised that daily checks of available freeboard will be undertaken; and weekly checks of the toe drains and embankments for evidence of erosion, slippage or cracks will be undertaken.

#### Risk Assessment

*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively) and depth to groundwater (14 mbgl), and determined that overtopping of the TSF or embankment failure would have midlevel onsite impacts and low level offsite impacts at a local scale. Therefore, the Delegated Officer considers the consequence to be moderate.

*Likelihood:* The Delegated Officer has considered the proponent controls (TSF spillway, frequent freeboard and embankment inspections, and adequate facility design) and determined that adverse impacts to the environment from overtopping/rupture of TSF embankment will only occur in exceptional circumstances. Therefore, the Delegated Officer considers the consequence to be possible.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for overtopping or embankment failure of the TSF during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with an embankment breach/overtopping of the TSF is acceptable, subject to appropriate operational regulatory control. Regulatory controls may include licence conditions requiring the maintenance of sufficient freeboard, daily visual inspection of freeboard and weekly inspections of toe drain and embankment, consistent with the proposed operator controls.

#### Residual Risk

*Consequence:* Moderate

*Likelihood:* Unlikely

*Risk Rating:* Medium



### **Tailings storage facility – emergency situation (pipeline rupture)**

#### Emission Description

*Emission:* Rupture of tailings and decant water pipelines resulting in discharge of tailings material and supernatant water into the environment.

*Impact:* Groundwater contamination, impacts to ecosystems receiving groundwater in the area. Deterioration of water quality impacting on stock health. Surface discharge to drainage lines, impacts to aquatic ecosystems and biota.

*Controls:* Northern Minerals has advised that tailings delivery and decant return pipelines will be contained within an earthen bunded trench between the process plant and TSF. Pipelines will be equipped with an automatic pressure drop cut-out and daily inspections of pipelines will be undertaken.

The specifications for the tailings and return water pipelines will be as followings:

- Tailings pipeline - 63 mm HDPE pipe (SDR11 PE100 PN16 – nominal working pressure of 1.6 megapascal (MPa)); and
- Return water pipeline - 40 mm HDPE pipe (SDR11 PE80 PN12.5).

The pipelines will be installed in accordance with the relevant provisions of Australian/New Zealand Standard AS/NZS 2033:2008 *Installation of polyethylene pipe systems*.

As previously described, ecotoxicological testing was carried out on the tailings materials to evaluate the risk of environmental hazard associated with loss of containment. The outcome of this assessment was tailings at Browns Range are “not classifiable as an environmentally hazardous substance”.

Groundwater is located approximately 14 mbgl at the location of the proposed TSF. The nearest ephemeral creek is located approximately 2 km from the TSF and Sturt Creek is located approximately 45 km from the premises.

#### Risk Assessment

*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively) and depth to groundwater (14 mbgl), and determined that discharges of tailings and/or return water in the event of a pipeline rupture will have low level onsite impacts and minimal offsite impacts. Therefore, the Delegated Officer considers the consequence to be minor.

*Likelihood:* The Delegated Officer has considered the proponent controls (pipeline bunding, automatic cut-out and daily inspections) and determined that adverse impacts to the environment from tailings/return water discharged in the event of a pipeline rupture will not occur in most circumstances. Therefore, the Delegated Officer considers the consequence to be possible.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for TSF and return water pipeline ruptures during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with tailings and/or return water discharged as a result of a pipeline rupture is acceptable, subject to appropriate operational regulatory control. Regulatory controls may include licence conditions relating to the implementation of automatic cut-outs on pipelines and daily inspections of tailing delivery and return water pipelines.



Residual Risk

*Consequence:* Minor

*Likelihood:* Possible

*Risk Rating:* Medium

**Evaporation pond – abnormal operation (seepage)**

Emission Description

*Emission:* Seepage of raffinate in event of liner breach.

*Impact:* Groundwater contamination, impacts to ecosystems receiving groundwater in the area. Deterioration of water quality impacting on stock health.

