Proposed Discharge Evaluation:

Coonderoo River Wetlands

This report was prepared for:

Simcoa Operations Pty Ltd (Moora)

December 2011

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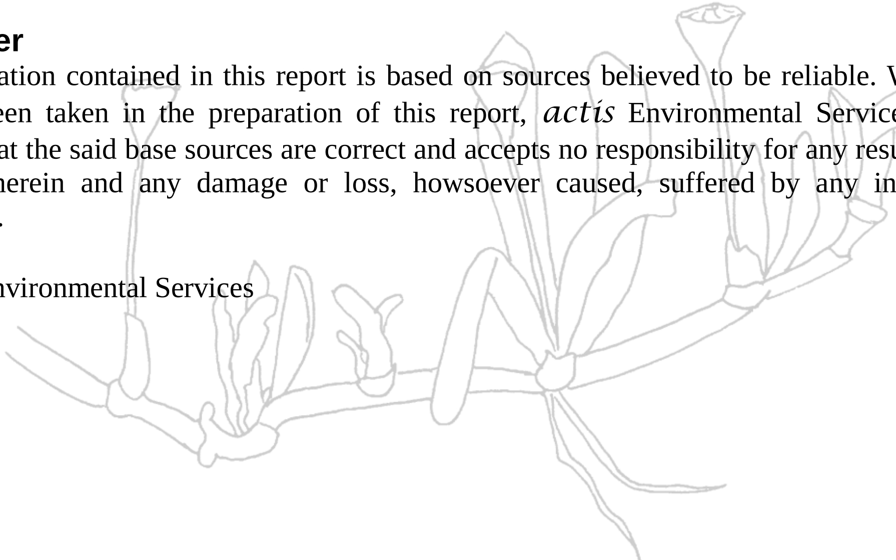


1 Executive Summary

Simcoa Operations Pty Ltd (Simcoa) commenced production in 1989. The company obtains high purity quartzite from a mine owned and operated by Simcoa at Moora, 180kms north of Perth (Mining Lease M70/191). The quartzite deposit contains more than two million tonnes of proven reserves and at least a further four million tonnes in the indicated and inferred resources category.

Smelting of the quartzite is at Kemerton, near Bunbury where two furnaces produce silicon continuously all year round. In excess of 33,000 tonnes of silicon and 8,500 tonnes of silica fume are produced per year. Smelting process uses about 80,000 tonnes of quartz and 27,000 tonnes of charcoal (which is made on site) per year.

Simcoa's Moora mine produces about 160,000 tonnes per annum of lump quartz though not all is of sufficient quality to be used in the Kemerton Smelter. The mine is expected to have an operational life of about ten years under the current mine plan.

It is proposed to deepen the mine to access further resource with final depth of the pit at 215 meters. Dewatering of the surrounding rock will be required to provide safe and dry conditions within the pit. Some of this water will be used at the mine which has water requirements of about 80,000 kL per annum. This water is groundwater taken from fractured rock formations near the mine.

The proposed pit dewatering will produce water surplus to the mine's water requirements (at least in the short term) and it is proposed to dispose of this water into a nearby creek (Kiaka Creek) which discharges into the Coonderoo River wetlands, itself part of the Moora Palaeodrainage system.

The groundwater from the dewatering of the pit is 'fresh' at TDS 656mg/L and coupled with the probability that the discharge after the initial drawdown will be intermittent is not expected to have any detrimental effect on Kiaka Creek or the Coonderoo River wetlands. The discharge would have an insignificant impact on the hydroperiod of the wetlands given that the wetlands have a surplus of evaporation potential during the summer months. It is possible that the discharge would intermittently wet the entire Kiaka Creek even in summer although the seepage rate is unknown and may account for a substantial volume. A small area of the immediate lake will be wet all year. During years where only the maintenance pumping occurs, the lakes may not receive any water during dry periods.

A site visit to the Moora Mine took place in November 2011 to ascertain potential dewatering discharge sites. There is a road and railway between the Mine and the eventual destination of the water – the Coonderoo River wetlands. Kiaka Creek was chosen for the discharge site because it is a substantial watercourse with multiple culverts beneath the road and with a small railway bridge. It is also close to the Mine.

No priority vegetation species were seen at the sites visited and the species were as to be expected in a periodic saline wetland system in the region. Both *Hydrocotyle coorowensis* (P2) and *Hydrocotyle vigintimilia* (P1) have been recorded in the region according to FloraBase however neither of these species was seen during the site visit. Of the two species, *Hydrocotyle coorowensis* has more likelihood of being found in the local area. The majority of the other priority species are terrestrial plants and not within the scope of this report as they will not be impacted by a discharge into the local wetlands.

None of these sites has a listed conservation value and while they have some conservation value as remnant vegetation they are unlikely to be detrimentally affected by a low salinity (fresh water) discharge.

Few aquatic invertebrate fauna were seen during the site visit as the water in the wetlands had been present for some time – many of these creatures are adapted to living in ephemeral wetlands and have the ability to hatch out quickly after sufficient rain, grow quickly to maturity then lay desiccation resistant eggs before succumbing to increased salinity, predators or lack of water. It is expected that given the right conditions the Coonderoo River wetlands would have the aquatic invertebrate species expected in wetlands of that type.

The flora and fauna of the discharge creek and receiving wetlands are not expected to be impacted by the chemical composition or change in hydro period due to the discharge. Short term changes in hydroperiod caused by the discharge into the Creek are unlikely to change the ecosystem.

Design and monitoring recommendations have been provided as part of this report.

2 Introduction

2.1 Project Location and Overview

Simcoa Operations Pty Ltd (Simcoa) commenced production in 1989. The company obtains high purity quartzite from a mine owned and operated by Simcoa at Moora, 180 kms north of Perth (Mining Lease M70/191). The quartzite deposit contains more than two million tonnes of proven reserves and at least a further four million tonnes in the indicated and inferred resources category.

Smelting of the quartzite is at Kemerton, near Bunbury where two furnaces produce silicon continuously all year round. In excess of 33,000 tonnes of silicon and 8,500 tonnes of silica fume are produced per year. Smelting process uses about 80,000 tonnes of quartz and 27,000 tonnes of charcoal (which is made on site) per year.

Simcoa's Moora mine produces about 160,000 tonnes per annum of lump quartz though not all is of sufficient quality to be used in the Kemerton Smelter. The mine is expected to have an operational life of about ten years under the current mine plan.

It is proposed to deepen the mine to access further resource with final depth of the pit at 215 meters. Dewatering of the surrounding rock will be required to provide safe and dry conditions within the pit. Simcoa proposes to discharge approximately Currently there is no water discharged from mine and existing water abstracted from bore (BH1) is used internally for dust control and vehicle washdown. Proposed discharge from a mine site that extracts more than 50,000 tpa of ore requires a Licence from the EPA under the Schedule 1 Part 1 Category 6 under the Environmental Protection Act 1986.

2.2 Ownership

Simcoa Operations Pty. Ltd
973 Marriott Road
Wellesley, 6233
Western Australia

2.3 Key Characteristics

Table 1 - Current Key Characteristics[1]

Element	Quantities/Description	Actual	Data Source
Quartzite Production	160,000 tonnes per annum of lump quartz (approximately)	89,680 tonnes lump quartz and ~80,000 tonnes fines by-product	AER 2010
Operational life	10 years (approximately) – under current mine plan	Approximately 10 years at a production rate of 160,000 tpa lump quartz	AER 2010
Total area of disturbance	Not more than 60 hectares	59 hectares	AER 2010

1 http://www.simcoa.com.au/attachments/download/31/November%202011%20Compliance%20Assessment%20Report%20-%20Appendix%20B.pdf

Element	Quantities/Description	Actual	Data Source
Area of rehabilitation	All disturbed areas	All areas disturbed by mining activities areas are subject to rehabilitation which is outlined in the rehabilitation schedule	N/A
Depth of pit	Not more than 215 metres RL	216 metres RL	AER 2010
Water requirements (Groundwater)	80,000 kL per annum (approximately)	65,314 kL	AER 2010
Water source	Superficial Formation	Superficial Formation	AER 2010

2.3.1 Government Departments

Discharge of groundwater and mine water requires licensing by the Department of Environment and Conservation (DEC) under Part V (Control of Pollution) of the *Environmental Protection Act* 1986 (WA). Proponents must provide sufficient information to the DEC to allow it to gain an appreciation of the extent to which discharge may impact on local hydrology and the ecology of the lake ecosystem. Extraction of groundwater requires approval and licensing is by the Department of Water.

