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VRXSILICA

18 October 2019

ASX ANNOUNCEMENT

Muchea BFS and Maiden Ore Reserve

VRX Silica Limited (**VRX Silica** or **Company**) (ASX: VRX) is pleased to announce details of its Bankable Feasibility Study (**BFS**) and maiden Probable Ore Reserve at its Muchea Silica Sand Project (**Muchea**), located 50km north of Perth, WA, the third BFS for the Company's three advanced silica sand projects.

Highlights:

- ***Muchea has outstanding financial metrics and is capable of producing very high-grade silica sand products***
- ***Ungeared NPV$_{10}$ of $338 million based on 25 years of a potential mine life of +100 years. Other key BFS outcomes:***

Post Tax, ungeared NPV$_{10}$	$337,900,000
Post Tax, ungeared NPV$_{20}$	$146,400,000
Post Tax, ungeared IRR	96%
Payback period (yrs) (post tax) (ramp up rate)	2.3
Exchange Rate US$/A$	$0.70
Life of Mine (yrs) (Scope of BFS Study)	25
Total Sales (initial 25 years) no escalation	$3,345,000,000
EBIT	$1,540,000,000
Cashflow after finance and tax	$1,123,000,000
Shares on Issue	404,318,617
EPS after tax (per year)	$0.11
Capex (2 mtpa)	$32,820,000
Capex contingency (inc)	20%
Life of Mine C1 costs, FOB Kwinana (inc royalties)	$32.74
Tonnes Processed (initial 25 years) (Mt)	54
Production Target (Mt) (initial 25 years) (BFS Study)	48.3
Probable Ore Reserves @ 99.9% SiO_2 (Mt)	18.7
Ore Reserve life (yrs)	9-10
JORC Resources (million tonnes)	208

Notes:
1: A proportion of the production target is based on Inferred Mineral Resource. There is a low level of geological confidence associated with Inferred Mineral Resources and there is no certainty that further exploration work will result in the determination of Indicated Mineral Resources or that the production target itself will be realised.
2. The Probable Ore Reserve and Inferred Mineral Resource underpinning the above production target has been prepared by a Competent Person in accordance with the requirements of the JORC Code 2012.
3. Full summary of economic assumptions for the BFS set out in this announcement.
4. All figures are presented in Australian dollars, unadjusted for inflation

- ***Total Probable Ore Reserve of 18.7 Mt @ 99.9% SiO_2 with 14.6 Mt @ 99.9% SiO_2 in the Mining Lease application area***
- ***Studies identify three high-grade high-value silica sand products in high demand in international markets***
- ***Full BFS annexed to this announcement***

ASX: VRX

Capital Structure

Shares on Issue: 404 million

Top 20: 47%

Unlisted Options: 72 million

Corporate Directory

Paul Boyatzis
Non-Executive Chairman

Bruce Maluish
Managing Director

Peter Pawlowitsch
Non-Executive Director

John Geary
Company Secretary

Company Projects

Arrowsmith Silica Sand Project, 270km north of Perth, WA.

Muchea Silica Sand Project, 50km north of Perth, WA.

Boyatup Silica Sand Project, 100km east of Esperance, WA.

Warrawanda HPQ Project south of Newman, WA.

Biranup base metals and gold Project adjacent to the Tropicana Gold Mine, WA.

The Company is actively assessing other silica sand projects in Australia.

The Probable Ore Reserve for Muchea totals **18.7 Mt @ 99.9% SiO_2** as reported in accordance with the JORC Code 2012 edition[1] (**JORC Code**), with **14.6Mt @ 99.9% SiO_2** contained within the area of the Company's Mining Lease application (M70/1390) for Muchea. This follows the Company's recent announcement of Probable Ore Reserves for Arrowsmith North and Central.

VRX Silica Managing Director Bruce Maluish said: *"This Reserve estimate is only a small portion of the silica sand Inferred Resource Estimate for the project but produces a very high-grade product which is in high demand in specialist Asian markets."*

"We have already had significant interest in the Muchea product that will command higher prices than products from our Arrowsmith North and Central silica sand projects."

"Muchea is a world class high-grade silica sand project which can support a substantial export industry for WA providing benefits to the State and the Muchea-Gingin district".

"Muchea will produce alternative high-grade products to Arrowsmith and will add to our available catalogue of products from our silica sand projects," said Maluish.

BFS Summary

The information in this report refers to the Muchea silica sand project, which is located 50km north of Perth in Western Australia, Figure 1.

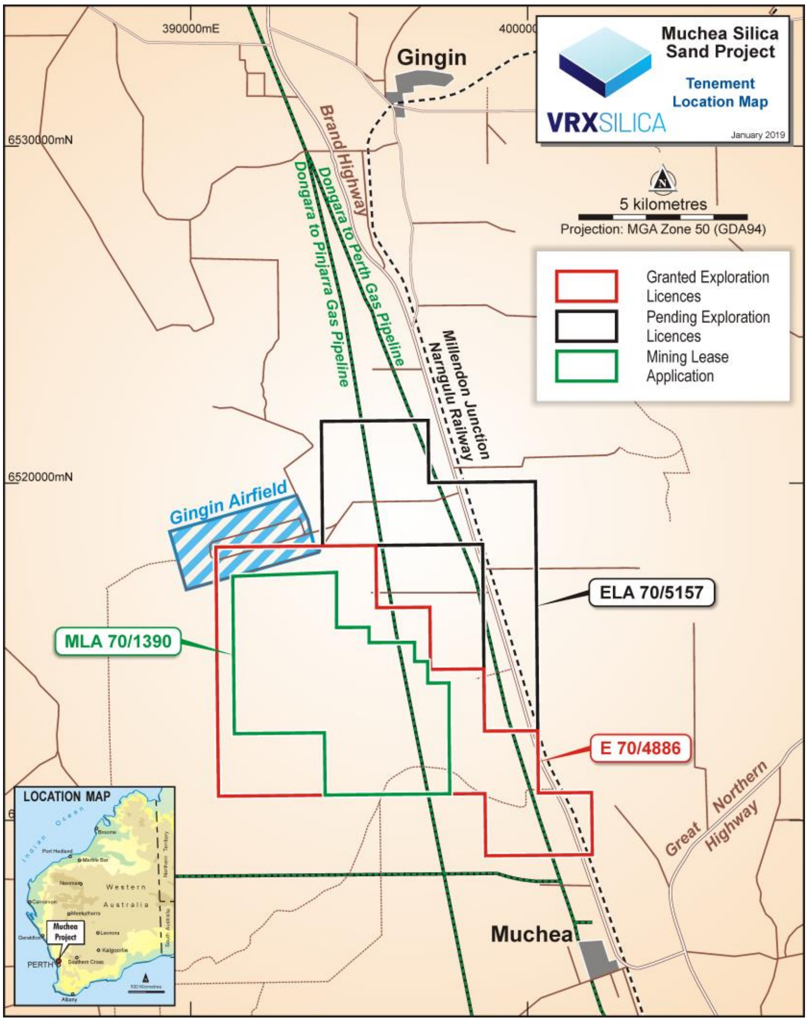

Figure 1: Muchea Project Location

[1] Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2012 Edition.

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Silica sand markets

Globally, silica sand is in a growth phase due to increasing demand from the construction sector, with both volume and value having increased worldwide. Sales of silica sand experienced a compound annual growth rate of approximately 8.7% in value terms from 2009 to 2016, with a market value of US$6.3 billion. This was due to its applications across a range of industries, including glass making as well as foundry casting, water filtration, chemicals and metals, along with the hydraulic fracturing process.

Accelerations in construction spending and manufacturing output worldwide are expected to drive growth in important silica sand-consuming industries, including the glass, foundry and building glass products sectors. Significant growth is projected in the hydraulic fracturing market as horizontal drilling for shale oil and gas resources expands, largely in North America.

The Asia-Pacific region is expected to remain the largest regional consumer of industrial sand through 2025, supported by the dominant Chinese market. The country's container glass industry will drive further silica sand sales, supported by rising production of glass bottles, particularly in the alcoholic beverage sector including wine and beer.

Products

High-grade silica sand is a key raw material in the industrial development of the world, especially in the specialist glass, metal casting, and ceramics industries. High-grade silica sand contains a high portion of silica (over 99.5% SiO_2) and is used for applications other than construction aggregates. Unlike construction sands, which are used for their physical properties alone, high-grade silica sands are valued for a combination of chemical and physical properties.

Global consumption of industrial silica sand is expected to climb 3.2% per year through 2022. Asia Pacific growth is higher than global growth and is expected to be around 5-6% per year. Ongoing economic and infrastructure development in the Asia/Pacific region will drive growth.

Glassmaking

Silica sand is the primary component of all types of standard and specialty glass. It provides the essential SiO_2 component of glass formulation; its chemical purity is the primary determinant of colour, clarity and strength in glass. Industrial sand is used to produce flat glass for building and automotive use, container glass for foods and beverages, and tableware. In its pulverised form, ground silica is required in the production of fibreglass insulation and for reinforcing glass fibres. Specialty glass applications include test tubes and other scientific tools, incandescent and fluorescent lamps.

Over the past 20 years growth in glass demand has exceeded GDP growth and continues to grow at circa 5% per annum.

Key points and assumptions

The BFS is based on only 25 years production from a potentially long-term +100 year mine life.

The maiden Probable Ore Reserve of **14.6 Mt @ 99.9% SiO_2** (see below) contained within the area of the Company's Mining Lease application and will support a 9-10 year project. This is estimated from the Indicated Mineral Resource only and constitutes approximately 39% of the estimated total production target (in terms of processed tonnes of silica sand) over the 25 year mine life. The Company intends to mine solely from Probable Ore Reserves during the initial 9-10 years of the project.

The balance is from Inferred Mineral Resource in the proposed mining area which is **61.4 Mt @ 99.6% SiO_2**, which the Company intends to mine from year 10 onwards. The Company has undertaken sufficient drilling to assume geological and metallurgical continuity of the sand deposit. There is negligible difference between the modelled sand in each category. In order to upgrade the Inferred Mineral Resource, the Company anticipates that an additional 2,000m of aircore drilling will be required. The cost for drilling, assaying and associated studies is estimated (at current rates) to be in the region of $200,000 and will need to be undertaken within the first 9-10 years of mining operations. Given the simple nature of the silica sand deposit at the project and the associated geological and metallurgical confidence, the Company expects that this additional drilling will be sufficient to realise the production target. Notwithstanding this, there is a low level of geological confidence associated with inferred mineral resources and there is no certainty that further exploration work will result in the determination of indicated mineral resources or that the production target itself will be realised.

The Company has been in discussions with both the Department of Premier and Cabinet and the Department of Jobs, Tourism, Science and Industry to identify options for the Company to gain access to ground within the area of File Notation Area 12671 (**FNA**), which is for the proposed "Perth and Peel Green Growth Plan for 3.5 million". Whilst that ground sits outside the proposed development area for the project and the FNA does not affect the modelled 25 years of production at Muchea detailed in the BFS, the Company is seeking access to this ground to extend the project's mine life to well beyond 25 years, and potentially over 100 years. Further details of the FNA are set out in the BFS.

The project will be a potentially new long-term industry for Western Australia with substantial economic benefits, including long-term employment and royalties with a significant economic contribution to the Muchea-Gingin district.

The Company has met with various local Members of State and Federal Parliament with great support for the project.

The Company has engaged with the Department of Water and Environmental Regulation following preliminary environmental studies to identify key issues pertaining to the project environmental approvals for mining particularly the vegetation for potential foraging by Carnaby's cockatoos.

VRX Silica has developed a mining and rehabilitation methodology specific to the environment at Muchea which will enable a successful restoration of mined areas.

A key challenge for industrial minerals projects is meeting market specifications. The silica sand market has specifications for parameters such as purity (e.g. SiO_2 content) in addition to tight specifications for trace elements such as Fe, Ti, Al and Cr in the glass industry.

The Company is confident that it can meet specifications for the ultra-clear glass market from Muchea.

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Key economic assumptions for the BFS are as follows:

Currency	Australian dollars *Sales contracts in Asia for silica sand are invariably based $US and a A$0.70 exchange rate has been applied*
Project life	25 years Total Probable Ore Reserve alone supports a 9-10 year project. Mining will occur solely from the Probable Ore Reserve during the first 9-10 years. There is a reasonable expectation that with further close spaced drilling the existing Inferred Mineral Resource would convert to Indicated Mineral Resource and subsequently Probable Ore Reserve. This will increase the mine life to well in excess of this time period, however the model is conservatively restricted to 25 years
Depreciation	15% rate on capital
Corporate tax rate	27% on taxable profit
Production	Steady state of production from Probable Ore Reserves over life of mine, with the first 2 years at 1 million tonnes per year and thereafter at 2 million tonnes per year *The Company has currently expressions of interest and letters of intent to purchase 3.5 million tonnes per year of Muchea products and expects further interest once these products are made available to the market*
Shares on Issue	404,318,617
NPV estimation discount rates	Standard financial modelling conducted at both 10% and 20% discount rates. *The 20% rate is generally above standard reporting rates but demonstrates that the Project is still financially robust at this higher rate*
Capital cost	Based on estimates ±15% from engineering companies with extensive experience in sand separation
Operating costs	A$32.74 C1 costs, including royalties *Based on first principles and current rates for equipment*
Sales revenue	US$38-55 (A$54-79) per dry metric tonne dependent on product type, product quality, contract terms and sales quantity *Revenue is constant based on current prices and ignores any projected growth in prices*
Maximum debt	A$30 million
Borrowing rates	12%
Accounts receivable	30 days
Accounts payable	30 days
Plant maintenance	5% of capital cost per year
Environmental bond	A$500,000 *May be substituted by the WA Department of Mines, Industry Regulation and Safety's "Mining Rehabilitation Fund"*
Capex contingency	20%
Recoveries	Muchea F80C (80ppm Fe_2O_3) 20% Muchea F80 (80ppm Fe_2O_3) 48% Muchea F150 (150ppm Fe_2O_3) 20% *Recoveries are based on CDE testwork at ±5%*

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Probable Ore Reserve

The Probable Ore Reserve for Muchea totals **18.7 Mt @ 99.9% SiO_2** as reported in accordance with the JORC Code with **14.6Mt @ 99.6% SiO_2** contained within the area of the Company's Mining Lease application (MLA70/1390).

VRX Silica has previously announced[2] an upgraded Mineral Resource Estimate (**MRE**) for Muchea of an **Indicated Mineral Resource** of **29 Mt @ 99.6% SiO_2** in addition to an **Inferred Mineral Resource** of **179 Mt @ 99.6% SiO_2** for a **Total MRE** of **208 Mt @ 99.6% SiO_2,** see Table 1.

Classification	Million Tonnes	SiO_2%	Al_2O_3%	Fe_2O_3%	LOI%	TiO_2%
Indicated	29	99.6	0.09	0.03	0.22	0.07
Inferred	179	99.6	0.05	0.02	0.23	0.1
Indicated + Inferred	208	99.6	0.06	0.02	0.23	0.1
**Note: Interpreted silica sand mineralisation is domained above a basal surface wireframe. The upper (overburden) layer within 0.5 m of surface is depleted from the modelled silica sand unit, being reserved for rehabilitation purposes. All classified silica sand blocks in the model are reported. Differences may occur due to rounding.*						

Table 1: Muchea Silica Sand Mineral Resource Estimate as at September 2019

VRX Silica has now completed necessary work to convert the Indicated Mineral Resource to Probable Ore Reserves. A summary of the work undertaken is included in this document, and in Appendix 1, JORC Table 1 Sections 1 to 4 set out in full in the BFS (annexed to this announcement).

Table 2 details the Probable Ore Reserve that will be produced from the mining of the Indicated Mineral Resource and processing in a purpose built, wet sand processing plant.

The plant will produce three saleable products for different markets with a **total Probable Ore Reserve of 18.7 Million tonnes**, with **14.6Mt @ 99.6% SiO_2** contained within the Mining Lease application (M70/1390) area.

Ore Reserve			**Global**	**Within M70/1390**					
Classification	**Product**	**Recovery**	**Million Tonnes**	**Million Tonnes**	**SiO_2%**	**Al_2O_3%**	**Fe_2O_3%**	**TiO_2%**	**LOI %**
Probable	Muchea-F80	48%	10.2	8.0	+99.9	0.02	0.008	0.030	0.1
	Muchea-F80C	20%	4.25	3.3	+99.9	0.02	0.008	0.030	0.1
	Muchea-F150	20%	4.25	3.3	99.8	0.07	0.015	0.035	0.1
		Total Reserve	**18.7**	**14.6**					

Particle Size				**Sieve Opening (µm Retained)**				
Product	**850**	**600**	**425**	**300**	**212**	**150**	**106**	**75**
Muchea-F80		0.5%	49%	50%	0.5%			
Muchea-F80C	9.0%	90.0%	1.0%					
Muchea-F150				0.5%	88%	11%	0.5%	

Table 2: Muchea Silica Sand Probable Ore Reserve as at October 2019

[2] ASX announcement of 17 June 2019, "Muchea Mineral Resource Estimate Upgrade".

Metallurgical Factors

CSA Global reviewed the metallurgical testwork to comply with Clause 49 of the JORC Code[3]. CSA Global has concluded that the available process testwork indicates likely product qualities for glass and ceramics is considered appropriate for eventual economic extraction from Muchea. In addition, potentially favourable logistics and project location support the classification of the Muchea deposit (in accordance with Clause 49) as an industrial mineral with an Inferred/Indicated Mineral Resource.

The extensive metallurgical testwork which has been completed by CDE Global at their facility in Cookstown, Northern Ireland, and Nagrom in Kelmscott, Perth, allowed for the creation of a catalogue of silica sand products that could be produced from Muchea[4] (see Table 3).

Chemical Composition (%)

Product	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O
Muchea-F80	+99.9	0.02	0.008	0.030	0.005	0.001	0.004
Muchea-F80C	+99.9	0.02	0.005	0.030	0.005	0.001	0.004
Muchea-F150	99.8	0.07	0.015	0.035	0.020	0.001	0.004

Particle Size **Sieve micron and % retained on sieve**

Product	850	600	425	300	212	150	106	75	53
Muchea-F80		0.5%	49%	50%	0.5%				
Muchea-F80C	9.0%	90.0%	1.0%						
Muchea-F150				0.5%	88%	11%	0.5%		

Table 3: Muchea saleable products from catalogue

These products become the recovered products which make up the Ore Reserve (see Table 2).

The mass balance of the particle sizes was analysed allowing for the recoveries of these products in a wet processing plant to be estimated.[5] The recovery of each product is shown in Table 4.

Product	Industry	Recovery
Muchea-F80	Glassmaking	48%
Muchea-F80C	LCD	20%
Muchea-F150	Glassmaking	20%
	Total Recovery	**88%**

Table 4: Muchea Product Recovery

[3] Reviewed as part of the metallurgical testwork for the Muchea maiden MRE, see ASX announcement of 20 November 2018, "Muchea Silica Sand Project Maiden Resource".
[4] ASX announcement of 26 February 2019, "Testwork Update and Product Catalogues".
[5] ASX announcement of 3 May 2019, "High Recovery from Silica Sand Process Plant Design".

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Material Modifying Factors – Mining Factors

The mining method chosen for Muchea is a rubber wheeled front-end loader, feeding into a 3mm trommel screen to remove oversize particles organics. The undersize sand is slurried and pumped to a sand processing plant which is located proximal to the Moora-Kwinana railway line. After processing, the silica sand is then loaded into railway trucks for bulk export from the Kwinana Bulk Terminal.

Mining of the in-situ sand will extract to the extent and base of the Indicated Resource/Probable Ore Reserve. This will leave a slightly undulating surface. Appropriate buffer zones are left from the adjacent stakeholders such as freehold land and the Dongara-Pinjarra gas pipeline. The pre- and post-mining topography is shown in Figures 2 and 3.

100% of the material in the mining area is considered to be sand that can be beneficiated to a saleable silica sand project. The top 500mm has been excluded from the MRE as it will be reserved for rehabilitation purposes. As there is no waste material, the recovery factor is considered to be 100% and ore loss therefore is considered to be 0%.

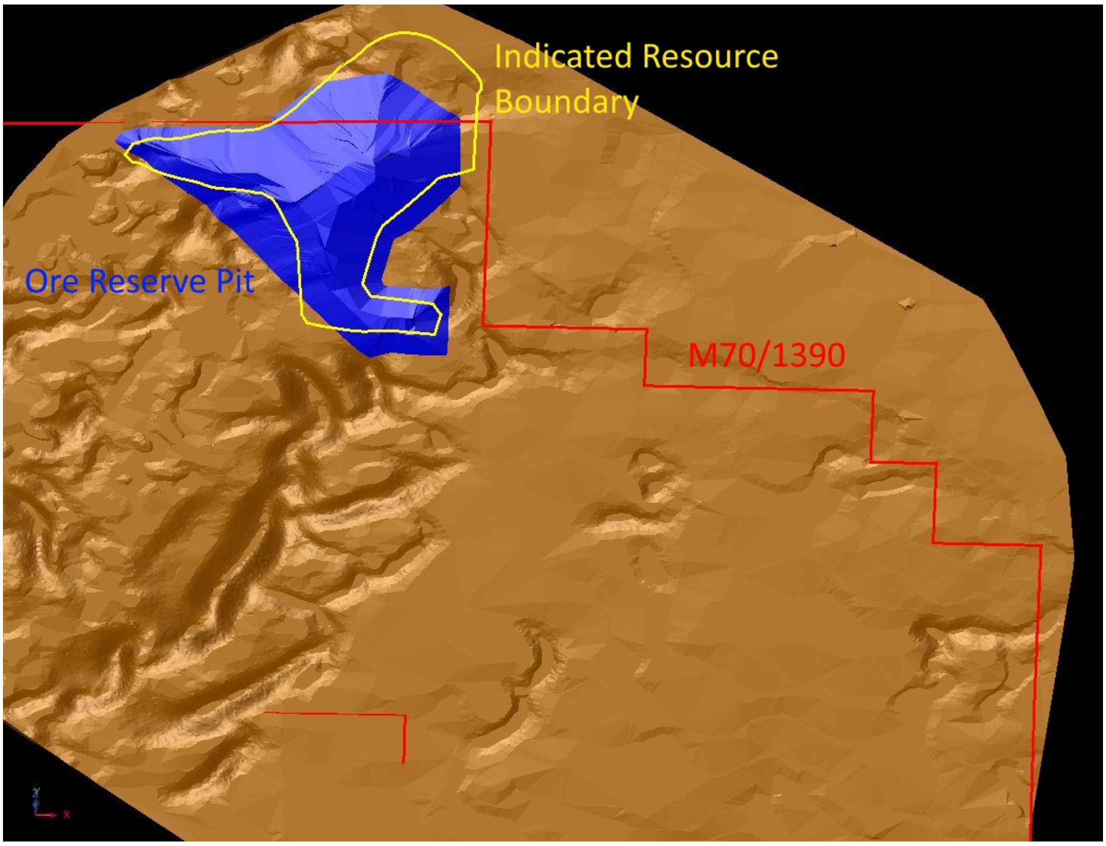

Figure 2: Muchea Pre-Mining Topography (10:1 vertical exaggeration)

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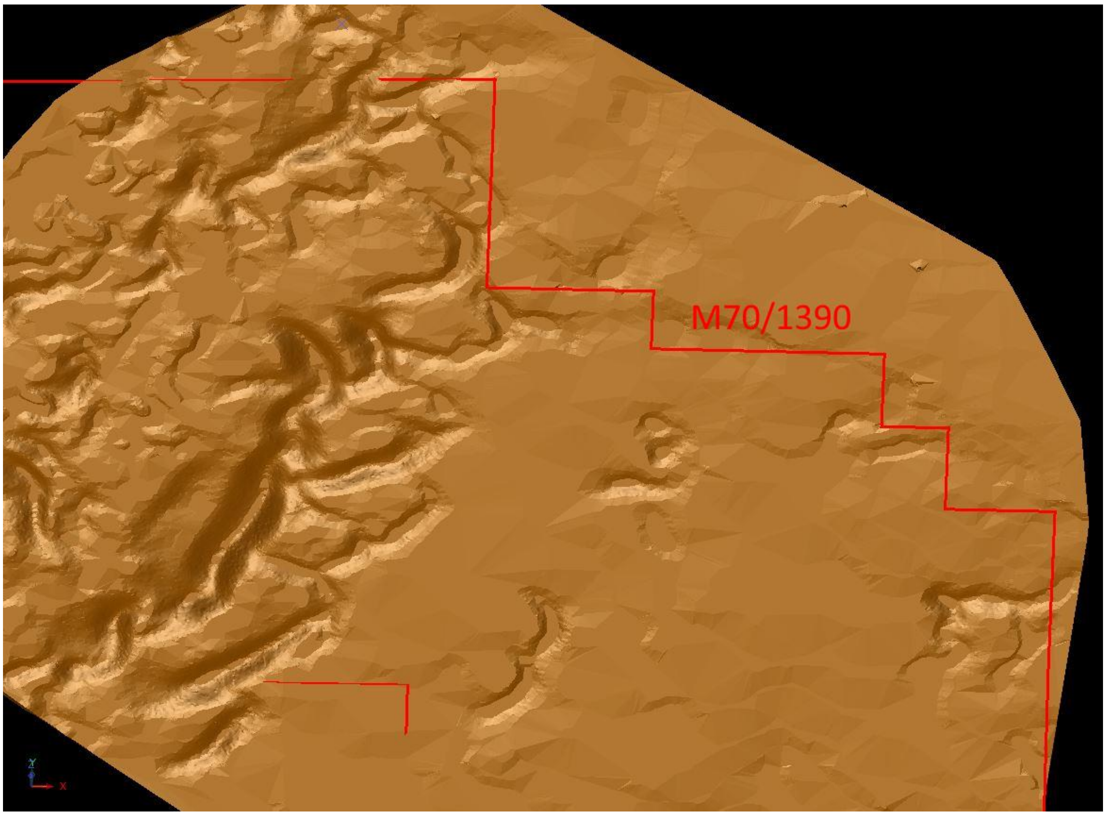

Figure 3: Muchea Post-Mining Topography (10:1 vertical exaggeration)

Material Modifying Factors – Environmental Studies

Development location:

- Mining is 100% on Unallocated Crown Land
- East of the Yeal Nature Reserve and State Forest
- West of Freehold land
- South of Gingin Airfield
- Approximately 25 km inland of the coast
- West of Chandala Brook (Registered Aboriginal Heritage Site)
- Outside of World Heritage Areas, National Heritage Places, Ramsar Wetlands, Conservation Reserves or Commonwealth Marine Reserves

The Probable Ore Reserve is located within an area of deep Bassendean sands, leached of nutrients. The vegetation type is Banksia Woodlands. The topography is low to medium dunes.

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Assessment Process:

- Pre-referral submission to the Federal Department of the Environment and Energy (**DotEE**)
- Final referral submission to the Federal Department of the Environment and Energy (**DotEE**)
- Submission of Section 38 referral to State Environmental Protection Authority (**EPA**)
- Seek an Accredited *Environment Protection and Biodiversity Conservation* Act 1999 (Cth) Assessment under the State *Environmental Protection Act* 1986 (WA) via an Environmental Review Document with public comment
- Undertake any further studies required
- Submission of Environmental Review Document

Mitigation Strategies:

- Proposed action lies within a large development envelope, allowing for the flexibility to target areas of lower significance to matters of national environmental significance (**MNES**)
- Disturbance will be kept to a minimum, up to 35 ha per year and 14 ha at any one time
- Progressive rehabilitation using topsoil re-location to ensure topsoil and plants are translocated intact to previously mined areas
- Conduct further surveys to identify MNES
- Use findings to steer the project and avoid MNES where possible

There are no mine tailings storage requirements.

There are no waste dumps.

Processing requires no chemicals.

Material Modifying Factors – Infrastructure

The project is located on vacant, unallocated crown land which is east of the Yeal Nature Reserve and Sate Forrest, west of Freehold land and south of the Gingin Airfield. The southern boundary is the limit of tenure. The Brand Highway is proximal to the area and access is via the sealed Timaru Road from Brand Highway. The rail line to the Kwinana Bulk Terminal runs east of the Brand Highway and will be used to transport the processed silica sand to the Kwinana Bulk Terminal for bulk export.

The project will require its own installed power and water infrastructure.

Labour will be sourced from the nearest towns, Gingin and Muchea (approximately 12km and 14 km, respectively, from the mine site) and there will be no accommodation at the mine site.

Costs

Operating costs

Operating costs were determined from first principles and are estimated to include all costs to mine, process, transport and load product on to ships.

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Royalties

The prevailing rate of royalty due to the State is used in VRX's economic assessments. The State Royalty rate is A$1.17 per dry metric tonne and reviewed every 5 years with the next review due in 2020.

A 1% net production royalty from the project will be payable to Australia Silica Pty Ltd.

There are no other royalties payable, though a royalty is in the process of being negotiated with Native Title claimants and has been included in the project metrics.

Revenue

Product Quality

Multiple products will be differentiated during processing subject to required particle size distribution by screening. Recovery of products has been independently assessed by CDE Global, a world leading silica sand testing laboratory.

Commodity Prices

Commodity prices for silica sand products have been determined by independent industry source Stratum Resources. The industry standard is that sales contracts are in US dollars. The exchange rate to convert to Australian dollars will be the prevailing rate at the time of payment.

Subject to final quality produced, the prices for the commodity will range from US$38 to US$55 per dry metric tonne Free on Board (**FOB**). There are no shipping cost estimates with all contracts to be based on FOB rates.

Revenue will be based on a negotiated per shipment basis per dry metric tonne FOB with payment by demand on an accredited bank letter of credit.

There will be no other treatment, smelting or refining charges.

Market Assessment

The Company has commissioned an independent assessment of the current market prices for proposed products by industry leader Stratum Resources. The assessment includes projections for future demand and supply of silica sand and concludes that there is a future tightening of supply of suitable glassmaking silica sand with a commensurate increase in price.

Sales volumes have been estimated as a result of received letters of intent and expressions of interest to purchase products.

Economic Factors

The Company's economic analysis has calculated at a 10% discounted ungeared post tax net present value (**NPV**). A 20% discounted NPV has also been calculated to demonstrate the strength of the economic analysis.

The assessment has not considered any escalated future product prices nor any inflation to operating costs. The analysis has used a US$/A$ exchange rate of US$0.70/A$1.00.

The analysis is based on a 25 year production profile with the Probable Ore Reserve supporting a 9-10 year project. Mining will occur solely from the Probable Ore Reserve during that period. There is a reasonable expectation that with further close spaced drilling the existing Inferred Resources would convert to Indicated Resources and Probable Reserves well in excess of this time period, however the model is conservatively restricted to 25 years. See under "Key Points and Assumptions" heading above for further information.

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Capital requirements are based on independent estimates.

The analysis is most sensitive to the exchange rate and sales prices.

The analysis indicates the financials of the project are very robust and there is a high confidence that a viable long-term mining operation can be justified.

Due to the higher-grade products the average sales price of Muchea silica sand products is higher than those from the Arrowsmith silica sand projects.

Social Factors

The Company lodged an application for a Mining Lease (M70/1390) on 17 January 2019. The application lies within the Whadjuk native title claim boundaries (WAD242/11), which is part of the South West Native Title Settlement. The Whadjuk people are represented by the South West Aboriginal Land and Sea Council Aboriginal Corporation. The Company is currently in negotiations with the claimant group with respect to this mining lease application including the Miscellaneous Licences applications required to access the project area, and the Company expects that an agreement will be reached between the parties allowing for the Mining Lease to be granted.

The project is wholly on unallocated crown land with little negative impact on local communities.

Project Funding

The financial model summarised in the BFS sets out the project metrics and provides a basis for the potential capital structure of the Company for the development of the project. Total capital expenditure at Muchea (for a 2 million tonnes per annum processing plant) is estimated at approximately A$33 million (the BFS details capital cost estimates).

The Company anticipates that the source of funding for the capital investment at Muchea will be any one, or a combination of, equity, debt and pre-paid offtake from the project. Whilst no final decision has been made in that regard, the financial model assumes a maximum A$30 million in debt.

The Company has received a number of enquiries and expressions of interest from debt financiers for the project. As noted above, the financial model provides for debt capacity and is designed to meet the expectations of any providers of potential debt funding for their due diligence and other internal requirements.

In addition, VRX has also received enquiries and expressions of interest from organisations across Asia for silica sand products from the project and holds signed letters of intent for substantial tonnages. A number of these organisations have expressed interest in becoming a funding partner of the Company for development of a mine by way of pre-paid offtake arrangements or commercial debt funding.

The balance of the Company's capital requirements will be funded from equity capital.

Whilst the envisaged project development requires a low capital intensity relative to a greenfields hard rock mining project, and any one of, or a combination of equity, debt and pre-paid offtake is planned, VRX has not as yet secured the required capital. The positive financial metrics of the BFS and feedback from potential funding partners provides encouragement as to the likelihood of meeting optimum project and corporate capital requirements.