*Controls:* The pond will be constructed with a compacted soil base and lined with a 1.5 mm thick HDPE geomembrane liner, which has a designed hydraulic conductivity of  $1 \times 10^{-9}$  m/s (Knight Piesold, 2016).

The typical concentration of thorium in raffinate is 0.06 mg/L. The typical concentration of uranium in raffinate is 0.16 mg/L, which compares with the ANZECC, 2000 livestock drinking water guideline for uranium of 0.2 mg/L. There is no comparable published value for thorium for livestock drinking water (Northern Minerals, 2017a).

Groundwater is located approximately 14 mbgl at the location of the proposed evaporation pond. The nearest ephemeral creek is located approximately 2 km from the evaporation pond and Sturt Creek is located approximately 45 km from the premises.

Northern Minerals has advised that two monitoring bores, one upstream and one downstream, will be installed at the evaporation pond. Each monitoring location will comprise of one shallow bore (5-10 m of the near surface horizon) to detect any seepage from the evaporation pond within the surface sediment and a deep bore to monitor any changes in the chemical composition of the groundwater. Each borehole will be cased and screened over an interval set in the field during installation and sealed back to surface with low permeability grout. Monitoring boreholes will be constructed prior to commissioning of the evaporation pond to accumulate background data specific to the storage location.

Northern Minerals will conduct monthly monitoring of groundwater levels, while groundwater chemistry (major component analysis – pH, total dissolved solids, major cations and anions, aluminium, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, manganese, molybdenum, nickel, lead, thorium, tin, uranium, vanadium and zinc) will be undertaken quarterly.

Northern Minerals has advised that embankments will be inspected daily for evidence of seepage.

Risk Assessment

*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively) and depth to groundwater (14 mbgl), and determined that raffinate seepage will have mid-level onsite impacts, low-level on-site impacts at a local scale and minimal offsite impacts at a wider scale. Therefore, the Delegated Officer considers the consequence to be moderate.

*Likelihood:* The Delegated Officer has considered the proponent control (compacted soil base under and HDPE liner) and determined that adverse impacts to the environment from evaporation pond



seepage could occur at some time. Therefore, the Delegated Officer considers the consequence to be possible.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for seepage from the evaporation pond during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with seepage from the evaporation pond is acceptable, subject to appropriate operational regulatory controls. Regulatory controls may include licence conditions relating to siting of containment infrastructure and requirements relating to liner permeability, consistent with the proposed operator controls considered in the risk assessment.

Ambient groundwater monitoring requirements will be applied to the licence to determine if seepage is impacting on groundwater quality.

#### Residual Risk

*Consequence:* Minor

*Likelihood:* Unlikely

*Risk Rating:* Medium

### **Evaporation pond - emergency situation (overtopping, loss of containment)**

#### Emission Description

*Emission:* Overtopping of evaporation pond, embankment failure or pipeline rupture resulting in discharge of raffinate into the environment.

*Impact:* Groundwater contamination, impacts to ecosystems receiving groundwater in the area. Deterioration of water quality impacting on stock health. Surface discharge to drainage lines, impacts to aquatic ecosystems and biota.

*Controls:* The embankment of the pond has been designed for average conditions plus an allowance of 300 mm depth below the spillway to store runoff from a 1 in 100 year 72 hour storm event.

The evaporation pond will be operated to maximise the area of water and thus evaporation losses. The average operating depth will be 1.9 m.

Northern Minerals has advised that raffinate pipelines will be contained within an earthen banded trench between the process plant and evaporation pond. Pipelines will be equipped with an automatic pressure drop cut-out. Pipeline specifications are 40mm HDPE pipe (SDR11, PE100 PN10).

Groundwater is located approximately 14 mbgl at the location of the proposed evaporation pond. The nearest ephemeral creek is located approximately 2 km from the evaporation pond and Sturt Creek is located approximately 45 km from the premises.

Northern Minerals has advised that daily checks of pipelines, available freeboard and discharge volumes will be undertaken.