2.3.2 Current Licensing

Discharge License: DEC/EPA none needed under current operation
Water Abstraction License: GWL 104693(4) 80,000kL/annum Department of Water
Mining lease: M 70/191 Department of Mines and Petroleum/ EPA Ministerial Statement 813

2.3.3 Site Closure

The total area of disturbance at the Simcoa Moora mine is approximately 60 hectares. Upon closure it is proposed to rehabilitate all disturbed areas.

2.4 Environmental Obligations and Objectives

The objective of dewatering discharge management is to maintain the integrity, function and environmental value of the site used for disposal of dewatering discharge.

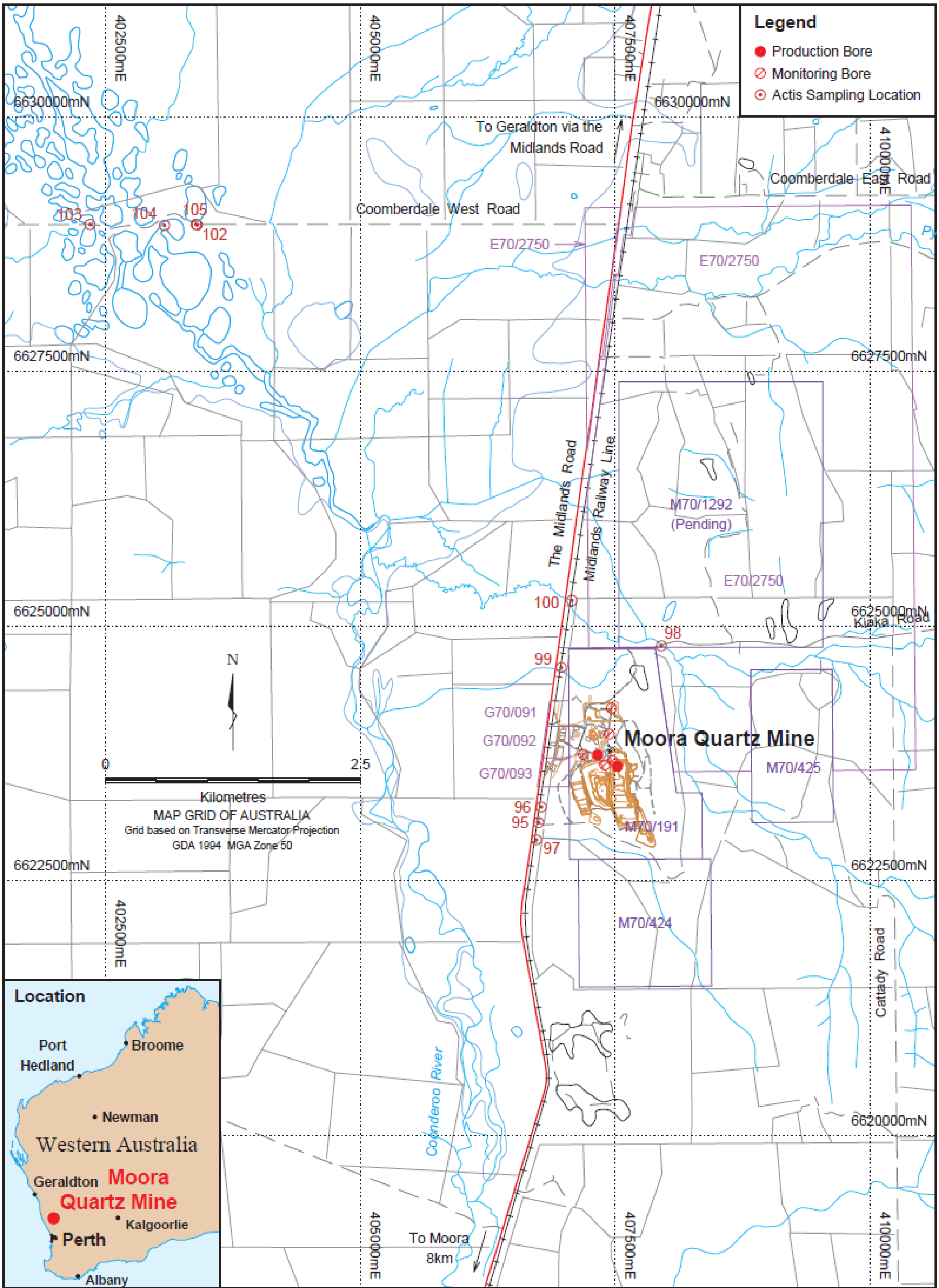
Dewatering discharge licenses are issued with the proviso that if the discharge is found to be harmful to the environment during a given monitoring period, the proponent must pay a fee. It is difficult to define 'harmful' discharge especially considering site-specific differences in the receiving environment.

2.5 Groundwater Abstraction Reporting

The Department of Water (DoW) regulates groundwater abstraction via the bore BH1 GWL 104693(4). Simcoa notifies the DoW of the status of the bore field and water quality and quantity abstracted each year through a Groundwater Production and Monitoring Report. No water has been discharged as the water has been used internally (80,000kL/annum).

2.6 Mine Water and Groundwater Monitoring Commitment

Simcoa is committed to monitoring the water quality and quantity and presence of metals within the receiving environment. Water monitoring of environmental effects will take place in accordance with statutory licence conditions.



SAPROLITE ENVIRONMENTAL	Client: SIMCOA OPERATIONS PTY LTD	Project: MOORA QUARTZ MINE	Date: December 2011
			Scale:
			Author: G.R./ S.C.
Checked: G.Richards	**PROJECT LOCATION**		Figure No.
Approved: G.Richards		A4	Plan No. **E0200-008**

3 Site Description

3.1 Project Location and Overview

Simcoa's Moora Mine is situated in a broad acre agricultural area about 10km north of the town of Moora, in the Shire of Moora. The natural environment in the area has been significantly altered through historic clearing of the original vegetation for farming prior to Simcoa's involvement. The Mediterranean climate and good soils prompted early settlement of the area just after the turn of the century, with significant clearing occurring in the area around the mine in the early 1900s. The area is typical of a wheatbelt farming area with the main agricultural pursuits being sheep farming and cropping. The mine is situated on a farm owned by the proponents, with the opportunity of the arable land able to be leased back to local farmers.

3.2 Groundwater Usage and Disposal

It is proposed to deepen the mine to access further resource with final depth of the pit at 215 meters. Dewatering of the surrounding rock will be required to provide safe and dry conditions within the pit. Some of this water will be used at the mine which has water requirements of about 80,000 kL per annum. This water is groundwater taken from fractured rock formations near the mine.

The proposed pit dewatering will produce water surplus to the mine's water requirements (at least in the short term) and it is proposed to dispose of this water into a nearby creek (Kiaka Creek) which discharges into the Coonderoo River wetlands, itself part of the Moora Palaeodrainage system.

The groundwater from the dewatering of the pit is relatively 'fresh' at TDS 656mg/L and the discharge after the initial drawdown will be intermittent.

3.3 Regional and Receiving Environment

3.3.1 Geography

In the area surrounding the mine the topography is one of low relief with local elevated hills, locally merging with undulating rises and depressions in the landscape. Ephemeral streams drain these low rises into the numerous clay pans and samphire flats of the Coonderoo River which are often subject to inundation. The mine site is located on a topographic rise in the area which backs onto a rocky outcrop to the east and slopes gradually to the west (broad farmland) and down onto the saline Coonderoo River flats.

3.3.2 Climate

The climate of the Moora area is Dry Warm Mediterranean, with dry hot summers and wet cold winters. Most rainfall occurs between May and August. The nearest evaporation pan data is recorded at Wongan Hills Research Station. Evaporation at 2,282mm per year[2] is higher than rainfall in this area. The average annual rainfall for the Moora area is about 460mm[3].