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Mine Plan

The production target for Muchea incorporates the maiden Probable Ore Reserve of 14.6 Mt @ 99.9% SiO_2 that sits within the Mining Lease application area (see above under “Probable Ore Reserve”) as well as a portion of the Inferred Mineral Resource.

The Inferred Mineral Resource available to mine within the Mine Plan Pit is 61.4 Mt @ 99.6% SiO_2.

In designing the Mine Plan Pit, the Company has examined the restrictions and constraints on mining activities in the context of surrounding areas and the interests of stakeholders, and planned accordingly. To that end, the Mine Plan Pit ensures:

- mining will not occur any closer than 100m to the Dongara to Pinjarra gas pipeline;
- mining will not occur any closer than 200m to the boundary of any freehold land and will be at least 600m from the nearest house; and
- the Mining Lease area does not intersect with the Gingin Airfield ground and mining will not occur any no closer than 250m to the boundary of the Gingin Airfield. In addition, mining will not occur under the flight lines to and from the airfield.

These buffer zones are at least equal to, or are in excess of, industry practice and legislative requirements (if any). In addition, the eastern boundary of the Mine Plan Pit is contiguous with the FNA (see above under “Key points and assumptions”) and does not intersect with any proposed conservation area under the Green Growth Plan.

The Mine Plan Pit therefore is not impacted by any known exclusion areas.

The maiden Probable Ore Reserve is estimated from the Indicated Mineral Resource only. This constitutes approximately 30% of the estimated total production target (in terms of processed tonnes of silica sand) over the 25 year mine life for the Project BFS estimates. It provides sufficient tonnage for the first 9-10 years of mining operations. The Company intends to mine solely from the Probable Ore Reserve during that period. Key assumptions underpinning the financial model for the Project are set out below, including timing for project start-up and ramp-up to full capacity. The financial model (see below and in the BFS) shows that Muchea is a viable project with the Probable Ore Reserve only, and the Inferred Mineral Resource is not the determining factor for its viability.

The ore which forms the Inferred Mineral Resource is contiguous with the Indicated Mineral Resource and has been categorised as lower confidence due to wider spaced drilling. (Drilling of the Indicated Mineral Resource is typically 50m spaced along existing tracks, whereas the Inferred Mineral Resource is drilled on a 400m spacing along existing tracks.)

The Company has undertaken sufficient drilling to assume geological and metallurgical continuity of the sand deposit. There is negligible difference between the modelled sand in each category and it is believed an additional 1,500m of drilling would be required to upgrade the inferred resource category. The cost for drilling, assaying and associated studies is estimated (at current rates) to be in the region of $250,000 and will need to be undertaken within the first 9 years of mining operations.

Given the simple nature of the silica sand deposit at the Project and the associated geological and metallurgical confidence, the Company expects that this additional drilling will be sufficient to realise the production target.

Notwithstanding the above, there is a low level of geological confidence associated with Inferred Mineral Resources and there is no certainty that further exploration work will result in the determination of Indicated Mineral Resources or that the production target itself will be realised.

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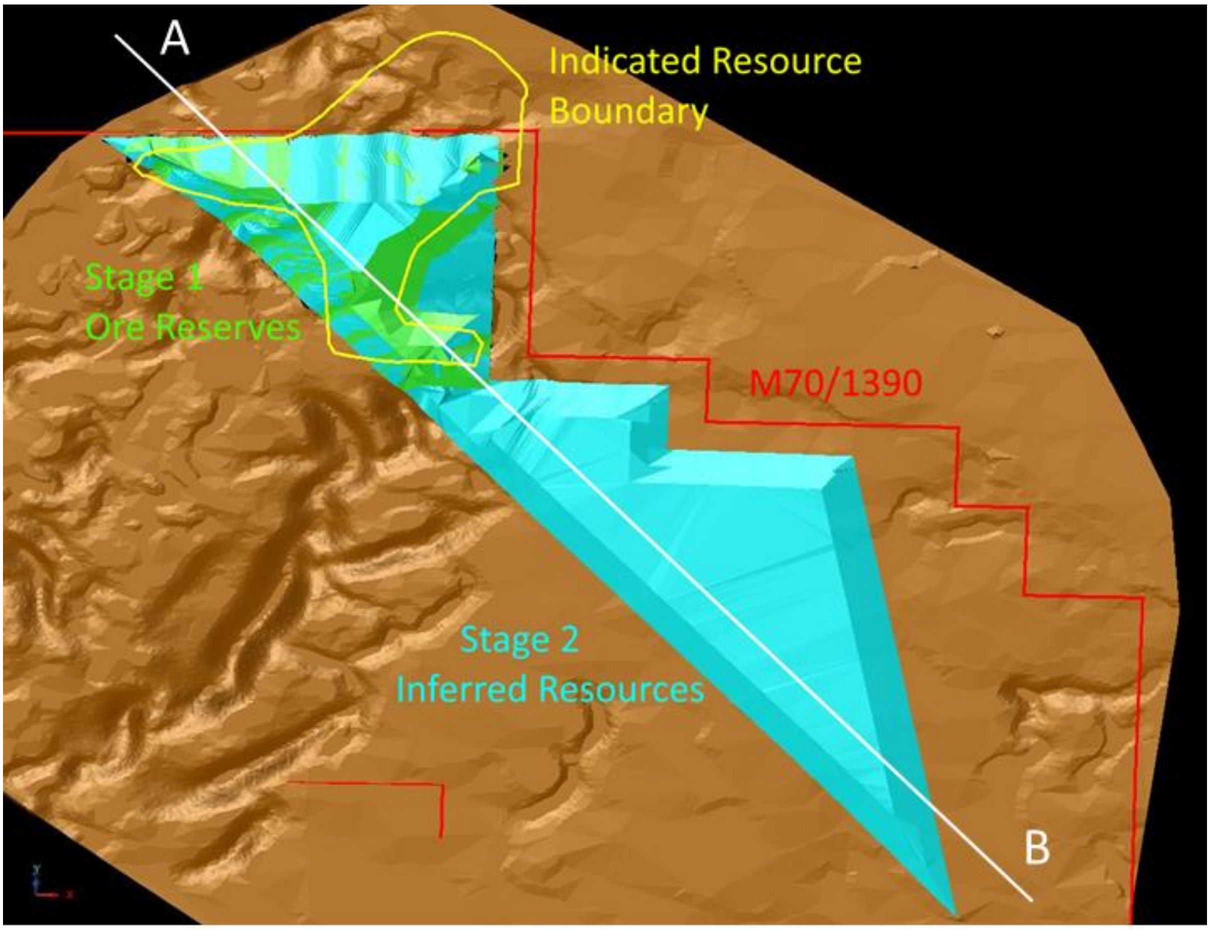

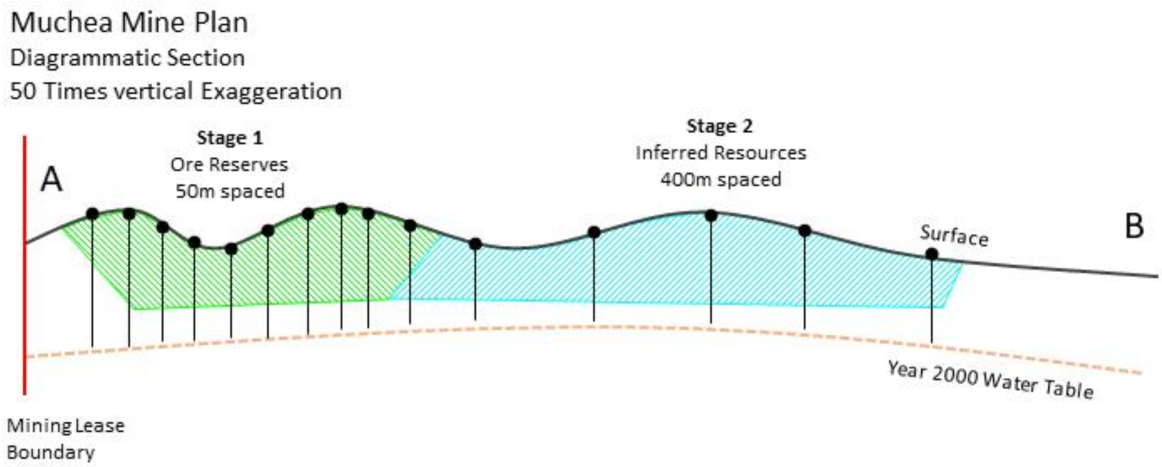

Figure 4: Muchea Post-Mining of Ore Reserves and Inferred Resources
Topography (5:1 vertical exaggeration)
Probable Ore Reserve within green boundaries and Inferred Mineral Resource within blue boundaries.

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Financial model

Based on the capital and operating cost estimates a financial model was developed for the purpose of evaluating the economics of the Project.

Key economic assumptions for the model are set out above and in detail in the BFS. The BFS contains further details, including a life of mine production profile and sensitivity analysis for the model.

Key outcomes from the BFS and summary financial model outputs are set out below, with the first column showing outputs from the aggregated Probable Ore Reserve and the Inferred Mineral Resource, and the second column showing outputs from the Probable Ore Reserve only.

Mining from the area of the Probable Ore Reserve only supports a 9-10 year mine life. The Company intends to mine solely from the Probable Ore Reserve during that period. The financial model shows that Muchea is a viable project with the Probable Ore Reserve only, and the Inferred Mineral Resource is not the determining factor for its viability.

	Muchea (Inc. Inferred)	Muchea (Reserve Only)
Post Tax, ungeared NPV_{10}	$337,900,000	$180,500,000
Post Tax, ungeared NPV_{20}	$146,400,000	$104,600,000
Post Tax, ungeared IRR	96%	96%
Payback period (yrs) (post tax) (ramp up rate)	2.3	2.3
Exchange Rate US$/A$	$0.70	$0.70
Life of Mine (yrs) (Scope of BFS Study)	25	15
Total Sales (initial 25 years) no escalation	$3,345,000,000	$1,011,000,000
EBIT	$1,540,000,000	$447,000,000
Cashflow after finance and tax	$1,123,000,000	$321,000,000
Shares on Issue	404,318,617	404,318,617
EPS after tax (per year)	$0.11	$0.09
Capex (2 mtpa)	$32,820,000	$32,820,000
Capex contingency (inc)	20%	20%
Life of Mine C1 costs, FOB Kwinana (inc royalties)	$32.74	$33.84
Tonnes Processed (initial 25 years) (Mt)	54	16
Production Target (Mt) (BFS Study)	(25 years) 48.3	(9-10 years) 14.6
Probable Ore Reserves @ 99.9% SiO_2 (Mt)	18.7	18.7
Ore Reserve life (yrs)	9-10	9-10
JORC Resources (million tonnes)	208	208

Notes:

1. There is a low level of geological confidence associated with inferred mineral resources and there is no certainty that further exploration work will result in the determination of indicated mineral resources or that the production target itself will be realised.
2. The Probable Ore Reserve and the Inferred Mineral Resource underpinning the above production targets have been prepared by a Competent Person in accordance with the requirements of the JORC Code.
3. Full summaries of economic assumptions are set out in the BFS.
4. All figures are presented in Australian dollars, unadjusted for inflation.

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Muchea, Arrowsmith North and Arrowsmith Central Project Metrics

Key BFS outcomes for Muchea, Arrowsmith North and Arrowsmith Central, and in aggregate, are set out below.

	Arrowsmith North	Arrowsmith Central	Muchea	Total
Post Tax, ungeared NPV_{10}	$242.3m	$147.6m	$337.9m	**$727.8m**
Post Tax, ungeared NPV_{20}	$99.8m	$56.1m	$146.4m	**$302.3m**
Post Tax, ungeared IRR	79%	60%	96%	**83%**
Payback period (yrs) (post tax) (ramp up rate)	2.4	2.8	2.3	**2.4**
Exchange Rate US$/A$	$0.70	$0.70	$0.70	**$0.70**
Life of Mine (yrs) (Scope of BFS Study)	25	25	25	**25**
Total Sales (initial 25 years) no escalation	$2,773m	$2,167m	$3,345m	**$8,285m**
EBIT	$1,144m	$737m	$1,540m	**$3,421m**
Cashflow after finance and tax	$835m	$539m	$1,123m	**$2,497m**
Shares on Issue	404,318,617			
EPS after tax (per year)	$0.08	$0.05	$0.11	**$0.25**
Capex (2 mtpa)	$28.3m	$25.9m	$32.8m	**$87m**
Capex contingency (inc)	20%	20%	20%	**20%**
Life of Mine C1 costs, FOB Kwinana (inc royalties)	$30.18	$27.67	$32.74	**$30.24**
Tonnes Processed (initial 25 years) (Mt)	53	51	54	**158**
Production Target (Mt) (BFS Study) (initial 25 Years)	47.7	39.6	48.3	**136**
Probable Ore Reserves (Mt)	204	18.9	18.7	**242**
Ore Reserve life (yrs)	102	10	9-10	
JORC Resources (million tonnes)	771	77	208	**1,056**

Notes:
1. A proportion of the production target for each of Arrowsmith Central and Muchea is based on Inferred Mineral Resource. There is a low level of geological confidence associated with inferred mineral resources and there is no certainty that further exploration work will result in the determination of indicated mineral resources or that the production target itself will be realised.
2. The Ore Reserves and, in the case of Arrowsmith Central and Muchea, the Inferred Mineral Resource underpinning the above production targets have been prepared by a Competent Person in accordance with the requirements of the JORC Code.
3. Full summaries of economic assumptions are set out in the BFS for each project[6].
4. All figures are presented in Australian dollars, unadjusted for inflation

[6] ASX announcements of 28 August 2019, "Arrowsmith North BFS and Maiden Ore Reserve" and 17 September 2019, "Arrowsmith Central BFS and Maiden Ore Reserve".

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Competent Persons' Statements

The information in this report that relates to Arrowsmith North, Arrowsmith Central and Muchea Exploration Results and Muchea Aircore Drilling Area Mineral Resources are based on data collected and complied under the supervision of Mr David Reid, who is a full-time employee of VRX Silica. Mr Reid, BSc (Geology), is a registered member of the Australian Institute of Geoscientists and has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and the activity being undertaken to qualify as a Competent Person under the 2012 edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code). Mr Reid consents to the inclusion of the data in the form and context in which it appears.

The information in this report that relates to Arrowsmith North, Arrowsmith Central and Muchea Auger area Mineral Resources is based on information compiled by Mr Grant Louw who is a full-time employee of CSA Global, under the direction and supervision of Dr Andrew Scogings, who is an Associate of CSA Global. Dr Scogings is a Member of the Australasian Institute of Mining and Metallurgy and a Member of the Australian Institute of Geoscientists. He is a Registered Professional Geologist in Industrial Minerals. Dr Scogings has sufficient experience relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as Competent Person as defined in the 2012 edition of the Australasian Code for the Reporting of Exploration Results, Mineral Resources, and Ore Reserves (JORC Code). Dr Scogings consents to the disclosure of information in this report in the form and context in which it appears.

The information in this report that relates to Arrowsmith North, Arrowsmith Central and Muchea Probable Ore Reserves is based on data collected and compiled under the supervision of Mr David Reid, who is a full-time employee of VRX Silica. Mr Reid, BSc (Geology), is a registered member of the Australian Institute of Geoscientists and has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and the activity being undertaken to qualify as a Competent Person under the 2012 edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves (JORC Code). Mr Reid consents to the inclusion of the data in the form and context in which it appears.

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About VRX Silica

VRX Silica Ltd (**VRX Silica**) (ASX: VRX) has significant silica sand projects in Western Australia.

The Arrowsmith North and Arrowsmith Central Silica Sand Projects, located 270km north of Perth, comprise five granted exploration licences and two mining lease applications pending. Bankable feasibility studies for both projects have been released, each demonstrating exceptional financial metrics.

The Muchea Silica Sand Project, located 50km north of Perth, comprises one granted exploration licence, with one mining lease application pending. Muchea is a world-class project with high purity silica sand in situ. A bankable feasibility study for the project has been released demonstrating outstanding financial metrics.

The Boyatup Silica Sand Project, located 100km east of Esperance, comprises two adjacent granted exploration licences. Initial indications are that this project will complement the Arrowsmith and Muchea projects while adding to the range of silica products capable of production.

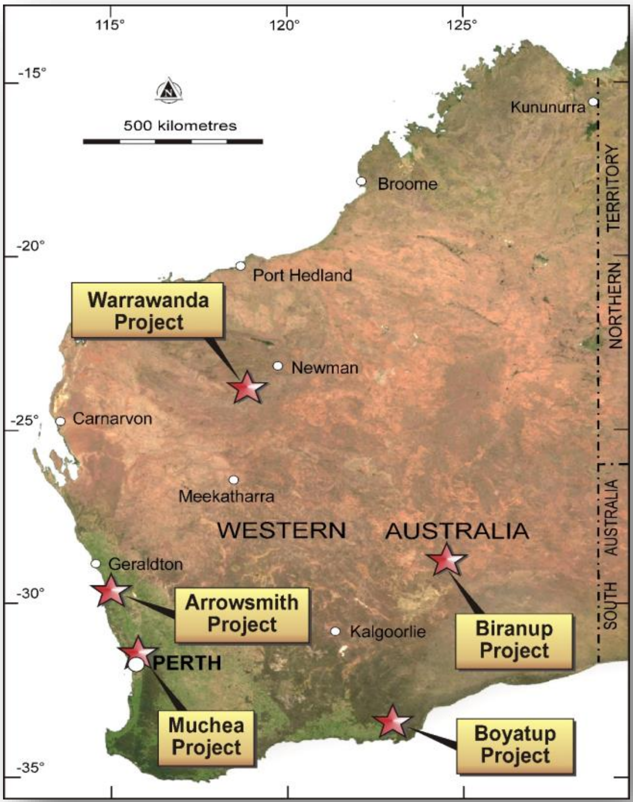
The Warrawanda Project, 40km south of Newman, WA is prospective for nickel sulphides.

The Biranup Project, adjacent to the Tropicana Gold Mine in WA's Goldfields, is prospective for gold and base metals.

Proven Management

The VRX Silica Board and management team have extensive experience in mineral exploration and mine development into production and in the management of publicly listed mining and exploration companies.

Project Locations



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VRX SILICA

Bankable Feasibility Study

Muchea

Silica Sand Project

18 October 2019

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Important Information

Nature of Document

This document has been prepared and issued by VRX Silica Limited (**Company**) to provide general information about the Company and the Muchea Silica Sand Project (**Project**). The information in this document is in summary form and should not be relied upon as a complete and accurate representation of any matters that a reader should consider in evaluating the Company or the Project. While management has taken every effort to ensure the accuracy of the material in this document, the Company and its advisers have not verified the accuracy or completeness of the material contained in this document.

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Forward-looking statements

Statements regarding plans with respect to the Company's mineral properties may contain forward looking statements. Statements in relation to future matters can only be made where the Company has a reasonable basis for making those statements. This document has been prepared in compliance with the JORC Code[1] and ASX Listing Rules. The Company believes it has a reasonable basis for making the forward-looking statements, including any production targets, based on the information contained in this document.

All statements, trend analysis and other information contained in this document relative to markets for the Company, trends in resources, recoveries, production and anticipated expense levels, as well as other statements about anticipated future events or results constitute forward- looking statements. Forward-looking statements are often, but not always, identified by the use of words such as "seek", "anticipate", "believe", "plan", "estimate", "expect" and "intend" and statements that an event or result "may", "will ", "should", "could" or "might" occur or be achieved and other similar expressions. Forward-looking statements are subject to business and economic risks and uncertainties and other factors that could cause actual results of operations to differ materially from those contained in the forward-looking statements. Forward-looking statements are based on estimates and opinions of management at the date the statements are made. The Company does not undertake any obligation to update forward- looking statements even if circumstances or management's estimates or opinions should change. Investors should not place undue reliance on forward-looking statements.

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[1] Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2012 Edition (**JORC Code**).

Cautionary statement

The production target for Muchea incorporates the maiden Probable Ore Reserve that sits within the proposed mining area for the Project and a portion of the Inferred Mineral Resource within the area. Given the simple nature of the silica sand deposit at the Project, the Company expects that additional drilling will be sufficient to upgrade the Inferred Mineral Resource and to realise the production target.

Notwithstanding the above, there is a low level of geological confidence associated with Inferred Mineral Resources and there is no certainty that further exploration work will result in the determination of Indicated Mineral Resources or that the production target itself will be realised.

The Probable Ore Reserve and Inferred Mineral Resource for the Project have been prepared by a Competent Person and a Competent Person's Statement is included in this document.

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Contents

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Figures

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Tables

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1 Overview

VRX Silica Limited (**VRX** or **Company**) is an ASX-listed silica sand exploration and development company (ASX: VRX). VRX is focused on developing silica sand assets in Western Australia.

This Bankable Feasibility Study (**BFS**) details the project and financial attributes supporting the development of VRX's Muchea Silica Sand Project (**Muchea** or **Project**).

Muchea is one of three separate, advanced silica sand projects being progressed by the Company, being Muchea, Arrowsmith North and Arrowsmith Central. This BFS is solely for Muchea.

The Company is proposing to mine and process raw sand from Muchea. The raw sand can be processed to a quality suitable for the glass making industry (including the ultra clear market).

The silica sand Probable Ore Reserve is substantial and will support a long-life mining and processing project with substantial benefits to the region and Western Australia generally.

Silica sand products will be transported by rail from Muchea to the Kwinana Bulk Terminal for export to Asian glass manufacturing and foundry industries.

Glass manufacturing product specifications are centred around the silica dioxide content of the silica sand, with consideration specifically attributed to other contained elements such as iron, titanium, aluminium and calcium, all of which affect the quality of the final glass products. Foundry industry product specifications are mostly centred around the size and shape of the silica sand grains.

Muchea can produce saleable products that meet the required specifications for both industries.

The Company has received enquiries and expressions of interest from organisations and also agents across Asia for these products and holds signed letters of intent for substantial tonnages. Subject to completion of the approvals process for mining, offtake agreements will be finalised before the Company makes a decision to proceed to mine.

VRX has lodged a Mining Lease application for the Project. The Company is currently undertaking negotiations for a mining agreement with the Native Title holders, which is required before the grant of the Mining Lease.

The Company is progressing the environmental approval process for the Project with both State and Federal Government authorities and completing additional requisite studies necessary for the grant of a Mining Permit.

Details of the work undertaken on the Project by the Company to-date and an economic evaluation that supports development of a mining operation follows.

2 Project Background

2.1 Project Location

Muchea is located 50 km north of Perth, WA and is between the regional towns of Muchea and Gingin, WA (Figure 1).

The Project is located adjacent to the Brand Highway and the Moora–Kwinana Railway, with a rail connection direct to Kwinana Bulk Terminal.

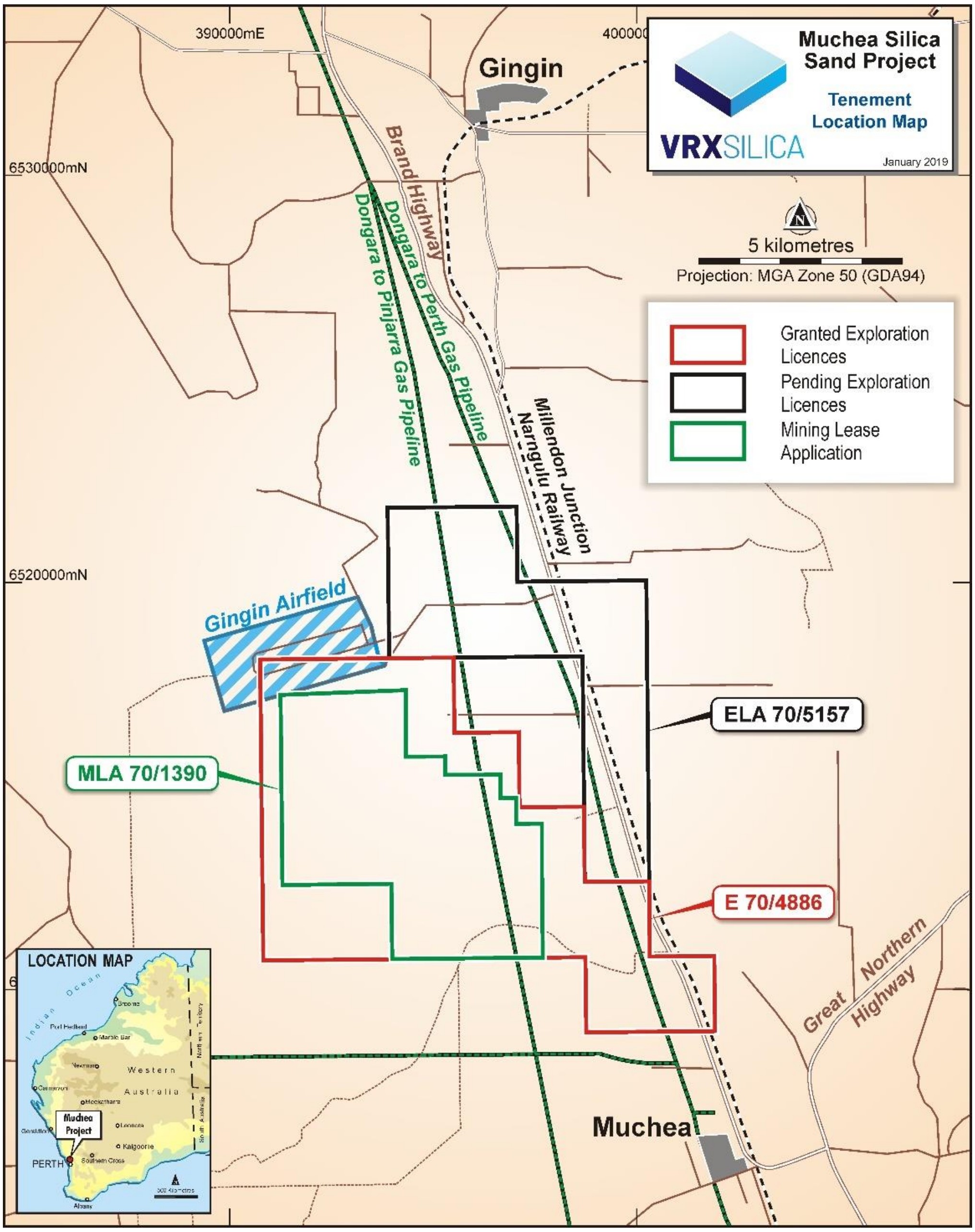

Figure 1: Muchea project and tenement location map

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2.2 Environmental Data

The Project occurs on the Bassendean landform and soils, which is part of the Lesueur Sandplains subregion, occurring on the elevated sand dune systems on the eastern edges of the Gnangara Mound to the northwest of Muchea and Bullsbrook.

Vegetation in the Project area is dominated by Banksia woodlands that are well represented on the Gnangara Mound in reserves. They are part of the listed Banksia woodlands on the Swan Coastal Plain threatened ecological community under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* and within the Priority 3 Ecological Community at State level.

Fauna assemblage is typical of the Lesueur Sandplains subregion and is moderately rich, but incomplete with some species locally extinct. The area is notable for a rich reptile assemblage and high proportion of non-resident birds, many of which are nectarivorous and exploit seasonal abundance of nectar and pollen from the species-rich flora. Few species of high conservation significance are present or expected, but the Carnaby's Black-Cockatoo is important, with known roost sites in the district and the species very likely to be a regular foraging visitor to the Project area.

There is a Crown Reserve area (42450) for Conservation of Flora and Fauna and Water 500m west of the Project area and also a State Forest Area (65). To the north is the Gingin Airfield. The Project sits atop of the Gnangara Underground Water Pollution Control Area. To the south is Department of Defence land associated with the RAAF Pearce airbase.

2.3 Site Topography and Drainage

The Project area lies within the Perth Basin, containing a succession of Quaternary to Permian age deposits up to a total of 12,000 m thick. It comprises a series of aeolian sand dune systems up to 25 m thick running north-west, south-east for up to the length of the Mining Lease area .

The surface is leached loose sand with very high transmissivity and drains from the Project area to the east. The seasonal Chandala Brook lies 3km to the east and flows only during very high rainfall events in to the Chandala Swamp.

A topographic image (pre-mining) is shown in Figure 14.

2.4 Climate

The climate in the Project area is associated with rainfall mainly in the winter months and seasonal fluctuations in temperature, Figure 2. The mean annual rainfall is 653.1 mm of precipitation (Bureau of Meteorology (BOM) 2017). The effectiveness of the rainfall events is influenced by higher temperatures and evaporation rates, with obvious seasonal changes between summer and winter.

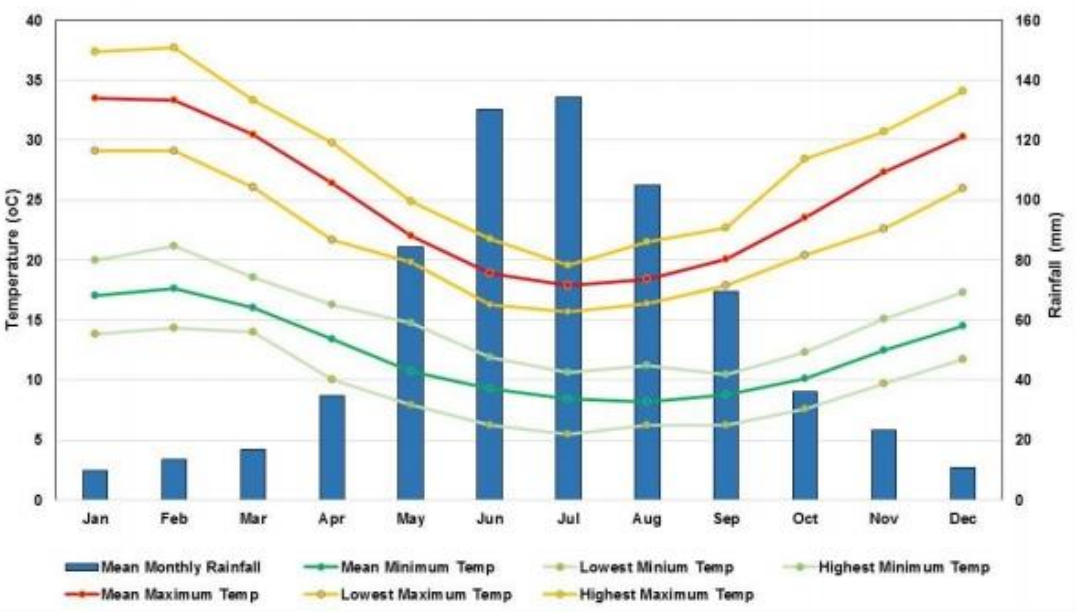

Figure 2: Rainfall and temperature data for Pearce Airbase (SE of the Project area)

2.5 Existing Infrastructure

The Project is located on unallocated crown land that is west of freehold land and bounded to the north and west by a Nature Reserve and Forest Reserve and south by a Department of Defence lease. The Brand Highway to the east is proximal to the area with access by Timaru Road or Airfield Road from the north. The Moora–Kwinana rail line lies to the east of the Project and will be used to transport the processed silica sand to the Kwinana Bulk Terminal for export.

The Project will require its own installed water infrastructure. Power can be sourced from high tention reticulated power adjacent to Brand Highway.

Labour will be sourced from the nearest towns Gingin and Muchea (approximately 14km and 12km, respectively, from the mine site) and there will be no accommodation installed at the mine site.

2.6 Political Overlay

The location of Muchea is within the jurisdiction of Western Australia and the Commonwealth of Australia.

Current Government positions relevant for the Project area and operations include:

Federal Minister

Christian Porter; MHR Pearce

State Ministers

Premier; Minister for State Development; Jobs and Trade; Mark McGowan; MLA for Rockingham

Treasurer; Ben Wyatt; MLA for Victoria Park

Minister for Transport; Rita Saffioti; MLA for West Swan

Minister for Energy; Mines and Petroleum; Industrial Relations; Bill Johnston; MLA for Cannington

Minister for Ports; Alannah MacTiernan MLC for the North Metropolitan Region

Minister for Environment; Stephen Dawson MLC for Mining and Pastoral Region

State MPs

MLA for Moore; Shane Love

Government Departments

Department of Transport (Includes Ports); Richard Sellers; Director General

Department of Mines, Industry Regulation and Safety (DMIRS); David Smith; Director General

Department of Jobs, Tourism, Science and Innovation (includes State Development) (DJTSI); Rebecca Brown; Director General

Department of Water and Environmental Regulation (DWER); Mike Rowe; Director General

Environmental Protection Authority; Chairman Dr Tom Hatton

Fremantle Ports; Chief Executive Officer; Chris Leatt-Hayter

Local Government

Shire of Chittering; Chief Executive Officer; Matthew Gilfellon

Shire of Chittering; Shire President; Gordon Houston

Shire of Gingin; Shire President; Ian (Sam) Collard

Shire of Gingin; Chief Executive Officer; Aaron Cook

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3 Ownership and Leases

Land in the Project area is vacant, unallocated Crown land with the State and Native Title claimants the only stakeholders.

