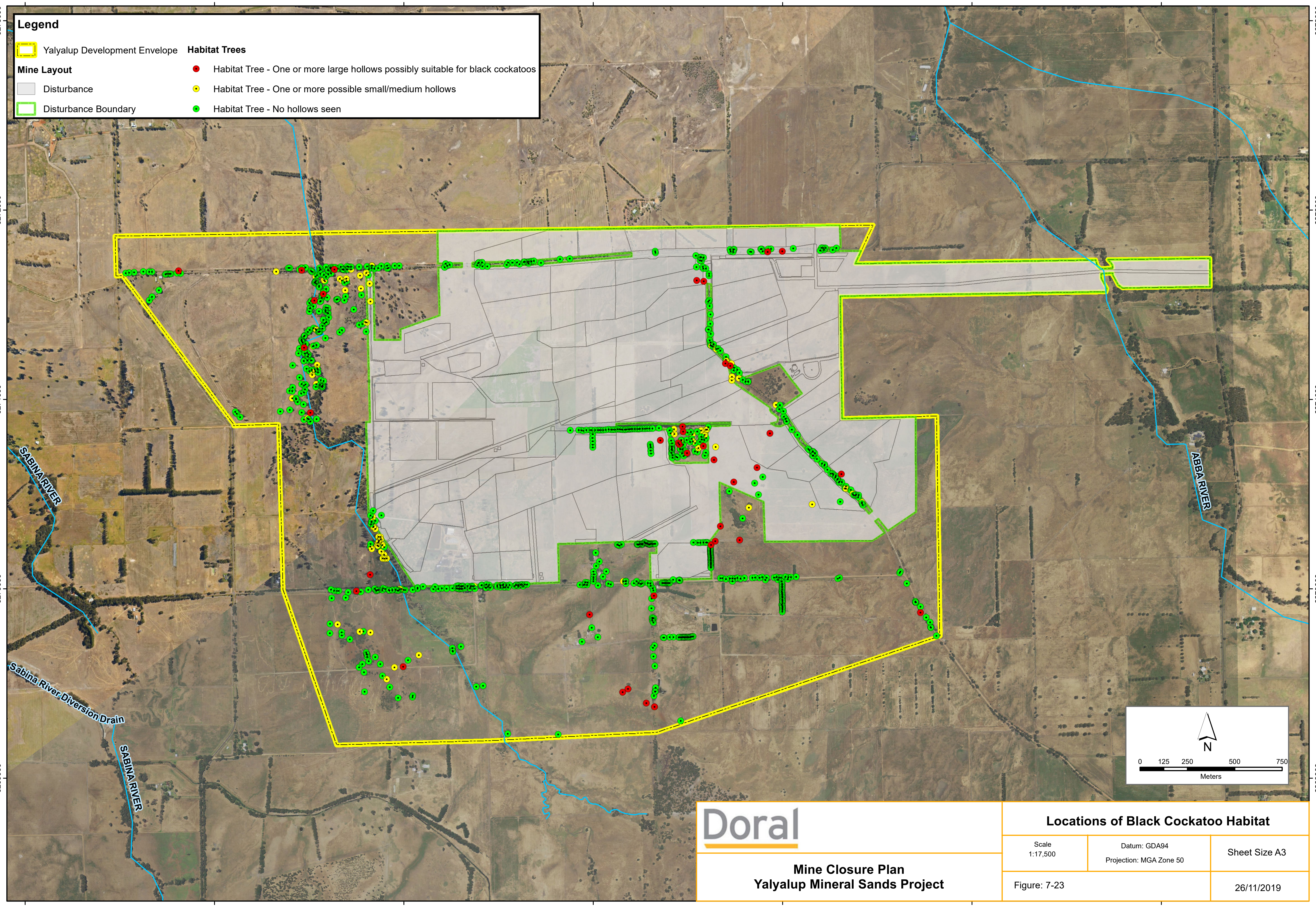
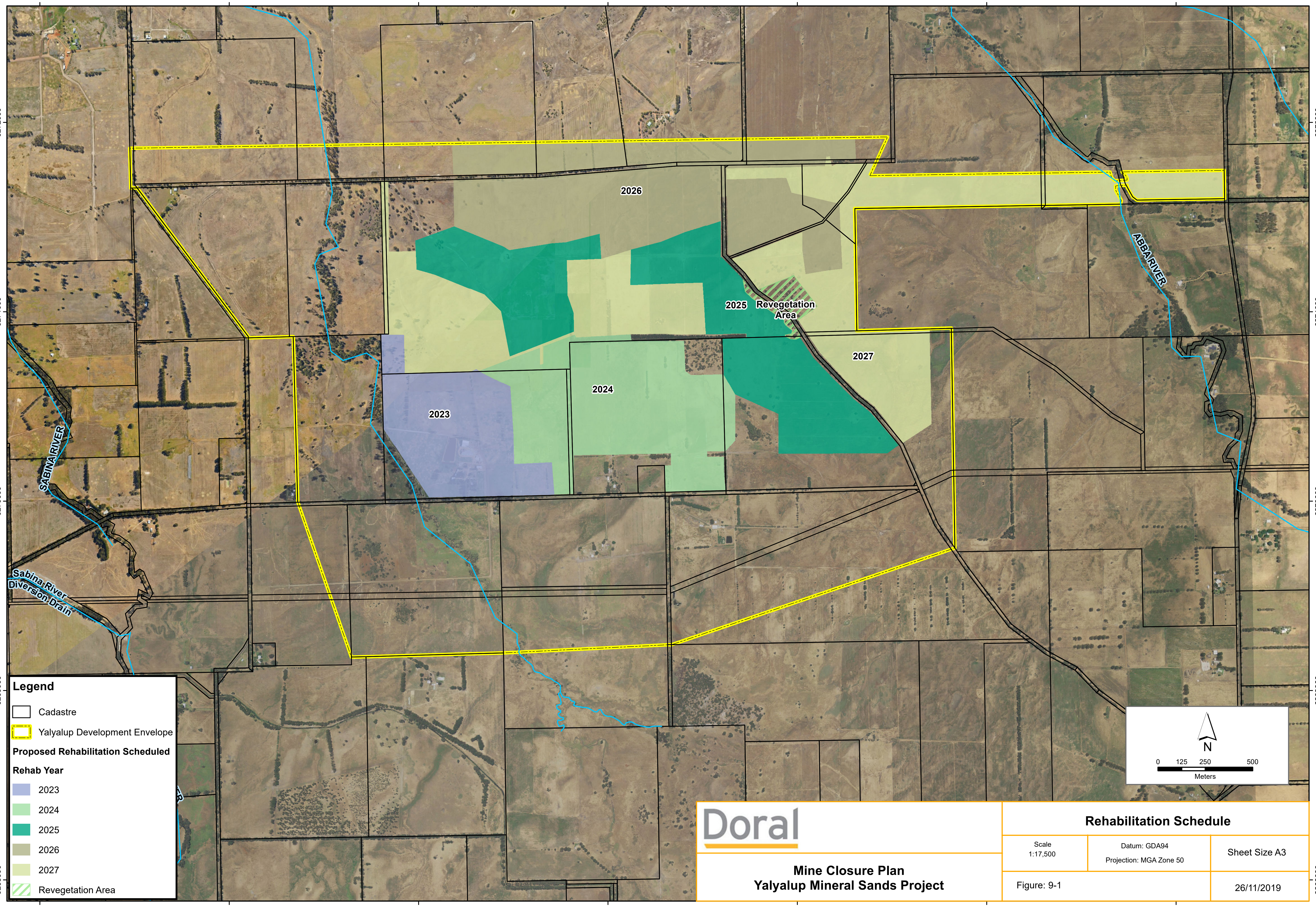


355000
356000
357000
358000
359000
360000
361000
6273000
6272000
6271000
6270000
6269000
Legend
Yalyalup Development Envelope
Mine Layout
Disturbance
Disturbance Boundary
Habitat Trees
Habitat Tree - One or more large hollows possibly suitable for black cockatoos
Habitat Tree - One or more possible small/medium hollows
Habitat Tree - No hollows seen
SABINA RIVER
Sabina River Diversion Drain
SABINA RIVER
ABBA RIVER
N
0 125 250 500 750
Meters
Doral
Locations of Black Cockatoo Habitat
Scale
1:17,500
Datum: GDA94
Projection: MGA Zone 50
Sheet Size A3
Mine Closure Plan
Yalyalup Mineral Sands Project
Figure: 7-23
26/11/2019



Doral

Rehabilitation Schedule

Scale 1:17,500

Datum: GDA94

Projection: MGA Zone 50

Sheet Size A3

Mine Closure Plan
Yalyalup Mineral Sands Project

Figure: 9-1

26/11/2019

APPENDIX 1

YALYALUP MINE ACID SULFATE SOIL MANAGEMENT PLAN

YALYALUP MINERAL SANDS PROJECT

ACID SULFATE SOIL INVESTIGATION AND MANAGEMENT PLAN

DECEMBER 2019

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1. INTRODUCTION

1.1 BACKGROUND

Doral Mineral Sands Pty Ltd (Doral) propose to mine the Yalyalup Mineral Sands Deposit, located approximately 11km east southeast of Busselton (Figure 1) on the Swan Coastal Plain (i.e. the Site). The Yalyalup deposit has an approximate disturbance footprint of ~453.3ha within a 924.8ha Development Envelope and encompasses an area Doral have been granted Retention Licence R70/0052, which covers an area of ~2,290ha. (Figure 2). The deposit is also located ~4km southeast of the Wonnerup Mine Site (Cristal Mining Australia), ~2.5km northwest of the Tutunup Mine site (Iluka Resources Ltd) and ~6km northeast of the Yoongarillup Mine Site (Doral).

The deposit occurs in an area depicted on an Acid Sulfate Soil (ASS) risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface'. Ore from the deposit will be mined progressively via a series of open-cut pits using dry mining techniques to an expected maximum depth of ~10.5mbgl. Dewatering of groundwater inflows into the mine pits will be required in some areas to enable dry mining to occur.