[2] BOM Station 008138 Wongan Hills Res. Station 1937-2011
[3] BOM Station008091 Moora 1897 – 2004

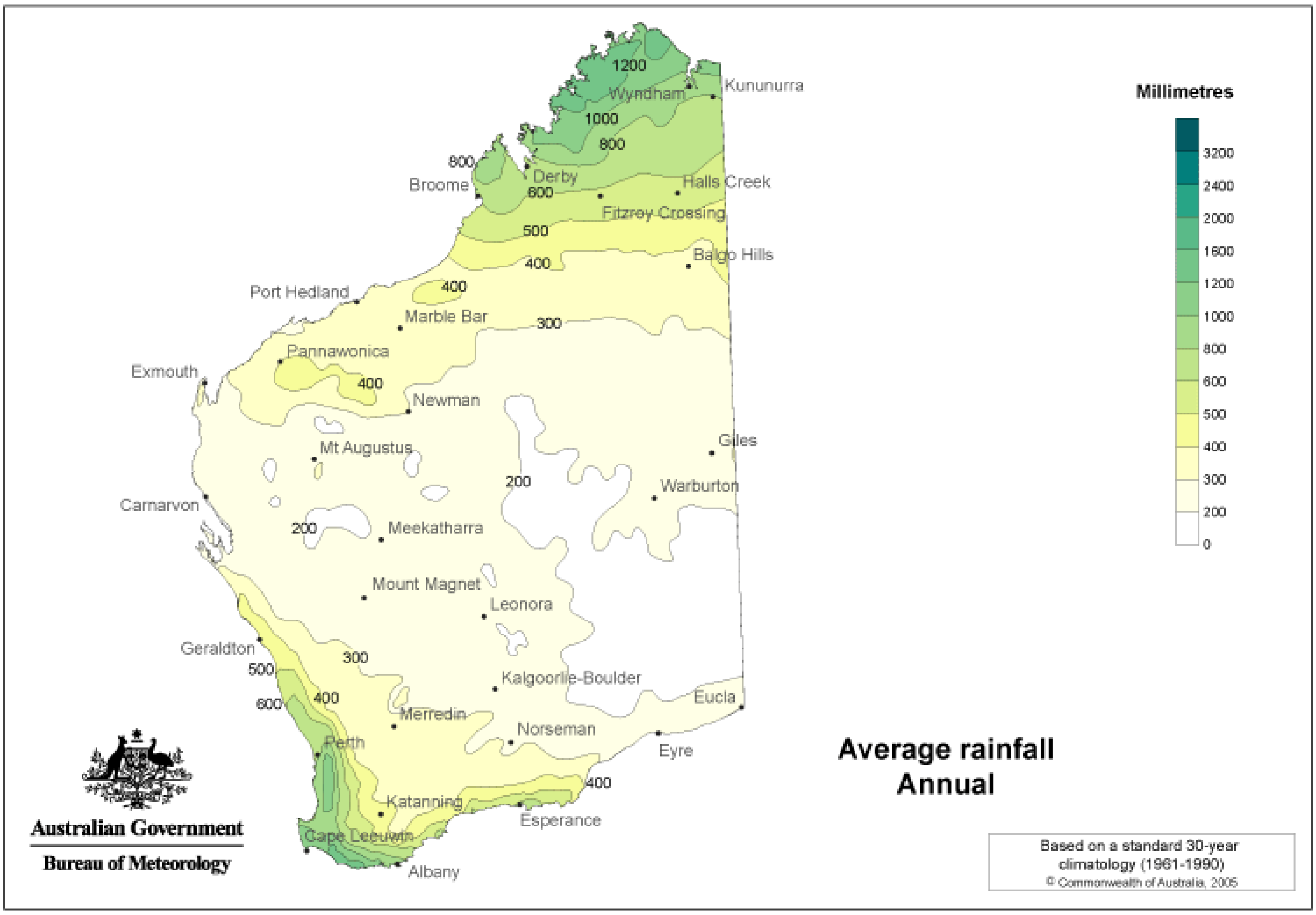


Figure 1 - Average Annual Rainfall for WA[4]

[4] http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/annual-monthly-rainfall.cgi

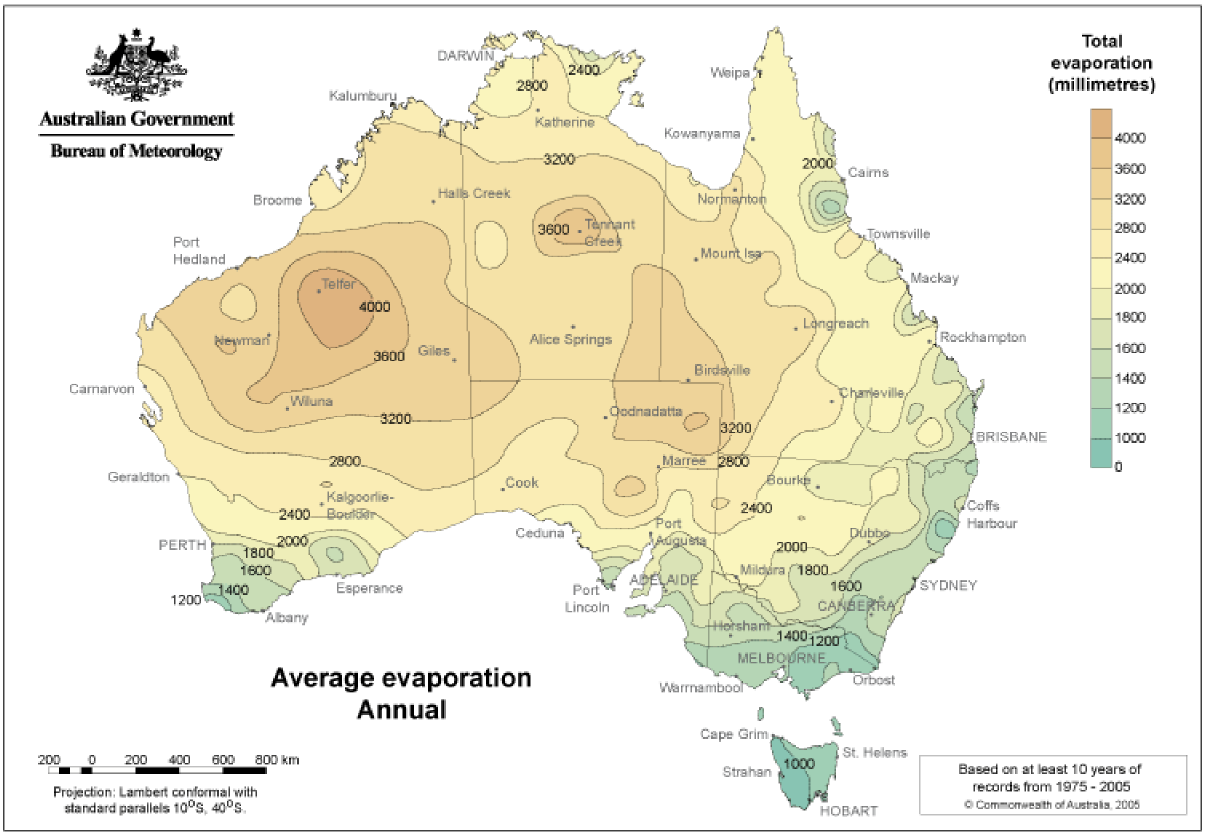


Figure 2 - Annual Evaporation of Australia (mm)[5]

Table 2 - Rainfall and evaporation data for region

	January	February	March	April	May	June	July	August	September	October	November	December	**Annual**
Rainfall[6] (mm)	11	14.3	19.8	25.4	60.9	90	88.6	63.8	38.6	24.9	12.8	9.6	**459.7**
Evaporation[7] (mm)	359.6	296.8	266.6	165	105.4	69	65.1	80.6	114	186	252	322.4	**2282.5**

[5] http://www.bom.gov.au/cgi-bin/climate/cgi_bin_scripts/evaporation.cgi
[6] BOM Station 008091 Moora 1897 – 2004
[7] BOM Station 008138 Wongan Hills Res. Station 1937-2011