The Project has one granted exploration licence E70/4886 covering 20 blocks or 64 km^2 and one pending exploration licence E70/5157 covering 9 blocks or 29 km^2.

The granted tenement is held in a VRX 100% owned subsidiary, Wisecat Pty Ltd, and the pending tenement is held by the Company. The tenements are not contiguous and do not have combined reporting status.

Wisecat Pty Ltd also has pending applications at Muchea for a Mining Lease (MLA70/1390), four Miscellaneous Licenses, one for the Search for Water over the Mining Lease area, the second for an access route south of the Mining Lease area, another for access to the central area from Timaru Road and another for access to the northern part of the tenement from Airfield Road.

Table 1 sets out tenement details for Muchea.

Tenement	Holders	Grant date	Expiry date / Purpose	Area
E70/4886	Wisecat Pty Ltd	27/03/2017	5/04/2023	64
E70/5157	VRX Silica Ltd	29/03/2018*		
M70/1390	Wisecat Pty Ltd	08/02/2019*	Mining Lease	29.2
L70/200	Wisecat Pty Ltd	13/03/2019*	Search for water	29.2
L70/202	Wisecat Pty Ltd	23/05/2019*	Access route	
L70/204	Wisecat Pty Ltd	23/05/2019*	Access route	
L70/206	Wisecat Pty Ltd	23/05/2019*	Access route	

Table 1: Muchea tenement details

** Application date (not yet granted)*

The Mining Lease application area is overlain by a File Notation Area 12671 (**FNA**) for the proposed "Perth and Peel Green Growth Plan for 3.5 million". See Figure 3. This sits outside of the proposed development area for the Project (see Section 5),

The FNA was lodged by the Department of Premier and Cabinet (**DPC**) following a Strategic Assessment of the Perth and Peel Regions to determine the areas to be managed within the Conservation and Land Management Act 1984 (WA) to protect conservation and recreation values of local or regional significance. The Green Growth Plan is currently under review by the State Government.

Whilst the FNA does not affect the modelled 25 years of production and proposed development at Muchea (see Section 19), the Company has been in discussions with both the DPC and the Department of Jobs, Tourism, Science and Industry to identify options for the Company to gain access to the FNA area so as to extend the Project's mine life to well beyond 25 years, and potentially over 100 years. This includes a proposal to swap non-FNA ground outside of the Mining Lease area but within the Company's existing tenements for FNA ground within the Mining Lease area. Discussions are continuing.

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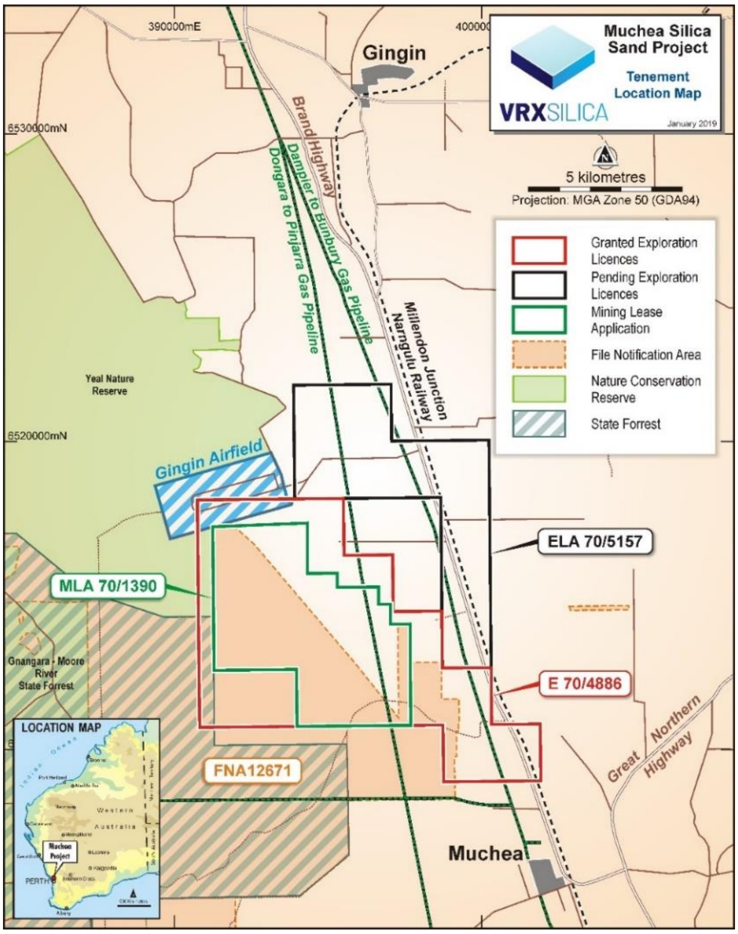

Figure 3: Muchea Project, showing overlapping FNA 12671 Area

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4 Native Title and Aboriginal Heritage

4.1 Claimant Parties

Muchea is located wholly within the Whadjuk Native Title Claim (WAD242/11) which is part of the South West Native Title Settlement. The Whadjuk people are represented by the South West Aboriginal Land and Sea Council Aboriginal Corporation.

4.2 Surveys

The Company has in place a standard Heritage Agreement which covers the Company's Exploration Licence at Muchea.

The Company has conducted an extensive Aboriginal Heritage clearance survey on all drill lines used in the drill programs. No sites of significance were noted. This was confirmed in a clearance report.

The Chandala Brook and Swamp were highlighted as sensitive areas.

4.3 Existing Registered Aboriginal Sites

The closest Registered Aboriginal Site is the Chandala Brook east of Brand Highway, and 3 kms east of the Project area.

This Site is not within the Mining Lease application area.

4.4 South West Native Title Settlement

The South West Native Title Settlement (**Settlement**) is the most comprehensive native title agreement negotiated in Australian history. Negotiated between the six Noongar Agreement Groups, represented by the South West Aboriginal Land and Sea Council (SWALSC) and the Government of Western Australia, the Settlement comprises of the full and final resolution of all native title claims in the South West of Western Australia, in exchange for the Settlement package. The agreement involves around 30,000 Noongar people and covers approximately 200,000 square kilometres.

The Settlement is a significant investment in both the Noongar community and the shared future of the Western Australian community as a whole. The Settlement will provide the Noongar people with long-term benefits and options for developing Noongar interests. It will also provide opportunities for the WA Government to work in partnership with the Noongar people to improve economic, social and cultural outcomes for the Noongar community. In addition the Settlement will deliver long term benefits to the WA Government and land users through the resolution of native title and the removal of all 'future act' obligations across the south west.

The full details of the Settlement are recorded in six Indigenous Land Use Agreements (**ILUAs**) made in compliance with the *Native Title Act 1993* (**NTA**) with the six Noongar Agreement Groups

Until the Settlement commences the NTA still applies to all land users planning activities in the Settlement Area and land users must still consider any planned developments or activities proposed in the Settlement area that may affect existing native title rights or interests. These native title rights may vary from the right for native title applicants to be consulted, to the right to negotiate and the right to compensation.

The commencement of the Settlement will resolve all native title rights and interests that may have existed in the ILUA area. The Settlement is not expected to commence until 2020.

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4.5 Negotiations

On the basis that the Settlement has not yet commenced, the Company is currently undertaking its Right to Negotiate with both the claimant group (Whadjuk) and the Government Party (Tenure and Native Title Branch of the Department of Mines, Industrial Regulation and Safety). The Company has no reason to believe that an agreement will not be reached between the parties.

Upon successful completion of the negotiations the Mining Lease will be granted, and a State Deed executed.

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5 Geology, Resources and Reserves

5.1 Geology

Most economically significant silica sand deposits in Western Australia are found in the coastal regions of the Perth Basin, and the targeted silica sand deposits are the aeolian sand dunes that overlie the Pleistocene limestones and paleo-coastline, which also host the regional heavy mineral deposits.

Within the Project area, data obtained from the Department of Agriculture soil mapping shows the area is predominanlty covered by deep Bassendean Sands (Figure 4).

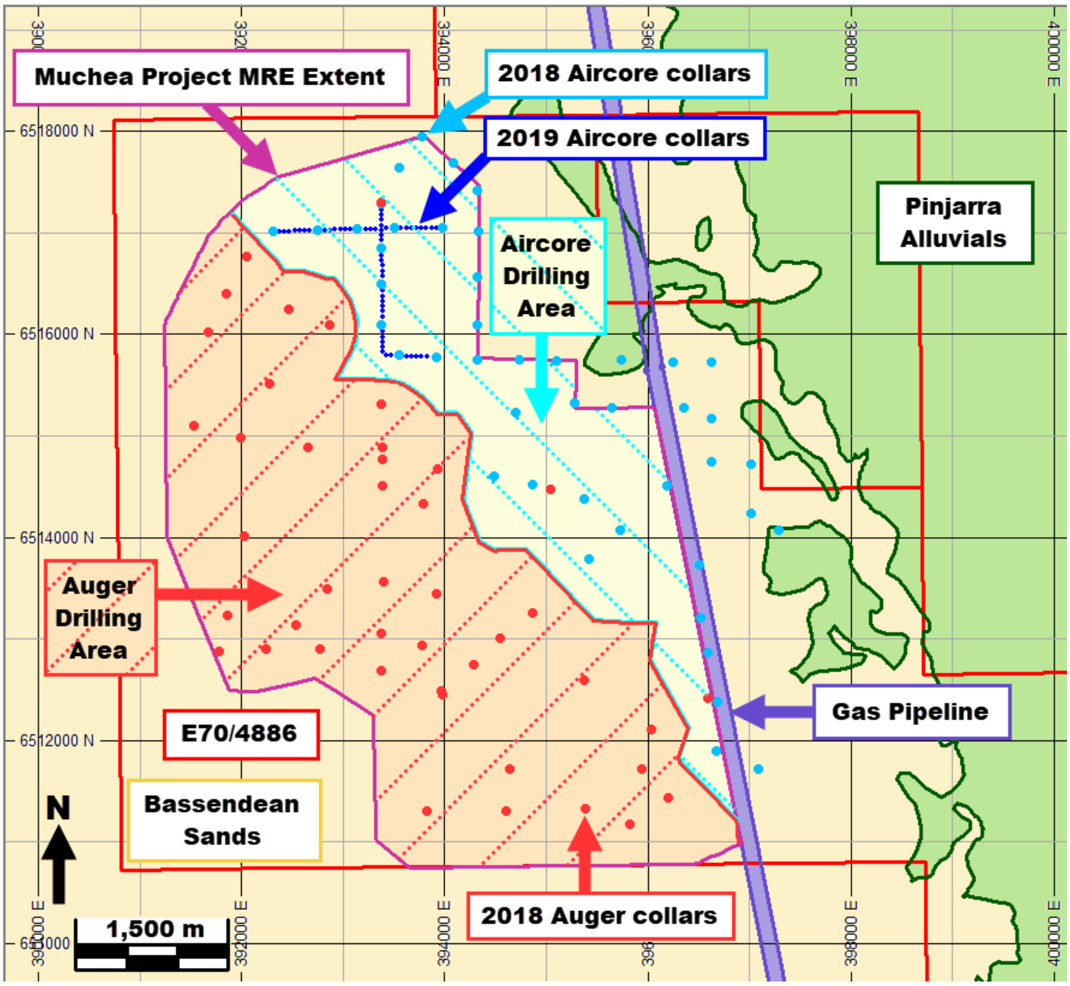

Figure 4: Simplified geology of the Muchea area.

Red dots – 2018 Air Core collars - Light Blue Dots, 2019 Air Core collars - Dark Blue Dots, Auger collars- Red Dots.

Tenements as in Figure 1.

Source: Outlines based on DOAG soil mapping data.

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5.2 Resources

5.2.1 Mineral Resource Estimate

The updated Mineral Resource estimate (**MRE**) for the Muchea Deposit comprises 208 Mt @ 99.6% SiO_2 [2] reported in accordance with the JORC Code[3].

The MRE is based on the results obtained from 44 hand auger drill holes for 260.7 m, and 103 air core (**AC**) drill holes for 1,401 m, to define the modelled silica sand layer.

Based on metallurgical testwork completed to-date, the silica sand at Muchea is readily amenable to upgrading by conventional washing and screening methods to produce a high-purity silica sand product with high mass recoveries. The high-purity silica sand product specifications are expected to be suitable for industries such as glass making and foundry sand.

The MRE results are shown in Table 2.

Classification	Million Tonnes	SiO_2%	Al_2O_3%	Fe_2O_3%	LOI%	TiO_2%
Indicated	29	99.6	0.09	0.03	0.22	0.07
Inferred	179	99.6	0.05	0.02	0.23	0.1
Indicated + Inferred	208	99.6	0.06	0.02	0.23	0.1

**Note: Interpreted silica sand mineralisation is domained above a basal surface wireframe. The upper (overburden) layer within 0.5 m of surface is depleted from the modelled silica sand unit, being reserved for rehabilitation purposes. All classified silica sand blocks in the model are reported. Differences may occur due to rounding.*

Table 2: Muchea Mineral Resource

The following summary presents a fair and balanced representation of the information contained within the MRE technical report:

- Silica sand mineralisation at Muchea occurs within the Bassendean Sand, which extends along the Swan coastal plains of the Perth Basin, parallel to the coast. (ASX LR 5.8.1 geology & geological interpretation)
- Samples were obtained from auger and aircore drilling. Quality of drilling/sampling and analysis, as assessed by the Competent Person, is of an acceptable standard for use in a Mineral Resource estimate publicly reported in accordance with the JORC Code. (ASX LR 5.8.1 Sampling & 5.8.1 Drilling)
- Major and trace elements apart from SiO_2 were analysed using a four-acid digest followed by Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry (ICP-OES) analysis at the Intertek Genalysis, Perth laboratory. Loss on Ignition at 1000°C (LOI) was analysed by Thermal Gravimetric Analyser. SiO_2 was back-calculated by subtracting all ICP major and trace elements plus LOI from 100%, as this is the most accurate way of determining SiO_2 content for samples with very high SiO_2. Certain of the ICP results were verified by X-Ray Fluorescence (XRF) analyses. (ASX LR 5.8.1 Analysis)
- The Auger drilling area Mineral Resources were estimated above a 3-d wireframe basal surface for the uppermost white silica sand layer. The basal surface is interpreted based on the geological logging, chemical analysis results and chip photography and the extents are limited to within the VRX nominated Muchea target area. The surfaces are based on the geological boundaries defined by logged sand types from the drill data and with reference to the publicly available soil mapping data. The surface humus layer is typically about 300 mm thick. In consultation with VRX, CSA Global considered that the upper 500 mm (overburden) is likely to be reserved for rehabilitation purposes. This overburden surface forms the upper boundary of the estimated Mineral Resource and is depleted from the reported Mineral Resources. The Aircore drilling area Mineral Resources were estimated using a polygonal area weighted analysis using equidistant polygons generated from the location of the Aircore drill holes. The down hole widths and grades were determined by visual and statistical analysis to determine the average grades in the volume defined by the

[2] ASX announcement of 17 June 2019, *"Muchea Mineral Resource Estimate Upgrade"*.

[3] Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, 2012 Edition (**JORC Code**).

polygons, where this extended below 3m above the year 2000 water table, this higher level was used to determine the average grades in the volume defined by the polygons. A 500mm upper layer has been removed from the estimation as it is likely to be reserved for rehabilitation purposes. (ASX LR 5.8.1 Estimation methodology)

- Auger drilling area grade estimation was completed using Ordinary Kriging with an inverse distance weighting to the power of two validation check estimate also completed. Aircore drilling area grades were estimate by the average grade down hole of sand weighted by the polygonal volume. (ASX LR 5.8.1 Estimation methodology)
- The Mineral Resource is quoted from all classified blocks above the defined basal surface wireframe for the upper white silica sand layer and below the overburden surface layer. (ASX LR 5.8.1 cut-off grades)
- The Mineral Resources are classified as Indicated and Inferred based on drill hole logging, drill hole sample analytical results, drill spacing, geostatistical analysis, confidence in geological continuity, and metallurgical / process test results. (ASX LR 5.8.1 classification)
- Roughly 10% of the interpreted mineralisation is considered extrapolated.
- The JORC Code Clause 49 requires that industrial minerals must be reported "in terms of the mineral or minerals on which the project is to be based and must include the specification of those minerals" and that "It may be necessary, prior to the reporting of a Mineral Resource or Ore Reserve, to take particular account of certain key characteristics or qualities such as likely product specifications, proximity to markets and general product marketability." (ASX LR 5.8.1 Mining, metallurgy & economic modifying factors)
- Therefore, the likelihood of eventual economic extraction was considered in terms of possible open pit mining, likely product specifications, possible product marketability and potentially favourable logistics and it is concluded that the Muchea silica sand deposit is an industrial Mineral Resource in terms of Clause 49. (ASX LR 5.8.1 Mining, metallurgy & economic modifying factors)

Reinterpretation

The industry standard analytical technique used to determine the SiO_2 grade is to calculate by difference. Samples are digested in a specialised four-acid digest and then analysed by means of Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry (ICP-OES) analysis which reads the quantities of element other than silica, Loss on Ignition at 1000°C (LOI) is determined by Thermal Gravimetric Analyser (TGA). These quantities are then deducted from 100% to determine the SiO_2 grade. The original MRE interpretation of high-grade sand was done preferentially using the SiO_2 grade.

As an example, Table 3 below, shows the changes to the high-grade sand composite that was used for MAC015 and MAC040 from the original aircore drilling program. In both cases the original modelled sand layer was only 3m due to the SiO_2 grade being the determinant. The reinterpretation is significantly deeper as it includes a deeper layer of low Fe_2O_3 sand which has higher amounts of clay and organic material, which reduces the difference calculated SiO_2 grade. Metallurgical testwork to date has proven that this material is easily upgraded to the same high-quality final product as the shallower white sand. As a result of this reinterpretation, 18 holes out of the original 46 holes that were drilled in in the Phase 1 program have been upgraded with respect to the depth of sand modelled.

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Hole ID	Depth From	Depth To	Colour	Al_2O_3	Fe_2O_3	TiO_2	LOI	SiO_2	Original Comp.	Reinterp. Comp.
MAC015	0	1	Lt Brown	591	286	1323	0.91	98.82	3m @ 99.28% SiO_2 **381ppm Fe_2O_3**	7m @ 99.24% SiO_2 **388ppm Fe_2O_3**
	1	2	White	365	429	922	0.3	99.50		
	2	3	White	393	429	1493	0.22	99.52		
	3	4	Lt Brown	1317	286	1690	0.38	99.22		
	4	5	Lt Brown	1230	429	1897	0.4	99.16		
	5	6	Lt Brown	1436	286	1805	0.3	99.26		
	6	7	Lt Brown	2099	572	2135	0.19	99.18		
	7	8	Lt Brown	6228	1859	3071	0.26	98.15		
	8	9	Lt Brown	9022	1573	1918	0.25	97.93		
	9	10	Lt Brown	3342	572	1850	0.22	99.05		
MAC040	0	1	White	378	143	874	0.89	98.92	3m @ 99.37% SiO_2 **268ppm Fe_2O_3**	11m @ 99.42% SiO_2 **494ppm Fe_2O_3**
	1	2	White	208	143	792	0.29	99.57		
	2	3	White	217	71	779	0.26	99.61		
	3	4	Lt Brown	370	143	1313	0.57	99.22		
	4	5	Lt Brown	317	143	1046	0.39	99.44		
	5	6	White	357	286	962	0.27	99.54		
	6	7	White	644	572	1905	0.43	99.22		
	7	8	Lt Brown	709	286	1268	0.37	99.36		
	8	9	Lt Brown	654	286	1088	0.21	99.55		
	9	10	White	998	429	1001	0.22	99.51		
	10	11	White	584	286	701	0.13	99.69		
	11	12	White	399	429	1349	0.11	99.65		

Table 3: High grade sand composite reinterpretation for MAC015 and MAC040

5.2.2 Drilling

Drilling over the Project area has been completed by means of hand auger along existing tracks (Figure 5) and Aircore drilling (Figure 6).

Hand auger hole depths ranged from 1.8 m to 11.4 m with an average depth of 5.4 m, while AC drilling ranged from 6 m to 36 m with an average depth of 13.6 m.

2018 drilling was completed at a nominal 400 m spacing along existing tracks, which are nominally between 400 m and 1,200 m apart. 2019 AC drilling was spaced 50 m along tracks focused on an area considered to be best for the commencement of mining (Figure 13).

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Figure 5: Sand sampling using a hand auger at Muchea

Figure 6: Landcruiser mounted Mantis 82 NQ sized aircore drill rig at Muchea

Geological logging

Geological logging defining the aeolian dune sand types based on field observations of the colour tone has been completed on all drilling intervals. Geological logging of drill samples is undertaken by the field geologist with samples retained in chip trays for later interpretation. Logging is captured in an excel spreadsheet, validated and uploaded into an Access database.

Sampling

The 100 mm screw auger drilling samples are 1 m down hole intervals with sand collected from a plastic tub which received the full sample, ~8 kg, from the hole. The first metre of the hole was cased using PVC tubing. All auger samples were weighed to determine if down hole collapse was occurring, if the samples weights increased significantly the hole was terminated to avoid up hole contamination. The sand was homogenised prior to sub sampling, two sub-samples, A and B, of ~200 g were taken from the drill samples. A bulk sample of ~5 kg was retained for each 1 m interval for metallurgical testwork. The "A" sample was submitted to the Intertek Laboratory in Maddington, Perth for drying, splitting (if required), pulverisation in a zircon bowl to a nominal -75 µm. The "B" sample was used for field duplicate samples inserted to the sample stream at a rate of 1 in 20.

Vertical NQ sized aircore (AC) drilling was completed by a Landcruiser mounted Mantis 82 drill rig to take 1m downhole samples. Drilling encountered only unconsolidated sand and was terminated either at the water table or extended when an iron rich layer was intersected. AC drill samples are 1m down hole intervals with sand collected from a cyclone mounted rotary cone splitter, 50:50 into a calico bag resulting in 2-3kg of dry sample, 2 x 200g sub-samples, A and B, are taken from the drill sample. The A sample is submitted to the laboratory and the B sample is retained for repeat analysis and QAQC purposes .

The analysis for multi-elements are determined by an initial specialised four-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon tubes on the pulverised samples. The digest is then analysed by means of Inductively Coupled Plasma Optical (Atomic) Emission Spectrometry (ICP-OES) analysis, with silica reported by difference. Loss on Ignition at 1000°C (LOI) was analysed by Thermal Gravimetric Analyser (TGA).

Mineral Resource modelling

The Auger drilling area Mineral Resources were estimated above a 3-d wireframe basal surface for the uppermost white silica sand layer. The basal surface is interpreted based on the geological logging, chemical analysis results and chip photography and the extents are limited to within the VRX nominated Muchea target area. The surfaces are based on the geological boundaries defined by logged sand types from the drill data and with reference to the publicly available soil mapping data. The surface humus layer is typically about 300 mm thick. In consultation with VRX, CSA Global considered that the upper 500 mm (overburden) is likely to be reserved for rehabilitation purposes. This overburden surface forms the upper boundary of the estimated Mineral Resource and is depleted from the reported Mineral Resources. The Aircore drilling area Mineral Resources were estimated using a polygonal area weighted analysis using equidistant polygons generated from the location of the Aircore drill holes. The down hole widths and grades were determined by visual and statistical analysis to determine the average grades in the volume defined by the polygons, where this extended below 3m above the year 2000 water table, this higher level was used to determine the average grades in the volume defined by the polygons. A 500mm upper layer has been removed from the estimation as it is likely to be reserved for rehabilitation purposes

The entire Muchea target area is defined on the basis of the soil mapping data as being underlain by a single mixed silica sand material unit, which consists of dominant pale deep sands with interspersed yellow sands. The bulk composite sample sent for metallurgical testing to CDE included material from all drilled intervals, not separated into pale or yellow silica sand. CSA Global in consultation with VRX's geologist has considered it most appropriate to model the entire area as a single silica sand layer. The metallurgical testing has demonstrated that the mixed silica sand making up the deposit can be beneficiated to the desired product specifications as discussed in the metallurgy and other sections in this report. The decision was also taken with reference to the current stage of resource development and the drill spacing making it impractical to attempt separation of sand types.

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All available samples in the Muchea area were flagged for further statistical analysis and use in the grade estimation. The drilling in Muchea is relatively shallow and the area with sufficient drilling data to imply geological and grade continuity, is limited to the area that is drilled at a nominal 400 m drill spacing in the target area. The classified Mineral Resources have a nominal maximum extrapolation of grade estimated material beyond drill data points of roughly 400 m, and are additionally constrained within the VRX nominated target area. Figure 7, shows the 2018 drilling plan with crosection A-B, showing the modelled sand layer.

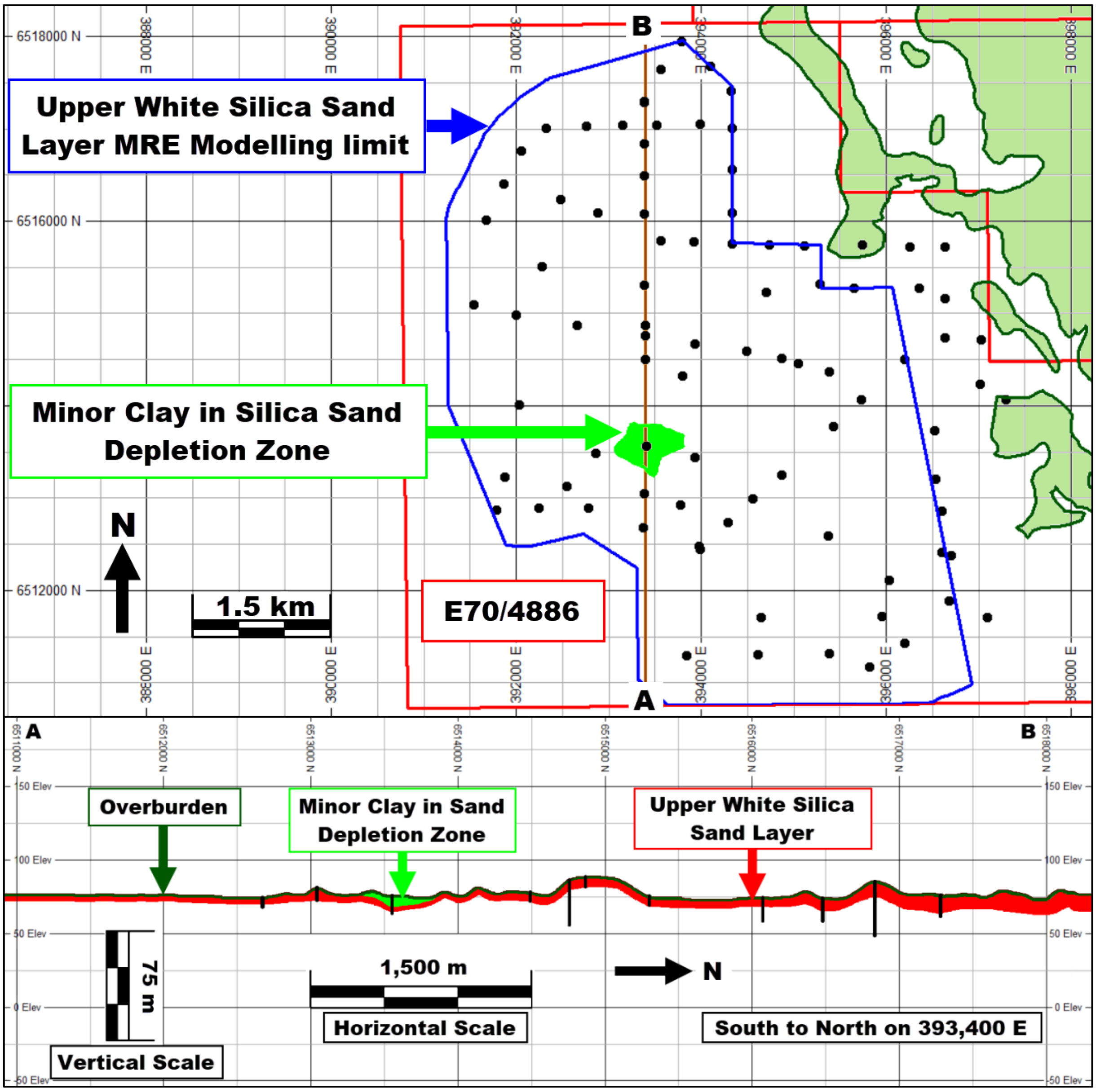

Figure 7: Drill Plan and Cross section A – B at 393,400mE

Looking west; 10 times Vertical exaggeration

5.2.3 Quality Assurance – Quality Control

VRX has provided CSA Global with an internal file note detailing procedures employed to ensure suitable levels of accuracy and precision are achieved by means of assay quality control work, and details provided in this section are largely derived from this note.

There is no certified, commercially available standard for high purity silica sand. VRX approached OREAS Pty Ltd to prepare a specialised run of 500 x 10 g packets, of their certified blank, OREAS 22e, without their usual 0.5% iron oxide pigment, this new standard has been denoted as VRX-22S. This material is generated from high purity silica sand as its base. As the sample does not include the pigment, and the exact composition of the pigment is unknown the certified values for OREAS 22e cannot be used. It should also be noted that the sample was prepared using a steel bowl pulveriser which will affect the total iron contained within the samples.

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VRX has started a process of establishing values for VRX-22S, initially by doing a "Round Robin" to three laboratories in Perth. 20 sample packets were sent to Intertek, 10 to SGS and 10 to Nagrom. They all completed duplicated analysis on the packets with half of the packets using the two different analytical techniques:

- SiO_2 by difference through four acid digestion with ICP-OES finish (4A/ICP-OES), and LOI by TGA,
- Fused bead X-ray fluorescence (XRF) analysis, direct reporting of SiO_2

The purpose of this exercise was twofold; first, to determine which analytical technique was most appropriate for high purity silica analysis and, second, to achieve a baseline set of values for the standard, VRX-22s. When comparing the XRF results with the 4A/ICP-OES results it becomes apparent that the XRF produces low variability results for all elements, including Si whereas 4A/ICP-OES has more variability. Generally, 4A/ICP-OES has lower detection limits, but these vary from laboratory to laboratory. When just comparing the SiO_2 value, it is believed that 4A/ICP-OES returns a better estimate of the true value, and further investigation has revealed that the "Industry Standard" for determining SiO_2 is the 4A/ICP-OES method tested here.

Overall CSA Global is of the opinion that the quality control work has demonstrated that the laboratory analyses and the sampling method has been appropriate, and the results of the chemical analysis are suitable for use in a reportable MRE.

Certified Reference Materials

CSA Global has completed a summary statistical analysis of the results from the round robin testing of the VRX-22S standard, with the results presented in Table 4. VRX geology staff expressed concern that the standard was not well enough understood using only the relatively few available analyses. Based on the fact that an additional 100 data points have been generated through the insertion of the standard to the sample stream, it was considered prudent to use the full available analysis result data set to establish a more robust statistical analysis of the values and variability that can be expected from the standard. The mean and standard deviation (SD) derived from this full data set analysis (Table 5) has been used as the basis for establishing the expected value and SD control lines in the control graph validating the laboratory analysis performance.

	Al_2O_3%	Fe_2O_3%	MgO%	TiO_2%	LOI%	SiO_2%
Number	40	40	40	40	40	40
Mean	0.126	0.038	0.005	0.040	0.082	99.699
Min	0.097	0.03	0.003	0.037	0.03	99.6369
Q1	0.122	0.036	0.004	0.039	0.050	99.677
Median	0.129	0.040	0.005	0.040	0.080	99.702
Q3	0.134	0.040	0.005	0.042	0.103	99.723
Max	0.141	0.05	0.0071	0.043	0.14	99.7503
Variance	0.0001	0.0000	0.0000	0.0000	0.0010	0.0008
Std Dev	0.0109	0.00438	0.0009	0.0018	0.0315	0.0279
Coeff Var	0.0869	0.1143	0.1933	0.0438	0.3839	0.0003

Table 4: Summary statistics for round robin testing of VRX-22s by 4A/ICP-OES

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	Al_2O_3%	Fe_2O_3%	MgO%	TiO_2%	LOI%	SiO_2%
Number	140	140	140	140	140	140
Mean	0.140	0.041	0.005	0.041	0.088	99.682
Min	0.097	0.03	0	0.037	0.01	99.5514
Q1	0.131	0.039	0.004	0.040	0.050	99.654
Median	0.139	0.040	0.005	0.042	0.080	99.689
Q3	0.154	0.042	0.005	0.043	0.120	99.708
Max	0.1767	0.06	0.0074	0.0474	0.2	99.8
Variance	0.0002	0.0000	0.0000	0.0000	0.0018	0.0020
Std Dev	0.0146	0.00562	0.0011	0.0021	0.0426	0.0452
Coeff Var	0.1043	0.1386	0.2314	0.0505	0.4860	0.0005

Table 5: Summary statistics for all testing of VRX-22s by 4A/ICP-OES

The VRX-22S standard was inserted to the drill sample submissions to the Intertek Laboratory in Maddington, in sequence, at a ratio of 1:20, with a total of 20 samples being analysed from within the Muchea sample submissions. Most analytes are very close to the assay method detection limit, so some inherent additional variability is expected to be seen in the results. Additionally, the preparation of the standard using a steel pulveriser is likely to introduce some variable low levels of iron to the sample. The statistical results of the standard analysis shown in Table 6 show that the mean results for the 20 submitted samples in the Muchea sample data stream are very close to the all testing dataset values, while the SD is somewhat more variable.