As mining will involve the disturbance of greater than 100m^3 of soil or sediment from below the natural water table in a Class II ASS risk area and also the lowering of the water table in a Class II risk area, Doral have undertaken a targeted ASS investigation in accordance with the Department of Water and Environmental Regulation (DWER) guideline *Investigation and identification of acid sulfate soils and acidic landscapes* (DER, 2015a) to assist in determining the potential presence and distribution of ASS, and if present provide details of proposed management measures.

1.2 OBJECTIVES

The objective of the ASS investigation and management plan (ASSMP) was to:

- Conduct soil sampling to identify the presence or the absence of ASS in areas likely to be disturbed;
- Assess the net acidity (comprising both existing and potential acidity) of soil at locations where mining is likely to result in disturbance below the natural groundwater table;
- Assess the baseline quality of groundwater (from existing landowner and DWER bores) that will require dewatering;
- Provide appropriate management measures, where required.

1.3 SCOPE OF WORK

The scope of works for the ASS investigation was developed based on Doral's resource definition drilling program which comprised 51 exploration drill holes (31 holes in December 2014 and a further 20 in December 2017) to approximately 2m below the maximum anticipated depth of disturbance. The scope of work included the following:

- Collection and logging of soil samples at 1m intervals from 51 targeted locations (i.e. deepest areas of excavation) to approximately 2m below the proposed maximum depth of excavation;
- Field testing of all soil samples for pH_F and pH_{FOX};
- Laboratory analysis using the Chromium Reducible Sulfur (CRS) method for samples with a pH_{FOX} <3 and/or other selected samples;

- Assessment of baseline groundwater quality from available existing groundwater monitoring wells;
- Preparation of an ASS investigation and management plan.

2. EXISTING ENVIRONMENT

2.1 LOCATION AND LANDUSE

The Yalyalup deposit is located within the City of Busselton ~11km east southeast of Busselton, WA (Figure 1). The Site currently encompasses an area Doral have been granted Retention Licence R70/0052, which covers an area of approximately 2,290ha. The ASS investigation was undertaken in areas south of Princefield Road, North of Yalyalup Road and between the Wonnerup South Road (west end) and Ludlow Hithergreen Road (eastern end) (Figure 2).

The Site is located in the Southern Perth Basin, approximately midway between the current coastline and the base of the Whicher Scarp. The Southern Perth Basin sediments are predominately Permian to Cretaceous aged with a thin cover of Pleistocene and Recent sediments.

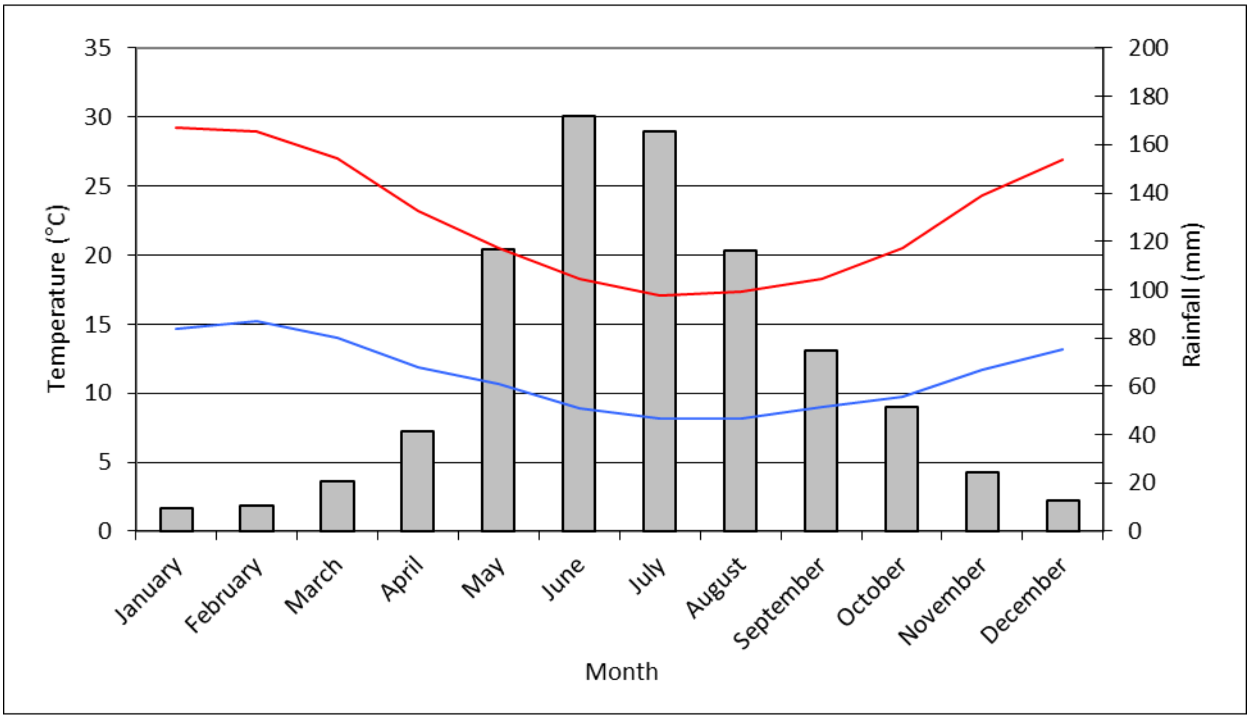
All land comprising the Site is zoned 'agricultural' in accordance with the City of Busselton's Local Planning Scheme (LPS) No. 21. The Site has been extensively cleared in the past 50-100 years for agricultural purposes. The dominant land use is cattle grazing and hay production. Land has also been used for dairy production in recent years with minor irrigation of pasture with untreated effluent water (sourced from dairy within Lot 843). Localised excavation of farm dams has exposed minor areas of the underlying sediments to the atmosphere.

Remnant vegetation within the Site bounds is restricted mainly to road reserves and creek lines, with other scattered clusters of native vegetation occurring in paddocks. Several landholders have planted tree belts that include pine trees and other non-endemic eucalyptus species.

2.2 CLIMATE

The Busselton area experiences a Mediterranean climate with warm to hot dry summers, and mild wet winters. High pressure cells dominate climatic patterns during summer and the passage of cold fronts and associated low pressure cells dominate during winter. Strong sea breezes occur from late November to early March. The annual rainfall generally falls within the 800mm and 1000mm range, peaking in June and July, as shown in Chart 1. In summer the average maximum temperature is 28°C with an average minimum temperature of 12°C. In winter the average maximum temperature is 16°C with an average minimum temperature of 5°C (Bureau of Meteorology, 2017).

CHART 1: ANNUAL AVERAGE CLIMATE DATA



Source: Bureau of Meteorology Busselton Station (Weather Station 009515).

2.3 GEOLOGY

The Site is located within the southern part of the Perth Basin, an elongate north–south rift trough with a series of sub-basins, shelves, troughs and ridges (AQ2, 2019a). The Site is wholly contained within the Bunbury Trough, a sub-basin containing a Permian–Cretaceous succession up to 11 km thick. The sub-basin is wedged between the Vasse Shelf and the Yilgarn Craton, bounded to the east by the Darling Fault and to the west by the Busselton Fault. The Site is included on the published 1:50,000 Environmental Geology Series map for Busselton (Belford, 1987) (Figure 3).

The upper geology sequence comprises the Quaternary-late Tertiary aged Superficial Formation, which are represented at the Site by the Bassendean Sand towards the top, the Guildford Formation and the Yoganup Formation towards the base. The Bassendean Sand forms a thin bed of fine to medium grained aeolian sand. The Guildford Formation consists predominantly of silty to sandy clay of fluvial origin. The Yoganup Formation comprises leached and ferruginous coarse-grained beach sand, with localised concentrations of heavy minerals and some sandy silt and clay layers. The superficial deposits commonly contain ironstone caprock, colloquially known as Coffee Rock, in the zone of water table fluctuation. At the Site, the Coffee Rock is generally 2-3m thick and is exposed at the surface in the eastern side of the Site, near and along the McGibbon Track. The thickness of the Superficial Formation is irregular, reaching a maximum of ~12m at the Site, but generally 7-8 m thick.

The Superficial Formation is unconformably underlain by Cretaceous age, riverine and deltaic sediments of the Leederville Formation, comprising discontinuous interbedded weakly consolidated sandstone, clayey sand, silt and shale. Three member units of the Leederville Formation are identified: Vasse Member, Mowen Member, and Quindalup Member, with only Vasse and Mowen Members, present in the Yalyalup area. The lower Vasse Member is highly stratified, containing sand beds interbedded with clay aquitards. Sand beds are generally up to 10m thick with overall unit thickness of 100m at the project site. The upper Mowen Member is dominated by clay and silt with some thin interbedded silty to medium grained sand, with a thickness of up to 10m. The Mowen Member is likely to be very thin or has a greater sand content, especially on the eastern side of the project area.

The Yarragadee Formation (the aquifer being targeted for the mine water supply) underlies the Leederville Formation, comprising predominantly weakly consolidated, medium to very coarse-grained quartz sandstone, with minor siltstone and shale beds. Based on lithology and age, this formation has been divided into four sub-units (sequentially, Unit 1 to Unit 4; Baddock et. al., 2005). Unit 1 occurs at the top of the formation and Unit 4 at the base, with all units likely to be present in the project area (a total thickness of approximately 900 m).

The Bunbury Basalt occurs discontinuously between the Yarragadee and Leederville Formations and the top of the basalt is typically highly weathered. The Bunbury Basalt is unlikely to be present at the Site, based on the literature (i.e. DWER drilling information records (DWER, 2019) and the Water Corporation Magnetic data survey (Baddock, et al., 2005).