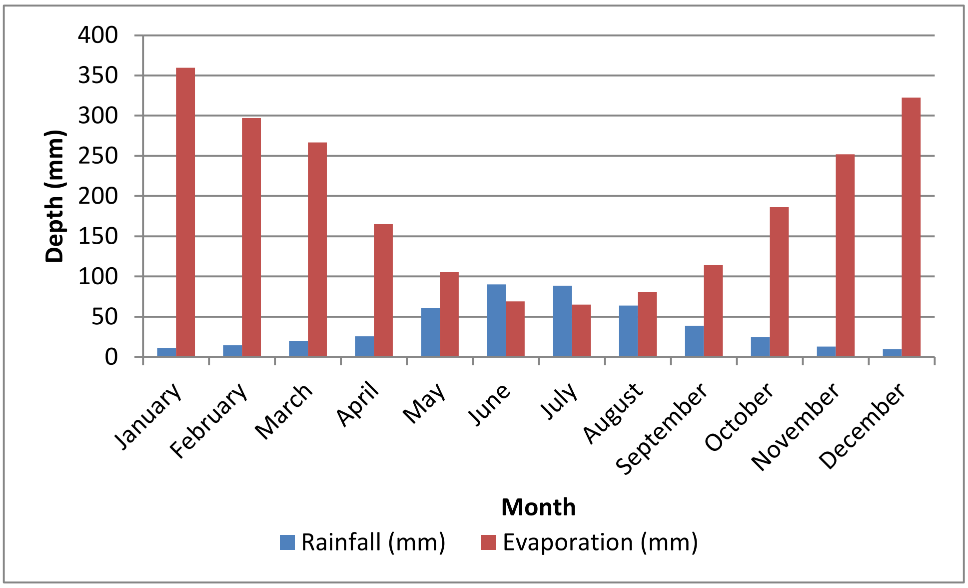


Figure 3 - Rainfall and Evaporation Statistics

3.3.3 Hydrogeology

The Department of Water (WA) Atlas describes the mine site generally as:
Aquifer Rocks of Low Permeability, Fractured and Weathered Rocks - Local Aquifers
Lithology: Sedimentary rocks, undifferentiated
Geological Age: Proterozoic

3.3.4 Palaeodrainage

The Coonderoo River flows from North to South and joins the Moore River and as such it is part of the Moore-Monger Drainage system. It is suggested ((Beard 1999), Yesertener *et al*. 2000) that a Palaeochannel links the Yarra Yarra Lakes system to the Moore River System – this Palaeochannel runs north to south, parallel to the Coonderoo River.

3.3.5 Catchment Area and Runoff

The catchment is the Moore River catchment which is approximately 13,600 km^2 in size. The mine site is in the upper third of the catchment in the Coonderoo/Marchagee sub catchment which is roughly 6,500 km^2 of which 6,000km^2 is above the mine site.

3.3.6 Hydrological Regime

Beard (1999) states: "With the aid of recent geological and topographic maps the Moore-Monger System can be quite readily understood, but it contains some unusual and interesting features. The system is roughly circular in plan with a diameter of about 300 km and an area of about 20 000 km2. It is composite and contains several historically distinct elements, the unifying feature of which is that they converge into the Yarra Yarra Lakes in the west. The lakes have an outlet, now only intermittently active, leading southward through an incised valley to join the North Branch of the Moore River at Moora. To the south, beyond Gillingarra, the channel unites with the East Branch and the combined river turns to the west and reaches the sea across the coastal plain. Both branches of the Moore River are active during the winter and above Moora there is an active channel, the Coonderoo River, in the northern part of the valley from about 10 km south of Lake Pinjarrega."

3.4 Vegetation

The study area is in the Victoria Plains System of the Avon Botanical District and in the Wheatbelt agricultural region of Western Australia. Remnant vegetation consists of York Gum Eucalyptus and Sheoak Casuarina with little understorey except exotic species of grass such as Wild Oats. Understorey that was seen during the November 2011 site visit consisted of: *Hakea preissii*, *Acacia* sp., *Calothamnus* sp., Quandong, *Allocasuarina* sp *Xanthorrhoea* sp. *Enchylaena* sp. and *Dianella* spp. Agriculture consists of wheat/sheep farming with some beef cattle.

3.4.1 Declared Rare Species

The area defined by the Moora boundary contains 97 priority vegetation species. Two of these are semi-aquatic: *Hydrocotyle coorowensis* (P2) and *Hydrocotyle vigintimilia* (P1).

3.5 Aquatic Invertebrates

The Coonderoo River wetland system is typical of the palaeodrainage systems in the wheatbelt with little gradient, and salts accumulating over time. Most of the year it consists of series of dry pans, with often poorly defined connecting channels, which overflow only after sufficient rainfall. Occasionally, after heavy and sustained rainfall, the pans, channels and surrounding samphire flats become inundated and eventually drain into the Moore River via the Coonderoo River.

Even though palaeodrainage systems and their associated satellite pans often have endemic aquatic invertebrate fauna, the Coonderoo River wetlands could contain all or some of the Brine Shrimp present in the Yarra Yarra claypans (linked to the Moore River System). These are: *Parartemia contracta*, *P. informis*, *P. longicaudata* or *P. serventyi* (Storey et al 2008). Dominance by Crustacea is typical of inland saline systems (Brendonck and Williams 2000) with Brine Shrimp, Tadpole Shrimp, Clam Shrimp and Seed Shrimp common throughout.

Many of the aquatic invertebrates in saline systems are able to survive the (naturally) hostile conditions of inundation and desiccation by going through ‘boom and bust’ life cycles. Their life cycles are relatively short – only a few weeks at best – and they lay salt and desiccation-resistant cysts which are able to survive in the lake/pan sediments for sometimes years. The dormancy of the cysts is broken when their surroundings are conducive to another life cycle – the fresh water from rain. The adult animals are able to cope with the gradual salinisation of their environment by evaporation and if conditions remain suitable will produce more than one generation (depending on species).

Aquatic invertebrates such as beetle, midge and sandfly larvae colonise suitable water bodies by flying in from other areas.

Due to the timing in the hydrological cycle of the Coonderoo River wetlands visited in November 2011 there were few species of aquatic invertebrates.

3.6 Chemical aspects of salt lakes

The salinity of inland saline waters ranges from 3g/L (arbitrary lower limit defined by (Williams 1998) to saturation of halite depending on the type of system. Ephemeral lakes are subject to wider salinity fluctuations than those that are permanent.

The pattern of ionic dominance in Western Australian salt lakes is nearly always Na^+>Mg^+>Ca^+>K^+ for the cations, and Cl^->SO_4^{2-}>HCO_3^{2-} for anions (pers. ob.). The cation pattern differs in some systems, usually those of low to moderate salinity, where Ca^+ replaces Mg^+.

The lakes are NaCl dominated with Na^+ values varying from 75% to 90% of cation equivalence and Cl^- accounting for 87% to 97% of anion equivalence (results from a study of 54 Western Australian salt lakes; Geddes et al. 1981).

Deviation from the normal pattern of ionic dominance occurs as a result of weathering of particular rock strata, or evaporative concentration or precipitation of particular salts (De Deckker 1983).

The similarity in ionic ratios of salt lakes and seawater suggests lake salts are of marine origin, however there is uncertainty as to whether they are derived from transported marine aerosols (cyclic salts) or relict marine deposits (connate salts) (De Deckker 1983).

4 Description of Potential Discharge Site

Kiaka Creek to the north of the Mine has been identified as a potential site for groundwater discharge from the proposed dewatering of the pit.

Kiaka Creek has a well-defined course with banks of up to a meter deep. The vegetation is *Casuarina* sp. and *Eucalyptus* sp. trees over sparse understorey consisting mostly of exotic grasses. Water flows would be seasonal and episodic, with fast flowing water and short-lived pools. Creeks of this nature contain few species of aquatic fauna.

Kiaka Creek terminates in the Coonderoo River Wetlands which then flows in a generally southerly direction to join the Moora River. The catchment is relatively flat and there may be some northerly flow depending on time of year and existing flows.

4.1 Description of Coonderoo River Wetlands

The Coonderoo River flows from North to South and joins the Moore River and as such it is part of the Moore-Monger Drainage System. It is suggested (Beard 1999, Yesertener *et al*. 2000) that a Palaeochannel links the Yarra Yarra Lakes system to the Moore River System – this Palaeochannel runs north to south, parallel to the Coonderoo River.

The Moore River is described as saline with a seasonal variation between 5,000-10,000mg/L at Quinns Ford (Mayer et al. 2005).

4.2 Vegetation

The Coonderoo River Wetland system is a historic saline system – perhaps somewhat affected by secondary salinization but not recently. The few dead trees surrounding the wetlands have been dead a number of years. Eight samphire species were identified at the three sites visited in November 2011, none of which are uncommon or endangered (Table 3). Samphires are succulent shrubs and sub-shrubs found at the margins of saline wetlands and populating saline seasonally damp areas (samphire flats).