Grade variable	Al_2O_3	Fe_2O_3	MgO	TiO_2	LOI	SiO_2
Detection Limit	0.01%	0.02%	0.004%	0.001%	0.01%	0.1%
Analysis Number	20	20	20	20	20	20
Expected Value	0.140%	0.041%	0.005%	0.041%	0.088%	99.682%
Analysis Mean	0.140%	0.042%	0.004%	0.041%	0.092%	99.691%
Expected Std Dev	0.0146	0.0056	0.0011	0.0021	0.0426	0.0452
Std Dev	0.0125	0.0066	0.0010	0.0023	0.0564	0.0592

Table 6: Comparison of performance of VRX-22S
(All testing against Muchea sample stream submission)

The control plot for SiO_2 is presented in Figure 8 and shows three values approaching the +3SD failure limit, but the standard performance is considered to be acceptable in the context of the overall mean results and acceptable field duplicate performance.

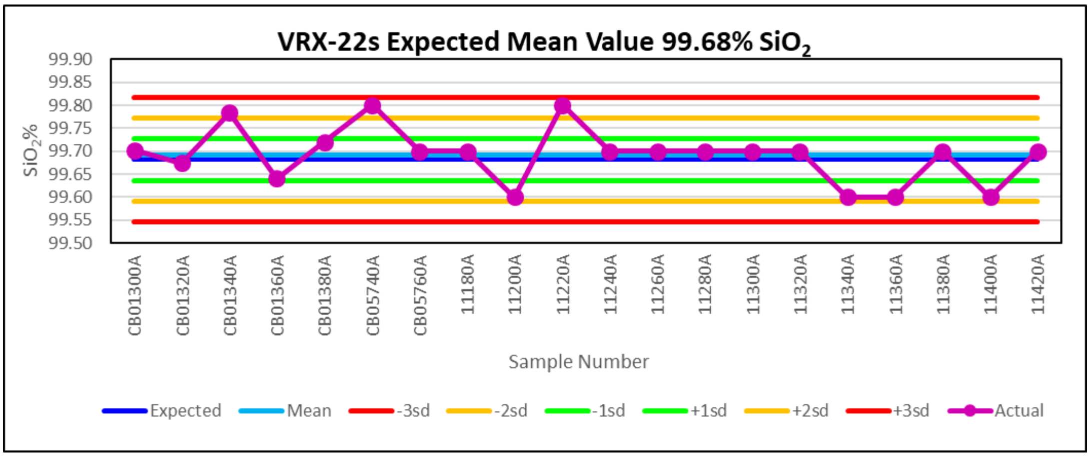

Figure 8: Control Chart for VRX-22S - SiO_2

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Blanks

It was not considered necessary to insert blanks to the sample stream as the VRX-22S material is effectively also a blank.

Field duplicates

Field duplicate samples were inserted in to the sample stream at a rate of 1 in 20, for 35 field duplicate samples. One sample was removed from the data set as it was significantly outlying for both LOI and Al_2O_3 analysis, resulting in the SiO_2 being incorrect. Analysis of the remaining 34 sample set mean grades shown in Table 7 shows that the grade variables have reasonably similar mean grade results, similar population variability and strong correlation coefficients. The exception is MgO which is very close to detection limit and with maximum analysed value of 0.012% is not considered a material failure issue.

Grade Variable	SiO_2 Prim	SiO_2 Dup	Fe_2O_3 Prim	Fe_2O_3 Dup	TiO_2 Prim	TiO_2 Dup
Number	34	34	34	34	34	34
Mean	98.87	98.82	0.05	0.04	0.11	0.12
Variance	2.49	2.83	0.00	0.00	0.00	0.00
Std Deviation	1.58	1.68	0.06	0.06	0.05	0.06
Coeff.Var	0.02	0.02	1.40	1.31	0.48	0.48
Correl Coeff.	0.994		0.964		0.938	
Grade Variable	**Al_2O_3 Prim**	**Al_2O_3 Dup**	**K_2O Prim**	**K_2O Dup**	**LOI Prim**	**LOI Dup**
Number	34	34	34	34	34	34
Mean	0.41	0.45	0.006	0.006	0.51	0.51
Variance	0.66	0.83	0.000	0.000	0.54	0.54
Std Deviation	0.82	0.91	0.002	0.003	0.74	0.74
Coeff.Var	2.01	2.03	0.394	0.452	1.45	1.44
Correl Coeff.	0.994		0.719		0.992	

Table 7: Summary statistics Primary vs field duplicate samples

Overall the duplicate SiO_2 grade analysis results appear to be reasonable when looking at both the scatter and q-q plots in Figure 9.

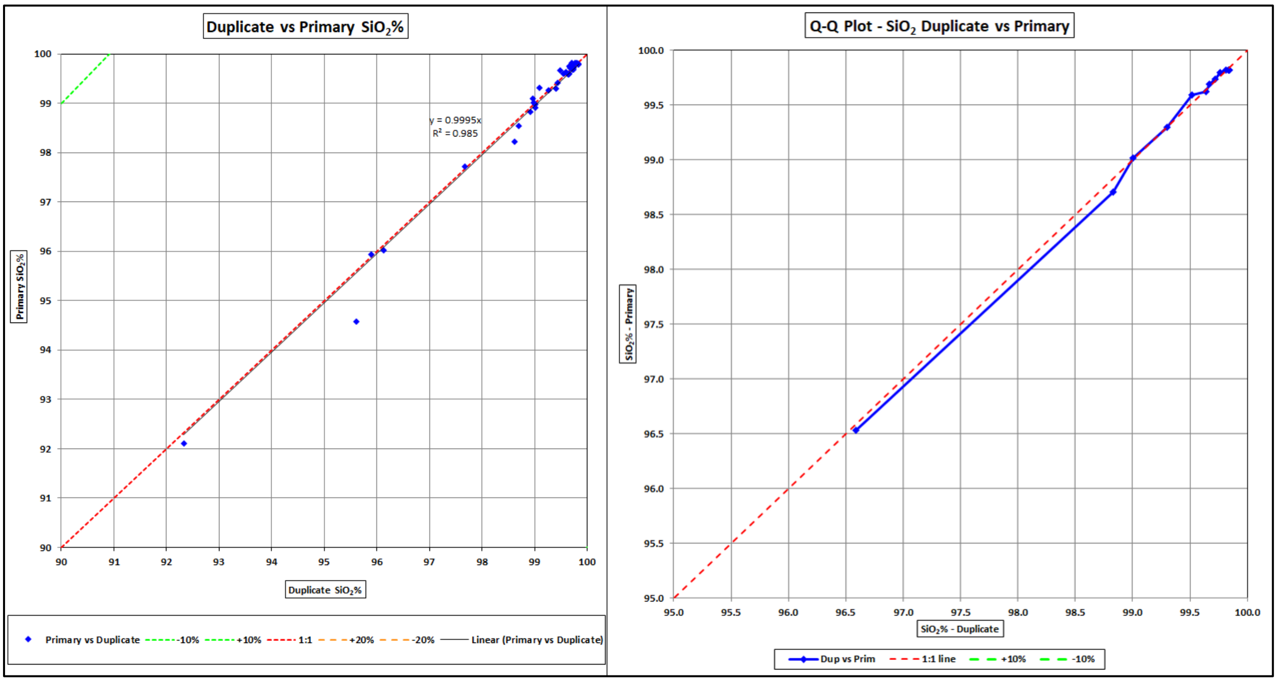

Figure 9: Scatter plot and Q-Q plot Primary vs field duplicate samples for SiO_2

Twin holes

Two sets of close spaced twinned auger with aircore drilling have been drilled (Figure 10).

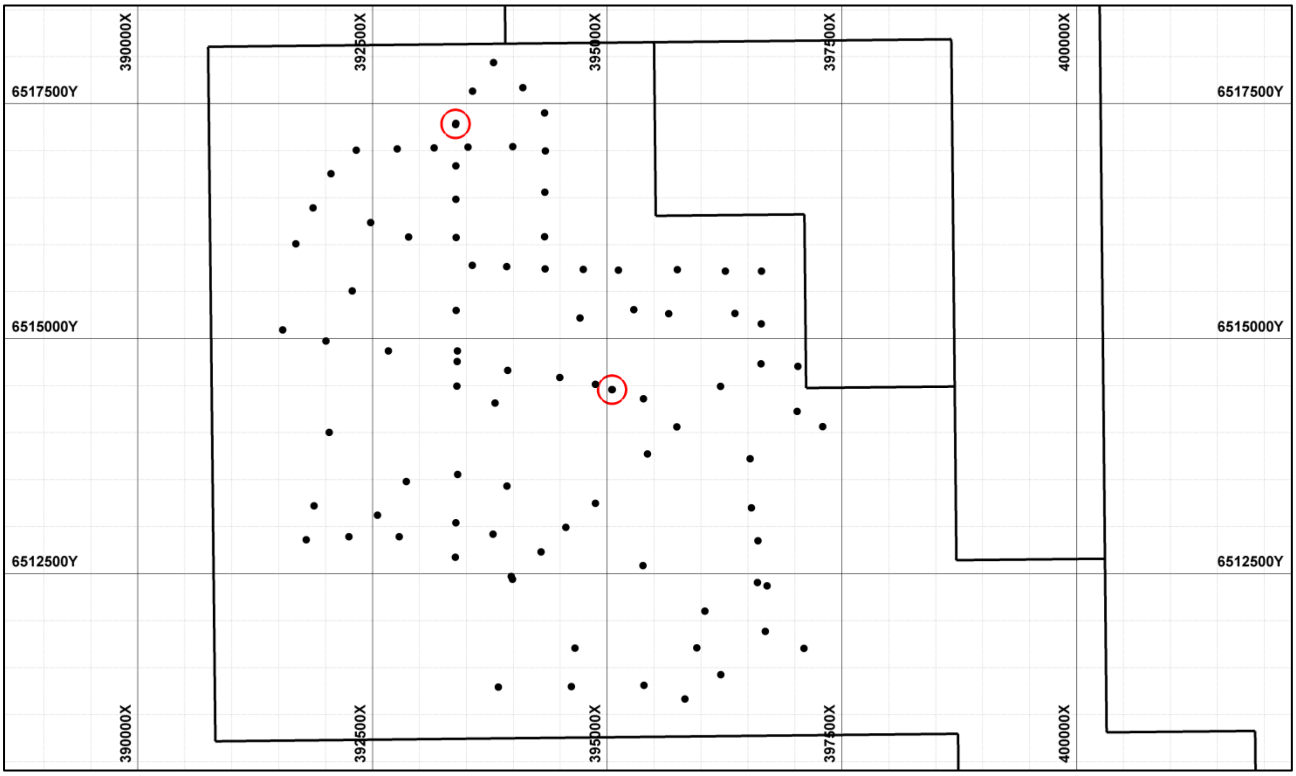

Figure 10: Map showing location of twin pairs MA029/MAC032 and MA032/MAC044

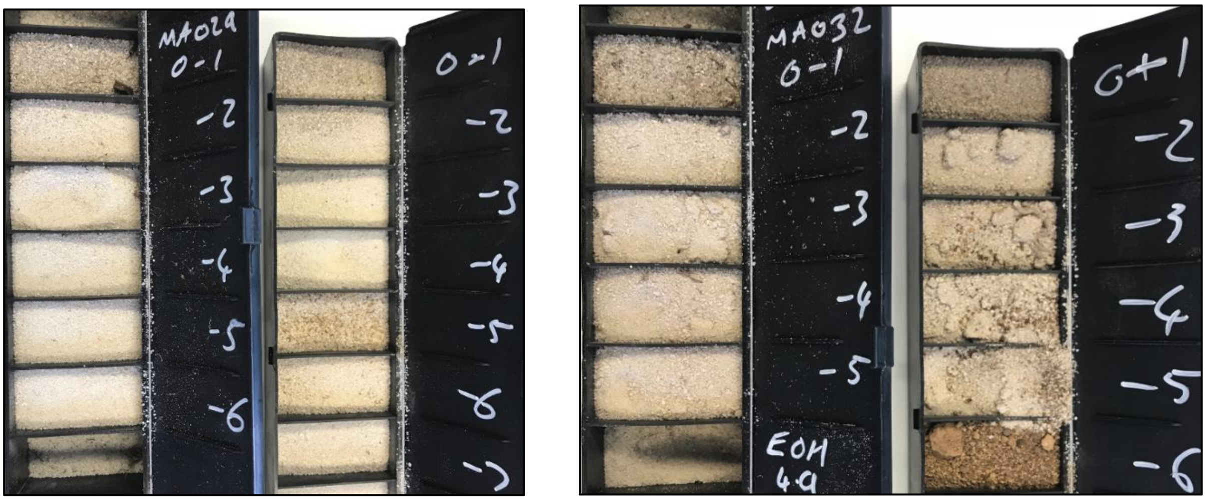

Figure 11: Chip trays of twins MA029/MAC032 (left) and MA032/MAC044 (right)

Comparison of similar depth intervals in shows that the component with the most significant variability between auger and aircore drilling is LOI, which then feeds into the SiO_2 grade. With Al_2O_3 and remaining other analytes at very low levels this difference is most likely due to variable small amounts of organic matter at these relatively shallow levels. The direct correlation between SiO_2 grade of the individual sample pairs is not specifically considered as these are twins not duplicates. The overall populations however are very similar with the mean SiO_2 grades for auger 99.51% and aircore 99.61%.

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Hole ID	From	To	Lithology	Al_2O_3	Fe_2O_3	TiO_2	LOI_{1000C}	SiO_2
MA029	0	1	SS	0.02	0.01	0.04	1.34	98.55
MA029	1	2	SS	0.02	0.01	0.04	0.07	99.84
MA029	2	3	SS	0.02	0.01	0.05	0.07	99.82
MA029	3	4	SS	0.02	0.01	0.05	0.09	99.80
MA029	4	5	SS	0.02	0.01	0.06	0.03	99.85
MA029	5	6	SS	0.02	0.01	0.08	0.06	99.80
MAC032	0	1	SS	0.06	0.01	0.05	0.59	99.26
MAC032	1	2	SS	0.05	0.01	0.06	0.18	99.68
MAC032	2	3	SS	0.03	0.01	0.07	0.09	99.78
MAC032	3	4	SS	0.03	0.01	0.07	0.10	99.77
MAC032	4	5	SS	0.18	0.06	0.09	0.47	99.16
MAC032	5	6	SS	0.05	0.03	0.11	0.15	99.63

Table 8: Auger / AC Twins MA029 / MAC032

Hole ID	From	To	Lithology	Al_2O_3	Fe_2O_3	TiO_2	LOI_{1000C}	SiO_2
MA032	0	1	SS	0.02	0.01	0.08	0.53	99.33
MA032	1	2	SS	0.02	0.01	0.08	0.28	99.59
MA032	2	3	CR	0.02	0.03	0.08	0.12	99.73
MA032	3	4	SS	0.02	0.01	0.08	0.16	99.71
MA032	4	4.9	SS	0.02	0.01	0.11	0.12	99.71
MAC044	0	1	BS	0.08	0.17	0.10	0.81	98.79
MAC044	1	2	BS	0.05	0.01	0.09	0.16	99.66
MAC044	2	3	BS	0.04	0.03	0.09	0.27	99.56
MAC044	3	4	BS	0.02	0.01	0.10	0.16	99.68
MAC044	4	5	CR	0.02	0.03	0.10	0.10	99.72

Table 9: Auger / AC Twins MA032 / MAC044

Due to the comparatively small amount of samples available for this analysis the overall populations were also considered. In order to ensure that a reasonably similar data set is assessed, the downhole depth was limited to 6 m (nominal mean auger drill depth) from within the upper white silica sand layer. The comparison showed the grade population distributions are very similar as can be seen in the histogram and probability overlay plots shown in Figure 12. Analysis of the summary statistics from these data (Table 10) shows they are all very similar and hence CSA Global considers both drilling type results suitable for use in a MRE.

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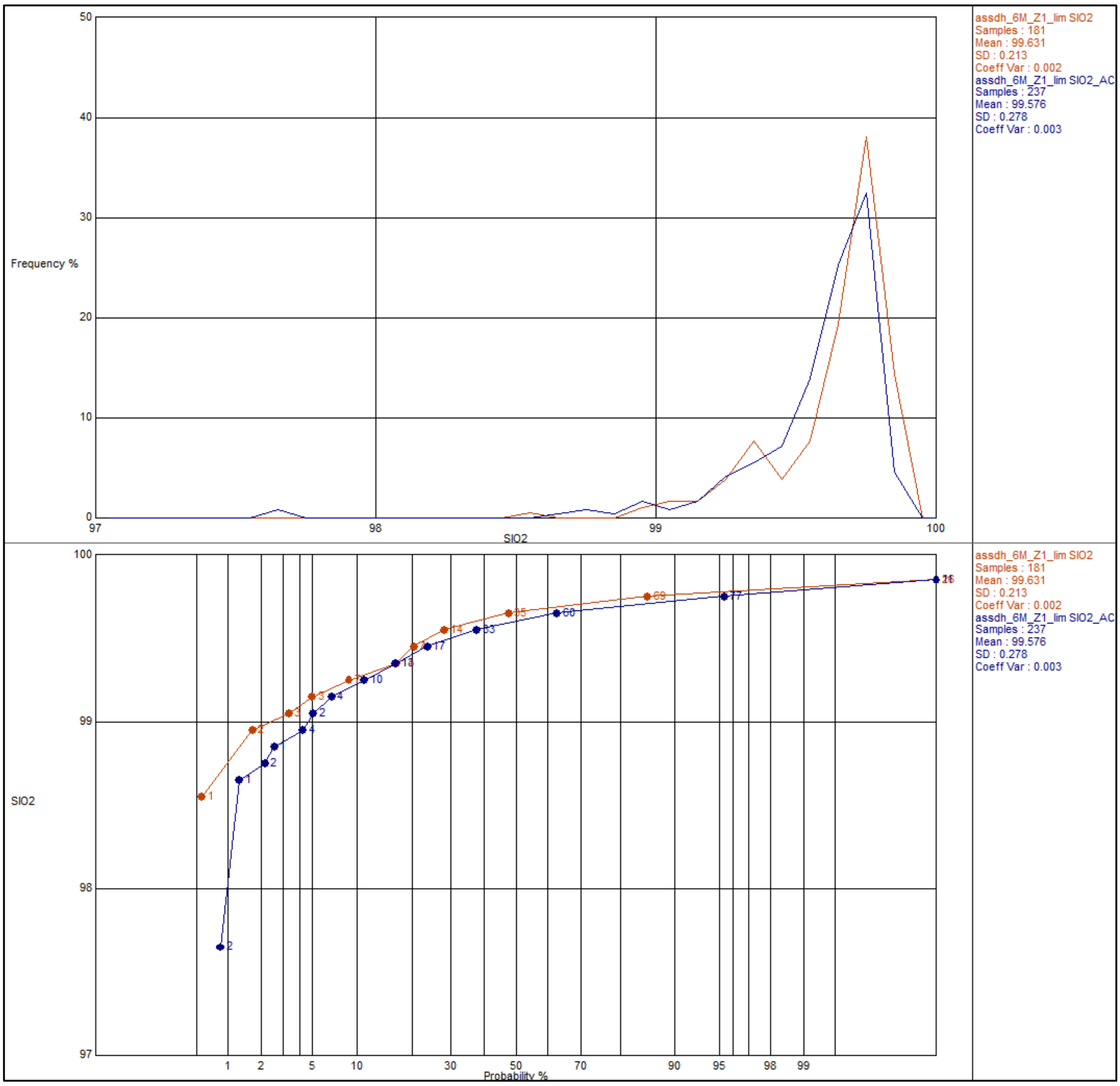

Figure 12: Auger (brown) and aircore (blue) drilling histogram and probability overlay plots

		Al_2O_3	Fe_2O_3	LOI_{1000C}	TiO_2	SiO_2
Auger	Number	181	181	181	181	181
	Minimum	0.01	0.01	0.02	0.04	98.55
	Maximum	0.27	0.09	1.34	0.16	99.86
	Mean	0.03	0.02	0.22	0.08	99.63
	Median	0.02	0.01	0.14	0.07	99.71
	Std Dev	0.03	0.01	0.21	0.02	0.21
	Coeff Var	0.87	0.72	0.93	0.32	0.00
Aircore	Number	237	237	237	237	237
	Minimum	0.01	0.01	0.02	0.05	97.62
	Maximum	0.26	0.17	2.12	0.23	99.86
	Mean	0.05	0.03	0.23	0.10	99.58
	Median	0.03	0.03	0.15	0.09	99.66
	Std Dev	0.04	0.02	0.25	0.03	0.28
	Coeff Var	0.87	0.77	1.10	0.31	0.00

Table 10: Summary statistics limited Auger and aircore data

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5.2.4 Density

Four, certified, dry *in situ* bulk density measurements were completed by Construction Sciences Pty Ltd using a nuclear densometer. Table 11 shows the mean results from the four measurements and the results of the moisture factor correction to a dry *in situ* density mean result of 1.66 t/m^3 which was used for all material in the MRE.

Mean Wet Density (t/m^3)	Mean Moisture %	Mean Dry Density (t/m^3)	Min. Dry (t/m^3)	Max. Dry (t/m^3)
1.69	1.8	1.66	1.61	1.69

Table 11: Density measurement results

5.2.5 Mineral Resource estimation

The Mineral Resource has been updated in the area that has been drilled by Aircore drilling. Figure 13, with the Auger drilled area unchanged, reported in the Appendix 1.

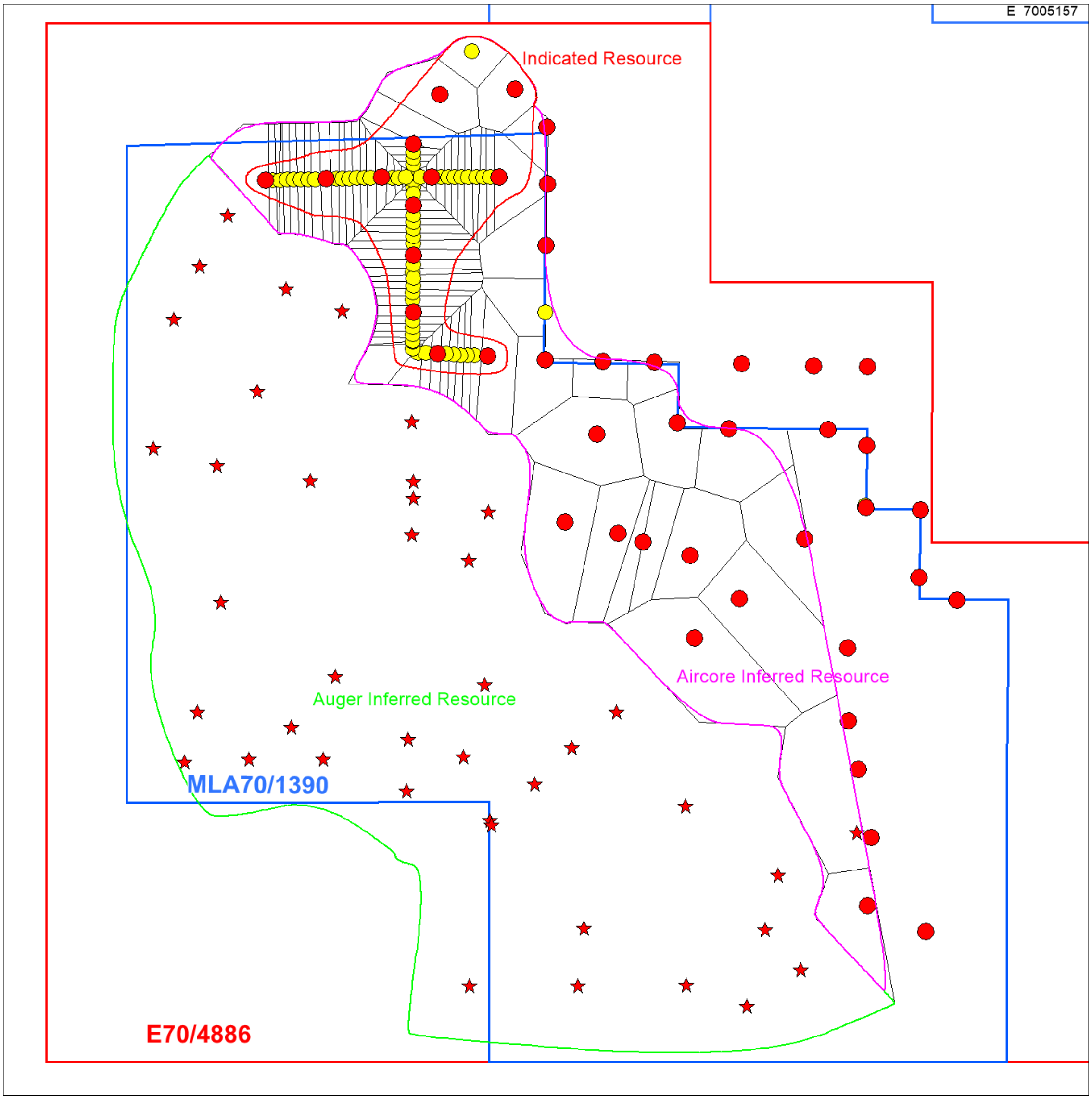

Figure 13: Muchea Update Resource Polygons and MRE Classification area
RED Stars = hand auger, RED Dots = Phase 1 Aircore, YELLOW Dots = Phase 2 Aircore

The updated MRE has been estimated using the area equidistant polygons generated from the Aircore drilling. The depth and grade of the sand in the polygons has been interpreted from the colour and assay grades of the 1m depth samples. The Phase 1 aircore holes were reinterpreted to focus more on the Fe_2O_3 levels rather then purely on the colour and the SiO_2 grade. The result of this is that the depth of modelled sand has changed in 18 holes out of the 46 holes that were drilled in the Phase 1 program, with an example of two changes shown in Table 12.

Hole ID	Depth From	Depth To	Colour	Original Comp.	Reinterp. Comp.	Al_2O_3	Fe_2O_3	TiO_2	LOI	SiO_2
MAC015	0	1	Lt Brown	3m @ 99.28% SiO_2 **381ppm Fe_2O_3**	7m @ 99.24% SiO_2 **388ppm Fe_2O_3**	591	286	1323	0.91	98.82
	1	2	White			365	429	922	0.3	99.5
	2	3	White			393	429	1493	0.2	99.52
	3	4	Lt Brown			1317	286	1690	0.3	99.22
	4	5	Lt Brown			1230	429	1897	0.4	99.16
	5	6	Lt Brown			1436	286	1805	0.3	99.26
	6	7	Lt Brown			2099	572	2135	0.19	99.18
	7	8	Lt Brown			6228	1859	3071	0.2	98.15
	8	9	Lt Brown			9022	1573	1918	0.2	97.93
	9	10	Lt Brown			3342	572	1850	0.2	99.05
MAC040	0	1	White	3m @ 99.37% SiO_2 **268ppm Fe_2O_3**	11m @ 99.42% SiO_2 **494ppm Fe_2O_3**	378	143	874	0.8	98.92
	1	2	White			208	143	792	0.2	99.57
	2	3	White			217	71	779	0.2	99.61
	3	4	Lt Brown			370	143	1313	0.5	99.22
	4	5	Lt Brown			317	143	1046	0.3	99.44
	5	6	White			357	286	962	0.2	99.54
	6	7	White			644	572	1905	0.4	99.22
	7	8	Lt Brown			709	286	1268	0.3	99.36
	8	9	Lt Brown			654	286	1088	0.21	99.55
	9	10	White			998	429	1001	0.2	99.51
	10	11	White			584	286	701	0.13	99.69
	11	12	White			399	429	1349	0.11	99.65

Table 12: Phase 1 Aircore drilling reinterpreted composites

The two examples shown in Table 12 are of reinterpreted sand composites where high quality sand was discounted in the previous model due to higher levels of Al_2O_3 (clay) and LOI (organics), with negligible effect on the Fe_2O_3 levels. This material lowered the SiO_2 grade and was thus excluded, both of these are easily removed in the sand processing plant. The net results is that in certain areas a significantly thicker zone of sand is amenable to processing and should therefore be included in the MRE.

The Mineral Resource is estimated above a 3-d wireframe basal surface for the uppermost white silica sand layer, Figure 7. Based on analysis of the results from the drilling data this basal surface appears to nominally follow the topographic surface. Only the uppermost white silica sand layer has been modelled at this stage despite the evidence in the deeper AC holes for additional white silica sand and yellow sand layers occurring below. This is due to the limitations on depth sampled from auger drilling, the variable depths of AC drilling and the drill hole spacing making interpretation of the geological extents of these layers difficult.

The basal surface of the uppermost white silica sand is interpreted based on the geological logging, chemical analysis results and chip photography from the auger and AC drilling and with reference to the topographic surface and publicly available soil mapping data. The modelled extents are limited to within the VRX nominated Muchea target area and are extrapolated to a nominal maximum of 400 m away from the drilling data. It should be noted that for some auger holes the full depth the uppermost white silica sand layer was not tested due to the limitations of the sampling methodology. The modelled basal surface therefore does not necessarily represent the full sand layer thickness over parts of the auger drilled area.

Over a small area in the central west of the modelled area, the surface white silica sand layer is overlain by a minor clay in white sand zone, defined by the Al_2O_3 content being nominally above 1%. The basal surface of this material has been modelled and it forms the upper boundary surface of the modelled white silica sand layer in this part of the model. This material has not been grade estimated and is not reported as part of the MRE.

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The surface humus layer is typically about 300 mm thick. In consultation with VRX, CSA Global considered that the upper 500 mm (overburden) is likely to be reserved for rehabilitation purposes. This overburden surface forms the upper boundary, Figure 7 of the estimated Mineral Resource and is depleted from the reported Mineral Resources.

5.2.6 Mineral Resource Classification

The Mineral Resource is classified as Inferred and Indicated according to the principles contained in the JORC Code.

Material that was classified as Indicated was considered by the Competent Person to be sufficiently statistically robust and informed by geological and sampling data to assume geological and grade continuity between data points.

Material that was classified as Inferred was considered by the Competent Person to be sufficiently informed by geological and sampling data to imply but not verify geological and grade continuity between data points.

The results of the MRE are presented in Table 2.

5.2.7 Classification and JORC Code 2012, Clause 49

Mineral Resource tonnes and in situ SiO_2 content are key metrics for assessing silica sand projects; however these projects also require attributes such as final product size distribution, purity, grain shape, mechanical strength and thermal stability to be evaluated to allow consideration of potential product specifications (e.g. Scogings, 2014). These specifications are some of the parameters that drive the value in silica sand projects.

Clause 49 of the JORC Code requires that industrial minerals such as silica sand that are produced and sold according to product specifications be reported "in terms of the mineral or minerals on which the project is to be based and must include the specification of those minerals".

Clause 49 also states that "It may be necessary, prior to the reporting of a Mineral Resource or Ore Reserve, to take particular account of certain key characteristics or qualities such as likely product specifications, proximity to markets and general product marketability".

Therefore, silica sand Mineral Resources must be reported at least in terms of purity and size distribution, in addition to SiO_2 and tonnes, and should also take account of logistics and proximity to markets.

Likely product specifications for the Muchea deposit are supported by the results of the composite sample process test work program undertaken by VRX in 2018 and 2019 at CDE Global in Northern Ireland.

Quartz (also known as silica) is produced commercially from a wide variety of deposits including unconsolidated sand, sandstone, quartzite, granite, aplite, and pegmatite. Silica sand and quartz are economical sources of SiO_2 used in glass and ceramics manufacture, for which key deleterious elements include iron and titanium. Silica sand is also used for foundry mould manufacture.

5.2.8 Glass and ceramics specifications

Though the production of glass requires a variety of different commodities, silica represents over 70% of its final weight. Its chemical purity is the primary determinant of colour, clarity and strength of the glass produced.

In the production of glass, there is both the need and requirement for silica to be chemically pure (composed of over 98% SiO_2), of the appropriate diameter (e.g. a grain size of between approximately 0.1 mm and 0.4 mm and with low iron content (less than approximately 0.04% Fe_2O_3). Refer to Tables 13, 14 and 15 for examples of chemical composition and size distribution for silica products for the glass and ceramics markets. Proposed VRX glass sand specifications are given in Tables 16 and 17; these are based on laboratory tests of drill sample composites in 2018 and 2019.

5.2.9 Conclusion supporting economic extraction

CSA Global is of the opinion that available process testwork indicates that likely product qualities for glass and ceramics sand are considered appropriate for eventual economic extraction from Muchea. In addition, potentially favourable logistics and project location support the classification of the Muchea deposit as an industrial mineral Inferred/Indicated Mineral Resource in terms of Clause 49.