2.4 HYDROGEOLOGY

Groundwater is present in the area within a multi-layered aquifer system. Three major aquifers have been identified within the Proposal area (ordered from shallow to deep), namely:

- Superficial;
- Leederville;
- Yarragadee.

A conceptual hydrogeological cross section in the proposal area is provided as Figure 2-4 and a detailed description of the three aquifers (from AQ2, 2019a) is provided below.

Superficial Aquifer

The Bassendean Sand, Guildford Formation and Yoganup Formation form an unconfined Superficial aquifer, with a maximum saturated aquifer thickness of ~9m at the Site. The Guildford Formation is present between the Bassendean Sand and Yoganup aquifers and is of low permeability, owing to its more clayey nature. The permeability of the superficial aquifer is variable and depends on sediment type, with saturated sands having higher permeability than clays. At the site, the Yoganup Formation forms the main portion of the aquifer, while the Bassendean Sand is generally only saturated in the wet season.

Leederville Aquifer

The Leederville Formation forms a multi-layered confined aquifer system, comprising discontinuous interbedded sequences of sand, clayey sand, silt and shale. It underlies the Superficial deposits across the Proposal area, coming to surface approximately ~5-10km to the south-east of the Site, where it forms outcrops in the Whicher Scarp/Blackwood Plateau.

At the Site, the Leederville aquifer generally comprises the Mowen Member of the Leederville Formation. The Mowen Member of the Leederville Formation, which overlies the Vasse Member is commonly considered as an aquitard due to its clayey nature. At the eastern portion of the modelled study area by AQ2 (2019a), the Mowen Member is likely to be very thin or has a greater sand content, resulting in the Leederville aquifer directly underlying the Superficial aquifer.

Yarragadee Aquifer

The Yarragadee Formation forms a confined Yarragadee aquifer below the Leederville aquifer. There are four sub-units within the Yarragadee Formation with distinct lithological properties. The Yarragadee aquifer is confined by the Leederville Formation. The Bunbury Basalt is discontinuously thin aquitard and it is believed not to be present at the modelled study area (AQ2, 2019a).

2.5 SURFACE WATER

Local Rivers

The Site is within the Wonnerup (Busselton Coast) Surface Water Management subarea and the Lower Sabina River sub-catchment. The Site is not within a proclaimed area for surface water management (DoW, 2009).

The Abba River crosses the northeast corner of the Site and the lower Sabina River lies ~900m beyond the southwest corner, both generally flowing in a northwesterly direction. The Lower Sabina River flows from below the Sabina Diversion Weir to the Ramsar listed Vasse-Wonnerup Wetlands. The Lower Sabina, Lower Vasse, Abba and Ludlow rivers drain into the Vasse-Wonnerup Wetlands, before discharging through the Wonnerup Inlet into Geographe Bay.

The Sabina Diversion Weir was constructed to allow overflow during extreme rainfall events from the Upper Sabina to the Lower Sabina, with regular flows through the Sabina Diversion Drain. The weir was over designed and the Upper Sabina catchment (78 km2) no longer contributes any flow directly to the Lower Sabina river, although some minor sub-drains in the upper catchment may spill in large events (Marillier, 2018). The flow upgradient of the Sabina diversion weir is directed through the Sabina Diversion Drain to the Vasse Diversion Drain system and out to the Geographe Bay, rather than to Vasse-Wonnerup Wetlands.

The Vasse-Wonnerup Wetlands catchment area is 473km^2, excluding the diverted sub-catchments (DWER, 2019). The Lower Sabina River catchment area of 45.5km^2 is less than 10% of the Vasse-Wonnerup Wetland Catchment. The Abba River is one of the other major tributaries to the Vasse-Wonnerup Wetland and has a catchment area of 137km^2 which is 29% of the Vasse-Wonnerup Wetlands catchment.

Other regional drainage features outside of the Vasse-Wonnerup Wetlands include the Vasse Diversion Drain, which has a catchment area of 303 km^2 and receives inflows from the diverted Upper Sabina (78 km^2) and Upper Vasse (catchment 180 km2) rivers (Marillier, 2018).

There are no stream gauges in the Lower Sabina catchment. The closest stream gauges are on the Upper Sabina at the Sabina Diversion (site 610025), and on the Abba River (site 610062). Marillier (2018) analysed gauge information and estimated average annual flows (2001–14) in the major ungauged rivers flowing to the Vasse Estuary Wetland. Marillier (2018) estimated the Lower Sabina discharge as 5.7 GL/year, less than half the Abba River volumes (12.5 GL/yr). In contrast, 4 GL/year is diverted away from Vasse-Wonnerup Wetlands along the Sabina Diversion Drain, and 24 GL/yr is diverted via the Vasse Diversion Drain (Marillier, 2018). The Ludlow River discharges the second highest volumes to the Vasse-Wonnerup Wetlands an annual average of 11.4 GL/yr based on DWER gauging station summary statistics (DWER, 2019).

On-Site Drainage

Several roads and man-made drains installed in the 20th century have modified the natural drainage pattern within the Development Envelope. These include the Princefield Rd drain located near the northern boundary of the Development Envelope and two other first order drainage lines which contribute to a tributary (Woddidup Creek) of the Lower Sabina River (downstream of the Sabina Diversion Weir).

2.6 WETLANDS

Approximately 90% of the Site is mapped as a wetland in the Geomorphic Wetlands of the Swan Coastal Plain dataset (DEC, 2008a), all of which has been assessed as being in the 'Multiple Use' management category, which is described as wetlands with few ecological attributes and functions remaining. The majority of the wetland area at the Site (~77%) is mapped as Palusplain (seasonally waterlogged flat), with small areas of Sumpland (seasonally inundated basin, ~3%) and floodplain (seasonally inundated flats, ~17%) (Figure 7). No wetlands of environmental significance are present at the Site

The Vasse-Wonnerup wetland, located approximately 4.6km to the northwest of the Site (Figure 1). This wetland is listed under the Ramsar convention as a wetland of international significance and is an extensive, shallow, nutrient-enriched, wetland system with widely varying salinities. Water levels in it have two principal components, the Vasse and Wonnerup lagoons (former estuaries), are managed through the use of weirs (flood gates) with the aim of minimising flooding of adjoining lands and of keeping sea water out. When the water level in the estuaries rises above sea level, hydrostatic pressure opens the floodgates and allows water to flow out to Wonnerup Inlet and the sea. When the level drops, the gates close, thereby preventing ingress of sea water (HydroSolutions, 2017).

Three reserve areas in the Busselton-Capel groundwater subarea are under ecological monitoring due to the presence of high sensitivity GDE's (DWER, 2009, Figure 1). These GDE's have management triggers and responses attached to them by DWER (Del Borello, 2008). These are labelled 'conservation' Sumpland and Floodplain, but are located approximately 6km the northeast and southwest of the Proposal.

2.7 ACID SULFATE SOIL RISK MAPPING

The Site occurs in an area depicted on DWER's online ASS risk map as Class II 'moderate to low risk of ASS occurring within 3m of natural soil surface' (www2.landgate.wa.gov.au) (Figure 8).

3. ACID SULFATE SOIL INVESTIGATION

3.1 SOIL SAMPLING METHODOLOGY

Doral undertook a targeted soil investigation in conjunction with resource definition drilling at the Site in mid-December 2014 and mid-December 2017 to assist in determining the presence and distribution of ASS at the Site and to characterise the various geological/geomorphological units. Drilling was undertaken using an air core drill rig, with soil samples collected and logged by Doral at 1m intervals from 51 locations (Figure 9). The drilling locations were spaced approximately 320m along the strike of the two deeper strandlines and drill holes were located at 80-120m spacing's across the widths of the anticipated deeper ore zones and across other areas of proposed disturbance. The depth of drilling at each location was targeted to approximately 2m deeper than the anticipated maximum depth of disturbance (10.5mBGL), with a maximum drilling depth of 13mBGL.

Following logging of the soil profile, soil samples were collected for initial screening via field testing (pH_F and pH_{FOX}). Samples were placed in clearly labelled ziplock bags with air excluded and placed in a 12V vehicle freezer whilst on site, allowing the samples to be stored below 0°C. Engraved sample tag labels were also included with all soil samples in the event sample names rubbed off the ziplock bags in transit. The samples were initially analysed for pH_F at Doral's laboratory during the December 2014 program and in the field during the December 2017 program. All samples were transported to the Australian Government National Measurement Institute (December 2014) and Chem Centre laboratory (December 2017) for analysis of pH_{FOX} before being placed on cold storage at the laboratory pending decisions about further analytical analysis.

3.2 SOIL SAMPLE ANALYSIS

Soil samples were recovered at 1m intervals and field tests were performed on all 502 primary samples (pH_F in the field, and pH_{FOX} in the laboratory). The procedure used for field testing is discussed in detail in DER (2015a). Following field testing, 118 of the 502 primary samples (approximately 25%) were selected for laboratory analysis using the Chromium Reducible Sulfur (CRS) suite method. Detailed analysis by CRS suite is used to determine whether soils are likely to generate net acidity, and if so, to quantify this acidity for comparison with action criteria used to determine management requirements. The CRS method is considered very reliable, and is less subject to interference from sulfides in organic matter or sulfate minerals. This method was selected primarily due to the site lithology which was observed to be clayey in nature.

3.3 SOIL ASSESSMENT CRITERIA

The ASS characteristics at the site were compared with guidance criteria provided in DER (2015a).

3.3.1 FIELD TEST CRITERIA

The results of field tests are considered to give an indication of which samples may represent ASS material. The DER recommend that soils which have low pH values (pH_F of $\leq$4, or pH_{FOX} of $\leq$3), or which exhibit a significant change in pH (ΔpH, as $pH_F - pH_{FOX}$) may indicate a soil with ASS characteristics (DER, 2015a).

As such field test results were compared with the following criteria to identify potential ASS horizons:

- A pH_F of 4 or less;
- A pH_{FOX} of 3 or less;

- A change in pH value (ΔpH) of at least 3 units.