DMP approved the Mining Proposal for the Browns Range pilot plant on 28 November 2016. The evaporation pond design would have been assessed as part of DMPs review of the Mining Proposal.

#### Risk Assessment



*Consequence:* The Delegated Officer has considered the distance to the nearest ephemeral creek and Sturt Creek (approximately 2 km and 45 km away respectively), depth to groundwater (14 mbgl) and quality of the raffinate liquid, and determined that unplanned discharges due to overtopping or loss of containment will have low level onsite impacts and minimal offsite impacts. Therefore, the Delegated Officer considers the consequence to be minor.

*Likelihood:* The Delegated Officer has considered the proponent controls (300 mm pond operating freeboard, evaporation losses maximised through appropriate operating depth, daily inspections of pipelines and operating freeboard, pipeline cut outs, emergency spillway) and determined that the likelihood of adverse impacts to the environment from raffinate discharging due to overtopping or loss of containment could occur at some time. Therefore, the Delegated Officer considers the consequence to be possible.

*Risk Rating:* The Delegated Officer has compared the consequence and likelihood ratings described above through the Risk Rating Matrix (Table 1) and determined the overall rating of risk for evaporation pond overtopping or loss of containment during operation to be **medium**.

#### Regulatory Controls

The Delegated Officer has determined that the risk associated with the evaporation pond overtopping or losing containment is acceptable, subject to appropriate operational controls as committed to by Northern Minerals. Regulatory controls applied to the licence may include conditions relating to siting of infrastructure, daily visual inspections of the pond freeboard and pipelines and implementation of automatic pipeline cut outs.

#### Residual Risk

*Consequence:* Minor

*Likelihood:* Possible

*Risk Rating:* Medium





## Appendix C

### Northern Minerals comments on draft Decision Report and Works Approval, dated 7 February 2017 (Northern Minerals, 2017b) and DER response

#### Assessed design capacity and Approved premises production or design capacity

##### **Northern Minerals state:**

That they aim to process approximately 180,000 tonnes of ore during the three year pilot trial. This value assumes that the pilot plant is operating at capacity between 9 and 10 months of the year. If the pilot plant was operated 12 months of the year, the throughput would be about 80,000 tonnes per year. Northern Minerals have requested the design capacity be changed from 60,000 tonnes per year to 80,000 tonnes per year to allow for year to year variability in production.

##### **DER response:**

The design capacity for Category 5 within the decision document and works approval has been changed to 80,000 tonnes per annual period.

#### Operating period

##### **Northern Minerals state:**

The decision document states that the pilot plant operations may cease during the wet season. Northern Minerals have provided clarification for the proposed reduction or cessation of the pilot plant operations during the wet season. This relates to the difficulty of road-based transport during very rainy periods. Northern Minerals expects that poor road conditions will mean that operations may be interrupted for at least two months each year, but this is naturally dependent on the weather. If weather conditions permit, operations could continue throughout the summer months.

##### **DER response:**

The decision document has been updated to clarify this.

#### Surface water management plan

##### **Northern Minerals state:**

The decision document and works approval reference a surface water management plan, which was based on the full scale operation. Northern Minerals commissioned an updated surface water management plan for the smaller scale pilot plant.

##### **DER response:**

DER has reviewed the updated surface water management plan for the pilot plant. References made within the decision document and works approval to the Golder Associated, 2015 surface water management plan have been changed to Golder Associates, 2017 and the updated surface water management plan.

#### Tailings and waste rock geochemistry

##### **Northern Minerals state:**

The decision document needs to carefully differentiate between properties of waste rock, ore and tailings. Appendix B Tailings storage facility – abnormal operation (seepage) details tailings deposition. Northern Minerals therefore assumes that waste rock used to construct the TSF is being considered here, based on this statement within the decision document *“It is noted that these tests suggest that only rare earth elements and selenium are present in rocks at levels that exceed the GAI values for measured elements”*. Northern Minerals have stated that a correct statement about waste rock would be *“Testing of representative samples of waste rock found that only boron and possibly selenium are present in waste rock at concentrations exceeding a GAI value of 3, which is commonly taken to represent significant enrichment (compared to average crustal abundances)”*.