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Market	SiO_2 %	Al_2O_3 %	Fe_2O_3 %
Flat glass	>99.5	<0.3	<0.04
Container flint glass	>98.5	<0.5	<0.035
Insulation fibre glass	>95.5	<2.2	<0.3
Porcelain	>97.5	<0.55	<0.2
Enamels	>97.5	<0.55	<0.02

Table 13: Silica chemical specifications for glass and ceramics markets

Source: Modified from Sinton (2006)

Specification	SiO_2 %	Other Elements %	Other Elements ppm
Clear glass-grade sand	>99.5	<0.5	<5,000
Semiconductor filler, LCD, and optical glass	>99.8	<0.2	<2,000
"Low Grade" HPQ	>99.95	<0.05	<500
"Medium Grade" HPQ	>99.99	<0.01	<100
"High Grade" HPQ	>99.997	<0.003	<30

Table 14: Silica sand and quartz chemical specifications by market

Source: Modified from Richard Flook (Hughes, E., Industrial Minerals Magazine, December 2013)

Sieve size	Mesh size	Flat glass	Flint container glass
mm	Openings per inch	Cumulative percent retained	Cumulative percent retained
1.18	14	0.0	0.0
0.85	18	<0.01	0.0
0.425	36	<0.1	<4
0.106	150	>92	>25
0.075	200	>99.5	>95

Table 15: Physical size specifications for glass sand

Source: Modified from Herron (2006)

Product	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O
Muchea-F80	+99.9	0.02	0.008	0.030	0.005	0.001	0.004
Muchea-F80C	+99.9	0.02	0.005	0.030	0.005	0.001	0.004
Muchea-F150	99.8	0.07	0.015	0.035	0.020	0.001	0.004

Table 16: VRX Silica – provisional Muchea glass sand chemical specifications

Source: VRX Silica ASX announcement February 2019

	Sieve micron and % retained on sieve								
Product	850	600	425	300	212	150	106	75	53
Muchea-F80		0.5%	49%	50%	0.5%				
Muchea-F80C	9.0%	90.0%	1.0%						
Muchea-F150				0.5%	88%	11%	0.5%		

Table 17: VRX Silica – provisional Muchea glass sand PSD

Source: VRX Silica ASX announcement February 2019

5.3 Reserves

VRX has completed the necessary work to convert the Indicated Mineral Resource to Probable Ore Reserves. A summary of the work undertaken is included in this BFS.

Table 18 details the Probable Ore Reserve that will be produced from mining of the Indicated Mineral Resource and processing in a purpose built, wet sand processing plant. Table 19 shows the paricle size distribution of the products. The plant will produce four saleable products for different markets with a **Probable Ore Reserve** for Muchea totalling **18.7 Mt @ 99.9% SiO_2** as reported in accordance with the JORC Code with **14.6 Mt @ 99.9% SiO_2** contained within the area of the Company's Mining Lease application (MLA70/1390).

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Ore Reserve

Classification	Product	Recovery	Global Million Tonnes	Within M70/1390 Million Tonnes	SiO_2%	Al_2O_3%	Fe_2O_3%	TiO_2%	LOI %
Probable	Muchea-F80	48%	10.2	8.0	+99.9	0.02	0.008	0.030	0.1
	Muchea-F80C	20%	4.25	3.3	+99.9	0.02	0.008	0.030	0.1
	Muchea-F150	20%	4.25	3.3	99.8	0.07	0.015	0.035	0.1
		Total Reserve	**18.7**	**14.6**					

Table 18: Muchea Silica Sand Probable Ore Reserve as at September 2019

Particle Size — **Sieve Opening (µm Retained)**

Product	850	600	425	300	212	150	106	75
Muchea-F80		0.5%	49%	50%	0.5%			
Muchea-F80C	9.0%	90.0%	1.0%					
Muchea-F150				0.5%	88%	11%	0.5%	

Table 19: Muchea Saleable Products, particle size distribution

5.3.1 Metallurgical Factors

As a part of the maiden MRE[4], CSA Global reviewed the metallurgical testwork to comply with Clause 49 of the JORC Code. CSA Global has concluded that the available process testwork indicates likely product qualities for glass, ceramics and foundry sand are considered appropriate for eventual economic extraction from Muchea. Favourable logistics and the location of the Project support the classification of Muchea in accordance with Clause 49 as an industrial mineral with an Inferred/Indicated Mineral Resource. The extensive metallurgical testwork which has been completed by CDE Global at their facility in Cookstown, Northern Ireland, and Nagrom in Kelmscott, Perth, allowed for the creation of a catalogue of silica sand products that can be produced from Muchea[5] (see Tables 16 and 17).

These products become the recovered products which make up the Ore Reserve (see Table 18).

The mass balance of the particle sizes was analysed allowing for the recoveries of these products in a wet processing plant to be estimated.[6]

The recovery of each product is shown in Table 20.

Product	Industry	Recovery
Muchea-F80	Glassmaking	48%
Muchea-F80C	LCD	20%
Muchea-F150	Glassmaking	20%
	Total Recovery	88%

Table 20: Muchea Product Recovery

[4] Reviewed as part of the metallurgical testwork for the Muchea maiden MRE, see ASX announcement of 20 November 2018, “Muchea Silica Sand Project Maiden Resource”.

[5]ASX announcement of 26 [3]February 2019, *“Testwork Update and product Catalogues”.*

[6]ASX announcement of 3 May 2019, *“High Recovery from Silica Sand Process Plant Design”.*

5.3.2 Material Modifying Factors – Mining Factors

The mining method chosen for Muchea is a rubber wheeled front-end loader, feeding into a 3 mm trommel screen to remove oversize particles and organics. The undersize sand is slurried and pumped to a sand processing plant which is located proximal to the Railway line to the Kwinana Bulk Terminal. After processing, the silica sand is loaded into railway trucks for bulk export from the Kwinana Bulk Terminal.

Mining of the dune sand will extract to a base 3m above the year 2000 watertable level. This will leave a slightly undulating surface. Appropriate buffer zones are left from the adjacent stakeholders such as freehold land. The pre- and post-mining topography is shown in Figures 14 and 15.

100% of the material in the mining area is considered to be sand that can be beneficiated to a saleable silica sand product. The top 500mm has been excluded from the MRE as it will be reserved for rehabilitation purposes. As there is no waste material, the recovery factor is considered to be 100% and ore loss therefore is considered to be 0%.

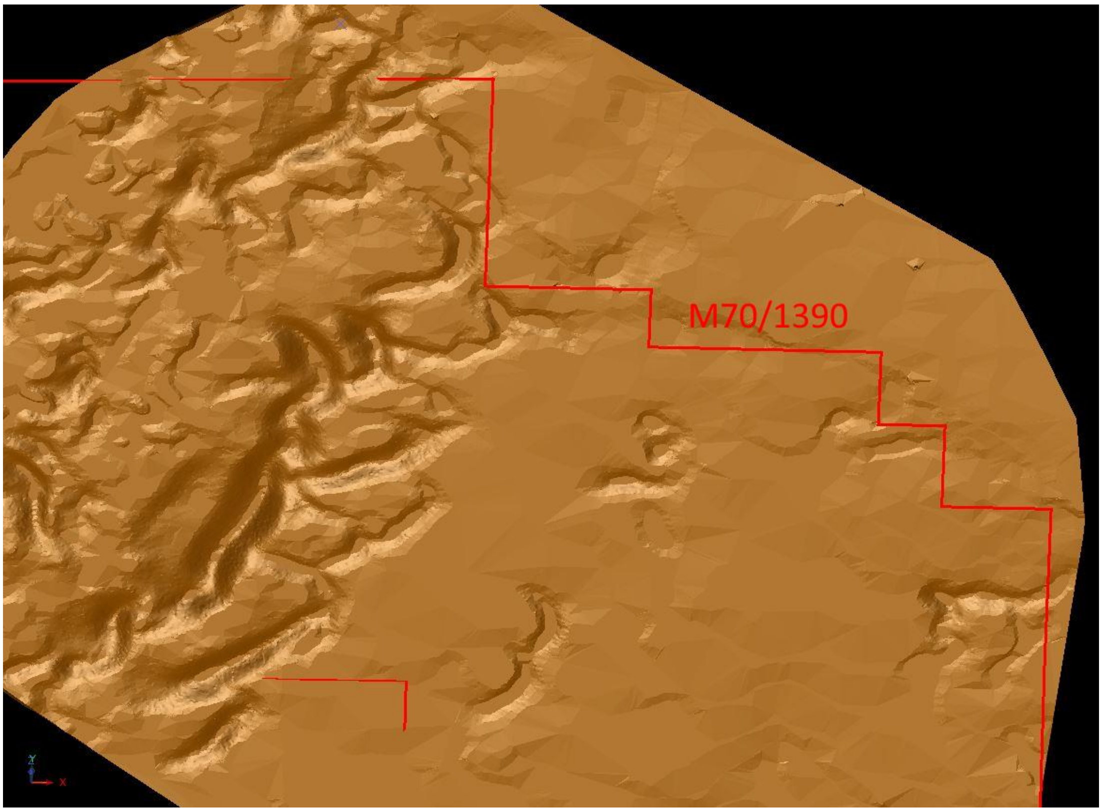

Figure 14: Muchea Pre-Mining Topography
(5:1 vertical exaggeration)

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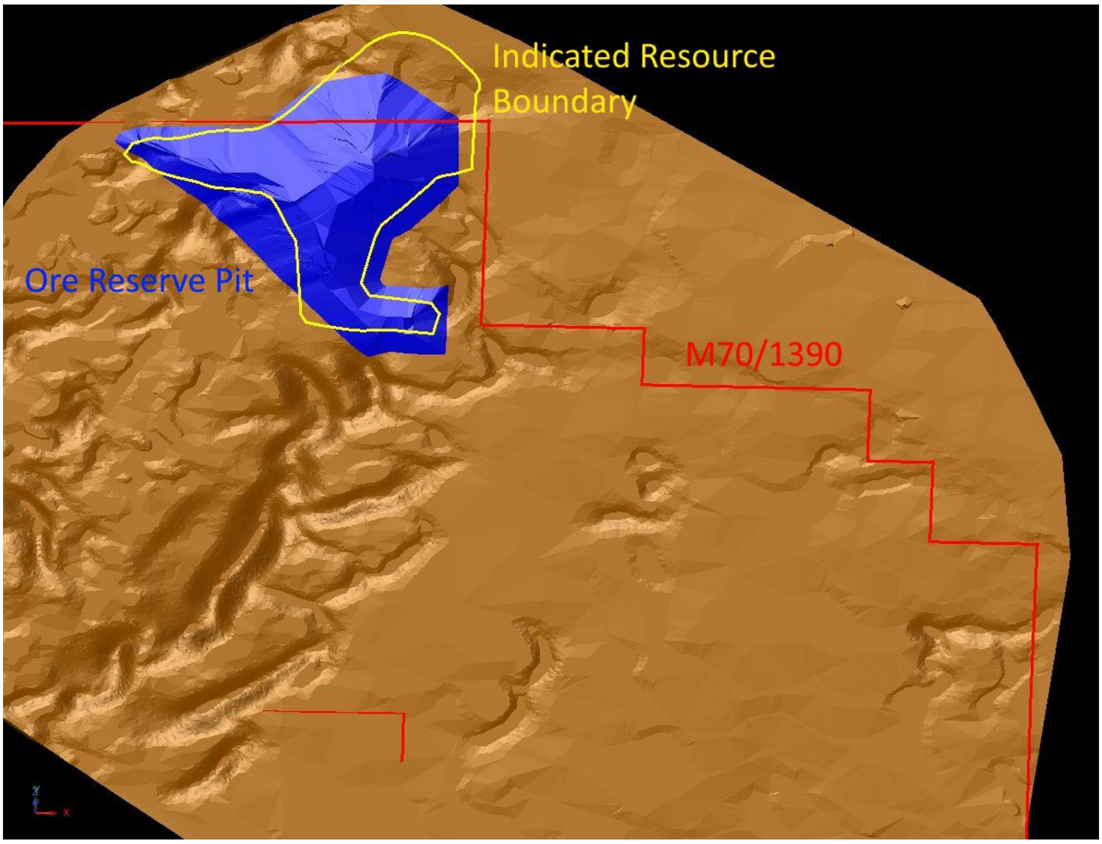

Figure 15: Muchea Post-Mining of Ore Reserves, Topography
(5:1 vertical exaggeration)

5.3.3 Material Modifying Factors – Environmental Studies

Development location

- Mining is 100% on Vacant Unallocated Crown Land (VCL)
- East of the Yeal Nature Reserve and State Forrest
- West of Freehold land
- South of Gingin Airfield
- Approximately 25 km inland of the coast
- West of Chandala Brook (Registered Aboriginal Heritage Site)
- Outside of World Heritage Areas, National Heritage Places, Ramsar Wetlands, Conservation Reserves or Commonwealth Marine Reserves

The Probable Ore Reserve is located within an area of deep Bassendean sands, leached of nutrients. The vegetation type is Banksia Woodlands. The topography is low to medium dunes.

Assessment Process:

- Pre-referral submission to the Federal Department of the Environment and Energy (**DotEE**) (Completed)
- Final referral submission to the Federal Department of the Environment and Energy (**DotEE**)
- Submission of Section 38 referral to State Environmental Protection Authority (**EPA**)
- Seek an Accredited *Environment Protection and Biodiversity Conservation* Act 1999 (Cth) Assessment under the State *Environmental Protection Act* 1986 (WA) via an Environmental Review Document with public comment
- Undertake any further studies required
- Submission of Environmental Review Document

Mitigation Strategies

- Proposed action lies within a large development envelope, allowing for the flexibility to target areas of lower significance to matters of national environmental significance (**MNES**)
- Disturbance will be kept to a minimum, up to 35 ha per year and 14 ha at any one time
- Progressive rehabilitation using topsoil re-location to ensure topsoil and plants are translocated intact to previously mined areas
- Conduct further surveys to identify MNES
- Use findings to steer the project and avoid MNES where possible

There are no mine tailings storage requirements.

There are no waste dumps.

Processing requires no chemicals.

5.3.4 Material Modifying Factors – Infrastructure

The Project is located on vacant, unallocated crown land which is east of the Yeal Nature Reserve and Sate Forrest, west of Freehold land and south of the Gingin Airfield. The southern boundary is the limit of tenure. The Brand Highway is proximal to the area and access is via the sealed Timaru Road from Brand Highway. The rail line to the Kwinana Bulk Terminal runs east of the Brand Highway and will be used to transport the processed silica sand to the Kwinana Bulk Terminal for bulk export.

The Project will require its own installed power and water infrastructure.

Labour will be sourced from the nearest towns, Gingin and Muchea (approximately 12 and 14 km, respectively, from the mine site) and there will be no accommodation installed at the mine site.

5.3.5 Costs

Operating costs

Operating costs have been determined from first principles and are estimated to include all costs to mine, process, transport and load product on to ships.

Royalties

The prevailing rate of royalty due to the State is used in VRX's economic assessments. The State Royalty rate is A$1.17 per dry metric tonne and reviewed every 5 years with the next review due in 2020.

A royalty rate is in the process of being negotiated with Native Title claimants and has been included in the project metrics.

Australian Silica Pty Ltd retains a Net Production Royalty of 1%.

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5.3.6 Revenue

Product Quality

Multiple products will be differentiated during processing subject to required particle size distribution by screening. Recovery of products has been independently assessed by CDE Global, a world leading silica sand testing laboratory.

Commodity Prices

Commodity prices for silica sand products have been determined by independent industry source, Stratum Resources. The industry standard is that sales contracts are in US dollars. The exchange rate to convert to Australian dollars will be the prevailing rate at the time of payment.

Subject to final quality produced, the prices for the commodity will range from US$38 to US$55 per dry metric tonne Free on Board (**FOB**). There are no shipping cost estimates with all contracts to be based on FOB rates.

Revenue will be based on a negotiated per shipment basis per dry metric tonne FOB with payment by demand on an accredited bank letter of credit.

There will be no other treatment, smelting or refining charges.

5.3.7 Market Assessment

The Company has commissioned an independent assessment of the current market prices for proposed products by independent industry source, Stratum Resources. The assessment includes projections for future demand and supply of silica sand and concludes that there is a likely future tightening of supply of suitable glassmaking silica sand with a commensurate future increase in price.

Sales volumes have been estimated as a result of received letters of intent and expressions of interest to purchase products.

The Company has received significant interest from potential buyers for the high-grade silica sand that can be produced from Muchea.

5.3.8 Economic Factors

The Company's economic analysis has calculated a 10% and 20% discounted ungeared post tax net present value (**NPV**). A 20% discounted NPV has also been calculated to demonstrate the strength of the economic analysis.

The analysis has not considered any escalated future product prices nor any inflation to operating costs. The analysis has used a US$/A$ exchange rate of US$0.70/A$1.00.

The analysis is based on a 9-10-year production profile.

Capital requirements are based on independent estimates.

The economic analysis is most sensitive to the exchange rate.

The analysis indicates the financials of the Project are very robust and there is a high confidence that a viable long-term mining operation can be justified.

5.3.9 Social Factors

The Company's Mining Lease application for Muchea lies within the Whadjuk People Native Title claim boundaries (WAD242/11).

The Company is currently in negotiations with both the claimant group (Whadjuk People) and the Government Party (Tenure and Native Title Branch of the Department of Mines, Industrial Regulation and Safety) with respect to the Mining Lease application. The Company expects that an agreement will be reached between the parties allowing for the mining lease to be granted.

The Project is wholly on vacant, unallocated Crown land and, therefore, there is negligible negative impact on local communities.

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5.3.10 Project Funding

The financial model summarised in Section 18 sets out the project metrics and provides a basis for the potential capital structure of the Company for the development of the Project. Total capital expenditure at Muchea (for a 2 million tonnes per annum processing plant) is estimated at approximately A$32.74 million. Section 16 details capital cost estimates.

The Company anticipates that the source of funding for the capital investment at Muchea will be any one of, or a combination of, equity, debt and pre-paid offtake from the Project. Whilst no final decision has been made in that regard, the financial model assumes a maximum A$30 million in debt.

The Company has received a number of enquiries and expressions of interest from debt financiers for the Project. As noted above, the financial model provides for debt capacity and is designed to meet the expectations of any providers of potential debt funding for their due diligence and other internal requirements.

In addition, the Company has also received enquiries and expressions of interest from organisations across Asia for silica sand products from the Project, and holds signed letters of intent for substantial tonnages. A number of these organisations have expressed interest in becoming a funding partner of the Company for development of a mine by way of pre-paid offtake arrangements.

The balance of the Company's capital requirements will be funded from equity capital.

Whilst the envisaged project development requires a low capital intensity relative to a greenfields hard rock mining project, and any one of, or a combination of equity, debt and pre-paid offtake is planned, VRX has not as yet secured the required capital. The positive financial metrics of the BFS and feedback from potential funding partners provides encouragement as to the likelihood of meeting optimum project and corporate capital requirements.

5.4 Mine Plan

The production target for Muchea incorporates the maiden Probable Ore Reserve of 14.6 Mt @ 99.9% SiO_2 that sits within the Mining Lease application area (see Section 5.3) as well as a portion of the Inferred Mineral Resource.

The Inferred Mineral Resource available to mine within the Mine Plan Pit is 61.4 Mt @ 99.6% SiO_2.

Figure 16 illustrates, at both topographical and cross-sectional perspectives, the locations of the maiden Probable Ore Reserve over the area and the Inferred Mineral Resource available to mine.

In designing the Mine Plan Pit, the Company has examined the restrictions and constraints on mining activities in the context of surrounding areas and the interests of stakeholders, and planned accordingly. To that end, the Mine Plan Pit ensures:

- mining will not occur any closer than 100m to the Dongara to Pinjarra gas pipeline;
- mining will not occur any closer than 200m to the boundary of any freehold land and will be at least 600m from the nearest house; and
- the Mining Lease area does not intersect with the Gingin Airfield ground and mining will not occur any no closer than 250m to the boundary of the Gingin Airfield. In addition, mining will not occur under the flight lines to and from the airfield.

These buffer zones are at least equal to, or are in excess of, industry practice and legislative requirements (if any). In addition, the eastern boundary of the Mine Plan Pit is contiguous with the FNA (see section 3) and does not intersect with any proposed conservation area under the Green Growth Plan.

The Mine Plan Pit therefore is not impacted by any known exclusion areas.

The maiden Probable Ore Reserve is estimated from the Indicated Mineral Resource only. This constitutes approximately 30% of the estimated total production target (in terms of processed tonnes of silica sand) over the 25 year mine life for the Project BFS estimates. It provides sufficient tonnage for the first 9-10 years of mining operations. The Company intends to mine solely from the Probable Ore Reserve during that period. Section 18.1 sets out key assumptions underpinning the financial model for the Project, including timing for project start-up and ramp-up to full capacity.

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The ore which forms the Inferred Mineral Resource is contiguous with the Indicated Mineral Resource and has been categorised as lower confidence due to wider spaced drilling. (Drilling of the Indicated Mineral Resource is typically 50m spaced along existing tracks, whereas the Inferred Mineral Resource is drilled on a 400m spacing along existing tracks.)

The Company has undertaken sufficient drilling to assume geological and metallurgical continuity of the sand deposit. There is negligible difference between the modelled sand in each category and it is believed an additional 1,500m of drilling would be required to upgrade the inferred resource category. The cost for drilling, assaying and associated studies is estimated (at current rates) to be in the region of $250,000 and will need to be undertaken within the first 9 years of mining operations.

Given the simple nature of the silica sand deposit at the Project and the associated geological and metallurgical confidence, the Company expects that this additional drilling will be sufficient to realise the production target.

Figures 52 and 53 (in Section 18.3) illustrate the expected production profile.

Notwithstanding the above, there is a low level of geological confidence associated with Inferred Mineral Resources and there is no certainty that further exploration work will result in the determination of Indicated Mineral Resources or that the production target itself will be realised.

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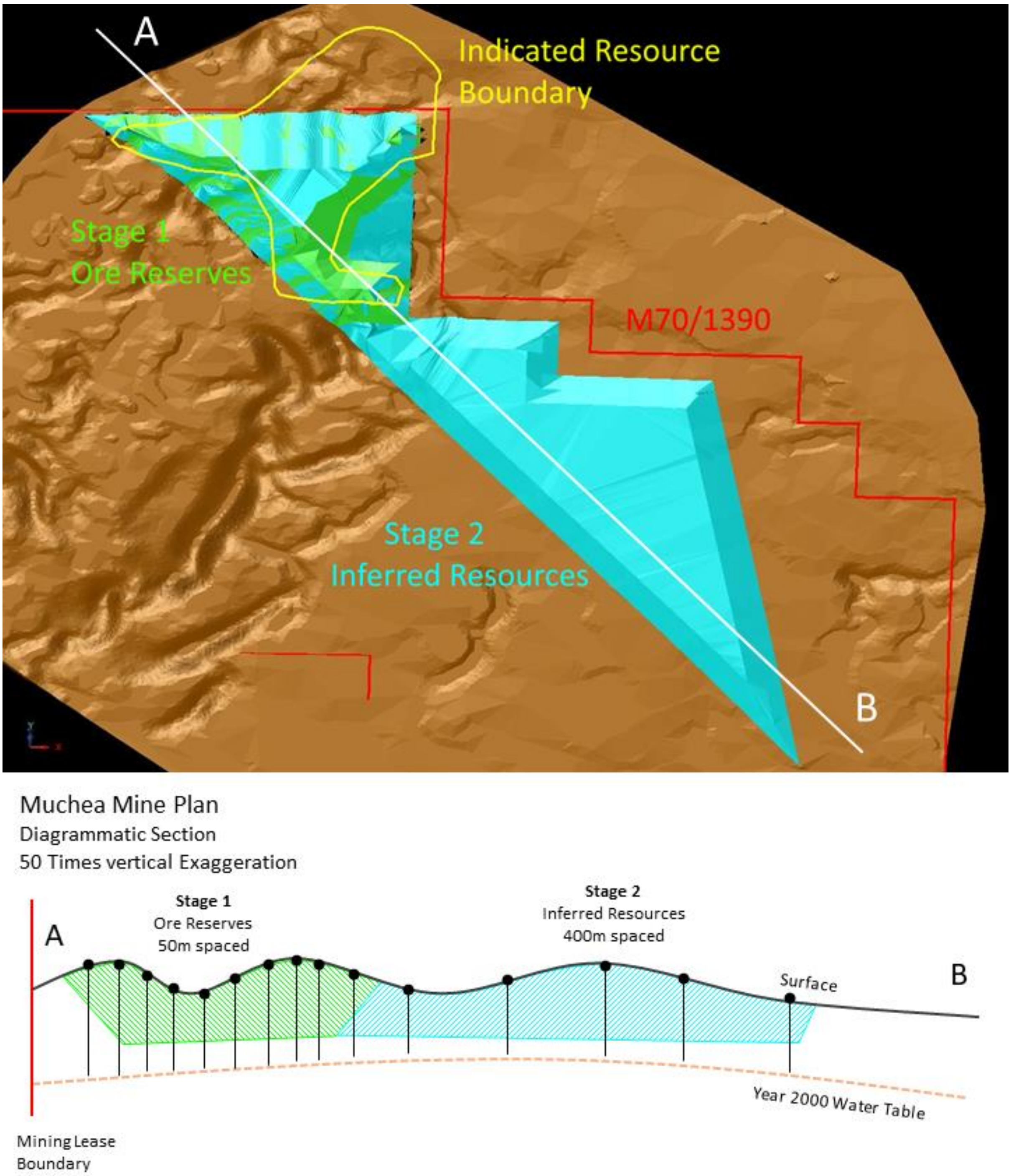

Figure 16: Muchea Post-Mining of Ore Reserves and Inferred Resources
Topography (5:1 vertical exaggeration)
Probable Ore Reserve within green boundaries and Inferred Mineral Resource within blue boundaries.

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6 Mining

The Project will utilise a unique and flexible mining and rehabilitation method to maximise production and the recovery of rehabilitated mined areas.

The proposed mining process is to sequentially mine 8-15 m of sand from below the base of the soil profile in 2.25 ha blocks (150 m x 150 m), with up to 8 blocks mined per year (18 ha).

High grade silica sand will be produced in line with the following sequential process:

1. An initial area of 150 m x 150 m will be cleared conventionally by dozing the topsoil to 400 mm into a topsoil stockpile to one side of the proposed mining area.

This windrow will be undisturbed for a significant time (up to 10 years). The windrow will be utilised as a seed bank and will be later reused as topsoil on the last area mined.

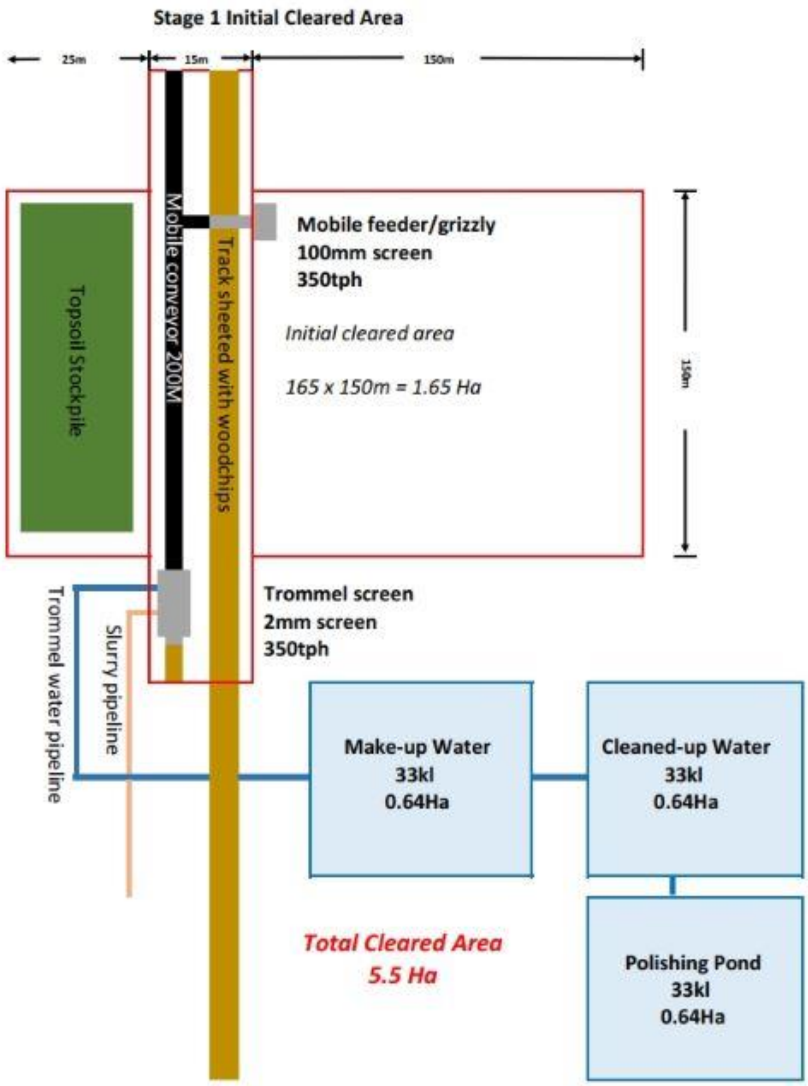

Figure 17: Mining process – initial cleared area

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2. A conveyor route will be established

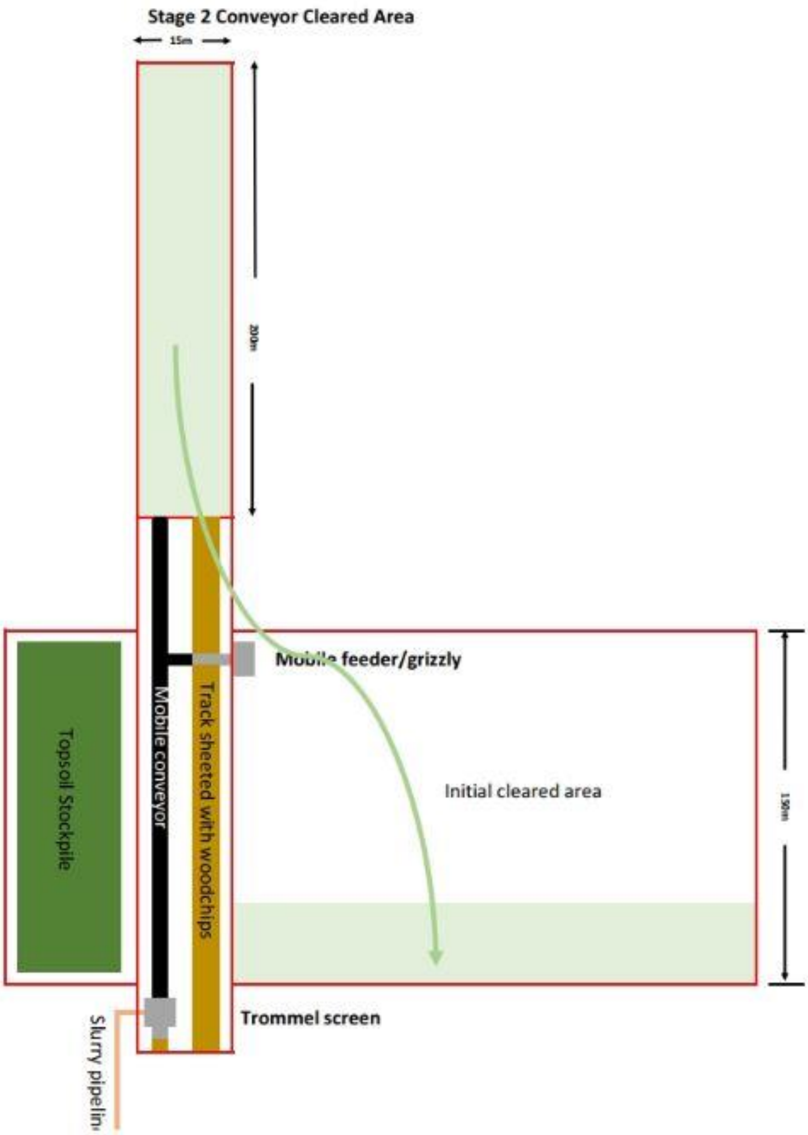

Figure 18: Mining process – conveyor cleared area

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3. Vegetation is trimmed in preparation for translocation.

This will utilise a dozer front mounted mulcher which will trim the vegetation to approximately 800 – 1000 mm above ground. This will create vegetation material which will later breakdown as a humus but most important will reduce the foliage and aspiration rates to increase the survival rates after the Direct Vegetation Transfer (**DVT**) in a low rainfall area.