3.3.2 NET ACIDITY CRITERIA

Net acidity (NA) results were calculated using the equations presented in *Acid Sulfate Soils Laboratory Methods Guidelines* (Ahern, 2004). The NA is calculated as the sum of actual acidity and potential acidity, as well as retained acidity (for low pH samples) and is used to characterise the current state and acid producing potential of the soils. Acid neutralising capacity is not included in the net acidity calculations, consistent with DER (2015a) guidance.

Actual acidity is available for release into the environment in the short term and is represented by Titratable Actual Acidity (TAA) values, using the CRS method, while potential acidity is represented by S_{CR} values. The pH_{KCl} of a sample is used to determine the net acidity equation, which varies for samples with alkaline pH (net acidity = potential acidity), near neutral pH (net acidity = actual + potential acidity), and acid pH (net acidity = actual + potential + retained acidity).

The NA results are compared to the DER (2015a) action criterion of 0.03%S (for projects where more than 1,000 tonnes of soil will be disturbed). If results exceed this criterion, it requires the preparation of an ASS Management Plan (ASSMP).

3.4 SOIL RESULTS

The data obtained from soil logs, field testing and CRS analysis is presented in Appendix 1. Chain of custody documentation and laboratory certificates are provided as Appendix 2.

3.4.1 FIELD TEST RESULTS

Field test results are summarised as follows:

- Field pH (pH_F) values range between 5.14 and 7.47, with an average of 6.36;
- Field pH peroxide (pH_{FOX}) values range between 1.50 and 6.90, with an average of 3.52;
- The change in pH (ΔpH) ranges between -0.23 and 5.05, with an average of 2.83.

Comparison to the DER (2015a) field test criteria for all 502 primary field tests indicates the following:

- 2 primary samples with a $pH_F \leq 4$ were identified;
- 189 primary samples (~38% of all samples) with a $pH_{FOX} \leq 3$ were identified;
- 218 primary samples (~47%) with ΔpH of three or greater were identified.

A significant fraction of samples would be considered to represent ASS material on the basis of the field test indicator values.

3.4.2 LABORATORY RESULTS

A total of 118 primary samples (~25% of total samples) were analysed via the CRS suite method from samples collected from 18 investigation locations. Samples were selected based on the field test results. The results of the laboratory CRS analyses are summarised as follows:

- Seven samples contained actual acidity (as s-TAA) in excess of the 0.03%S action criterion;
- 73 samples contained potential acidity (as S_{CR}) equal to or greater than the 0.03%S action criterion;
- Using the standard net acidity equation, NA values range from <0.01%S to 2.535%S.

Comparison of the CRS results to the assessment criteria indicates the following:

- 75 of the 118 samples analysed contained NA in excess of the 0.03%S action criteria.

Based on the calculated NA values, using the appropriate NA equation on the basis of the pH_{KCl} results, there are a total of 75 samples (64%) which exceed the 0.03%S NA action criterion, with values ranging from 0.03%S to 2.535%S. The maximum actual acidity (as s-TAA) is 0.035%S, and the maximum potential acidity (as S_{CR}) is 2.5%S. The maximum NA calculated from the CRS results is 2.535%S, with an average NA of 0.28%S for samples exceeding the DER (2015a) NA action criterion.

3.5 INTERPRETATION

Field results indicate that Site soils are generally slightly acidic to neutral as a large proportion of pH_F results are within the pH6.0 to pH7.0 range. This indicates that there is very little actual acidity present in the soil profile, which is confirmed by the laboratory results, which show very little acidity is present as s-TAA. However, field results also show a high proportion of samples with $pH_{FOX} \leq 3$ and a ΔpH above 3pH units, indicating that there is additional potential acidity yet to be released into the soil profile. This is also confirmed by the laboratory CRS results which show 75 of the 118 samples analysed, contain NA as S_{CR} above the action criterion (0.03%S).

4. GROUNDWATER ASSESSMENT

4.1 GROUNDWATER MONITORING WELL LOCATIONS

Doral installed six groundwater monitoring wells into the Superficial aquifer to assist in assessing the baseline quality of groundwater and its vulnerability to acidification. The well network comprised the six Doral monitoring bores (well IDs YA_MB01S, YA_MB02S, YA_MB04S, YA_MB07S, YA_MB09S and YA_MB10S), and in addition four private landowner bore were accessed for monitoring (well IDs SCPD29A, SCPD28A, TS012M, 20005166). Well locations and IDs are shown on Figure 10.

Water quality and water level monitoring of the Superficial and Leederville aquifers was undertaken to assess the baseline water quality from July 2017- October 2019. Results were detailed in the *Hydrogeology Assessment* (AQ2, 2019a), with relevant information repeated or utilised herein.

4.2 ASSESSMENT CRITERIA

Groundwater quality at the Site is compared with guidance criteria provided in (DER, 2015b) to assess whether ASS processes may have taken place at or in the vicinity of the Site. Criteria used for this assessment include the following:

- A sulfate: alkalinity ratio greater than 0.2;
- A pH less than 5;
- Soluble aluminium concentration of greater than 1 mg/L.

In addition, samples are considered in light of indicative guidelines presented in DER (2015b) regarding the buffering capacity of groundwater when considering alkalinity and pH levels.

The analytical results were also compared with criteria for Australian Drinking Water Guidelines (ADWG), Non-Potable Use Groundwater (NPUG), and the Fresh Water Guidelines (FWG) in due to the presence of the Sabina River. These criteria are summarised in DWER's document *Assessment and Management of Contaminated Sites* (DER, 2014).

4.3 ANALYTICAL RESULTS

A summary of the average groundwater quality as at October 2019 (AQ2, 2019) is provided in comparison to the relevant assessment criteria are presented below in Table 1 for the Superficial aquifer.

TABLE 1: SUMMARY OF SUPERFICIAL GROUNDWATER QUALITY

LOCATION	pH	Total Alkalinity mgCaCO3/L	Total Acidity mgCaCO3/L	SO_4 (mg/L)	Cl (mg/L)	SO_4: Cl RATIO	SO_4: Alk RATIO	Al (mg/L)	Fe (mg/L)	Mn (mg/L)
ASSESSMENT CRITERIA (mg/L)										
ASS	<5	NV	40	NV	NV	0.5	0.2	1	NV	NV
ADWG	**6.5-8.5**	**NV**	**NV**	**500**	**NV**	**NV**	**NV**	**0.003**	**0.3**	**0.5**
NPUG	*NV*	*NV*	*NV*	*NV*	*NV*	*NV*	*NV*	*0.2*	*0.3*	*5*
FWG	6.5-8.5	NV	NV	NV	NV	NV	NV	0.055	0.3	1.9
ANALYTICAL RESULTS (mg/L) (Mean of results from Jan 19- October 19)										
YA_MB01S	**5.81**	49.70	53.20	113.45	405.05	0.28	2.28	**0.023**	**0.522**	0.072
YA_MB02S	**5.72**	38.87	88.54	75.84	449.65	0.17	1.95	**0.042**	**10.287**	0.370
YA_MB04S	**5.67**	32.97	85.54	40.94	404.32	0.10	1.24	**0.024**	***7.931***	0.198
YA_MB07S	**5.49**	11.22	25.92	27.98	62.19	0.45	2.49	**0.012**	*0.099*	0.008
YA_MB09S	**5.78**	41.17	48.22	111.46	337.98	0.33	2.71	**0.020**	*0.077*	0.010
YA_MB10S	**5.80**	28.59	36.62	122.82	369.94	0.33	4.30	**0.016**	***1.513***	0.006
SCPD29A	**5.99**	63.00	60.45	125.63	944.09	0.13	1.99	**0.035**	***0.973***	0.078
SCPD28A	**5.44**	35.20	108.78	23.66	221.39	0.11	0.67	**0.022**	**6.240**	0.124
TS012M	**5.63**	60.99	114.67	112.32	416.22	0.27	1.84	**0.010**	**4.809**	0.037
20005166	**6.32**	90.01	30.82	128.82	235.54	0.55	1.43	**0.061**	0.123	0.034

A comparison of the results to the ASS indicator criteria indicates the following for the Superficial aquifer quality:

- pH values range from 5.44 to 6.32, with an average of 5.77 and do not exceed the ASS indicator value of pH5.0;
- The average total acidity concentration at the seven out of the ten monitoring of locations exceeded the DWER recommended maximum total acidity concentration of 40mg$CaCO_3$/L, with the maximum (average) acidity of 114.67mg$CaCO_3$/L from TS012M;
- The average alkalinity for the for all locations was 45.17mg$CaCO_3$/L, a moderate level of alkalinity, that is indicative that inadequate buffering capacity is available to maintain stable pH in areas vulnerable to acidification;
- The sulfate to alkalinity ratio for all groundwater samples exceeds 0.2;
- Dissolved aluminium concentrations are below 1mg/L for all samples.

A comparison of the groundwater results to the ADWG criteria indicates the following:

- The pH of all samples is below the recommended range of 6.5-8.5;
- Dissolved aluminium concentrations of all samples exceeded the criterion of 0.003mg/L;
- Dissolved iron concentrations of seven locations exceed the 0.3mg/L criteria.

A comparison of the groundwater results to the NPUG criteria indicates the following:

- One sample exceeds the dissolved aluminium criteria;
- Two samples exceed the dissolved iron criteria.

A comparison of the groundwater results to the FWG criteria indicates the following:

- The pH of all samples is below the recommended range of 6.5-8.5;
- One sample exceeds the dissolved aluminium criteria of 0.003mg/L;
- Seven samples exceed the dissolved iron criteria of 0.3mg/L.