No priority species were seen at the sites visited and the species were as to be expected in a periodic saline wetland system in the region. Both *Hydrocotyle coorowensis* and *Hydrocotyle vigintimilia* have been recorded in the region according to FloraBase however neither of these species was seen during the November 2011 visit. Of the two species, *Hydrocotyle coorowensis* has more likelihood of being found in the local area. The majority of the other priority species are terrestrial plants and not within the scope of this report as they will not be impacted by a discharge into the local wetlands.

4.3 Water Chemistry

Surface water was sampled at two locations (WP102, WP104) in the potential discharge location and a further sample (WP96) from a standing water body that may replicate Kiaka Creek as the creek was dry at the time of sampling. The results are given in Table 7 (page 30) and Table 8 (page 31).

4.3.1 Total Dissolved Solids

The Coonderoo River Wetlands are intersected by the Coomberdale West Road and water from two points along this road was sampled at the time of the November visit.

The first sample was taken from a wetland to the side of the main channel which would be continuous with the wetland system during regional flooding but otherwise is separate. The TDS (Total Dissolved Solids) of this water was 30,000mg/L.

The second water sample was taken from the main channel of the Coonderoo River Wetlands; the deepest point which would flow first in a flood event. The TDS at the time of the November visit was 68,000mg/L.

Another water sample was taken from a seasonally wet area adjacent to the railway line near the Mine Site. The TDS of this water was 480mg/L. This wetland was not contiguous with the Coonderoo River Wetlands and will not be affected by any discharge from the mine site.

4.3.2 pH

The pH of sites WP103 and 104 was alkaline at 8.4 and 8.7. The Kiaka Creek surrogate was also alkaline at 7.6.

4.3.3 Ions

The ions in the wetlands follow the pattern of ionic dominance in Western Australia salt lakes is nearly always $Na^+ > Mg^+ > Ca^+ > K^+$ for the cations, and $Cl^- > SO_4^{2-} > HCO_3^{2-}$ for anions (pers. ob.).

The similarity in ionic ratios of salt lakes and seawater suggests lake salts are of marine origin, however there is uncertainty as to whether they are derived from transported marine aerosols (cyclic salts) or relict marine deposits (connate salts) (De Deckker 1983). Given the location in the landscape the salt is most likely to have originated from marine aerosols.

4.3.4 Salt Load

According to (Hingston and Gailitis 1976) salt load from marine aerosols in the region of Moora would be approximately 15kg/yr/ha or 33kg of TDS per year per hectare. The salt load for the sub-catchment below the mine and entire Coonderoo/Marchagee sub-catchment would be 1,800 and 21,000 tonnes of salt per year respectively.

4.4 Fringing Vegetation

Two creeks with the potential for discharge disposal were viewed during the November 2011 site visit. Both creeks were somewhat eroded with steep clay banks (especially WP100 or Kiaka Creek, the northern of the two). Vegetation consisted of Casuarina and Eucalyptus trees over mainly exotic grasses, including wild oats. These creeks are typical of Wheatbelt creeks with periodic flows. There was little remnant understorey. The northern of the two creeks (Kiaka Creek) was quite deep in places with the banks more than one meter high from the base. The southern creek was shallower. Neither creek showed any signs of salt.

Both creeks discharge into the series of periodic ponds and wetlands named the Coonderoo River. Vegetation was sampled at three different sites, all adjacent to the Coomberdale West Road, which intersects the wetland. The first site (WP103) was a natural saline wetland which was perched and not continuous with the main channel except during large floods. The vegetation consisted of *Casuarina* sp. around the higher wetland rim with *Enchylaena* sp., *Mesembryanthemum nodiflorum* (introduced), *Tecticornia indica* subsp *bidens*, *T. doleiformis*, and *T. pergranulata* in zones towards the bare playa.

The second site (WP104) was the main channel of the Coonderoo River wetlands. As seen at WP103 samphires grow in zones from the wettest point to the highest point. There were no trees near the site but shrubs of *Hakea preissii* were at the highest point with *Enchylaena* sp., *Mesembryanthemum nodiflorum* (introduced), *Tecticornia indica* ssp. *bidens, T. doleiformis*, Frankenia sp., *T. halocnemoides* ssp. *tenuis*, *T. undulata*, *T. syncarpa*, *T. peltata*, *T. pergranulata* and *Sclerostegia moniliformis* in descending order. There was a large amount of *Ruppia* (Eelgrass) in the water.

The third site (WP105) was a wetland with less saline water than the other two. There were many birds present including Swans, Black winged Stilts and ducks. There were a few samphire species in zones away from the water – *Tecticornia moniliformis* standing in the water, *Frankenia* sp., *T. halocnemoides* ssp. *tenuis*, *T. doleiformis*, *T. pergranulata* and *T. indica* ssp. *bidens*. There were some *Casuarina* sp. trees at the highest point away from the water. The water at this site was not tested.

No priority species were seen at these sites and the species were as to be expected in a periodic saline wetland system in the region (Table 3).

None of these sites has a listed conservation value and while they have some conservation value this is unlikely to be detrimentally affected by a fresh water discharge. The conservation status of the Kiaka Creek and roadside vegetation would be medium-low according to 'Roadside Conservation Value Categories' (DEC), whereas the Coonderoo River wetlands would have a medium-high status.

Table 3 - Wetland vegetation at three sites in the Coonderoo River wetlands

Wetland species	WP103	WP104	WP105
Enchylaena sp	x	x	
Frankenia sp		x	x
Mesembryanthemum nodiflorum	x	x	
Ruppia sp		x	
Tecticornia doleiformis	x	x	x
T. halocnemoides ssp *tenuis*		x	x
T. indica ssp *bidens*	x	x	x
T. moniliformis		x	x
T. peltata		x	
T. pergranulata	x	x	x
T. syncarpa		x	
T. undulata		x	

4.5 Aquatic Invertebrate Fauna

Two of the sites with water present were sampled for invertebrate fauna. As water had been present for a length of time it was not expected to find any of the more short-lived aquatic fauna due to short life cycles and predation. It is quite possible that after dry periods followed by rain, short-lived native Brine Shrimp *Parartemia* sp., Tadpole Shrimp *Triops* sp. and Clam Shrimps would be present in the Coonderoo River Wetlands.

The first site was WP96 which was a small wetland beside a railway embankment. The water was fresh with a TDS of 480 mg/L. There were some aquatic fauna, including *Daphnia* sp., *Aedes* sp. Mosquito larvae and water snails – *Isidorella newcombi*.

The second site sampled was the main channel of the Coonderoo River wetlands. The TDS at this site was 68,000 mg/L. Again there were some aquatic fauna, mainly water snails – *Potamopyrgus* sp. and Ostracods (or Seed Shrimps) – *Bennelongia* sp.

5 Discharge Characteristics

5.1 Discharge Volume

The discharge volumes are shown in Table 4 below. The chemical characteristics of the discharge water are given in Table 7 (page 30) and Table 8 (page 31). It is thought that after initial pumping, recharge will be slow. If this occurs as modelled, pumping and groundwater discharge will be periodic.

Table 4 - Discharge volumes and salt load

Year	Drawdown			Maintenance			Total Discharge (+20%)	Average daily Discharge		Salt load
	L/s	KL/d	KL/yr	L/s	KL/d	KL/yr	KL/yr	L/s	KL/d	t/yr
2012	-	-	-	-	-	-	-	-	-	-
2013	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2014	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17
2015	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2016	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17
2017	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2018	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17
2019	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2020	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17
2021	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2022	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17
2023	30	2,592	54,432	20	1,728	46,656	121,306	3.8	332.3	79.58
2024	-	-	-	20	1,728	53,568	64,282	2.0	176.1	42.17

5.2 Discharge Composition

The discharge water has a low TDS of 656mg/L. In comparison drinking water with less than 600mg/L is considered as having good palatability and 600-900 mg/L as fair[8].

The ratio of major ions in the discharge is approximately the same as the receiving waters in the Wetlands.

All measured metals (minor ions) in the discharge were below detection limit.