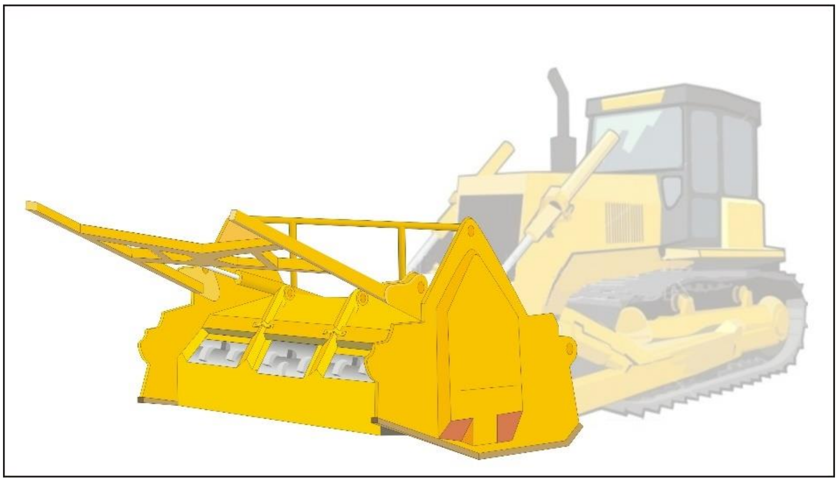

Figure 19: Mining process – vegetation trimmed

4. The ground will then be ripped using a dozer mounted scythe which will rip the shrub root systems at 400 mm below ground level.

This will reduce the root disturbance when later excavated by front end loader (**FEL**) during the DVT sequence.

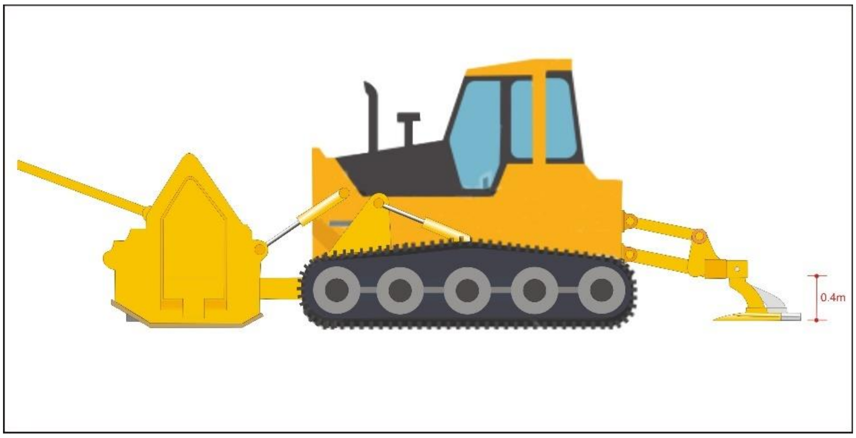

Figure 20: Mining process – ground ripped below shrub root systems

5. *Intact vegetation and topsoil are translocated via DVT and silica sand mined in panels.*

A modified FEL will be used to excavate a 3 m x 3 x 400 mm sod of topsoil which will include the relatively undisturbed microbial and invertebrate content. The sod including the topsoil and vegetation will be translocated to the previously mined area.

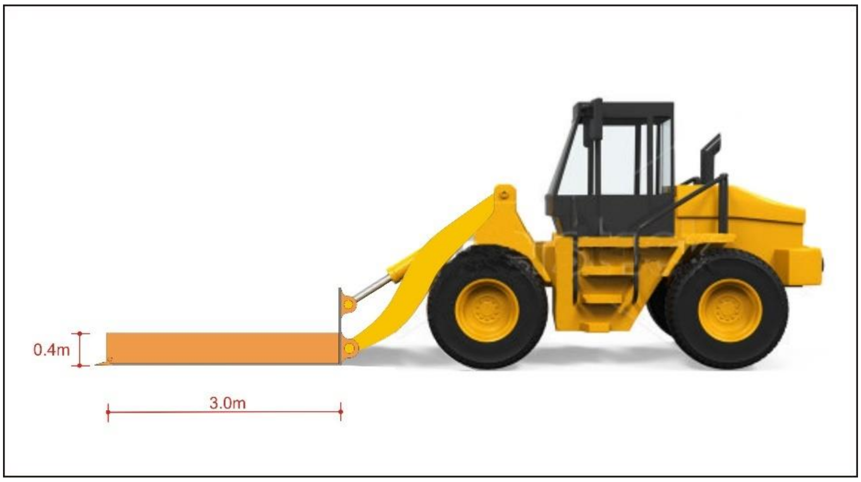

Figure 21: Mining process – vegetation and topsoil translocated

Silica sand is extracted in 2.25 ha panels following DVT.

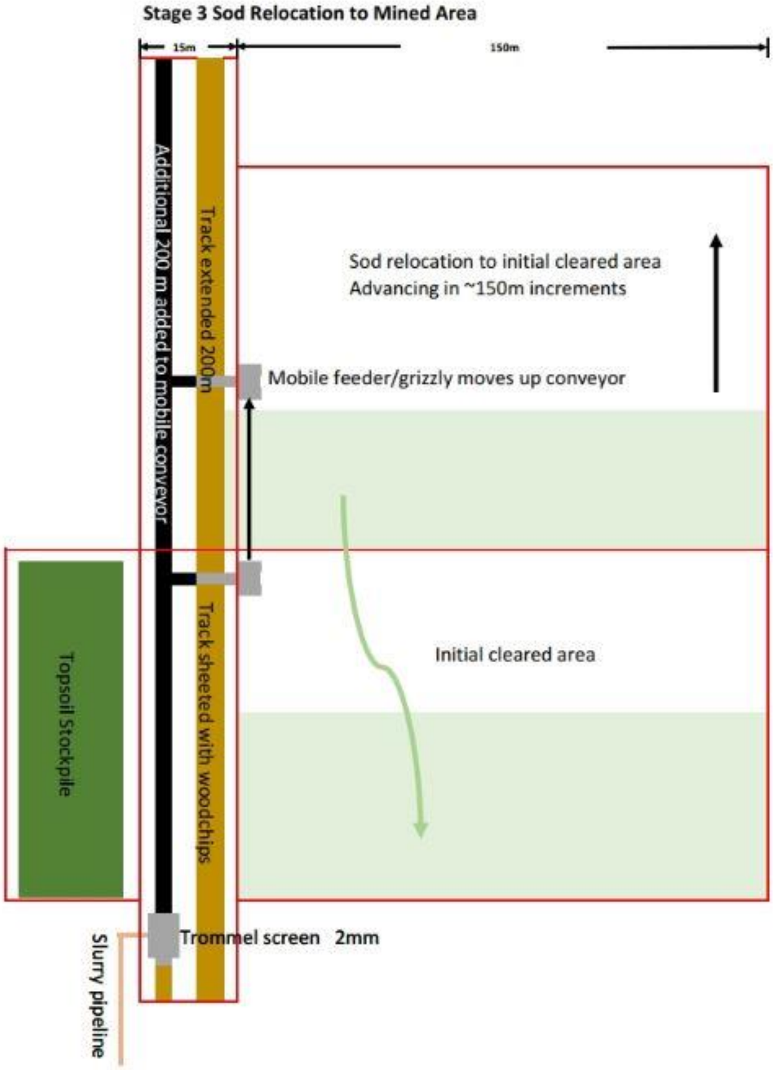

Figure 22: Mining process – silica sand mined in 2.25 ha panels

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The process is continuous. Following extraction the mined 2.25 ha panel is rehabilitated with intact vegetation and topsoil translocated via DVT from the next 2.25 ha panel

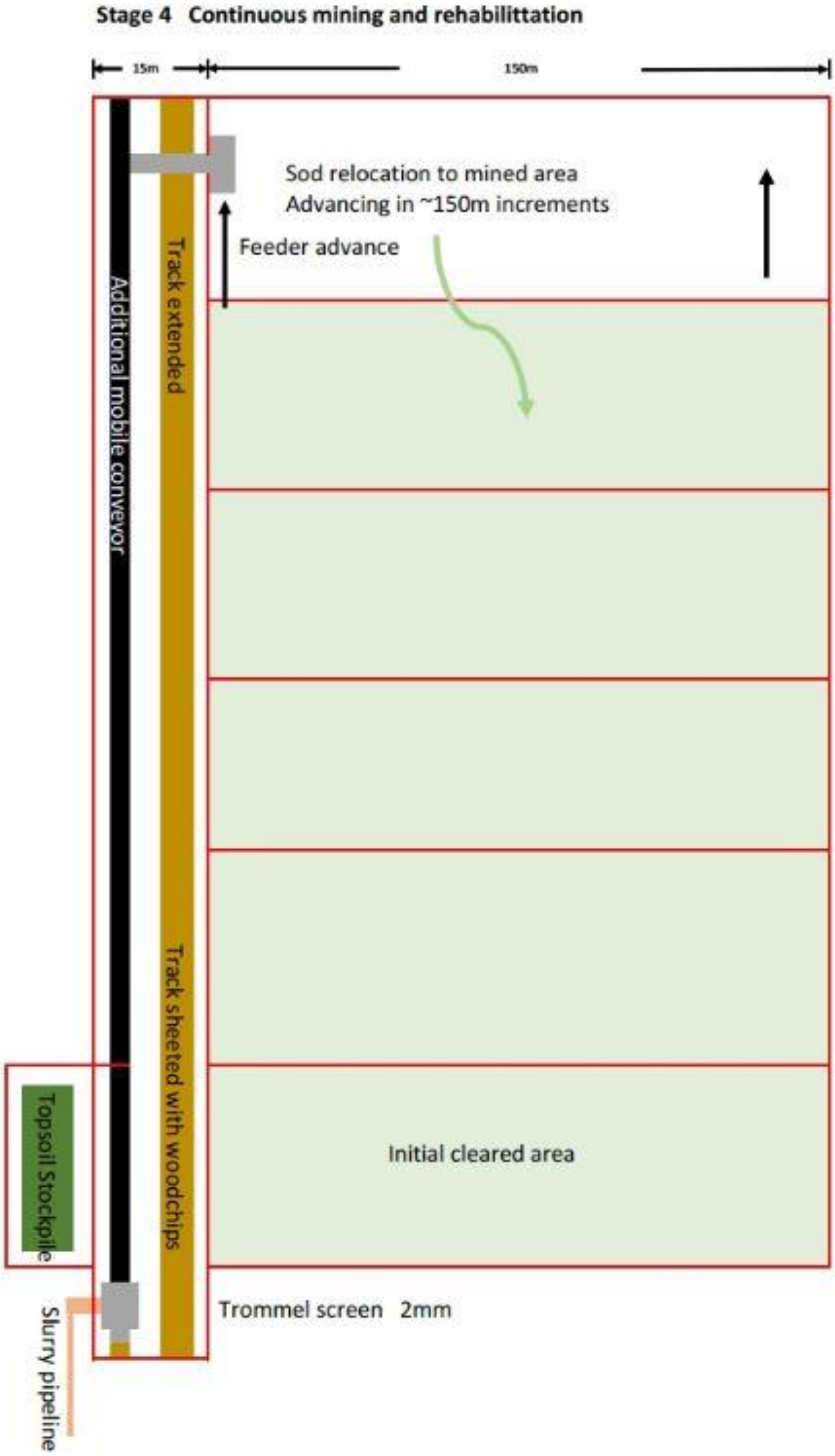

Figure 23: Mining process – continuous process of mining and rehabilitation

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6. Silica sand is screened and conveyed to a rotating trommel

Mined silica sand is shifted via a conventional front end loader to a feeder bin for transfer on to a conveyer. This mobile feeder site is located at the mine face.

Figure 24: Mining process – silica sand loaded and screened

The trommel will have a water washed 3 mm screen that will remove any oversize and organic material. The silica sand will then be slurried (water sand mixture) and pumped to an off-site processing plant for beneficiation into a final saleable product.

7. Mining continues to the extent of the conveyor system

The mining and conveyor will advance in 150 m x 150 m panels with continuous DVT rehabilitation to the extent of the conveyor system, at which point the process will revert to the other side of the conveyor and retreat back to the initial mined area.

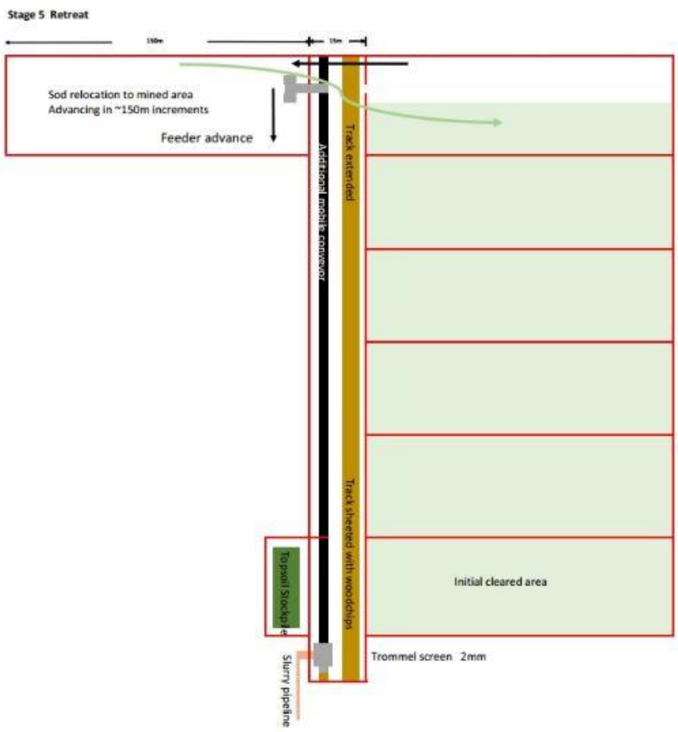

Figure 25: Mining process – mining continues to the extent of conveyor, then retreats

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8. ***Mining continues in panels to the initial cleared area at which point the previously stockpiled topsoil will be spread across the final mined panel***

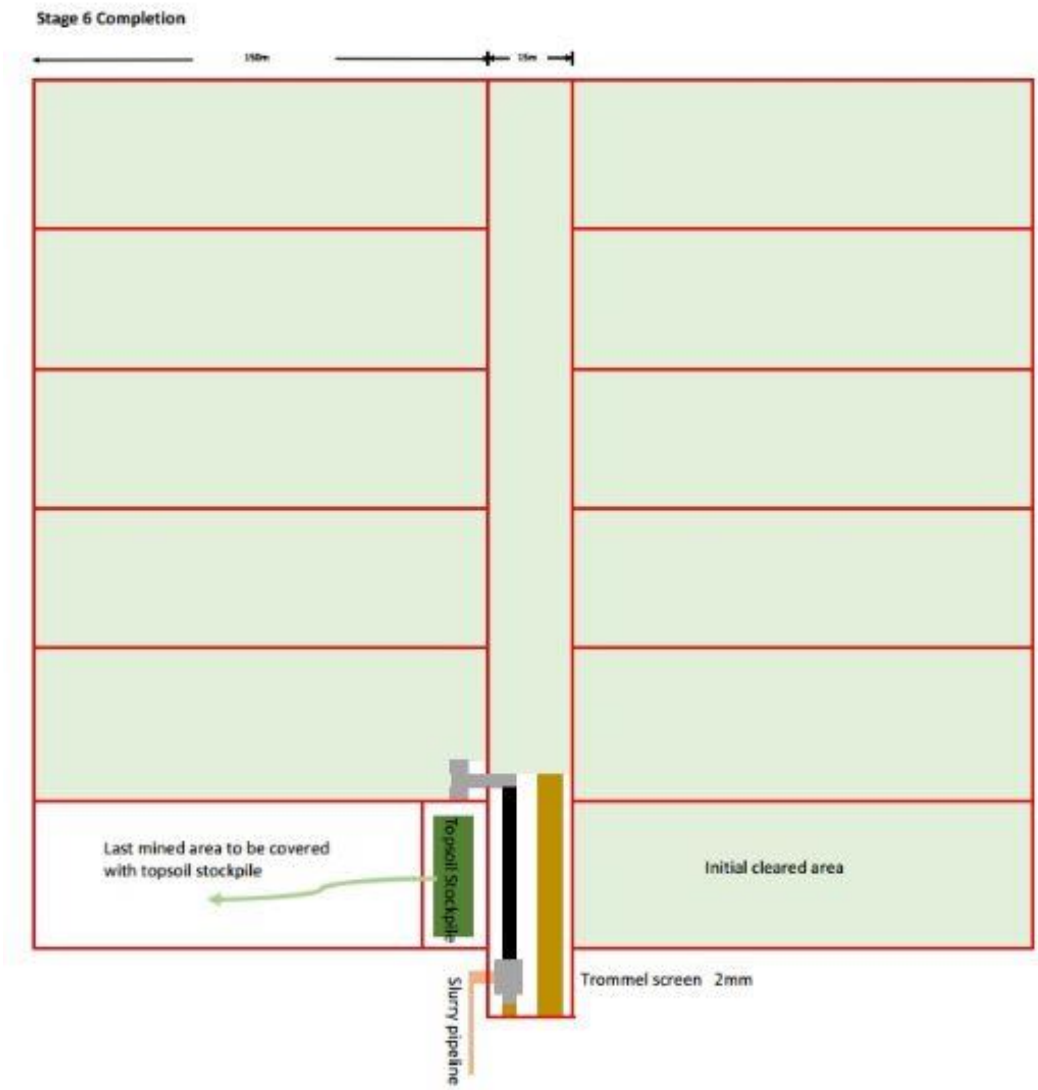

Figure 26: Mining process – mining continues in retreat to initial cleared area

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9. ***The conveyor will then have a transverse added component and move the mining to a new area where the process will be repeated.***

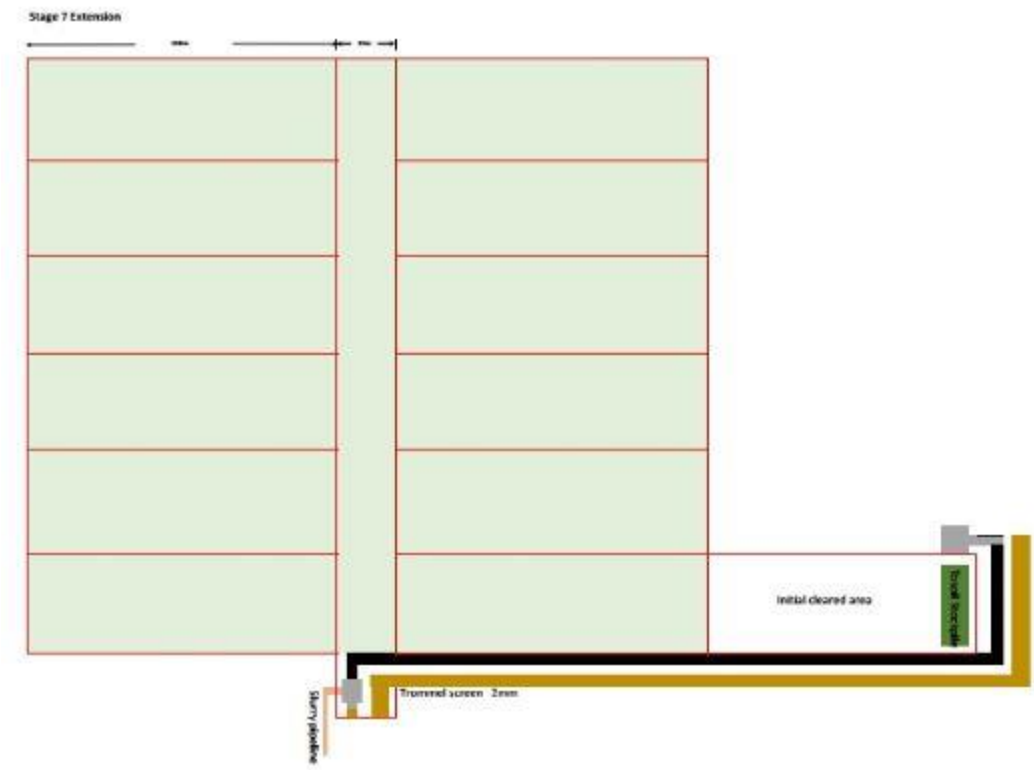

Figure 27: Mining process – process is repeated

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7 Metallurgy

7.1 Sampling

A composite auger sand sample from Muchea was sent to CDE Global, in Cookstown, Northern Ireland for testing. The sample was screened at 4 mm to remove oversize particles. The remaining material was then subjected to an attrition process followed by spiral separations (Figure 28). The summary below was extracted from CDE Global's report (*Testing report, lab quotation number 0032; also refer to the Company's ASX announcement of 20 September 2018*).

7.2 Attrition and washing tests

Attrition testing was carried out at a retention period of 5 minutes, with the sample washed after attritioning to remove any liberated fine particles. Spiral testing was then carried out with approximately 80 kg of attritioned material. Attrition scrubbing is a process whereby minerals such as quartz can be cleaned, by the action of particles impacting one another and the removal of coating impurities such as clay. The attritioned sample was analysed for particle size distribution (Table 25) and a visual comparison is shown in Figure 29.

7.3 Spiral tests

Two different cut points were utilised in the spirals testing: an aggressive cut which produces high quality material but a lower yield and a conservative cut which produces material of a reduced quality but with a higher yield. The samples then underwent wet magnetic separation to explore the possibility of reducing the magnetic mineral content. The products from each stage of testing were chemically analysed to give an overview of the composition of each product (Tables 21 and 22).

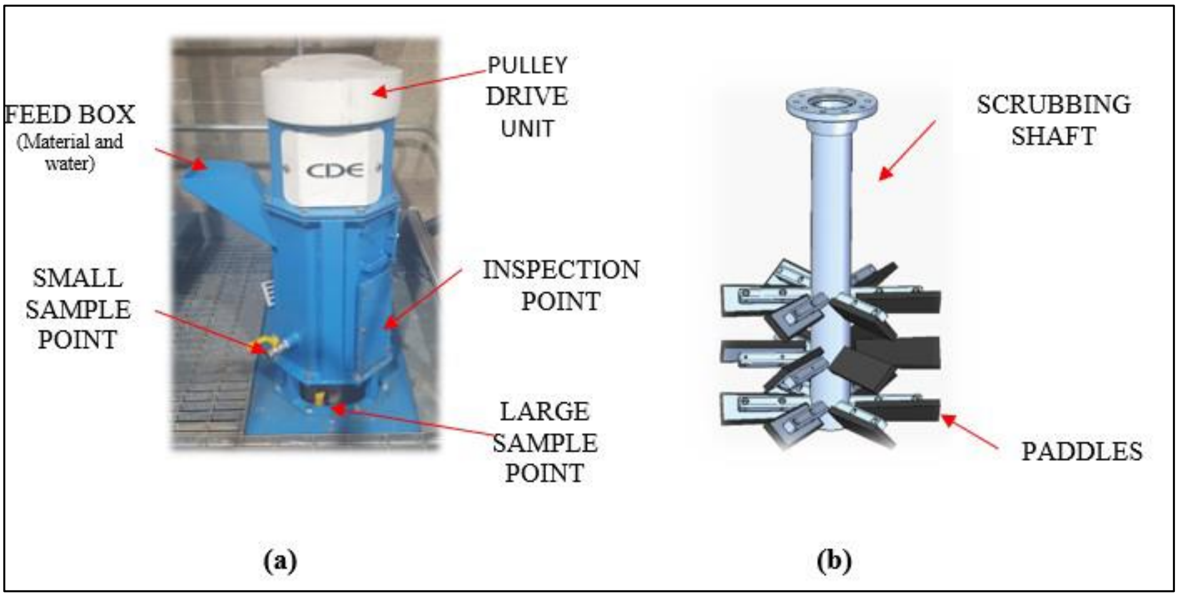

Figure 28: Lab scale attrition mill (left) and paddle shaft from lab scale attrition mill (right)

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Figure 29: Muchea – visual comparison

Raw material (left), post-attrition pre-washed material (centre) with post attrition, washed material (right)

7.4 Chemical analyses

Chemical analysis showed a general decrease in Al_2O_3 with processing; attritioning and washing the material removed the largest fraction of Al_2O_3. The spiral separation process produced samples where the largest fraction of Al_2O_3 was found in the heavy mineral fraction. Magnetic separation resulted in the largest fraction of Al_2O_3 being in the magnetic fraction. The results for Fe_2O_3 follow the same general trend as for Al_2O_3.

The percentage fraction of SiO_2 in the samples increased during the test process. Attritioning and washing the material removed fines and silt, which increased the SiO_2 content. The spirals test produced samples where the largest fraction of SiO_2 was found in the light fraction. Magnetic separation indicated that the largest fraction of SiO_2 was in the middlings fraction.

7.5 Conclusions - glass and ceramic specifications

In the production of glass, there is both the need and requirement for silica to be chemically pure (composed of over 98% SiO_2), of the appropriate diameter (a grain size of between approximately 0.1 mm and 0.4 mm) and with low iron content (less than approximately 0.04% Fe_2O_3). Refer to Tables 13, 14 and 15 for examples of chemical and size distribution for silica products for the glass and ceramics markets. CSA Global is of the opinion that available process testwork indicates that likely product quality is considered appropriate for industrial mineral applications such as glass manufacture.

7.6 CDE Global testwork – 2019

Raw material remaining from first phase of testwork was removed from storage and was screened at 1 mm to remove oversize material and organics (Figure 30). These two fractions were screened to obtain particle size distributions (PSD) which are presented in Table 21. Chemical analyses are presented in Table 22 and show that the +1 mm material contains less Al_2O_3, Fe_2O_3 and TiO_2 than the feed material, probably because there is less clay in the +1 mm fraction.

The sand was then wet screened through a 0.212 mm sieve and PSD test run which showed that the +0.212 mm material contains some fines (3.25% passing the 0.212 mm sieve) and in contrast the -0.212 mm sample contains a large amount of fines with 27.2% passing the 0.053 mm sieve. Chemical analysis showed that the -0.212 mm fraction contains more Al_2O_3 and Fe_2O_3 than the +0.212 mm fraction, due to higher clay fraction in the finer sample.

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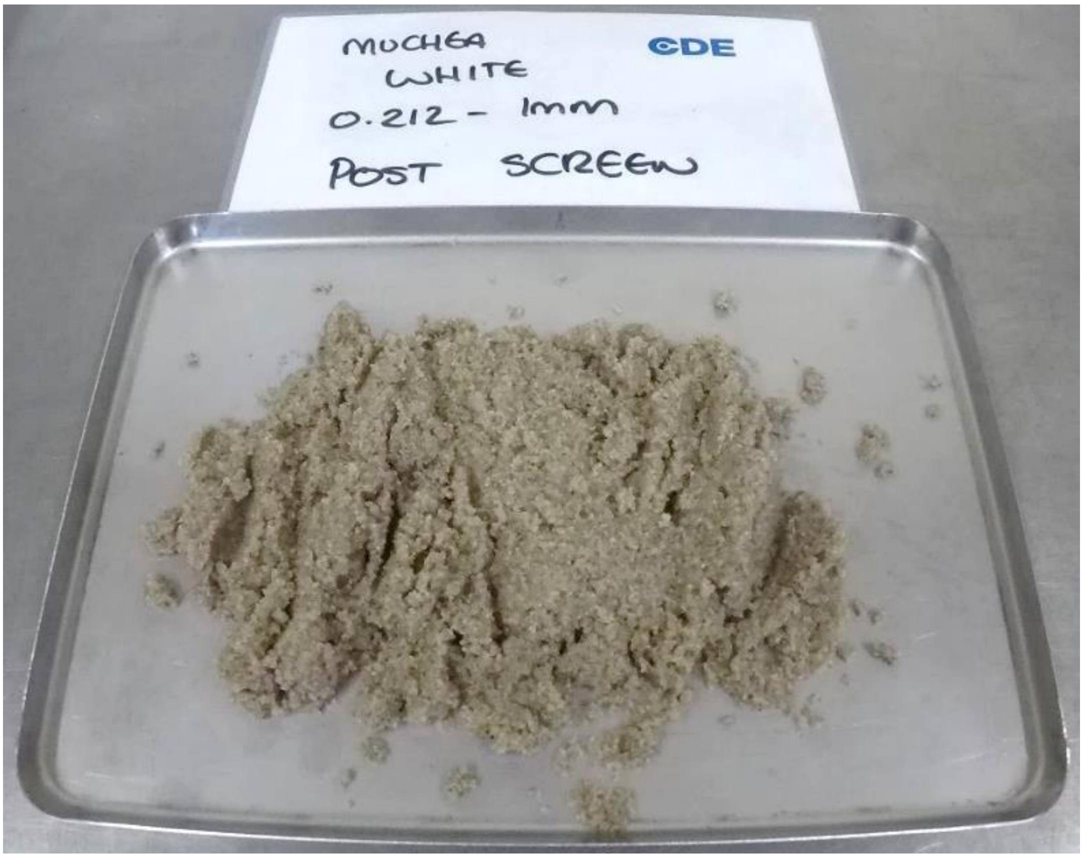

Figure 30: Muchea sand after screening -0.212mm to 1 mm

7.7 Attrition and washing tests

The 0.212-1 mm fraction was then attritioned for 5 minutes and washed over a 0.063 mm sieve, highlighting that the attrition and washing process removed fine particles, and reduced Al_2O_3, Fe_2O_3 and TiO_2 contents (Tables 21 and 22).

7.8 Spiral tests

The 0.212 mm material was then processed in a spirals test unit and three fractions were produced, namely heavy, middling and light. Particle size distribution analysis showed that the heavies contain the highest amount of fines and that the lights contain the lowest amount of fines. This is probably because fine-grained dense minerals containing Fe and Ti are concentrated with the heavy fraction. This observation was borne out by chemical analysis which showed that Al_2O_3, Fe_2O_3 and TiO_2 are highest in the heavy fraction. These elements are lowest in the middling and light fractions, and lower than the feed material.

Sieve sizes	Post attrition & wash 1	Post attrition & wash 2, post 0.212mm screen	-0.212mm material
mm	% passing	% passing	% passing
1.700	100.0	100.0	100.0
1.180	100.0	100.0	100.0
0.850	99.1	99.2	100.0
0.600	81.4	81.9	99.9
0.425	49.0	49.1	99.6
0.300	22.8	21.3	98.7
0.212	5.5	3.1	90.2
0.150	1.6	0.2	12.7
0.106	0.2	0.1	1.1
0.075	0.1	0.1	0.3
0.053	0.1	0.1	0.2

Table 21: Muchea particle size distribution before and after attritioning

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Process stage	Sample description	Mass	Fe_2O_3	MnO	TiO_2	Al_2O_3	LOI_{1000C}	SiO_2
		%	%	%	%	%	%	%
Feed	Raw Material		0.017	0.000	0.041	0.056	0.23	99.64
Attrition process and EvoWash Simulation	Attritioned & washed material		0.012	0.000	0.035	0.030	0.11	99.80
Spiral test 1. High grade, low yield	Heavies	12.27	0.025	0.000	0.039	0.056	0.08	99.75
	Middlings	32.34	0.010	0.000	0.020	0.032	0.08	99.83
	Lights		Samples Lost					
Spiral test 2. Low grade, high yield	Heavies	0.80	0.075	0.005	0.175	0.060	0.06	99.59
	Middlings	57.60	0.011	0.002	0.022	0.036	0.11	99.80
	Lights	41.60	0.010	0.002	0.021	0.034	0.07	99.85
Mag Sep Feed	Low grade, high yield - lights + middlings mixed		0.010	0.002	0.024	0.029	0.02	99.90
Magnetic separation of spiral test 2	Magnetics	0.41	0.252	0.013	0.376	0.125	0.21	98.97
	Middlings	7.31	0.009	0.001	0.021	0.034	0.05	99.87
	Non-magnetic	92.27	0.007	0.001	0.018	0.026	0.1	99.84

Table 22: Summary chemistry of samples processed at CDE Global, Northern Ireland.
(Analyses by ICP method)

7.9 Magnetic separation tests

The middling and light fractions from the spiral testwork were combined to form the feed for magnetic separation tests. The composite was then processed through a magnetic filter to generate magnetic, middling and non-magnetic fractions (Figure 31). Three magnetic strengths namely 0.5 Tesla, 0.65 Tesla and 1.0 Tesla were used.

The separation process works by passing sand and water slurry through a magnetised matrix in what is known as a 'HI Filter Unit'. Material which passes freely through the filter is described as non-magnetic, whereas the magnetic material adheres to the filter. At the end of the test, the HI Filter is de-energised and flushed using compressed air and water to discharge the magnetic particles which have collected in the magnetic matrix.

Magnetic separation results in an increase in SiO_2 and a decrease in Al_2O_3, Fe_2O_3 and TiO_2 in the non-magnetic fraction compared with the feed material (Tables 27 and 28).

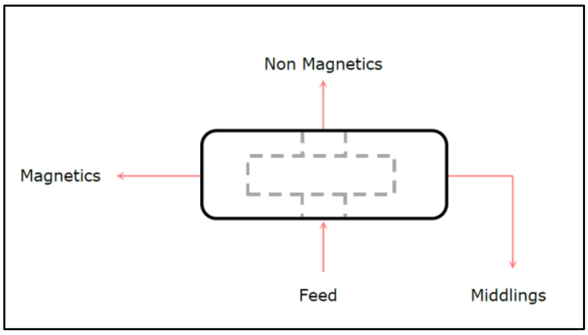

Figure 31: Schematic diagram of the magnetic filter separation process

7.10 Conclusions for products

Process testwork on a composite drill sample indicates that the Muchea deposit is suitable for the production of silica sand for glass and ceramics markets.