4.3.1 SUMMARY OF LOCAL LEEDERVILLE AQUIFER GROUNDWATER RESULTS

Baseline monitoring of the Leederville aquifer groundwater quality was undertaken by sampling existing wells within or around the Site (Figure 10) and reported by AQ2 (2019). A summary of field and laboratory water chemistry results reported by AQ2 (2019) as compared to some relevant ASS and water quality guidelines is that:

- Field pH was in the range of 5.2 (20005356) 6.6 (Lot758_Bore); acidic to slightly acidic, but below the ASS indicator criteria;
- Total Acidity ranged from 50 to 200mg$CaCO_3$/L, generally greater than the ASS indicator of 40mg$CaCO_3$ /L;
- Total Alkalinity ranged from 20 to 90mg$CaCO_3$/L, low to moderate levels of alkalinity, that is indicative that inadequate buffering capacity is available to maintain stable pH in areas vulnerable to acidification;
- Sulphate concentrations are generally below 40mg/L, except for 20005356 (60 to 140mg/L) and below the AWDG assessment criteria (500mg/L);

- Concentrations of dissolved metals were generally low, except, as noted by AQ2 (2019) for the iron concentrations that were recorded to be elevated and between 20 and 35mg/L. These levels significantly exceed the drinking water and freshwaters guidelines of 0.3mg/L;
- Field TDS concentrations ranged between 350 mg/L (Lot552_Bore) and 1,050 mg/L (20005356), generally below 800 mg/L, indicating water being fresh to marginal.

4.4 INTERPRETATION

Groundwater results from baseline monitoring groundwater monitoring undertaken by Doral, indicate that Superficial groundwater quality beneath the Site is slightly acidic due to pH levels generally <6.0 (although above the ASS indicator value of pH5.0), elevated total acidity concentrations of up to 110mg$CaCO_3$/L and moderate total alkalinity concentrations. The alkalinity/sulfate ratio indicates that groundwater is being affected by, or has already been affected by, the oxidation of sulfides. Moderate alkalinity concentrations coupled with a pH of <6.0 indicates groundwater is generally inadequate to maintain a stable pH in areas vulnerable to acidification.

Groundwater quality in the Leederville Aquifer is also considered to be acidic as evidenced by the high total acidity concentrations (up to 200mg$CaCO_3$/L) and pH generally <6.0. Alkalinity concentrations are in the low to moderate range indicating that groundwater is inadequate to maintain a stable, acceptable pH level. A comparison of the generally low levels of alkalinity compared to sulfate also indicates that groundwater is being affected by, or has already been affected by, the oxidation of sulfides.

5. MINING AND DEWATERING PROCESS

Two methods of ore extraction will be undertaken for the Yalyalup deposit.

Surface Ore

Following the removal and stockpiling of topsoil, the shallow 1-4m 'windblown ore' reserves will be mined using a Front End Loader, and fed into the mobile in-pit hopper.

Strand Ore

For the deeper strand ore areas, once topsoil and subsoil (where available and not ore to surface) are stripped and stockpiled, overburden (where present) will be removed via excavator and trucks. Removed overburden (where identified as ASS) will be immediately transported to an open pit void prior to being neutralised with suitable alkaline material and backfilled simultaneously into an open pit void. An initial pit void will be required to allow neutralising and backfilling of overburden to occur immediately. Exact depths of ore and overburden will vary for each pit, with current drill data suggesting mining will not exceed 10.5mbgl. Ore will be mined in a series of lifts, to a maximum depth of ~10.5mbgl. Pits will be mined on a slight incline from the deepest point and then mined moving up gradient in order to retain pit water within a sump at the deepest point on the pit floor. This form of dewatering is known as 'passive' as no dewatering apparatus (e.g. spears) are used to actively abstract water and groundwater drawdown below the base of the pit (i.e. below 10.5m) is highly unlikely to occur. Only suction pumps (no submersible pumps) are used for dewatering and the suction pumps are set up at a level to maintain a 0.5m saturated pit floor. Mine pit dewater is pumped from the sump to the process water dam (PWD) for reuse.

Alkaline (lime sand) material will be added into the in-pit hopper during the excavation of ore to increase/maintain the pH (pH5.5) and buffering capacity within the wet concentration process and outgoing sand tails. The screened slurry is then pumped to the feed preparation plant where it will move through a trommel and scrubber for removal of material greater than 3mm. Oversize materials (i.e. > 3mm) will be returned to the pit void or used to sheet internal mine site roads.

From the feed preparation plant, the ore will be transported via pumps and pipelines to the wet concentration plant where the process requires all particles >2.4 mm to be removed from the ore. The feed preparation plant will also be able to operate from an ore stockpile (ROM) to maintain ore feed during night time activities. It is anticipated the wet concentrator plant will operate at a nominal throughput rate of 400TPH to produce ~380,000 tonnes of HMC over the life of mining. The HMC will be stockpiled onsite on a limestone pad with leachate collection and the moisture content is then reduced by allowing the stockpile to drain, prior to transportation to the Picton Dry Separation Plant.

Two waste streams are produced from the wet concentration plant; sand tails and clay slurry. Sand tails (including the unreacted lime sand added to the in-pit hopper) are hydraulically returned as a slurry to the mine pits as rapidly as possible to maximise rebound of groundwater levels. The clay slurry is directed to the thickening circuit, where flocculent agglomerates clay fines, producing clay slurry. Additional neutralising material may be added (to the return clay slurry circuit), where required.

Clay tails are either pumped into solar evaporation ponds (SEPs) to allow settlement and drying or co-disposed with sand tails. Dried clay tails from the SEPs will be removed from the ponds (during the dry months) and placed in-pit with sand tails. Where possible co-disposal of clay fines and sand tails will be undertaken during mining whereby the clay tails are disposed with the sand tails into the pit voids at the same time. This provides a more heterogeneous distribution of soil particle sizing and improves the hydraulic conductivity and permeability of the returned soil profile. The majority of the water will be decanted from the SEPs and pumped or gravity fed back to the PWD for use as process water.

6. SOIL MANAGEMENT STRATEGY

The Yalyalup deposit is mapped as Bassendean Sands in an area mapped as having a moderate to low risk of ASS (Class II) occurring within 3m of the natural soil surface. Results derived during Doral's ASS investigation show that Site soils proposed for excavation and dewatering contain NA in excess of the DWER's action criterion of 0.03%S. Therefore, soils will require management once excavation activities begin.

The general sequence of mining and processing is as follows:

1. Removal and stockpiling of topsoil and available subsoil (where not ore to surface);
2. Either overburden or mineral sands ore will be excavated:
    a. For strand deposit ore, which is overlain by several metres of overburden, initial excavation will be to remove overburden:
        i. Overburden, will be excavated and immediately backfilled simultaneously with alkaline material into a pre-existing mine void, or will be stored and managed appropriately prior to backfilling or re-use onsite;
        ii. Excavation and processing of ore commences.
    b. Where ore is present at surface, such as for dunal deposit materials, excavation and ore processing will commence immediately (after stripping of topsoil).
3. For all ore that is excavated, processing commences when the material is fed into the in-pit hopper, with the addition of lime sand (as necessary to maintain process materials at pH5.5), and transported as a wet slurry to the wet concentration plant;
4. Processing of the slurried materials results in the ore materials being separated into three process streams; HMC, sand tails and clay fines:
    a. The HMC is initially stockpiled onsite on a limestone pad with leachate collection (refer to Section 6.6) prior to transport off-site for further treatment at Doral's Picton Dry Plant;
    b. The clay fines and sand tails waste streams are managed either by co-disposal into mine voids or managed as waste material (in SEPs) prior to being backfilled on-site into mine voids that have been created.

In addition to the general sequence of mining and processing, if necessary, unprocessed materials may be utilised for construction of roads or infrastructure, with the material being referred to from herein as ''construction material''.

The soil management strategies presented in the following sections are intended to minimise the risk of ASS impacts.

6.1 TOPSOIL AND SUBSOIL MANAGEMENT

Topsoil and subsoil (where available) will be stripped to a combined depth of ~300mm and stockpiled prior to use in progressive rehabilitation. In accordance with DER (2015b), topsoil will not require neutralisation if the pH of surface soils (0-300mm) is less than pH4.0. Should the pH of this material be less than pH4.0, neutralisation will be undertaken using suitable alkaline material to ensure a revised validation criterion of pH5.0 is achieved.

6.2 OVERBURDEN MANAGEMENT

The strandline deposit ore at Yalyalup is overlain by ~2 to 5m of overburden which will require excavation and management prior to accessing the ore (following lowering of the water table).

On the basis that overburden will not be processed, overburden that has been identified as ASS (i.e. NA > 0.03%S) will be removed via excavator and trucks or dozers. Removed overburden will then be immediately transported to an open pit void and backfilled simultaneously with a suitable alkaline material at an appropriate rate to account for the acidity (refer to Section 6.7). The backfilling process will aim to mix the neutralising material with the overburden as far as practical. A guard layer of alkaline material will initially be added to the base and walls (where practical) of the mine void to limit potential for oxidation. An initial pit void will be created to allow direct backfilling to occur. Material from the initial pit void will be treated with alkaline material (refer to Section 6.7), verified and suitable for re-use in other areas of the Site (i.e. construction purposes etc).

Sand tails and/or co-disposed sand and clay, will then be hydraulically returned over the neutralised overburden, as soon as practical, in order to maintain/return the overburden material to anoxic conditions. In addition, unused (unreacted) alkaline material (e.g. lime sand) becomes a portion of the outgoing sand tails, resulting in a homogenous application of additional alkalinity to the overburden material. Neutralised clay fines will also be backfilled into mine voids when required.

Overburden identified as ASS that cannot be immediately backfilled into an open pit void will be temporarily stored on a guard layer of alkaline material for less than 70 hours, prior to being backfilled simultaneously with alkaline material (i.e. neutralised), as described above. (i.e. equivalent to DWER's short-term stockpiling timeframe).

Overburden identified as ASS that is unable to be backfilled into an open pit void within 70 hours will be stockpiled on a treatment pad (refer to Section 6.6), treated with a suitable alkaline material at an appropriate rate (refer to Section 6.7), verified and then backfilled within 21 days (i.e. DWER's medium-term stockpiling timeframe).