5.3 Impact on Hydroperiod

The wetland area needed to evaporate the discharge is on average approximately 10ha based on Class A evaporation and rainfall and allowing for increased salinity and surface area. The discharge would have an insignificant impact on the hydroperiod of the wetlands given that the wetlands have a surplus of evaporation potential during the summer months. It is expected that the discharge would wet the entire Kiaka Creek even in summer although the seepage rate is unknown and may account for a substantial volume. A small area of the immediate lake will be wet all year. During years where only the maintenance pumping occurs, the lakes may not receive any water during dry periods. It is expected that the discharge will present at the nearest lake in all wet periods. That is, the flow would be higher than normal.

[8] National Water Quality Management Strategy Australian Drinking Water Standards 6 2011

In summary, during summer and maintenance flows the discharge water is likely to partially wet the Creek leading to the wetlands. During peak flows the water is likely to reach the local wetland. In winter the creeks will already be wet and the water will present at the local wetlands during maintenance and peak flows. The result will be that the local creeks with a discharge are likely to support more water dependant ecosystems on at least a temporary annual basis. The increased water period is unlikely to impact on the existing ecosystem due to its temporary nature. If the creek riparian ecosystem was important it may be better to discharge during winter and increase the hydroperiod in the valley wetlands which have the greater capacity to absorb and evaporate the water volume and the ecosystem that is resistant to a wetter environment. It would also mean that less weed species may grow in the creeks even on a temporary basis.

5.4 Impact on salinity and salt load

The salinity of the discharge is less than the creek and the receiving lakes and therefore no impact from the discharge salinity is expected.

The accumulation of salt or salt load is very low with less than 80 tonnes of salt being discharged per year. This is much less than what is arriving from aerosols in the catchment. The catchment is saline and discharges to the sea so the increased salt is considered to be trivial.

5.5 Sediment

Sediment in any discharge has a serious effect on the receiving wetlands as it reduces soil permeability and other wetland functions. The discharge under consideration is not expected to have any sediment entrained as the water is from cased bores. The review would be different if sediment was anticipated.

It is expected that the discharge be pumped into an intermediate dam to settle potential TSS and other pollutants that may arise. This dam could also be used to recycle water for internal and external usage. The discharge point will need to be monitored and designed to reduce sediment transfer and pollutants.

6 Discussion

6.1 Alternatives to Discharge

An alternative to discharging is to retain the water on site. Calculations based on local evaporation and rainfall are shown in Table 5.

There are a number of scenarios that need to be considered. Approximately ten hectares would be needed to evaporate the discharge over two years if there was no demand for the water onsite or locally. The depth would peak at 1.2 metres during the higher discharge months. An assumed seepage has not been used in this rough calculation but normally seepage would account for a third of the water loss if the pond is unlined.

Table 5 - Meteorological Volume Movements

	Water Volume Kl/year/ha
Rainfall	4,600
Gross Evap	14,400
Nett Evap	9,800

Table 6 Estimated Ponded Area needed without discharge (ha)

	Without seepage	With seepage	Usage[9]
Evaporation plus	9	7	1

This land is available to the south west of the mine but the value of constructing a temporary dam in farmland situated above a main road and railway is questionable.

If a non-permeable evaporation dam was needed, the cost of lining a dam is approximately fifteen dollars per metre or $150,000 per ha (approximately one million dollars for the dam). This can be reduced by using a lighter membrane material. A clay based dam is a lot cheaper (perhaps a tenth of the cost) and depends largely on local material and machinery availability.

6.2 Conclusions and recommendations

The Simcoa Moora Quartzite Mine is located in land cleared for agriculture with some remnant trees and little understorey. The groundwater that is proposed to be taken from the mine site is fresh and after initial pumping is expected to become intermittent.

A nearby seasonal creek (Kiaka Creek) has been identified as a suitable site to discharge this groundwater. Kiaka Creek drains into the Coonderoo River, which in turn joins the Moore River near Moora.

No priority vegetation species were identified at the sites visited, including the proposed Kiaka Creek discharge site. None of these sites has a listed conservation value and while some sites have some conservation value as remnant vegetation this is unlikely to be detrimentally affected by a fresh water discharge.

[9] Used 80,000kL pa but current usages is lower 63,000 kL pa

The evaluation is based on the entire abstraction being discharged. This is unlikely to be the case. Internally the water would be used for dust control and wash-downs. This is currently 63,000kL per annum as per the Environmental Audit November 2011.

The fresh nature of the water to be taken from the Moora Mine means it could be seen as a potential asset to a local farmer and/or Moora Shire. Enquiries should be made locally to see if the water could be utilised.

6.2.1 Monitoring Program

It is suggested that a monitoring program during discharge includes:

- Water quality parameters – conductivity, TDS, TSS and pH, measured at the discharge point, road crossing, and one downstream location. This should take place on a monthly basis.
- Discharge water volumes – flow meter
- Vegetation – at the time of the site visit there was little vegetation visible. After rain or during ground water discharge period, vegetation recruitment or revitalisation of dormant plants should be monitored at least at three points along the creek and downstream. This should take place in winter once a year.
- Aquatic invertebrates – after rain (or discharge water) fills creek ponds an invertebrate survey should be undertaken to ascertain any species present, at least at three points along the creek and downstream. This could also take place once a year.

6.2.2 Design Factors for Discharge

- The discharge point should be out of a dam with a catchment.
- The capacity of the dam needs to be able to retain 6-12 hours of peak flow.
- The discharge should be elevated from the bottom of the dam and ideally a small subdivision of the dam with an over flow.
- A hydrocarbon barrier should be placed before the discharge point even though it is unlikely to be needed.

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8 Appendix

8.1 Sample Points

WP95

This site was beside a railway embankment. The surrounding vegetation consisted of *Eucalyptus* sp., *Casuarina* sp., and *Acacia* sp. over *Hakea preissii*, Quandong and *Calothamnus* sp.

Figure 4 - WP95 to South

Figure 5 - WP95 to North

WP96
This was a ditch wetland beside the railway embankment. The water was fresh and contained water snails, water mites and other invertebrates.

The surrounding vegetation consisted of *Hakea preissii* and *Acacia* sp. over *Calothamnus* sp., Quandong and *Allocasuarina* sp. The vegetation was not pristine and contained many weedy grass species such as wild oats.

WP97
This was a culvert beneath the railway embankment and also beneath the road – it appeared to carry water from the wheat paddock back towards WP97. The vegetation here was open *Acacia* spp. over *Xanthorrhoea* sp. and *Dianella* spp. with many exotic grasses, including wild oats.

Figure 6 - WP97 culvert

WP98
This was a creek culvert beneath the road. Vegetation consisted of *Casuarina* sp. and *Eucalyptus* sp. with no obvious understorey – exotic grass species.

Figure 7 - WP98 creek culvert

WP99

This site was a culvert beneath the railway and the road. As at WP97 it appears that water comes from the wheat paddock on the other side of the road and flows back through the culverts. The vegetation was *Eucalyptus* sp. over exotic grasses.

Figure 8 - WP99 culvert beneath railway

WP100A

This site was the main creek (Kiaka Creek) beneath the railway and the road. The vegetation was *Casuarina* sp. and *Eucalyptus* sp. over sparse understorey which was mostly exotic grasses with some *Enchylaena* sp. and other shrubs.

Figure 9 - WP100A railway over Kiaka Creek

WP100B
This was the same site as 100A but was the road culvert. The vegetation was *Casuarina* sp. and *Eucalyptus* sp. with no understorey, only exotic grasses.

Figure 10 - WP100B Kiaka Creek at road culvert

WP103
This site was a natural saline wetland within the Coonderoo River wetland system which was 'perched' – not continuous with the main 'channel', though during large flood events it would join the main system. The vegetation consisted of *Casuarina* sp. around the higher wetland rim with *Enchylaena* sp., *Mesembryanthemum nodiflorum* (introduced), *Tecticornia indica* subsp *bidens*, *T. doleiformis*, and *T. pergranulata* in zones towards the bare playa. There were no birds present.

WP104

This site is the main drainage line of the Coonderoo River wetland system – there is a culvert beneath the road at this point. The wetland system is a historic saline system – perhaps somewhat affected by secondary salinization but not recently. The few dead trees surrounding the wetlands have been dead a number of years. As seen at WP103 samphires grow in zones from the wettest point to the highest point. There were no trees near the site but shrubs of *Hakea preissii* were at the highest point with *Enchylaena* sp., *Mesembryanthemum nodiflorum, Tecticornia indica* ssp. *bidens*, *T. doleiformis*, Frankenia sp., *T. halocnemoides* ssp. *tenuis*, *T. undulata*, *T. syncarpa*, *T. peltata*, *T. pergranulata* and *Tecticornia moniliformis* (?) in descending order. There was a large amount of *Ruppia* (Eelgrass) in the water.