Sieve size (mm)	Sieve size (US mesh)	Raw material % passing	+1mm material % passing
1.700	12	100.0	97.6
1.180	16	99.9	92.6
0.850	20	97.6	33.1
0.600	30	83.1	15.5
0.425	40	56.4	12.2
0.300	50	31.9	8.8
0.212	70	13.9	6.3
0.150	100	5.4	4.3
0.106	140	2.5	3.3
0.075	200	1.9	2.7
0.053	270	1.4	2.3

Table 23: Muchea raw material and +1mm oversize material PSD results

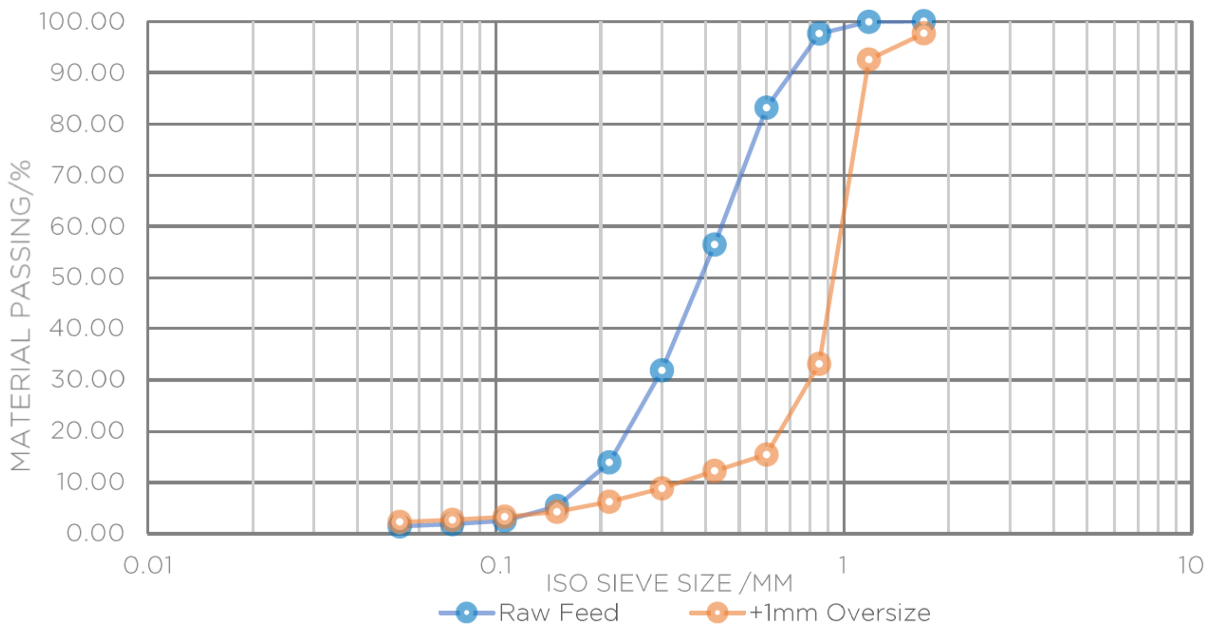

Figure 32: PSD curves for Muchea raw material and +1mm oversize material (CDE Global 2019)

Process Stage	Sample Name	Analysis method	Al_2O_3	CaO	Fe_2O_3	MgO	SiO_2	TiO_2
			%	%	%	%	%	%
Feed	Raw material	XRF	0.12	<0.01	0.01	<0.01	98.35	0.06
		ICP-MS	0.056	0.004	0.017	0.002	99.86*	0.041
1 mm screen	>1mm material	XRF	0.53	0.01	0.02	<0.01	98.37	0.06
		ICP-MS	0.143	0.005	0.0284	0.0018	99.77*	0.0274

** Calculated value*

Table 24: Chemical analysis of Muchea raw material and +1mm oversize

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Sieve Sizes	Post attrition & wash 1	Post attrition & wash 2, post 0.212mm screen	-0.212mm material
	% passing	% passing	% passing
1.700	100.0	100.0	100.0
1.180	100.0	100.0	100.0
0.850	99.1	99.2	100.0
0.600	81.4	81.9	99.9
0.425	49.0	49.1	99.6
0.300	22.8	21.3	98.7
0.212	5.5	3.1	90.2
0.150	1.6	0.2	12.7
0.106	0.2	0.1	1.1
0.075	0.1	0.1	0.3
0.053	0.1	0.1	0.2

Table 25: Muchea post attrition wash
(Post attrition and wash 2 post 0.212 mm; -0.212 mm PSD results)

Process Stage	Sample Name	Analysis method	Al_2O_3	CaO	Fe_2O_3	MgO	SiO_2	TiO_2
			%	%	%	%	%	%
Attrition and EvoWash 1	Post wash	XRF	0.09	0.01	<0.01	0.01	>100	0.02
		ICP-MS	0.028	0.006	0.0091	0.0011	99.92*	0.0228
Attrition and EvoWash 2. 0.212 mm screen	-0.212 mm	XRF	0.11	0.01	0.03	0.01	>100	0.09
		ICP-MS	0.061	0.01	0.0259	0.0021	99.81*	0.06
	+ 0.212 mm	XRF	0.08	0.01	0.01	0.01	>100	0.01
		ICP-MS	0.024	0.005	0.008	0.0010	99.93*	0.0179

** Calculated value*

Table 26: Chemical analysis of Muchea
(Post attrition and wash 2 post 0.212 mm; -0.212 mm)

Process Stage	Sample Identification	Al_2O_3	CaO	Fe_2O_3	K_2O	MgO	SiO_2	TiO_2	Total	LOI_{1000C}
		%	%	%	%	%	%	%	%	%
Magnetic Separation Feed Material	Feed	0.08	0.01	0.01	<0.01	<0.01	99.95	0.03	100.2	0.09
0.5T Magnetic Separation	Magnetics	0.19	0.02	0.19	0.01	0.01	99.56	0.18	100.4	0.18
	Middlings	0.08	0.01	0.01	<0.01	<0.01	>100.0	0.03	100.25	0.09
	Non-magnetics	0.08	0.01	<0.01	<0.01	<0.01	99.97	0.03	100.3	0.13
0.65T Magnetic Separation	Magnetics	0.12	0.01	0.15	0.01	0.01	99.45	0.09	100.05	0.22
	Middlings	0.07	0.01	0.01	<0.01	<0.01	100	0.03	100.3	0.17
	Non-magnetics	0.08	<0.01	<0.01	<0.01	<0.01	99.09	0.03	99.46	0.25
1.0T Magnetic Separation	Magnetics	0.13	0.02	0.16	0.01	0.01	98.75	0.07	99.31	0.13
	Middlings	0.07	<0.01	0.01	<0.01	<0.01	99.88	0.03	100.15	0.15
	Non-magnetics	0.06	0.01	<0.01	<0.01	<0.01	>100.0	0.03	100.5	0.26

Table 27: XRF chemical analysis of Muchea magnetic separation tests 0.5T, 0.56T and 1.0T

Process Stage	Sample Identification	Al_2O_3 %	CaO %	Fe_2O_3 %	MgO %	*SiO_2 %	TiO_2 %
Magnetic Separation Feed Material	Feed	0.031	0.007	0.012	0.002	99.93	0.018
0.5T Magnetic Separation	Magnetics	0.214	0.008	0.052	0.002	99.70	0.022
	Middlings	0.038	0.006	0.014	0.001	99.92	0.018
	Non-magnetics	0.036	0.005	0.013	0.001	99.93	0.018
0.65T Magnetic Separation	Magnetics	0.065	0.014	0.129	0.007	99.72	0.060
	Middlings	0.027	0.005	0.009	0.001	99.94	0.018
	Non-magnetics	0.032	0.006	0.010	0.001	99.93	0.019
1.0T Magnetic Separation	Magnetics	0.028	0.005	0.011	0.001	99.93	0.019
	Middlings	0.064	0.015	0.128	0.006	99.72	0.062
	Non-magnetics	0.027	0.005	0.009	0.001	99.94	0.018

Table 28: ICP-MS chemical analysis of Muchea magnetic separation tests 0.5T, 0.56T and 1.0T

Figure 33: Muchea sand microscope picture
(0.212-0.425 mm non-magnetic fraction Sphericity = 0.6 and roundness = 0.4)

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The Project will utilise existing technology widely used in the mineral sands separation industry.

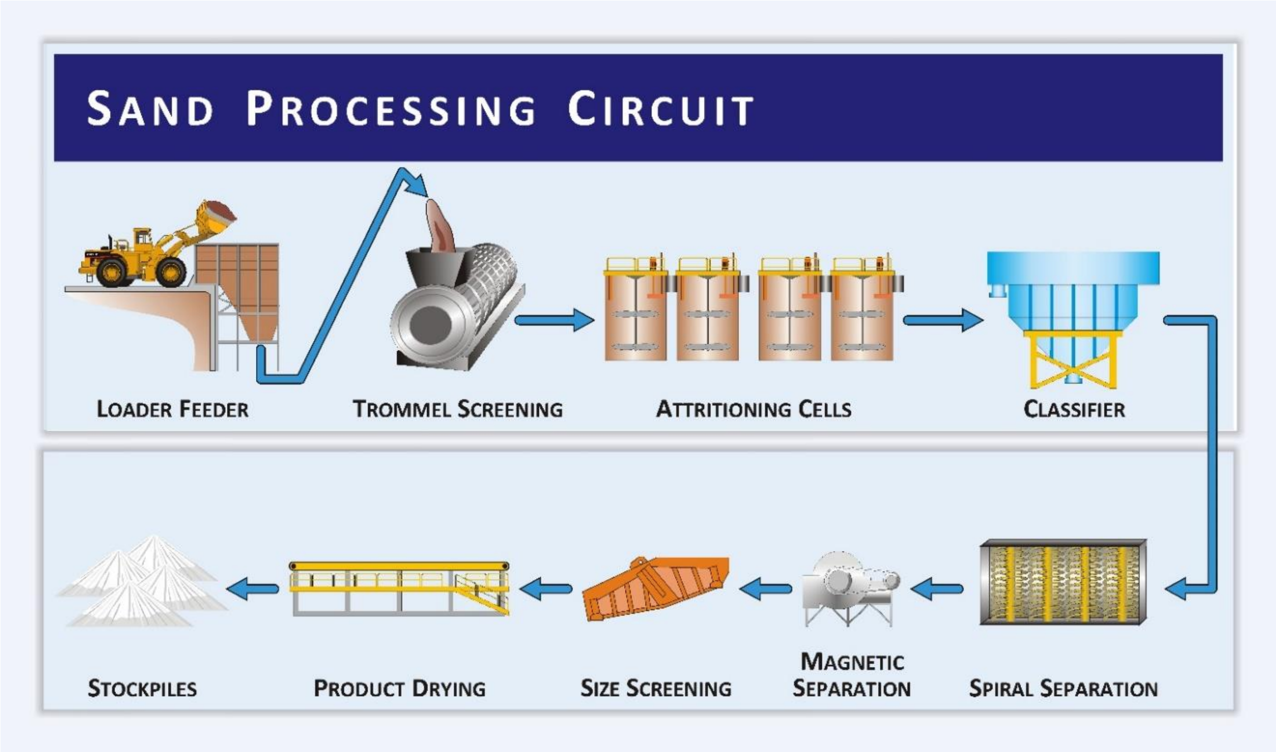

Figure 34: Processing circuit

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8 Mill Residue

8.1 Water Management

The processing plant will utilise a thickener and polishing ponds to recycle 95% of the processing water.

8.2 Residue Management

The processing plant will produce a tailings residue of up to 40,000 tonnes per year of fine-grained clay. The clay will be predominately aluminium and titanium with some iron. The clay contains no heavy metals or significant deleterious elements. A series of high-pressure cyclones will be utilised to produce a near dry (2-3% moisture) tail as clay and recover the water for re-use. The clay can be returned to the mined area and spread over the remaining sand after mining and before the VDT procedure. There is also a local market for tailings residue as a soil conditioner in the local sandy agricultural areas.

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9 Infrastructure

9.1 Roads

The project will be accessed via the sealed Timaru Road from Brand Highway

9.2 Mine Services Area

The mine services area of 0.5 Ha will include demountable offices, workshop and ablutions.

9.3 Accommodation

No accommodation will be constructed or is required on the site

9.4 Fuel Storage

Fuel storage will require one 55,000 litre bunded fuel storage ISOTainer facility for mining operations.

9.5 Water Supply and Distribution

9.5.1 Raw Water

Processing will recycle 95% of water and require 500 Megalitres per year as top up process water. Water will be stored in a 80 m x 80 m lined storage dam constructed in the vicinity of the feeder station. An additional two similar sized dams will be required to polish processing plant return water before being re-used.

Water supply will be from a bore sunk to the Yarragadee deep acquifer and piped to the storage dam at the processing plant site. The Company has a pending application for a Miscellaneous License for the Search for Water over the Mining Lease area. Water allocation in the area is largely distributed and the Company may have to purchase water rights to ensure adequate proces water.

9.5.2 Potable Water

Potable water requirements will be from off site and trucked to a day storage tank.

9.6 Waste Disposal

The site will generate very little waste products which will be disposed of offsite. Waste hydrocarbon products will be disposed of offsite at licensed disposal sites.

9.7 Power Supply

The Project is adjacent to high tension grid power which can be reticulated by aerial power lines as required.

The Company will undertake a study to determine the economics of accessing the nearby Dongara and Dampier gas pipelines to power a long-term power facility.

Total power requirements will be 4 Megawatts at the processing plant site and an additional 4 megawatts required for the feeder and pump stations.

9.8 Communications

The site has mobile phone coverage and will utilise VHF channels for site communications.

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10 Product Logistics

10.1 Rail

There is a rail connection from the Project area to the Kwinana Bulk Termianl, which is used to transport grain from the Moora grain terminal The rail is rated at 19 tonnes per axle and is a Tier 1 railway line. The nearest rail turnaround is at Gingin. Rail operations for Muchea would most likely use the Gingin passing bay to swap ends for locomotives. There is very little rail traffic on the route.

The owner of the line is Arc Infrastructure Pty Ltd, a subsidiary of Brookfield Infrastructure Partners L.P..

While Arc Infrastructure owns and maintains the railway line, it does not operate rolling stock.

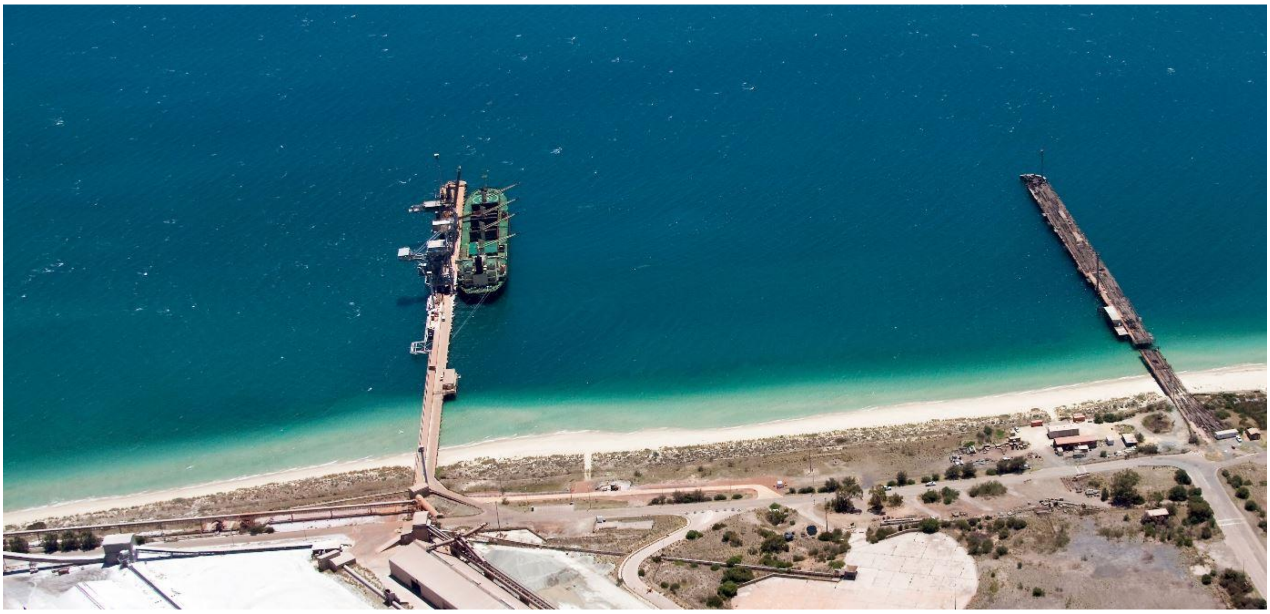
The main operators in Western Australia are Watco Group, Pacific National and Aurizon. Carriages will be similar as for grain or iron ore cartage; namely, covered wagons with bottom dumping. All operators have available carriages but locomotives are in short supply. Each operator will require six months' notice to begin haulage operations. All operators have submitted haulage proposals.

The rail capacity can haul up to 2 million tonnes per year with one train set. The rail operators have estimated that up to 4 million tonnes per year and two train sets is the maximum capacity without significant upgrades to the rail operations.

10.2 Port

Kwinana Bulk Terminal port operations are operated by Fremantle Ports, which owns the rail unloading and ship loading equipment and leases storage areas.

The Company has engaged with the Fremantle Ports Authority for planning for unloading, storage and shiploading and has received indicative operating costs, barrier limits and capacity.



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11 Environment, Water and Social Factors

11.1 Community

Muchea is located on vacant, unallocated Crown land. It is predominately located within the Shire of Chittering.

The closest communities are Muchea, 12 km by bitumen road to the south and Gingin, 14 km by bitumen road to the north. Both towns are expected to be the main source of personnel for mining and processing operations.

Muchea is a suburb of the Shire of Chittering located on the Brand Highway 50 kms north of Perth. The area was first surveyed as farmland in 1845 as part of a property to be owned by George Moore. The opening of a railway siding in the area between 1892 and 1898 caused permanent structures to be built and by 1903 farmlots were surveyed close to the siding. The townsite was later gazetted in 1904.

Gingin is a small town located on the Brand Highway, approximately 67 kms north of Perth. It is the council seat for the Shire of Gingin.

11.2 Studies and Surveys

The Company has undertaken detailed surveys and investigations regarding flora and vegetation, fauna, inland waters and social surroundings for the Project area.

Table 29 sets out a summary of the surveys undertaken, potential impacts and impact management plans.

EPA Factor*	Surveys and investigations undertaken	Potential impact(s) – based on the surveys	Management of impacts
Flora and Vegetation	Desktop (2017) and Field study of Flora and Vegetation, Spring 2018 (Mattiske). Key notes: • Survey covers the northern part of the Development Envelope • No listed Threatened or Priority Flora found were recorded within the survey area to date. • A number of Endangered and Threatened Species have been recorded within 5kms of the project area. The majority of these occur on the lying landforms to the east of the survey area which are subjected to seasonally water-logging and that have been cleared for mainly	Vegetation Clearing: • Mining will occur in 2.25 ha blocks (150 m x 150 m), up to 10 blocks will be mined each year (22 ha) • 10 ha of vegetation will be cleared for long term infrastructure, this will last the life of the mine • A total of 13 ha will be 'open' at any one time (inclusive of long term clearing) • This strategy will result in 900 ha of vegetation being cleared and rehabilitated over the life of the Proposal. No clearing of Threatened Flora (will be avoided if new specimens found during surveys) Clearing of Priority Flora could occur and their survival after VDT cannot be guaranteed at this stage.	• Detailed flora and vegetation survey over DE to identify areas of significance (i.e. significant flora and vegetation) • Any Threatened Flora records will be avoided • Long-term clearing restricted to 12 ha for mining and processing infrastructure. • Mining will be carried out in panels, with only 2.25 ha of active mining area at any one time. • Direct rehabilitation will happen in parallel with mining, using VDT • Vegetation will be removed in situ and transferred directly to already mined and landformed areas to retain vegetation and rootstock • It is expected that the the Banksia species *Banksia attenuata - Banksia menziesii - Banksia ilicifolia* will require propagation and planting. • Flexibility is provided by a 900ha development envelope • By utilising a large development envelope it is possible to select areas to mine which will not have a significant impact on vulnerable flora and vegetation

EPA Factor*	Surveys and investigations undertaken	Potential impact(s) – based on the surveys	Management of impacts
	agricultural activities. • No Threatened Flora with high likelihood of occurrence • Bushland is considered Excellent-Pristine • One TECs and two PECs are interpreted to be present,	The health of 900 ha of vegetation will be affected by the VDT method.	• Implementing VDT results in a greater likelihood of retaining the complete vegetation assemblage. This method retains hard to rehab flora such as recalcitrant sedge type species
Terrestrial Fauna	Level 1 Fauna Survey, Summer 2018 (Bamford Consulting Ecologists) Key notes: • Survey covers part of the DE • No Threatened Fauna found in DE to date • Vegetation represents Carnaby's Black Cockatoo foraging habitat • No Malleefowl mounds recorded • High pest numbers (feral cats, foxes and dogs)	• Habitat clearing (refer above for size and method). • All habitat predicted to be potential Carnaby's Black Cockatoo foraging habitat • Vegetation is not expected to provide nesting or roosting habitat • No impacts to active Malleefowl mounds (will be avoided if found) • Direct impacts (mortality, injury) to conservation significant fauna from clearing and mining operations could occur • Impacts to fauna habitat health are expected to be minimised due to VDT method	• Detailed fauna survey over DE to identify areas of significant habitat • Refer above for clearing method • If roosting trees are recorded they will be avoided • If active Malleefowl mounds are recorded they will be avoided
Inland Waters	Hydrogeological Feasibility Assessment, January 2019 (HydroConcept). Key notes: • All mining to occur above water table • Water supply to target deeper Yarragadee Aquifer • No defined surface drainage due to sandy soils • No contamination risk – process plant simply washes clays (2%) out of sand	• Changes to surface water infiltration and flows due to removal of 8 – 15 m of silica sand and deposition of clays • Potential impact on other groundwater users of the Yarragadee Aquifer.	• Abstraction will be from the Yaragadee Aquifer which will minimise the impact on groundwater dependent ecosystems (if present) or users of the surficial aquifer. • Abstraction managed under RIWI Act • Other groundwater users identified in close proximity to the Proposal were for agricultural purposes from the Gnangara Mound Acquifer and the Water Corporation from the Yarragadee Aquifer. • Landforming of the mined areas to maintain a natural water regime.

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EPA Factor*	Surveys and investigations undertaken	Potential impact(s) – based on the surveys	Management of impacts
Social Surroundings	None to date. No registered Aboriginal or European heritage sites in DE	• Noise and dust impacts unlikely given small scale of operations and distance to residents (buffer distance can be maintained) • Impacts to Aboriginal heritage sites expected to be able to be avoided if recorded	• Buffer distance between operations and residential properties • Use of existing rail – no transport on public roads • Aboriginal heritage surveys to be completed • Heritage sites to be avoided if recorded, or S18 approval if it cannot be avoided (unlikely)

Table 29: Summary of flora and vegetation, fauna, inland waters and social surroundings

11.3 Environment

The Project site Bassendean landform and soils as defined by Churchward and McArthur (1980). The survey area occurs on the elevated sand dune systems on the eastern edges of the Gnangara Mound to the northwest of Muchea and Bullsbrook on the Lesueur Sandplain, Figure 35.

The climate is warm Mediterranean with a hot, dry summer and a cool, wet winter.

The dominant land uses are dryland agriculture, conservation and crown reserves.

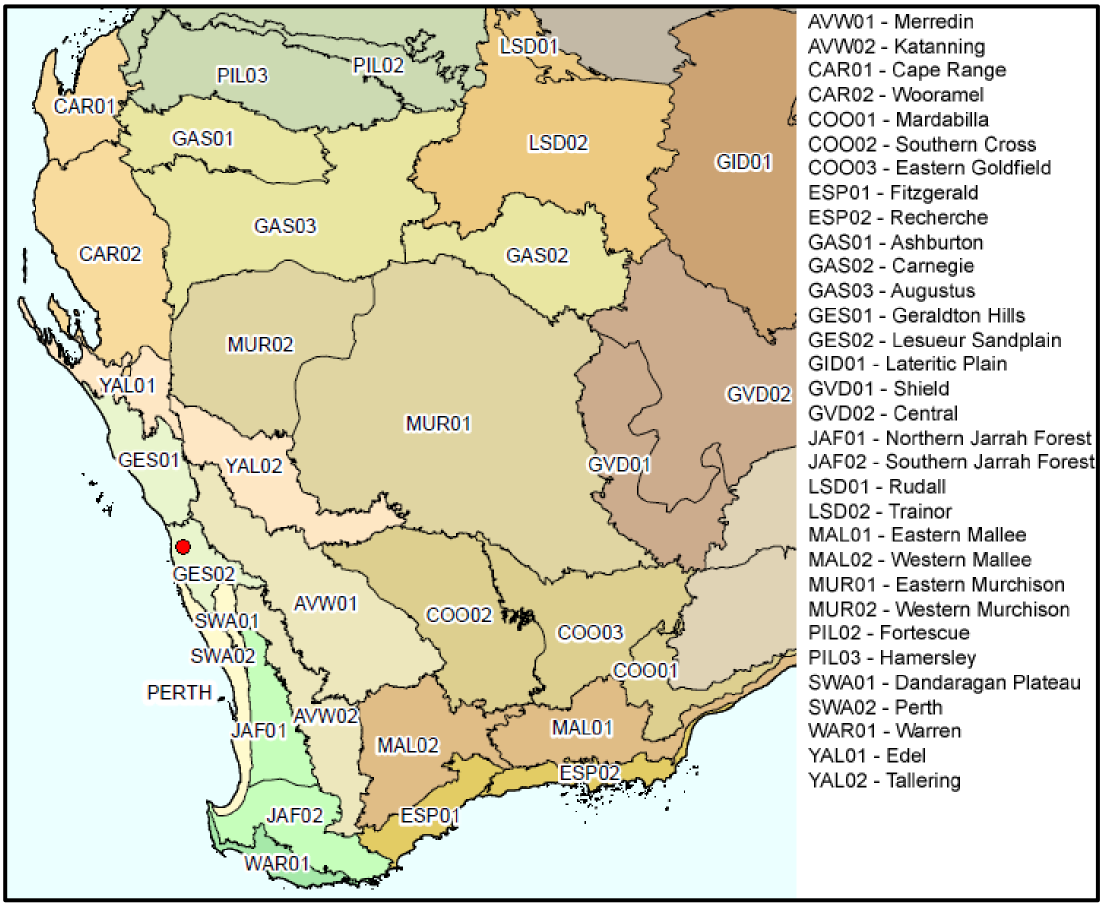

Figure 35: Bioregions across Western Australia
(Project area in the Lesueur Sandplain subregion)

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11.4 Vegetation and Flora

Vegetation in the Project area primarily consists of Bassendean landform and soils as defined by Churchward and McArthur (1980). The survey area occurs on the elevated sand dune systems on the eastern edges of the Gnangara Mound to the northwest of Muchea and Bullsbrook.. There is a seasonal drainage line (Chandala Brook and Chandala Swamp) running through the area 3-4kms east of the Project area.

Mattiske Consulting Pty Ltd was commissioned in October 2018 by VRX Silica Ltd to undertake a flora and vegetation survey of the Muchea Silica Sands Project (Muchea Project) area northwest of Muchea, WA. VRX is currently exploring their Muchea Project tenement for high quality silica sand.

Mattiske Consulting Pty Ltd completed a desktop assessment of the Muchea Project area in 2017 (Mattiske Consulting Pty Ltd 2017) in order to identify ecological values that have the potential to be impacted by the proposed silica sand extraction activities. The assessment found that there is a range of threatened and priority flora and fauna species and ecological communities that occurs or has the potential to occur in the project area. The key recommendation of the desktop report was that if the project activities were to intensify, then detailed flora and fauna studies should be undertaken in the project area, in order to validate the findings of the desktop assessment. This report outlines the methodology and results of the detailed flora and vegetation survey carried out in August-October 2018.

Location and Scope of Project

The Muchea Project area is located within elevated Bassendean sand dunes over eastern edge of the Gnangara Mound, in exploration mining tenement E70/4886, covering approximately 5850 ha, west of the Brand Highway between the towns Muchea and Gingin, Western Australia (Figure 1).

The majority of the tenement lies on private property within the Shire of Chittering, although a strip 900 m wide along the northern edge falls in the Shire of Gingin (including part of the area surrounding Gingin Airfield) and a strip 500 m wide along the western edge sits partially within State Forest and partially within the Yeal Nature Reserve in the City of Wanneroo. In the southeast the tenement crosses both the Dampier Bunbury Gas Pipeline and the Brand Highway.

The Muchea Project area lies within the Drummond Botanical Subdistrict (Swan Coastal Plain Subregion) of the Southwest Botanical Province Beard (1990). In the Interim Biogeographic Regionalisation for Australia (IBRA, version 7) (Department of the Environment and Energy (DotEE) 2019a), the Muchea Project area lies within the Perth subregion (SWA02) of the Swan Coastal Plain region.

The flora and vegetation survey described in the report was focussed on two priority areas of the Muchea Project area, covering 486.0 ha, that were identified by VRX as the areas most likely to be initially developed. Thirty-three sites were surveyed inside the Priority Areas and twenty-five outside.

Tenement E70/4886	GDA94_50J	
	Easting mE	Northing mN
Priority Area 1	393536	6517636
	393929	6517390
	393931	6515724
Border Area 1 & Area 2	392038	6517177
	392589	6516688
	393767	6515301
Priority Area 2	391580	6515302
	391526	6517002

Table 30: Location of Muchea Project priority areas

Environmental Legislation and Guidelines

The following key Commonwealth (federal) legislation relevant to this survey is the:

- *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).*

The following key Western Australian (state) legislation relevant to this survey includes the:

- *Biodiversity Conservation Act 2016 (BC Act) and Regulations 2018;*
- *Biosecurity and Agriculture Management Act 2007 and Regulations 2013; and*
- *Environmental Protection Act 1986;*

Furthermore, key Western Australian guidelines relevant to this survey are the:

- *Environmental Factor Guideline: Flora and Vegetation (Environmental Protection Authority [EPA] 2016a); and*
- *Technical Guidance – Flora and vegetation surveys for environmental impact assessment (EPA 2016b).*

Objectives

The objective of the survey was to undertake a flora and vegetation assessment of the Muchea Project area including:

- A review of the findings of the desktop assessment (Mattiske Consulting Pty Ltd 2017) to assist in refining the approach for the field studies;
- Undertake a survey of the Muchea Project area, and in particular the Priority Areas, at a suitable scale that allows the vegetation communities to be delineated, including replicate survey sites in similar vegetation types to enable statistical analysis of flora species data;
- Collect and identify the vascular plant species present in both the survey sites and opportunistically in order for a more complete assessment of the flora in the survey are to be made;
- Review the conservation status of the vascular plant species recorded by reference to current literature and listings by the Department of Biodiversity, Conservation and Attractions (DBCA) and plant collections held at the Western Australian State Herbarium (WAH), and listed by DotEE (2019b) under the EPBC Act;
- Collate and analyse data and compare with local and regional datasets and analyses;
- Define and map the vegetation communities, Floristic Community Types (FCTs) and Site-Vegetation Types (SVTs) in the Priority Areas of the Muchea Project;
- Define and map the location of any Threatened and Priority flora and any Threatened and Priority Ecological Communities located within the Priority Areas;
- Define any management issues related to flora and vegetation values;
- Provide recommendations on the local and regional significance of the vegetation communities; and
- Prepare a report summarising the findings**.**

Methods

Desktop Assessment

A desktop assessment (Mattiske Consulting Pty Ltd 2017) was conducted using FloraBase (WAH 1998-), NatureMap (Department of Parks and Wildlife 2007-) and the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) Protected Matters Search Tool* (DoTEE 2013) databases, to identify the possible occurrence of threatened and priority flora and fauna, and threatened and priority ecological communities within the Muchea Project area. Additionally, the land systems, pre-European vegetation, vegetation complexes and Site-Vegetation Types of the Muchea Project area were identified. Introduced flora (weeds) and fauna (feral animals) potentially present in the survey area were also noted. Previous flora studies from the Gnangara Mound (Mattiske Consulting Pty Ltd 2002, 2018) were also used to identify species that could potentially occur within the Muchea Project area.

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Field Survey

A detailed field assessment of the flora and vegetation of the Muchea Project area within the tenement E70/4886, with a focus on the Priority Areas, was undertaken by botanists from Mattiske Consulting Pty Ltd, from August to October 2018, in accordance with methods outlined in *Technical Guidance – Flora and vegetation surveys for environmental impact assessment* (EPA 2016b). All botanists held valid collection licences to collect flora for scientific purposes, issued under the BC Act.