6.3 ORE MANAGEMENT

Excavated ore that has been identified as ASS (i.e. NA >0.03%S) will be processed through the wet concentration plant as soon as possible. As this material is maintained in the form of a wet slurry (i.e. saturated), the risk of sulfide oxidation is greatly reduced and as such will not require any active soil management if in this state. The process slurry is maintained at pH5.5 to assist with the separation process. As such, alkaline material (lime sand) will be added to the in-pit hopper during the excavation of ore to maintain pH5.5and increase buffering capacity within the wet concentration process. Unused (unreacted) lime sand becomes a portion of the outgoing sand tails, resulting in the addition of extra buffering capacity to this waste stream. The rate at which lime sand is added to the in-pit hopper will be determined through regular Total Sulfur assays, as well as pit dewater, wet plant thickener and/or tails return water field pH monitoring.

Any ore material that is not processed immediately upon excavation will be placed on a guard layer of alkaline material and stockpiled for a period of no more than 70 hours (i.e. short-term stockpiling timeframes). Ore that cannot be processed within 70 hours will be stockpiled on a treatment pad (constructed as per Section 6.6) and will be processed or neutralised and verified within 21 days (i.e. medium-term stockpiling timeframe).

6.4 PROCESSED MATERIALS MANAGEMENT

Processing of ore results in three streams of material, HMC, clay fines and sand tails. The three processed streams are then dealt with in the following manner:

- HMC is stockpiled on a limestone pad and stored on-site until transport to Doral's Picton dry processing plant for further processing;
- Sand tails are hydraulically returned into pit voids (including as co-disposal);
- Clay fines are either hydraulically co-disposed with sand tails into pit voids or directed to SEPs to be consolidated for future disposal into mine voids.

Management of each of the process streams is detailed in the following sections.

6.4.1 HMC

The HMC resulting from processing will be stockpiled and stored on a limestone pad, constructed as per Section 6.6, until it is transported offsite. Leachate emanating from the stockpiled HMC will be captured and returned to the ore processing circuit, which is maintained at pH5.5.

6.4.2 SAND TAILS

Sand tails resulting from ore processing will be hydraulically returned to pit voids as a single waste stream and/or co-disposed with clay fines into pit voids. This material will have been maintained in a saturated state, with conditions maintained at pH5.5 throughout the process. Furthermore, the unused (unreacted) lime sand that was added to the process at commencement of the ore processing sequence (i.e. at the in-pit hopper) will form part of this process stream, resulting in the addition of buffering capacity to the locations where this material is hydraulically returned.

Sand tails will be regularly assayed for Total Sulfur to ensure concentrations are below 0.03%S. If necessary, additional lime sand will be incorporated during hydraulic disposal.

Return water from the Sand tails/co-disposal (i.e. collected runoff from the tails and returned to the process water dam) will be routinely field monitored for pH in order to manage the addition of neutralising limestone and maintain the pH of the recirculating water circuit above 5.5.

6.4.3 CLAY FINES

Clay fines will be managed by either:

- Immediate co-disposal with sand tails by hydraulic return to mine voids; or
- Directed to a SEP for storage and future use as void backfill.

Clay fines that are immediately co-disposed with sand tails will be maintained in a saturated state prior to disposal and will include additional buffering capacity provided by the unused (unreacted) lime sands within the sand tails material. This material will be regularly assayed for Total Sulfur to ensure concentrations are below 0.03%S.

Clay fines material that are directed to the SEPs will also be regularly assayed for Total Sulfur to ensure concentrations are below 0.03%S. If insufficient buffering capacity is identified (i.e. Total Sulfur >0.03%S), additional alkaline material (lime sand) will be added prior to being discharged into a SEP. In addition to regular testing during discharge, this material will be re-tested following consolidation and drying within the SEP, prior to final disposal. The purpose of the pre-disposal testing is to ensure the pH and acid neutralising capacity of material is adequate to mitigate post-disposal risk to the receiving environment.

Leachate from the SEP's will be directed back towards the ore processing circuit, which is maintained at pH5.5.

6.5 CONSTRUCTION MATERIAL MANAGEMENT

Overburden and non-processed material identified as ASS (i.e. NA >0.03%S), that will be used for site construction purposes (i.e. roads, pads, bunds etc) will either be:

- Neutralised and verified for re-use within 70 hours of excavation; or
- Stockpiled on a treatment pad (as described in Section 6.6) for up to 21 days prior to neutralisation, verification and re-use.

Neutralisation and verification sampling of this material will be undertaken using the rates and criteria provided in Section 6.7.

6.6 TREATMENT PAD

Treatment pads to store any form of material (i.e. overburden, unprocessed material and HMC) will be constructed of compacted crushed limestone of not less than 300mm thickness, be graded to ensure good drainage, and all sides will be bunded with limestone or similar alkaline material to a minimum height of approximately 150mm above the surface of the pad to prevent lateral run-off. A leachate collection system will also be present to manage run-off from rainfall events.

6.7 NEUTRALISATION RATE AND VERIFICATION TESTING

Table 2 presents the uncorrected neutralisation rate calculated using the following equation (DER, 2015b):

Lime required (kg $CaCO_3/m^3$) = Soil density (t/m^3) x NA (%S x 30.59) x 1.02 x safety factor (1.5) x 100/ENV

It should be noted that this liming rate is provided as a guide only, as it is based on samples analysed for CRS predominantly from the ore zone and not of the actual overburden material. Doral intends to conduct regular Total Sulfur assays of the overburden material to enable adjustment of the liming rate. The measurement of Total Sulfur provides a low-cost analytical technique that may be used to estimate the maximum potential environmental risk from acid produced by the oxidation of sulfides (Ahern, 2004). For this estimate it is assumed that all sulfur measured is in the form of pyrite or other metal or metalloid disulfides (Ahern, 2004).

TABLE 2: LIMING RATE CALCULATION

A: Soil Density (tonne/m^3)	1.65
B: NA (%S)	0.28
C: Conversion Factor (%S to kg lime/tonne soil, including 1.5 x safety factor)	46.80
A*B*C: Uncorrected Liming Rate (kg $CaCO_3/m^3$ soil)	**21.6**

The liming rate presented in Table 2 has been calculated using an assumed bulk density of 1.65 t/m^3 and the average NA values for soils exceeding the action criterion at the Site (0.28%S); it is uncorrected for effective neutralising value (ENV). That is, uncorrected liming rates assume that the treatment will be undertaken using pure calcium carbonate which can all be directly utilised. As aglime (also known as lime sands), the most common agent, is not 100 % calcium carbonate and has particle size variations leading to a reduction in its chemical availability, the values presented in Table 2 will need to be corrected for ENV. A lime certificate providing information about the neutralising value and particle size distribution of the neutralising agent will be required. This is to be provided by the supplier. As an indication, the effective neutralising value of commonly available aglime/limesand may be in the order of 70%, which would yield a corrected liming rate of approximately 31kg$CaCO_3$/m^3 soil.

Treated material will be subject to validation sampling at a rate consistent with (DWER, 2018) guidance in *Landfill Waste Classification and Waste Definitions 1996 (As Amended 2018)*. Samples are to be undertaken to represent 'batches' of treatment.

All samples are to be assessed for pH_F and pH_{FOX}. The accuracy of the field testing program will be initially 'calibrated' by sending approximately 25% of samples for Total Sulfur analysis.

Samples meeting the following criteria (DER, 2015b) will be deemed to be effectively neutralised:

1. Visually, the neutralising material must be well-blended with the soil.
2. Samples require a pH_F of between 6.0 and 8.5.
3. Samples require a pH_{FOX} of at least 5, to indicate that there is neutralising capacity greater than the existing plus potential acidity of the soil.
4. Total Sulfur concentrations need to be <0.03%S.

6.8 SAND TAILS NEUTRALISATION AND VERIFICATION

Sand tails will include unused (unreacted) lime sands resulting from the addition of lime sands to the excavated ore material at the in-pit hopper. The sand tails will also be co-disposed with clay fines. The incorporation of this material into the sand tails will result in the addition of acid neutralising capacity to the receiving environment of the sand tails.

Testing of the sand tails waste stream will be undertaken to ensure the material has been effectively neutralised, as per the following criteria:

1. Co-disposed materials must be well mixed prior to hydraulic reburial.
2. Samples require a pH_F of between 6.0 and 8.5.
3. Samples require a pH_{FOX} of at least 5, to indicate that there is neutralising capacity greater than the existing plus potential acidity of the soil.
4. Total Sulfur concentrations need to be <0.03%S.

6.9 CLAY FINES NEUTRALISATION AND VERIFICATION

Clay fines will be either co-disposed with sand tails into the mine voids or directed to a SEP for consolidation prior to final disposal into a mine void.

Clay fines sent to a SEP will be managed by addition of sufficient alkaline material to ensure that the acid neutralising capacity exceeds the acidity present within this material. Clay fines that are co-disposed will be treated by mixing with sand tails and/or by addition of appropriate alkaline material (lime sand) to ensure the material has been neutralised. Testing of the clay fines waste stream will be undertaken prior to either co-disposal in mine voids or storage in SEPS to ensure the following criteria are met:

1. Visually, the neutralising material must be well-blended with the soil.
2. Samples require a pH_F of between 6.0 and 8.5.

3. Samples require a pH_{FOX} of at least 5, to indicate that there is neutralising capacity greater than the existing plus potential acidity of the soil.
4. Total Sulfur concentrations need to be <0.03%S.

Clay fines that are contained within the SEPs will also be tested prior to disposal into mine voids and if necessary be treated by addition of alkaline material (lime sand), to ensure that sufficient acid neutralising capacity is present in to overcome future oxidation of sulfidic material. The aforementioned criteria must be met prior to removal or disposal of consolidated material from the SEPs.

6.10 DOCUMENTATION OF SOIL MANAGEMENT

Documentation of soil management will be maintained as follows:

- Source and volume of ASS material requiring neutralization;
- Source and volume of neutralising material used;
- Verification sampling undertaken;
- Final location of treated material.