Figure 11 - WP104 main channel Coonderoo River wetlands

Figure 12 – WP104 main channel Coonderoo River wetlands south

WP102/105

This site was a freshwater wetland with many birds present – Black Swans, Ducks and Black Winged Stilts. There were a few samphire species in zones away from the water – *Tecticornia moniliformis* standing in the water, *Frankenia* sp., *T. halocnemoides* ssp. *tenuis*, *T. doleiformis*, *T. pergranulata* and *T. indica* ssp. *bidens*. There were some *Casuarina* sp. trees at the highest point away from the water. The water at this site was not tested as this wetland is not continuous with the others unless the region is flooded.

Figure 13 - WP105 Black Winged Stilts and Ducks

8.2 Smelting Process

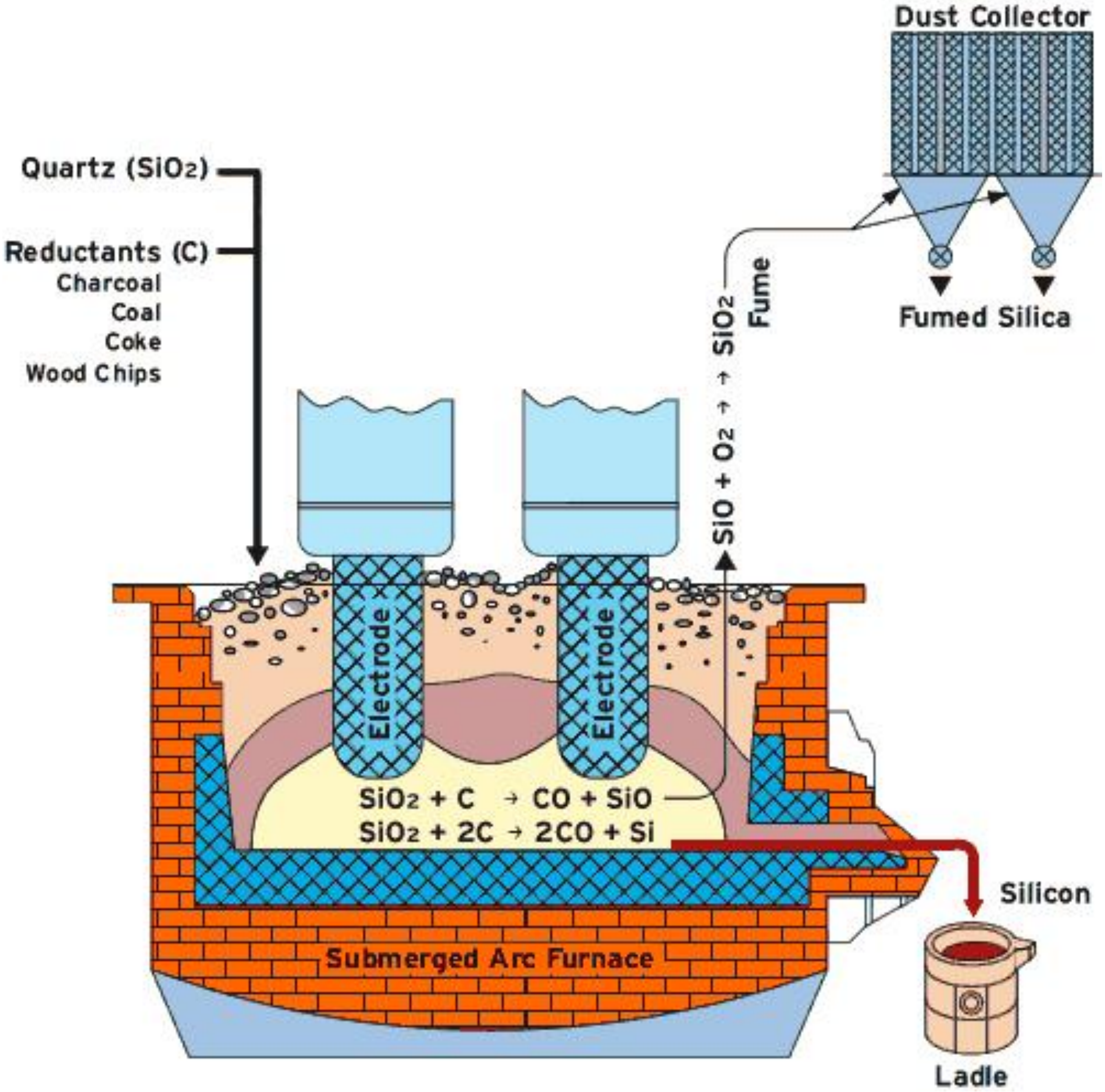

Figure 14 - Simplified diagram of smelting process

8.3 Chemical Analysis

Table 7 - Chemical Analysis of Brines – Major Ions

		Description	WP96	WP103	WP104	BH2
Analyte Name	**Units**	**Reporting Limit**	**Result**	**Result**	**Result**	**Result**
pH	pH Units	0.1	7.6	8.7	8.4	7.6
Conductivity @ 25 C	µS/cm	2	710	36000	94000	1100
Total Dissolved Solids (180°C)	mg/L	10	480	30000	68000	656
Total Suspended Solids (105°C)	mg/L	5	5	79	220	<5
Total Alkalinity as CaCO3	mg/L	5	60	130	66	
Carbonate Alkalinity as CO3	mg/L	1	<1	20	7	<1
Bicarbonate Alkalinity as HCO3	mg/L	5	73	120	66	240
Chloride	mg/L	1	170	14000	30000	240
Sulphate	mg/L	1	140	1600	6800	26
Nitrate, NO_3 as NO_3	mg/L	0.05	0.08	<0.05	<0.05	11
Total Nitrogen (calc)	mg/L	0.05	4.7	3.5	2.8	2.4
Total Phosphorus	mg/L	0.01	0.31	0.17	0.12	0.05
Calcium, Ca	mg/L	0.2	12	240	2200	44
Iron, Fe	mg/L	0.02	2.4	<0.4	<0.4	<0.02
Potassium, K	mg/L	0.1	12	110	560	3.2
Magnesium, Mg	mg/L	0.1	3.4	620	1300	44
Manganese, Mn	mg/L	0.005	0.038	<0.1	<0.1	<0.005
Sodium, Na	mg/L	0.5	170	6900	15000	120
Aluminium, Al	mg/L	0.02	3.3	<0.4	<0.4	<0.02
Anion-Cation Balance	%	-100	0	-8	-7	-3
Oil and Grease in Water	Oil and Grease					<5

Table 8 - Chemical Analysis of Brines - Metals

		Description				
Analyte Name		**Limits**	**96**	**103**	**104**	**BH2**
Silica, Soluble	mg/L	0.05	7.80	3.20	<0.5	17.00
Total Arsenic	mg/L	0.02	<0.02	<0.2	<0.2	<0.02
Total Cadmium	mg/L	0.005	<0.005	<0.05	<0.05	<0.005
Total Chromium	mg/L	0.005	<0.005	<0.05	<0.05	<0.005
Total Copper	mg/L	0.005	0.02	<0.05	<0.05	<0.005
Total Lead	mg/L	0.005	<0.005	<0.05	<0.05	<0.005
Total Nickel	mg/L	0.005	0.01	<0.05	<0.05	<0.005
Total Zinc	mg/L	0.01	0.01	<0.1	<0.1	<0.01
Mercury	mg/L	0.00005	<0.0001	<0.0001	<0.0001	<0.00005

8.4 Vegetation Species

Table 9 - Vegetation Species

Wetland species	WP103	WP104	WP105
Enchylaena sp	x	x	
Frankenia sp		x	x
Mesembryanthemum nodiflorum	x	x	
Ruppia sp		x	
Tecticornia doleiformis	x	x	x
T. halocnemoides ssp *tenuis*		x	x
T. indica ssp *bidens*	x	x	x
T. moniliformis		x	x
T. peltata		x	
T. pergranulata	x	x	x
T. syncarpa		x	
T. undulata		x	