**DER response:**

The decision document has been updated to remove *"It is noted that these tests suggest that only rare earth elements and selenium are present in rocks at levels that exceed the GAI values for measured elements"* and replaced with *"Testing of representative samples of waste rock found that only boron and possibly selenium are present in waste rock at concentrations exceeding a GAI value of 3, which is commonly taken to represent significant enrichment (compared to average crustal abundances)"* as proposed by Northern Minerals.

**Northern Minerals state:**

In reference to the *"Additionally, the Delegated Officer notes that GAI values are not necessarily a good indicator of whether particular chemical constituents will be leached at potentially harmful concentrations into soil pore water under specific geochemical conditions"*, that they did not (and would not) use GAI values as an indication of leachability. Standard leachability tests have been conducted on waste rock and tailings. Standard ecotoxicity tests have also been carried out on tailings.

**DER response:**

The statement *"Additionally, the Delegated Officer notes that GAI values are not necessarily a good indicator of whether particular chemical constituents will be leached at potentially harmful concentrations into soil pore water under specific geochemical conditions"* has been removed from the decision document.

**Northern Minerals suggests:**

That the statement *"Information on the potential leachability of elements under the geochemical conditions present in waste rock at the Browns Range sites suggests that fluoride, cadmium, zinc, cobalt, mercury, nickel, antimony, selenium and thallium could have elevated concentrations in leachate after a prolonged period of leaching (Smith, 2007)"* be deleted as it is unhelpful and misleading. Northern Minerals state that the article by Smith, 2007 is a very general introduction to mineral geochemistry and should not be used to infer or suggest waste rock geochemical behaviour at Browns Range. The decision document should rely on interpretation of relevant technical investigations conducted for Browns Range (Attachments 9I and 9C of the works approval application).

**DER response:**

The above statement has been removed from the decision document. DER reviewed the data from the geochemical testing, which indicated that mercury, thallium and gadolinium have the potential to reach levels that may adversely affect the suitability of groundwater for livestock (and wildlife) water supply if leachate from waste rock and tailings were to percolate to groundwater, so a statement to this effect has been added to the decision document.

**Northern Minerals suggests:**

That the statement *"Of these elements, only zinc, cobalt, nickel, antimony and thallium have been assessed in the geochemical testing program for Browns Range"* be deleted given the comment above. Leachability results for mercury and selenium in waste rock are provided in the Intertek report. Northern Minerals have stated that both mercury and selenium were not detected above the analytical limit of reporting.

**DER response:**

The above paragraph has been removed from the decision document.

**Northern Minerals suggests:**

That the statement *"of the elements which have ANZECC (2000) stock water criteria, only mercury is considered to have the potential to exceed the stock water criterion of 2 µg/L after seepage has"*



*infiltrated through the unsaturated zone and has mixed with and been diluted by groundwater. Thallium also has the potential to adversely affect the quality of stock water. Although thallium does not currently have a stock water criterion set in the ANZECC (2000) guidelines, it is known to be highly toxic when present in elevated concentrations in potable water. Consequently, the Department of Health has set an interim guideline value of 0.5 µg/L for thallium in potable water” be deleted as it is uncertain whether the description is for testing of waste rock or tailing. In either case, they dispute the conclusion that there is potential for seepage from the TSF to result in exceedance of ANZECC guideline values for mercury in water used for livestock on the basis that none of the geochemical test results for the materials at Browns Range support this conclusion.*

Northern Minerals also state that the comments about thallium are speculative, not factual. Measured concentrations of thallium in leachate from Browns Range waste rock, ore and tailings were presented in the works approval application. All measured concentrations in leachate were at least an order of magnitude lower than the “interim guideline value” cited in the decision document.

**DER response:**

The above paragraph has been removed from the decision document.