7. DEWATERING MANAGEMENT STRATEGY

7.1 DEWATERING PROCESS AND EXTENT

Dewatering to the required depth of excavation will occur passively as groundwater enters the mining excavation voids. The water will be pumped from the pit using a suction pump set at a level to maintain a 0.5m saturated pit floor and sent through to a sump prior to reaching the unlined process water dam where it mixes with other water from other mine processes. The use of passive dewatering reduces the extent of groundwater drawdown as far as practical.

The extent of groundwater drawdown is also reduced by recharge resulting from the hydraulic backfill of the pit voids with sand tails and clay fines. The pit backfilling acts to recharge groundwater levels rapidly, compared to unassisted rebound by aquifer hydraulic head pressures only. The expedited recharge, thereby reduces the extent of dewatering influence and returns the soil profile to anoxic conditions. Unreacted lime sand that was added to the ore slurry at the in-pit hopper (to ensure the process stream pH is maintained at pH6.0) also ends up in the sand tails waste stream, assisting to buffer the pH of the groundwater system as rebound occurs.

7.2 DEWATERING MONITORING

One sample point will be established to monitor the dewatering effluent quality at a location prior to the water reaching the process water dam (pit dewatering sump) and a second sample point will be established at the process water dam.

The following monitoring program will be conducted for the pit dewatering sump (pre-treatment) and process water dam (post-treatment):

- Field testing for pH, electrical conductivity (EC), total titratable acidity (TTA) and Total Alkalinity (TAlk) will occur three times a week (Monday, Wednesday and Friday);
- Monthly laboratory analysis for pH, EC, TDS, total acidity, total alkalinity, dissolved aluminium, dissolved iron and dissolved manganese.
    - If total aluminium is above 1mg/L then additional laboratory analysis will be required for the following total metals; arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc.

7.3 DEWATERING TRIGGER VALUES AND TREATMENT

DER (2015b) guidelines require that dewatering effluent with a pH of less than pH6.0 or total acidity of >40mg$CaCO_3$/L or total alkalinity < 30mg$CaCO_3$/L, be treated via addition of a neutralising agent prior to re-infiltration (i.e. hydraulic return of sand tails and/or clay fines into mine void).

As groundwater has been shown to be slightly acidic, the following trigger values will apply to the monitoring of dewatering effluent from the pit dewatering sump (pre-treatment) and also within the process water dam:

- Field pH <5.5 or
- TTA >40 mg$CaCO_3$/L; or
- Total Alkalinity <30 mg$CaCO_3$/L.

Should any of these criteria be triggered, dewatering effluent will be treated via the addition of a suitable neutralising agent. In the event that the water within the process water dam exceeds the trigger values, active management of process water prior to re-infiltration (via clay fines and sand tails) or discharge from the water circuit will be required.

7.4 CONTINGENCY PLAN

In the event that monitoring of the dewatering effluent reaches a trigger value listed in Section 7.3, the initial response (apart from neutralisation) will be to increase the monitoring listed in Section 7.2 to daily field testing and weekly laboratory testing of the affected areas.

If trigger values listed in Section 7.3 are reached at the process water dam, the initial contingency measure will be to treat the process water through the addition of a suitable alkaline material to the ore feed and or the tails return water sump until the water is above the trigger values. Whilst the process water dam is outside of the trigger values, discharge of process water off site will cease.

Any off-site emergency discharge of water from the process water dam will be managed and monitored through DWER licensing under Part V of the EP Act before any process water is discharged.

Monitoring of the pit dewatering sump will provide prior indication that treatment is likely to be required at the process water dam. If the trigger values listed in Section 7.3 in the pit dewatering sump (pre-treatment) are exceeded, the contingency action will be to add a neutralising agent to the thickener.

8. GROUNDWATER MANAGEMENT STRATEGY

The disturbance of ASS material can lead to the release of acid and mobilisation of metals, causing contamination of groundwater which may cause offsite impacts to groundwater and other environmental receptors such as groundwater dependent ecosystems. Indirect disturbance via dewatering is a primary concern, as areas of the Site contain ASS material below the usual groundwater table interface which may be exposed to oxidation via dewatering. Indirect acidification via dewatering may lead to acidic or metal-rich groundwater plumes which have the potential to affect onsite or offsite receptors. In order to identify potential groundwater impacts, monitoring of groundwater quality will take place, and the results will be compared against baseline values. If required, contingency measures will be developed and implemented.

8.1 GROUNDWATER MANAGEMENT

As the ore body is mined using dry mining techniques, the ore located below the natural groundwater table, will need to be dewatered. Although the dewatering process will be passive, reducing the radius of influence of dewatering compared to active dewatering (i.e. such as spears), a significant area will eventually be impacted by the passive dewatering. Groundwater modelling conducted by (AQ2) predicted the following drawdown extents to the Superficial Aquifer:

- The maximum drawdown extent of 0.1m extends outside of the perimeter of the mine disturbance area is 700m to the north, 250m to the south, 300m to the east and 450m to the west, at various times during the mine life for the dry climate scenario (considered to represent worst case scenario).
- The maximum drawdown extent of 0.1m extends outside of the perimeter of mine disturbance area is 600m to the north, 200m to the south, 300m to the east and 400m to the west, at various times during the mine life for the wet climate scenario.

It is therefore considered appropriate to monitor groundwater to assess possible impacts of the reduction in groundwater levels during mining.

8.2 GROUNDWATER MONITORING WELLS

Six site-specific Superficial Aquifer groundwater monitoring wells installed at the Site and monitored data from 2017-2019 (Figure 10) has been used to consider baseline Superficial Aquifer groundwater quality (Section 4). Data from these wells has been used to develop site-specific trigger criteria to monitor changes in groundwater levels and quality, as outlined in the following sections.

8.3 GROUNDWATER MONITORING PROGRAM

The following monitoring program will be conducted during dewatering operations for the superficial groundwater monitoring well network:

- Monthly monitoring of groundwater levels;
- Monthly field testing for pH, EC, TTA and temperature;
- Monthly laboratory analysis for pH, EC, TDS, total acidity, total alkalinity, chloride, sulfate, dissolved aluminium, dissolved iron and dissolved manganese. (If Al >1 mg/L then the sample will also be analysed for As, Cd, Cr, Cu, Pb, Hb, Ni, Se, Zn).

The results will be compared to site-specific trigger criteria that have been developed based on baseline monitoring results.

At the completion of dewatering operations, groundwater monitoring will continue as above for six months (or until any adverse trends have stabilised) then on a quarterly basis for an additional 12 months.

8.4 DEVELOPMENT OF GROUNDWATER ASSESSMENT TRIGGER CRITERIA

Site-specific groundwater trigger criteria have been developed for each well comprising the Doral's Superficial Aquifer monitoring well network. To develop the trigger values for each specific well location, baseline data was compared to DWER guideline values and the most appropriate value adopted as the well specific Trigger Value.

Baseline data was assessed statistically, using the mean plus or minus two standard deviations (mean+/-2SD) to develop concentration values likely to be reflective of the baseline conditions for parameters noted by DER (2015b), that indicate that groundwater may been affected by the oxidation of sulfides.

The calculated well specific concentrations for the relevant parameters are shown in the following table, compared to the DWER guideline concentrations indicative of sulfide oxidation.

TABLE 3: COMPARISON OF WELL SPECIFIC CONCENTRATION LIMITS TO DWER ASS INDICATORS OF SULFIDE OXIDATION

ANALYTE	pH	Total Alkalinity $mgCaCO_3/L$	Total Acidity $mgCaCO_3/L$	SO_4: Cl RATIO	SO_4: Alk RATIO	Al (mg/L)
	CHEMICAL INDICATOR OF SULFIDE OXIDATION (DER, 2015b)					
	<5	NV	>40	>0.5	>0.2	>1
LOCATION	WELL SPECIFIC UPPER OR LOWER CONCENTRATION LIMITS (MEAN +/– 2 SD OF BASELINE GROUNDWATER MONITORING RESULTS)					
YA_MB01S	5.58	30.95	129.32	0.37	2.87	0.11
YA_MB02S	5.45	14.57	249.09	0.23	1.58	0.46
YA_MB04S	5.45	20.93	180.22	0.12	0.98	0.08
YA_MB07S	5.19	7.43	66.31	0.53	2.37	0.09
YA_MB09S	5.53	27.56	122.18	0.55	3.80	0.09
YA_MB10S	5.56	24.96	104.78	0.51	4.31	0.08
SCPD29A	5.58	47.35	134.99	0.16	1.84	0.25
SCPD28A	5.18	24.06	261.46	0.12	0.67	0.05
TS012M	5.24	43.31	277.12	0.36	1.98	0.03
20005166	5.87	32.98	143.40	0.86	1.03	0.44

In order to determine relevant well specific trigger criteria that indicate significant changes to site groundwater, the trigger criteria that has been selected is based on the most meaningful value of the:

- DER (2015b) guideline value; or
- The calculated trigger criteria.

That is, if the background data indicates the parameter already exceeds a DWER guideline value, then the site-specific value is used as a trigger to indicate deterioration of baseline groundwater quality.

The selected trigger criteria for each well location is shown in the following table.