Figure 15 - *Tecticornia doleiformis*

Figure 16 - *Tecticornia peltata*

Figure 17 - *Tecticornia pergranulata*

Figure 18 - *Tecticornia indica* ssp. *bidens* (tall), *T. halocnemoides*

8.5 Priority Species Search

NatureMap Species Report
Kingdom Plantae
Shire Boundary MOORA

1. 3210 *Acacia anarthros* P3
2. 14050 *Acacia arcuatilis* P2
3. 14051 *Acacia aristulata* T Y
4. 14062 *Acacia cochlocarpa subsp. cochlocarpa* T
5. 14064 *Acacia congesta subsp. cliftoniana* P1
6. 14066 *Acacia cummingiana* P3
7. 3338 *Acacia flabellifolia* P3
8. 14123 *Acacia isoneura subsp. nimia* P3
9. 14625 *Acacia trinalis* P1
10. 3594 *Acacia vassalii (Vassal's Wattle)* T
11. 29437 *Anigozanthos humilis subsp. Badgingarra (S.D. Hopper 7114)* P2
12. 1262 *Arnocrinum drummondii* P3
13. 19948 *Baeckea sp. Bunney Road (S. Patrick 4059)* P2
14. 17126 *Baeckea sp. Moora (R. Bone 1993/1)* P3
15. 20421 *Baeckea sp. Perth Region (R.J. Cranfield 444)* P3
16. 32696 *Banksia dallanneyi subsp. pollosta* P3
17. 5377 *Beaufortia bicolor* P3
18. 31606 *Blackallia nudiflora (Wedge-leaved Cryptandra)* P3
19. 1583 *Caladenia cristata (Crested Spider Orchid)* P1
20. 19217 *Caladenia drakeoides* T
21. 18039 *Caladenia dundasiae* P1 Y
22. 5396 *Calothamnus accedens* P4
23. 5421 *Calothamnus pachystachyus* P4
24. 19977 *Calytrix ecalycata subsp. pubescens* P1 Y
25. 5471 *Calytrix platycheiridia* P2
26. 35641 *Chamelaucium sp. Wongan Hills (B.H. Smith 1140)* P3
27. 13115 *Chorizema humile* T
28. 29495 *Commersonia sp. Bindoon (C. Wilkins & F. & J. Hort CW 2155)* P1
29. 14000 *Conospermum densiflorum subsp. unicephalatum* T
30. 1870 *Conospermum eatoniae* P3
31. 5504 *Darwinia acerosa (Fine-leaved Darwinia)* T
32. 11963 *Daviesia debilior subsp. sinuans* P3
33. 3806 *Daviesia dielsii* T
34. 6775 *Dicrastylis velutina* P3
35. 12936 *Diuris recurva* P4
36. 28242 *Eremaea sp. Cairn Hill (B. Morgan 532)* P1 Y
37. 7266 *Eremophila scaberula* T
38. 13093 *Eucalyptus absita (Badgingarra Box)* T
39. 12894 *Eucalyptus arachnaea subsp. arrecta* P3
40. 16887 *Eucalyptus macrocarpa x pyriformis* P3
41. 5741 *Eucalyptus pendens (Badgingarra Mallee)* P4
42. 13040 *Eucalyptus pruiniramis* T
43. 14279 *Eucalyptus rhodantha var. petiolaris* P4
44. 14280 *Eucalyptus rhodantha var. rhodantha* T
45. 12880 *Eucalyptus subangusta subsp. virescens* P3
46. 16944 *Eucalyptus x carnabyi* P4
47. 3888 *Gastrolobium appressum (Scaleleaf Poison)* T
48. 3904 *Gastrolobium hamulosum (Hookpoint Poison)* T
49. 3922 *Gastrolobium rotundifolium (Gilbernine Poison)* P3
50. 23492 *Gompholobium roseum* P2
51. 7491 *Goodenia arthrotricha* T
52. 19434 *Grevillea amplexans subsp. adpressa* P1
53. 1958 *Grevillea asparagoides* P3

54. 33580 *Grevillea bracteosa subsp. bracteosa* T
55. 1976 *Grevillea christineae* T
56. 2013 *Grevillea granulosa* P3
57. 14414 *Grevillea haplantha subsp. recedens* P3
58. 2036 *Grevillea makinsonii* P3
59. 2067 *Grevillea pinifolia (Pine-leaved Grevillea)* P1
60. 14422 *Grevillea thyrsoides subsp. pustulata* P3
61. 16952 *Guichenotia tuberculata* P3
62. 6835 *Hemiandra gardneri (Red Snakebush)* T
63. 6847 *Hemigenia curvifolia* P2
64. 1292 *Hensmania stoniella* P3
65. 5145 *Hibbertia miniata (Orange Hibbertia)* P4
66. 14589 *Hydrocotyle coorowensis* P2
67. 14991 *Hydrocotyle vigintimilia* P1
68. 4003 *Jacksonia carduacea* P3
69. 14744 *Jacksonia pungens* T
70. 4033 *Jacksonia velutina* P4
71. 5036 *Lasiopetalum lineare* P3
72. 7578 *Lechenaultia juncea (Reed-like Leschenaultia)* P3
73. 5963 *Melaleuca sclerophylla* P3
74. 3051 *Menkea draboides* P3
75. 14726 *Micromyrtus rogeri* P1
76. 31577 *Papistylus grandiflorus* P2
77. 14084 *Persoonia chapmaniana* P3
78. 2285 *Petrophile biternata* P3
79. 12733 *Podotheca pritzelii* P3
80. 12732 *Podotheca uniseta* P3
81. 6015 *Regelia megacephala* P4
82. 13068 *Scaevola globosa* P3
83. 17606 *Schoenus griffinianus* P3
84. 14675 *Scholtzia sp. Gunyidi (J.D. Briggs 1721)* P2
85. 33081 *Stylidium sp. Moora (J.A. Wege 713)* P2
86. 16374 *Synaphea quartzitica* T Y
87. 16773 *Synaphea rangiferops* P2
88. 20734 *Thelymitra pulcherrima* P2
89. 29458 *Tricoryne sp. Wongan Hills (B.H. Smith 794)* P2
90. 10880 *Urodon capitatus* P3
91. 12410 *Verticordia dasystylis subsp. oestopoia* P1
92. 12431 *Verticordia huegelii var. tridens* P3
93. 12434 *Verticordia insignis subsp. eomagis* P3
94. 14716 *Verticordia muelleriana subsp. muelleriana* P3
95. 6111 *Verticordia polytricha (Northern Cauliflower)* P4
96. 12468 *Verticordia venusta* P3
97. 12471 *Verticordia wonganensis* P2

Conservation Codes

T - Rare or likely to become extinct
X - Presumed extinct
IA - Protected under international agreement
S - Other specially protected fauna
1 - Priority 1
2 - Priority 2
3 - Priority 3
4 - Priority 4
5 - Priority 5
Y[10] Endemic for Area

[10] For NatureMap's purposes, species flagged as endemic are those whose records are wholly contained within the search area. Note that only those records complying with the search criterion are included in the calculation.

8.6 Salt Lakes – an introduction

The arid and semi-arid interior of Western Australia contains some of the largest regions of salt lakes on the Australian continent (Geddes et al. 1981). These range from being small periodically filled basins to lakes which are over 100km in length. Contrary to popular belief, these lakes are not wastelands, but unique and ancient natural systems, which support a range of plant and animal species in their surrounds and within (Williams 1993).

Salt lakes are remnant external river systems (now called palaeodrainage systems) which flowed during the Tertiary era. The progression to a more arid climate and lengthy periods of tectonic stability has led to the drying of these rivers and formation of the present lakes (Geddes et al. 1981).

Salt lakes generally consist of numerous flat areas, which contain many smaller salt lakes, gullies, clay pans and samphire flats. The lakes are predominantly dry with hyper-saline surface waters generally evident in winter months following rainfall events and more permanent waters in years of exceptionally high rainfall.

Salt lakes are not only of ecological importance, but also have economic, aesthetic, scientific, educational and Aboriginal mythological values. Furthermore, 0.006% of global water is contained in salt lakes compared with 0.007% contained in inland freshwater systems, illustrating the major contribution of salt lakes to the global hydrological cycle (Williams 1998).

Figure 19 - Way Point Sites and Coonderoo River Wetland System