**Northern Minerals suggests:**

*That the statement “Given that the short term leaching tests carried out indicate that thallium levels were in the range of 10-20 µg/L, there is the potential for this element to exceed a concentration of 0.5 µg/L in groundwater near waste rock dumps and tailings storage areas when leachate from these materials mixes with groundwater” be deleted as it is not clear whether the reference is to the testing of tailings or waste rock. In either case, the decision document is mistaken as the highest concentration of thallium reported in any leachate sample (in this case tailings sample) was 0.02 µg/L.*

**DER response:**

The above paragraph has been removed from the decision document.

**Northern Minerals states:**

*In reference to “The leaching study indicates that elevated concentrations of rare earth elements are likely in TSF leachate (Golder Associates, 2015). This group of elements is known to be toxic to a wide range of organisms (Pagano et al., 2015) with the toxicity generally increasing with their atomic number. There are currently no ANZECC trigger values for these elements, although a preliminary criterion of 4 µg/L has been established to protect aquatic ecosystems from lanthanum contamination (Herrmann, et al., 2016). The Delegated Officer notes that leachate concentrations of rare earth elements are generally being less than 100 µg/L, which means that levels of most rare earth elements in groundwater would unlikely reach levels of potential concern for livestock drinking water unless there was a significant decrease in the pH of leachate from the waste rocks. An exception to this is gadolinium (Gd) which had leachate concentration in excess of 1 mg/L in some samples”, that the ecotoxicological study by Golder did not show “elevated” concentrations of rare earth elements in TSF leachate. That in fact, the Golder reports said very little about rare earth element concentrations in leachate (with the exception of yttrium), because initial screening tests show the concentrations of rare earth elements in tailings are low.*

Northern Minerals also state that the comments about gadolinium concentrations are incorrect. The highest concentration of gadolinium observed in leachate (from a sample representative of the Wolverine ore zone) was 2.199 µg/L. The highest concentration of gadolinium observed in tailings leachate was 3.146 µg/L.

**DER response:**

The above paragraph has been removed from the decision document.



**Northern Minerals requests:**

That DER reviews the proposed monitoring suite below considering the comments provided by Northern Minerals for tailings and waste rock geochemistry above:

*“the Delegated Officer will also require the analysis of the following:*

- *Field parameters: pH, Electrical Conductivity, Redox Potential, Total Acidity, Total Alkalinity;*
- *Major ions: sodium, potassium, calcium, magnesium, chloride, sulfate and bicarbonate;*
- *Metals: cadmium, zinc, cobalt, mercury, nickel, selenium, thallium and gadolinium; and*
- *Radiological constituents: Gross-alpha and Gross-beta”.*

Northern Minerals have stated that they see no justification for including metals or radiological constituents currently listed in the monitoring suite. If the objective of the programme is to provide early warning of seepage from the TSF, then the most predictive and reliable parameters are: pH, Electrical Conductivity, magnesium and sulfate as these are characteristics of the stored tailings.

**DER response:**

DER has considered Northern Minerals request. Monitoring required on the Works Approval is to establish background data prior to operation.

The Delegated Officer considers that radiological impacts are regulated by DMP according to the *Mines Safety Inspection Regulations 1995*, the *Radiation Safety Act 1975* and Regulations and the requirements of the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) *Code of Practice and Safety Guide on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. On this basis, monitoring of radiological constituents has been removed.

For the operational licence, the Delegated Officer agrees that infield parameters are the best immediate seepage indicator. However given the long lifetime of the TSF, for longer term risk analysis and considering kinetic testing is still to be undertaken, the Delegated Officer will require the operational licence to have the full suite of parameters sampled 6 monthly, and immediately should changes in the field observation monitoring suite be detected.

Reporting period

**Northern Minerals requests:**

A reporting period from 1 January to 31 December in the same year, as this aligns with other statutory reporting requirements for the Browns Range Project.

**DER response:**

The works approval has been updated to reflect this.



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