TABLE 4: YALYALUP ASS GROUNDWATER TRIGGER CRITERIA

ANALYTE	pH	Total Alkalinity $mgCaCO_3/L$	Total Acidity $mgCaCO_3/L$	SO_4: Cl RATIO	SO_4: Alk RATIO	Al (mg/L)
LOCATION	WELL SPECIFIC TRIGGER CONCENTRATION (mg/L)					
YA_MB01S	<5	<30.95	>129.32	>0.5	>2.87	>1
YA_MB02S	<5	<14.57	>249.09	>0.5	>1.58	>1
YA_MB04S	<5	<20.93	>180.22	>0.5	>0.98	>1
YA_MB07S	<5	<7.43	>66.31	>0.53	>2.37	>1
YA_MB09S	<5	<27.56	>122.18	>0.55	>3.80	>1
YA_MB10S	<5	<24.96	>104.78	>0.51	>4.31	>1
SCPD29A	<5	<47.35	>134.99	>0.5	>1.84	>1
SCPD28A	<5	<24.06	>261.46	>0.5	>0.67	>1
TS012M	<5	<43.31	>277.12	>0.5	>1.98	>1
20005166	<5	<32.98	>143.40	>0.86	>1.03	>1

8.5 TRIGGER CRITERIA RESPONSE

The trigger values are inherently conservative and the initial response to an exceedance by any parameter will be to establish the context of the exceedance and determine whether the result requires re-sampling/analysis, immediate further action, or no response at all. A key measure for the context of an exceedance is to consider whether multiple triggers are exceeded.

Initial response to exceedance of any trigger value will be:

- Review exceedance in relation to any site wide changes or trends in key ASS risk parameter (pH, TTA and TAlk);
- Review sample collection, handling and analysis methods and procedures to ensure appropriate methods were used;
- Review groundwater level data, dewatering effluent quality data and current mining operations to consider possible causal factors;
- If necessary, re-sample affected locations as soon as practical (i.e. within 2-weeks) to confirm whether or not the groundwater quality parameter(s) exceed the trigger value;
- Increase on-going monitoring frequency of the affected monitoring well(s).

Secondary responses will be developed based upon situation specific outcomes from the initial responses, but will include the following immediate further action responses:

- If it is confirmed that the pH and TTA exceed trigger criteria in successive sampling events, the sampling frequency for field parameters will be increased to fortnightly; and/or
- When it is confirmed that any other groundwater quality parameters have deteriorated to levels outside of the background-based trigger levels; then
- Inform DWER that contingency monitoring is being undertaken; and
- Prepare a contingency action plan suited to the level of risk that confirmed adverse groundwater quality poses to potential receiving environments, such as down gradient groundwater users or environmental receptors.

8.6 REPORTING

The monthly groundwater monitoring results will be compared to trigger levels within 7 days of receipt of analytical results. The presence or absence of results that exceed trigger values will be recorded on a monthly groundwater log. If contingency measures are required, the initial response and/or any secondary responses will be recorded in the groundwater log within 24 hours.

The groundwater log, field results and laboratory documentation of each year will be reported in the Annual Environmental Report (AER).

9. REFERENCES

Ahern, C. M. (2004). *Acid Sulfate Soils Laboratory Methods Guidelines.* Queensland Department of Natural Resources, Mines and Energy.

AQ2. (n.d.).

AQ2. (2019). *Yalyalup Mineral Sands Project, Hydrogeological Assessment. Unpublished report prepared for Doral Mineral Sands. November 2019.*

AQ2. (2019a). *Yalyalup Mineral Sands Project, Hydrogeological Assessment. Unpublished report prepared for Doral Mineral Sands. November 2019.*

Baddock, L., Vine, J., & Leathersich, M. (2005). *South West Yarragadee Hydrogeological Investigations and Evaluation, Southern Perth Basin. Infrastructure Planning Branch.* Water Corporation.

Belford, S. (1987). *Busselton Sheet 1930 I, Environmental Geology Series, Geological Survey of Western Australia.*

Davidson. (1995). *Hydrogeology and Groundwater Resources of the Perth Region. Geol. Soc. WA Bulletin 142.*

DEC. (1996). *Landfill Waste Classification and Waste Definitions 1996 (As amended December 2009).* Department of Environment and Conservation (DEC).

DEC. (2008). *Geomorphic Wetlands of the Swan Coastal Plain GIS Mapping dataset. Department of Environment and Conservation. Perth, Western Australia.*

DEC. (2008a). *Geomorphic Wetlands of the Swan Coastal Plain GIS Mapping dataset. Department of Environment and Conservation. Perth, Western Australia.*

Del Borello. (2008). *Management triggers and responses for groundwater-dependent ecosystems in the South West groundwater Areas. Water resource allocation planning series Report 31, Department of Water, Western Australia.*

DER. (2014). *Assessment and Management of Contaminated Sites.* Department of Environment regulation (DER). Government of Western Australia.

DER. (2015a). *Identification and Investigation of Acid Sulfate Soils and Acidic Landscapes.* Government of Western Australia, Department of Environment Regulation (DER).

DER. (2015b). *Treatment and Management of Soil and Water in Acid Sulfate Soil Landscapes.* Guideline, Government of Western Australia, Department of Environment Regulation (DER).

DoW. (2009). *Whicher Area Surface Water Allocation Plan. Water resource and planning series Report 19. Department of Water, Western Australia.*

DoW. (2009). *Whicher Area Surface Water Allocation Plan. Water resource and planning series Report 19. Department of Water, Western Australia.*

DWER. (2018). *Landfill Waste Classification and Waste Definitions 1996 (as amended 2018).*

DWER. (2019). *https://catalogue.data.wa.gov.au/dataset/hydrographic-catchments-catchments/resource/ec69cff9-404e-4a6e-8a7b-10e7fcda8316.*

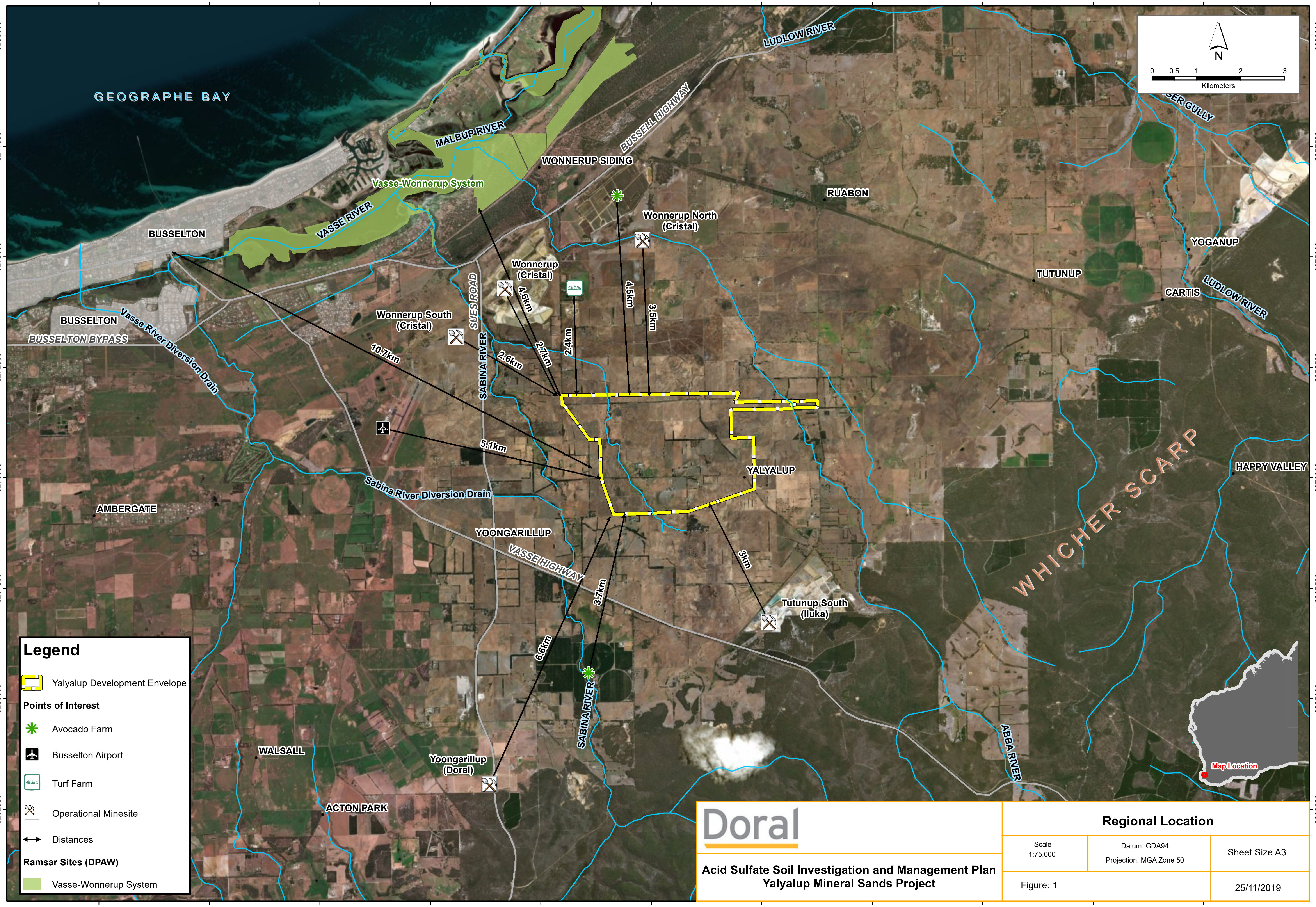
Hirschberg. (1989). *Busselton shallow-drilling groundwater investigation: Western Australia Geological Survey, Professional Papers, Report 25, p. 17-37.*

HydroSolutions. (2017). *Initial Hydrogeological Assessment: Proposed Yalyalup Mineral Sands Mine. .* Unpublished report prepared for Doral Mineral Sands Pty Ltd.

Marillier, B. (2018). *Reconnecting rivers flowing to the Vasse Estuary, Water Science Technical Series, report no. 81, Water Science Branch, Department of Water and Environmental Regulation (DWER), Perth, Western Australia.*

Schafer, D., Johnson, S., & Kern, A. (2008). *Hydrogeology of the leederville aquifer in the western Busselton-Capel Groundwater Area. Hydrogeological record series Report HG31.* Department of Water.

FIGURES



Doral	Regional Location		
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Acid Sulfate Soil Investigation and Management Plan Yalyalup Mineral Sands Project	Figure: 1		25/11/2019