The geographic co-ordinates defining the Muchea Project area were supplied by VRX Silica Ltd. Aerial photographic maps (February 2016) of the proposed Muchea Project area were prepared and supplied by CAD Resources (Carine, WA). Survey sites for the Muchea Project area were selected using aerial photographic maps and field observations. A total of 58 sites, both pre-selected and selected while in the field (17 within Priority Area 1, 16 in Priority Area 2, and 25 outside the Priority Areas) were surveyed to sample all vegetation types, with replication, within the Muchea Project area. Locations for the sites are given in Appendix B.

Survey sites consisted of pegged 10 m x 10 m quadrats. Flora and vegetation were described and sampled systematically at each survey site, and additional opportunistic collections were undertaken wherever previously unrecorded plants were observed. At each quadrat the following floristic and environmental parameters were recorded:

- GPS location (GDA94 datum, zone 50J);
- Photograph representative of the site;
- Local site topography and aspect;
- Soil type and colour;
- Outcropping rocks, their type and abundance;
- Surface cover (coarse fragments);
- Approximate time since fire;
- Vegetation condition;
- Vegetation structure; and
- For each vascular plant species, the average height and the percentage cover (of both alive and dead material) over the survey site.

All plant specimens collected during the field surveys were dried and processed in accordance with the requirements of the WAH. The plant species were identified based on taxonomic literature and through comparison with pressed specimens housed at the WAH. Where appropriate, plant taxonomists with specialist skills were consulted. Nomenclature of the species recorded is in accordance with the WAH (1998-).

Survey Timing

According to *Technical guidance – Flora and vegetation surveys for environmental impact assessment* (EPA 2016b), the recommended primary survey timing for the Southwest Botanical Province, in which the Muchea Project area is located, is Spring (September-November). The field survey work was timed, where possible, to align with peak flowering periods of conservation significant flora with the potential to occur in the Muchea Project area. The desktop assessment indicated that 25 of the 26 potential conservation significant species were likely to be flowering over the months August-October (Table 31). The survey was conducted over 6 days on the dates 20, 23 and 24 August, 19 and 20 September, and 11 October 2018.

Rainfall for the 3 months preceding August 2018 was 329 mm, only 19 mm below average, with the 12 months prior to the start of the field surveys having rainfall 28 mm above average (Bureau of Meteorology 2019); therefore the flowering times for flora species are not expected to differ from those shown in Table 31.

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Family	Species	SCC	FCC	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
APIACEAE	*Eryngium pinnatifidum* subsp. Palustre (G.J. Keighery 13459)	P3	-									x	x	x	
ASTERACEAE	*Pithocarpa corymbulosa*	P3	-	x	x	x	x								
CYPERACEAE	*Cyathochaeta teretifolia*	P3	-	x								x	x	x	x
	Eleocharis keigheryi	T	V								x	x	x	x	
	Lepidosperma rostratum	T	E						x	x	x	x	x	x	
ERICACEAE	*Andersonia gracilis*	T	E										x	x	
	Leucopogon squarrosus subsp. *trigynus*	P2	-						x	x	x	x	x		
FABACEAE	*Acacia drummondii* subsp. *affinis*	P3	-							x	x				
	Isotropis cuneifolia subsp. *glabra*	P2	-								x	x	x		
	Jacksonia sericea	P4	-	x	x								x	x	x
HAEMODORACEAE	*Anigozanthos viridis* subsp. *terraspectans*	T	V										x	x	
HALORAGACEAE	*Meionectes tenuifolia*	P3	-										x	x	x
	Myriophyllum echinatum	P3	-											x	
MYRTACEAE	*Chamelaucium* sp. Gingin (N.G. Marchant 6)	T	E									x	x	x	x
	Darwinia foetida	T	CE									x	x	x	
	Verticordia serrata var. *linearis*	P3	-									x	x		
ORCHIDACEAE	*Caladenia huegelii*	T	E									x	x		
	Diuris purdiei	T	E									x	x		
	Drakaea elastica	T	E										x	x	
	Thelymitra stellata	T	E										x	x	
POLYGONACEAE	*Rumex drummondii*	P4	-								x	x	x	x	
PROTEACEAE	*Grevillea curviloba* subsp. *curviloba*	T	E										x		
	Grevillea curviloba subsp. *incurva*	T	E								x	x			
	Grevillea evanescens	P1	-							x	x	x			
	Grevillea thelemanniana	T	CE					x	x	x	x	x	x	x	
STYLIDIACEAE	*Stylidium longitubum*	P4	-										x	x	x
% of species in peak flower				*4*	*0*	*0*	*4*	*0*	*4*	*4*	*11*	*15*	*37*	*22*	*0*
Monthly total rainfall (mm)				*69.4*	*1.2*	*0.8*	*16.6*	*62.2*	*116.8*	*150.4*	*126.0*	*88.4*	*26.2*	*1.4*	*36.6*
Long-term average monthly rainfall (mm)				*9.7*	*13.4*	*16.9*	*34.8*	*84.3*	*130.2*	*134.2*	*104.8*	*69.5*	*36*	*23.2*	*10.8*
Survey effort (number of person field days)				-	-	-	-	-	-	-	*12*	*6*	*4*	-	-

Table 31: Peak flowering time for Threatened and Priority flora species potentially present in Project area

Potential threatened and priority flora from previous survey (Mattiske Consulting Pty Ltd 2003) and desktop assessment (Appendix B). "x" denotes species is flowering; red highlight indicates species is at peak flowering (WAH 1998-). Green monthly rainfall records indicate a higher than average rainfall; red indicates lower than average rainfall; rainfall statistics were sourced from weather station 009053 (Bureau of Meteorology 2019).

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Survey Limitations

An assessment of the survey against a range of factors which may have had an impact on the outcomes of the present survey was made (Table 32). Based on this assessment, the present survey has not been subject to constraints which would affect the thoroughness of the survey, and the conclusions which have been formed.

Potential Survey Limitation	Impact on Survey
Sources of information and availability of contextual information (i.e. pre-existing background versus new material).	**Not a constraint.** The vegetation of the Gnangara Mound has been mapped at three scales by Heddle et al. (1980), Mattiske Consulting Pty Ltd (2002) and Beard et al. (2013). Mattiske Consulting Pty Ltd has completed various monitoring surveys in the area relating to this programme since the 1970's (Mattiske Consulting Pty Ltd 2002).
Scope (i.e. what life forms, etc., were sampled).	**Not a constraint.** Vascular flora species were the focus of the survey and any unknown species or species that resembled threatened or priority flora was thoroughly sampled.
Proportion of flora collected and identified (based on sampling, timing and intensity).	**Potential constraint.** While many plants were in flower during the survey, a proportion of plants encountered during the survey were sterile and may impact the ability to identify some specimens to species level. Orchid species may not emerge each year if conditions are not favourable.
Completeness and further work which might be needed (i.e. was the relevant survey area fully surveyed).	**Not a constraint.** Species accumulation curve analysis indicates that 77% of potential flora species were recorded in the Priority Areas. The large area of the exploration tenement and the need to concentrate survey effort on two priority areas meant that some parts of the entire Muchea Project area may require further sampling.
Mapping reliability.	**Not a constraint.** Handheld GPS units were used for the survey, which for a majority of field conditions have an accuracy level of ± 5 m. Aerial photos from February 2016 were supplied by CAD. The date of these is after any fire events in the Muchea Project.
Timing, weather, season, cycle.	**Not a constraint.** The survey timing was appropriate for the area and the flowering times of the vegetation.
Disturbances (fire flood, accidental human intervention, etc.).	**Not a constraint.** No disturbances were encountered within the survey areas that had the potential to adversely affect the survey completion. Fire has had an impact on vegetation throughout the Muchea project area; however, most of the Priority Areas mapped in this particular survey were subject to fire at the same time in the past (2003) and so all vegetation surveyed should have been affected in a consistent manner.
Intensity (in retrospect, was the intensity adequate).	**Not a constraint.** The flora and vegetation survey was undertaken by ten botanists over six days at 58 survey sites to ensure thorough coverage of the survey area. Sites were replicated in each potential vegetation community. Flora that were unknown or resembled threatened or priority flora were collected, the location and habitat noted, and the number of plants estimated.
Resources (i.e. were there adequate resources to complete the survey to the required standard).	**Not a constraint.** Adequate resources (time, equipment and personnel) were available to carry out the survey.
Access problems (i.e. ability to access survey area).	**Not a constraint.** Access to the survey area was not restricted by the land owners or managers or by track conditions. However, sporadic rain that occurred throughout the intended survey period significantly increased the risk of spreading *P. cinnamomi*, thus postponing survey work to later dates.
Experience levels (e.g. degree of expertise in plant identification to taxon level).	**Not a constraint.** The team carrying out the survey work comprised one Principal Scientist, one Senior Botanist, three Experienced Botanists/Ecologists and five Botanists/Ecologists, all of whom had experience working in the Swan Coastal Plain subregion. Any unknown or potential threatened or priority flora species were collected and identified, utilising resources available at the WAH and consultation with expert taxonomists where appropriate.

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Measures taken to improve the robustness of data and analysis.	**Not a constraint.** In order to apply statistical analysis to this survey's dataset, various data were simplified. The proportion of data edited was very small and effects on the overall results checked at each step of editing.
Comparisons with external databases	**Not a constraint.** Data recorded in this survey were compared with the Floristic Community Types (FCTs) determined for Swan Coastal Plain vegetation by Gibson *et al*. (1994). These datasets are not directly comparable and therefore comparison between the vegetation communities interpreted from this survey and the FCTs is not a definitive measure of the presence or absence of particular FCTs in the project area, and hence the related Priority Ecological.

Table 32: Potential flora and vegetation survey limitations within the Project area

Analysis of Site Data

The methods used to analyse the data collected are outlined below.

Species accumulation curve

A species accumulation curve based on accumulated species versus sites surveyed was prepared from the Muchea Project data using the software *EstimateS* (Colwell 2013) to indicate the level of adequacy of the survey effort. As the number of survey sites increases, and correspondingly the size of the area surveyed increases, there should be a diminishing number of new species recorded. At some point, the number of new species recorded becomes essentially asymptotic. The asymptotic value was determined using Michaelis-Menten modelling and provided an incidence-based coverage estimator of species richness (Chao 2004). When the number of new species being recorded for survey effort expended approaches this asymptotic value, the survey effort can be considered to be adequate.

Vegetation Communities

Plymouth Routines in Multivariate Ecological Research v7 (PRIMER) statistical analysis software was used to analyse species-by-site data and discriminate survey sites on the basis of their species composition (Clarke and Gorley 2015).

Data were prepared for use in PRIMER using several simplification measures. To down-weight the relative contributions of quantitatively dominant species, a presence-absence transformation was applied to the data set. Where species were identified with a "?" and the same species with certainty, the "?" identification was merged with the certain one. Annual species, specimens not identified to species level and singletons (species recorded at a single quadrat and not forming a dominant structural component nor listed in the Gibson et al. (1994) FCTs) were excluded from the data set prior to analysis. Only two species had more than one subspecies or variety; these were not collapsed to the species level. Introduced species were not specifically removed, as these comprised only seven species, of which five were annual, one was a singleton and one was identified to genus level only, and hence all were removed from the dataset anyway.

Computation of similarity matrices was based on the Bray-Curtis similarity measure. Hierarchical Clustering was used in conjunction with Similarity Profile, Similarity Percentages, quadrat descriptions, quadrat photographs and aerial photographs; combining these methods increased the understanding of quadrat inter-relations and thus the ability to accurately delineate those vegetation communities based on species composition.

Floristic Community Types

The desktop assessment identified one Threatened Ecological Community (TEC) and several Priority Ecological Communities (PECs) with the potential to occur in the Muchea project area. Each of these ecological communities is correlated with a Floristic Community Type (FCT) as defined by Gibson et al. (1994) for the Swan Coastal Plain. To identify possible TECs and PECs in the Muchea project area, the vegetation communities determined based on this survey's data were compared to the FCTs. A subset of the FCTs for the Swan Coastal Plain was used for comparison, namely FCTs 4, 8,20a, 20b, 21a, 21b, 21c, 22, 23a and 23b (180 sites).

Taxa which were identified to the subspecies and variety levels were revised to the specific level to reduce the tendency to create further statistical variation in the analysis that was considered unwarranted. Appropriate multivariate analyses were used to compare current data to the Gibson et al. (1994) species by quadrat data, and inferences were based on dominant species. It is important to

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note that areas for this survey were mapped based on extrapolated quadrat data from a single flora assessment, rather than accumulated species data over successive seasons within known vegetation community types as per Gibson et al. (1994). Consequently, assigned FCTs within the survey area are inferred and not absolute, i.e. a vegetation code assigned to an FCT is inferred to resemble floristic aspects of that FCT as defined by Gibson et al. (1994).

Mattiske Site-Vegetation Types

Site-Vegetation Types (SVTs) as defined by Mattiske Consulting Pty Ltd (2002) were inferred in the desktop assessment to occur in the Muchea project area. Appropriate multivariate analyses were used to compare the vegetation communities as defined in this survey to the Mattiske Consulting Pty Ltd (2002) SVTs, and inferences were based on dominant species, topography, and comparison with the earlier Mattiske Consulting Pty Ltd (2002) mapping (based on aerial photography and field verification and sampling within the different site-vegetation types over four decades.

The SVTs were based on the earlier work of Havel (1968) on the Swan Coastal Plain and the expansion of these SVTs to the wider Gnangara Mound by Mattiske Consulting Pty Ltd (2002). Neither the Havel (1968) nor Mattiske Consulting Pty Ltd (2002) surveys had sites within the specific Muchea project area. Havel's (1968) sites were located in state forest to the west and south of this survey, with a handful of sites along the western border of the Muchea project area. The sites used in Mattiske Consulting Pty Ltd (2002) were generally to the north, west and south of this survey area, with the site nearest to the Muchea project area being within the Gingin Airfield immediately to the north.

Vegetation Descriptions

Vegetation descriptions were based on Alpin's (1979) modification of the vegetation classification system of Specht (1970), to align with the National Vegetation Information System (NVIS). Vegetation communities were described at the association level of the NVIS classification framework, as defined by the Executive Steering Committee for Australian Vegetation Information (2003).

11.4.1 Field Survey Results

Flora

A total of 196 vascular plant taxa, representative of 96 genera and 39 families, were recorded within the Muchea Project area. The majority of taxa recorded were representative of the Myrtaceae (28 taxa), Fabaceae (20 taxa), Stylidiaceae (12 taxa) and Ericaceae (11 taxa). Only seven taxa were identified as introduced species.

In comparison, over a survey area approximately twice as large (around 1.3 ha surveyed over a project area measuring approximately 25 km by 50 km versus 0.6 ha surveyed over approximately 5 km by 5 km in the Muchea Project area) in the Gnangara and East Gnangara Mound Survey of 2001 (Mattiske Consulting Pty Ltd 2003), 463 taxa were identified, comprising 233 genera and 66 families. A total of 60 introduced taxa and two Priority flora species were recorded. Monitoring of a similar but slightly smaller area (approximately 1.0 ha) in 2017 (Mattiske Consulting Pty Ltd 2018) resulted in identification of 302 taxa representative of 172 genera and 59 families, with 37 introduced taxa and one Priority flora species recorded.

Some plant species could not be identified accurately to species level due to the absence of sufficient taxonomic characters to enable accurate identification. In most cases this was due to plant material being sterile or lacking sufficient taxonomic features to permit accurate identification to species level. In these cases the species is identified as, for example, *Asteraceae* sp. or *Beaufortia* sp. Of the 196 taxa recorded in this survey, eight were identified to family level and 36 to genus level only, while 21 taxa were identified to variety or subspecies level.

Annual species (including those which can be annual or perennial depending on local conditions) represented 12.8 % (25 taxa) of all recorded plants within the Muchea Project area. Of the annual species, 20.0 % were introduced species (5 taxa). The average species richness for the 58 survey quadrats was 28.4 ± 0.9 (mean ± standard error), with a range of 7 to 37 species per quadrat.

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A species accumulation curve was used to evaluate the sampling adequacy and is presented in Figure 36. The incidence-based coverage estimator of species richness was 260. Based on this value and the total of 196 species recorded, approximately 75 % of the flora species potentially present within the Muchea Project area were recorded. If the calculation is repeated for the Priority Areas only, approximately 77% of the flora species potentially present within the Priority Areas were recorded.

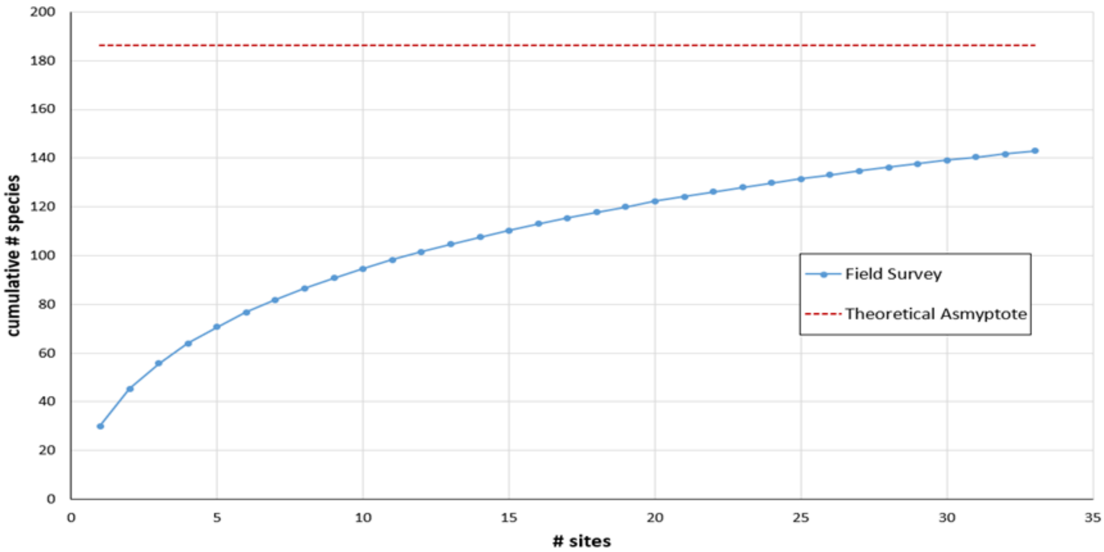

Figure 36: Species Accumulation Curve for the Priority Areas

Threatened and Priority Flora

No threatened flora species pursuant to pursuant to Part 2, Division 1, Subdivision 2 of the BC Act and as listed by DBCA (2018a), or pursuant to section 179 of the EPBC Act or listed by the DotEE (2019b), were recorded within the Muchea Project Area. No priority flora species, as listed by DBCA (2018b) were recorded within the Muchea Project Area.

Other Significant Flora

The taxon *Schoenus brevisetis sens.* lat. was observed at one site (outside the Priority Areas). It was identified at the WAH by M. Hislop on 18/03/2019. Hislop noted (2019) that "*Schoenus brevisetis, S. caespititius & S. pedicellatus* together constitute a difficult species complex which is not well-resolved taxonomically. This specimen could possibly also be a young plant of BE 1250 [*Schoenus caespititius*]". The site (6F) is in vegetation community B.

Introduced (Weed) Species

A total of seven introduced (weed) taxa were recorded within the Muchea Project area, four identified to species level (*Aira cupaniana, Gladiolus caryophyllaceus, Hypochaeris glabra and Ursinia anthemoides subsp. anthemoides*) and three to genus or family level (*Asteraceae sp., Gladiolus sp. and Pentameris* sp.). None of these are declared pest organisms (see Appendix A3 for definitions) pursuant to section 22 of the *Biosecurity and Agriculture Management Act 2007* (WA). On DBCA's list of environmental weeds for the Swan region (Department of Parks and Wildlife 2016) they are ranked for ecological impact and invasiveness as shown in Table 33.

Species	Ecological Impact	Invasiveness
Aira cupaniana	Unknown	Unknown
Gladiolus caryophyllaceus	High	Rapid
Hypochaeris glabra	High	Rapid
Ursinia anthemoides subsp. *anthemoides*	Unknown	Rapid

Table 33: Ecological impact and invasiveness rankings for introduced species recorded in Project area (Department of Parks and Wildlife 2016)

Vegetation

The Muchea Project area lies within the Drummond Botanical Subdistrict (Swan Coastal Plain Subregion) of the Southwest Botanical Province Beard (1990). In particular, the survey area lies within

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the Bassendean Dune System, where the overall vegetation cover is characterised by Beard (1990) as Banksia low woodland, with the vegetation in swampy areas in dune swales comprising Melaleuca, heath communities and reeds.

The mapping of pre-European vegetation, vegetation complexes and SVTs is described in the desktop assessment and summarised here.

The Pre-European vegetation comprises 'Low woodland dominated by *Banksia'* (949.2) and 'Mosaic of Low woodland dominated by *Banksia* with Shrublands dominated by teatree thicket' (1014.1) (Beard et al. 2013).

The Bassendean North vegetation complex covers the Muchea Project area; vegetation ranges from Low open forest and Low open woodland of *Banksia* species and *Eucalyptus todtiana* to Low woodland of *Melaleuca* species and Sedgelands on the moister sites (Heddle et al. 1980).

Mattiske Consulting Pty Ltd (2002) identified 25 SVTs occurring within the broader Gnangara mound area. Those of relevance to this survey are; woodlands, low woodlands and open low woodlands. The woodlands are dominated by *Banksia* sp. or *Melaleuca* sp. overstorey with occasional *Eucalyptus* sp. or *Corymbia calophylla* over a Myrtaceous and Proteaceous shrub layer over low shrubs and herbs with *Xanthorrhoea preissii*. The data from this survey are compared with the SVTs of Mattiske Consulting Pty Ltd (2002) in order to provide regional context.

Vegetation Communities

A summary description of the seven vegetation communities are given below. All sites are Low woodlands.

A: Low woodland of *Banksia attenuata* and *Banksia menziesii* with occasional *Eucalyptus todtiana* over *Jacksonia floribunda* over *Eremaea pauciflora* and *Scholtzia involucrata* over Beaufortia *elegans, Bossiaea eriocarpa* and *Petrophile linearis* over *Drosera erythrorhiza, Lyginia barbata* and *Patersonia occidentalis* on white-grey sand. Occurs predominantly on mid slopes, but also flats and upper slopes.

B: Low open woodland of *Banksia attenuata* and *Banksia menziesii* over *Jacksonia floribunda* and *Xanthorrhoea preissii* over *Scholtzia involucrata* and *Verticordia nitens* over *Leucopogon conostephioides* over *Dasypogon bromeliifolius* and *Patersonia occidentalis* on white-grey sand. Occurs mostly on lower slopes and valley floors in moister sites (but not as wet as those for M).

F: Low woodland of *Banksia attenuata* and *Banksia menziesii* over *Allocasuarina humilis* and *Jacksonia floribunda* over *Scholtzia involucrata* and *Stirlingia latifolia* over *Conostephium pendulum, Melaleuca* ?*trichophylla* and *Petrophile linearis* over *Burchardia congesta, Drosera drummondii* and *Lyginia barbata* on white-grey sand. Occurs on upper slopes and some ridges.

G: Low woodland of *Banksia attenuata* and *Banksia menziesii* over *Jacksonia floribunda* over *Eremaea pauciflora* var. *calyptra* and *Hibbertia subvaginata* over *Calytrix flavescens, Leptomeria empetriformis* and *Petrophile linearis* over *Lyginia barbata* and *Phlebocarya ciliata* on white-grey-brown sand. Occurs on mid slopes and some upper slopes.

H: Low woodland of *Banksia attenuata* and *Banksia menziesii* over *Jacksonia floribunda* over *Hibbertia subvaginata* and *Scholtzia involucrata* over *Leucopogon conostephioides*, *Melaleuca* ?*trichophylla* and *Petrophile linearis* over *Lyginia barbata* and *Patersonia occidentalis* on white-grey-brown sand and sandy loam. Occurs predominantly on flats but also across a range from lower slopes to ridges. This is the most common community.

J: Low woodland of *Eucalyptus todtiana*, *Banksia menziesii* and *Banksia attenuata* over *Jacksonia floribunda* over *Eremaea pauciflora* var. *calyptra, Hibbertia subvaginata* and *Scholtzia involucrata* over *Beaufortia elegans, Bossiaea eriocarpa* and *Philotheca spicata* over *Lyginia barbata* and *Patersonia occidentalis* on white-grey sand and sandy loam. Occurs mostly on upper slopes.

M: Low woodland of *Melaleuca preissiana* and *Banksia attenuata* over *Kunzea glabrescens* and *Xanthorrhoea preissii* over *Hibbertia subvaginata* over *Dasypogon bromeliifolius* on white-grey-brown sands and sandy loams or moist black loam and clay peat. Occurs in moist valley floors and flats.

The total area mapped and percentage cover for each delineated vegetation community. Low woodland communities accounted for 96.0 % (466.5 ha), and Low open woodlands 4.0 % (19.6 ha) of the mapped Priority Areas. Community A lies on high dunes almost completely to the south of the Priority Areas, with only a very small patch situated just inside the southern boundary of the Priority

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Areas. Several patches of communities B, F, G and J are situated inside the Priority Areas. Community H is the least restricted in its distribution and covers a large part of the Priority Areas. Community M almost entirely occurs outside the Priority Areas, although the edge of one small patch (centred about site 1IC) sits just within the western boundary of the Priority Areas.

Banksia attenuata and Banksia *menziesii* dominated the upper stratum in all of the vegetation communities except M. Other species (*Eucalyptus todtiana, Melaleuca preissiana*) did form a significant part of the canopy in communities J and M, but only in one site did these species reach a height greater than 10 m. These tree species, along with *Nuytsia floribunda*, appear in other vegetation communities, but not in significant numbers. Hence the entire Muchea Project area is covered by Low woodlands.

In all communities other than M, *Jacksonia floribunda* was commonly found in the tall shrub layer throughout the entire survey area. This species is listed by Gibson et al. (1994) in FCT 23b, but is not listed by Mattiske Consulting Pty Ltd (2002) in their SVTs. Other tall shrubs found in a number of sites include *Allocasuarina humilis, Kunzea glabrescens* and *Xanthorrhoea preissii*. In the mid shrub stratum *Eremaea pauciflora* var. *calyptra*, *Hibbertia subvaginata* and *Scholtzia involucrata* were common throughout the area, while in the low shrub layer *Bossiaea eriocarpa, Leucopogon conostephioides*, *Melaleuca* ?*trichophylla* and *Petrophile linearis* and were often found. *Patersonia occidentalis* and *Lyginia barbata* were frequently recorded in the herbaceous layer.

Floristic Community Types

It was noted in the desktop study that any data collected during field studies in the Muchea Project area should be “analysed and compared with the Gibson et al. (1994) regional database developed from quadrats on the Swan Coastal Plain to enable further clarification of the alignment of the local [vegetation] communities with the SCP23b floristic community.”

Results from the PRIMER analysis were not definitive, as there are limitations associated with determining and mapping the presence of FCTs within the survey area. Unsurprisingly, comparative analysis between survey quadrats and vegetation communities in the current survey and that of Gibson *et al*. (1994) species by quadrat data show significant dissimilarities, a false negative. However, by using the results of the statistical analysis as a guide, and examining the frequency and dominance of key FCT defining species recorded in the current survey, inferences can be made about the FCTs which are most closely aligned with the vegetation communities as interpreted in this survey.

Seven sites from Community M (1B, 1D, 1IC, 1MB, 4A, 4B and 4D) were clustered with two Gibson et al. (1994) sites which are part of FCT 21c (Low lying *Banksia attenuata* woodlands or shrublands).

All other sites from this survey fell onto branches of the dendrogram more dissimilar to Gibson sites than to themselves internally; however, the nearest branches were dominated by Gibson et al. (1994) sites which are part of FCTs 22 (*Banksia ilicifolia* woodlands), 23a (Central *Banksia attenuata-Banksia menziesii* woodlands) and 23b (Northern *Banksia attenuata-Banksia menziesii* woodlands). There are only five sites throughout this survey that have occurrences of *Banksia ilicifolia*, and two are in vegetation community M (which corresponds with FCT 21c as described above); it is therefore unlikely that most of the surveyed area aligns with FCT 21 c. FCTs 23a and 23b are very similar in species composition; given the geographic distribution of these two FCTs, it is more likely that the sites from this survey align with those of FCT 23b.

These FCTs correspond closely with TECs and PECs.

Threatened and Priority Ecological Communities

The TEC ‘Banksia Woodlands of the Swan Coastal Plain’, listed as Endangered at Federal level and as a Priority 3 PEC at State level, is inferred to occur throughout the Muchea Project area.

Two PECs, both ranked as Priority 3 at State level, making up a subset of the *Banksia Woodlands* TEC are inferred to occur within the Muchea Project area. These are ‘Low lying *Banksia attenuata* woodlands or shrublands (‘floristic community type 21c’)’ and ‘SCP Northern *Banksia attenuata* – *Banksia menziesii* woodlands (‘floristic community type 23b’)’.

The ‘Shrublands and Woodlands on Perth to Gingin ironstone (Perth to Gingin ironstone association) of the Swan Coastal Plain’ TEC is listed as Endangered at Federal level and as Critically Endangered at State level. This may occur along the northeastern boundary of the Muchea Project area, but definitely not within the Priority Areas. This is associated with FCT 8 ‘Herb rich shrublands in claypans’ (Meissner & English 2005).

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Site-Vegetation Types

The main determinants of the location of different plant species and their associations on the northern Swan Coastal Plain are the underlying site conditions and the local climatic conditions (Mattiske Consulting Pty Ltd 2002).

The mapping codes of Mattiske Consulting Pty Ltd (2002) are based on the A to K code as developed by Havel (1968), with an additional number to designate the variation in structure and composition. The Bassendean dune system supports the SVTs - F1, G1, G2, G3, H1, H2, H3, H4, I1, J1, J2, K1, K2, K3, K4 and K5. The F1 unit forms an intermediate type between the Spearwood and the Bassendean dunes systems. The gradient on the slopes of the Bassendean dune system is reflected in the shift from the G1 to G3 types on the drier upper slopes, through the H1 to H4 on the mid slopes, I1 on the moister lower slopes, J1 to J2 on the seasonally wetter soils on the lower slopes to the range of damplands and wetlands on the K1 to K5 types (Mattiske Consulting Pty Ltd 2002).

Six of the SVTs as defined in Mattiske Consulting Pty Ltd (2002) for the Gnangara Mound overlap with the FCTs as defined by Gibson et al. (1994) for the Swan Coastal Plain within the Bassendean dune system:

- FCT 4: *Melaleuca preissiana* damplands as defined by Gibson et al. (1994) occurs on the eastern edges of the Bassendean dune system and in seasonally moister and wetter swamps within the Bassendean dune system. The key species also occur in the K1 – SVT as defined by Havel (1968) and Mattiske (Mattiske Consulting Pty Ltd 2002).
- FCT 23b: Northern Banksia attenuata – Banksia menziesii woodlands as defined by Gibson et al. (1994) occurs on the Bassendean dune systems. The key species overlap with the SVTs G1 and H1 and form part of the continuum on the sandier soils.

The following SVTs were interpreted to correspond to the seven vegetation communities interpreted from this survey's data (see vegetation mapping in Figure 37):

G1: The drier, uppermost SVT, G1, represented in the Muchea Project area corresponds with vegetation communities A and J. These communities occur on mid and upper slopes respectively. Eucalyptus todtiana is commonly found in the overstorey, along with Banksia attenuata and Banksia menziesii over species that tolerate drier Bassendean dunes with leached grey sands.

H1: Vegetation communities B, F and G all align with type H1. These communities comprise a range of topographical positions, from lower slopes and valley floors for community B, through mid slopes for community G to upper slopes for F. All three communities have a canopy of Banksia attenuata and Banksia menziesii over a tall shrub layer that includes Jacksonia floribunda amongst other species. The differences between these communities are defined by understorey species reflective of their topographic position, e.g., the tall shrub layer of community B also includes Xanthorrhoea preissii and the herbaceous layer Dasypogon bromeliifolius, whilst for community F the tall shrubs include Allocasuarina humilis and for community G the herbaceous layer includes Phlebocarya ciliata.

I1: The most really widespread community interpreted to occur in this survey, H, corresponds with SVT I1. Quadrats making up community H are mostly on flats and slopes of the Bassendean dune system. Vegetation in this community is "typical" for the Muchea Project area i.e., it lacks any distinguishing species that differentiate it from any of the other five communities with canopy dominated by Banksia sp. (communities A, B, F, G and J); although it tends to occur on the lower slopes and flats.

K1: Vegetation community M aligns most closely with this SVT, which is characterised by an overstorey containing Eucalyptus rudis, Melaleuca preissiana and Banksia ilicifolia with only occasional Banksia attenuata and Banksia menziesii. Community M occurs on the lowest, wettest areas of the survey, generally in the eastern part of the Muchea Project area. This community and hence SVT - K1 almost entirely occurs outside the Priority Areas, although the edge of one small patch (centred about site 1IC) sits just within the western boundary of the Priority Areas.

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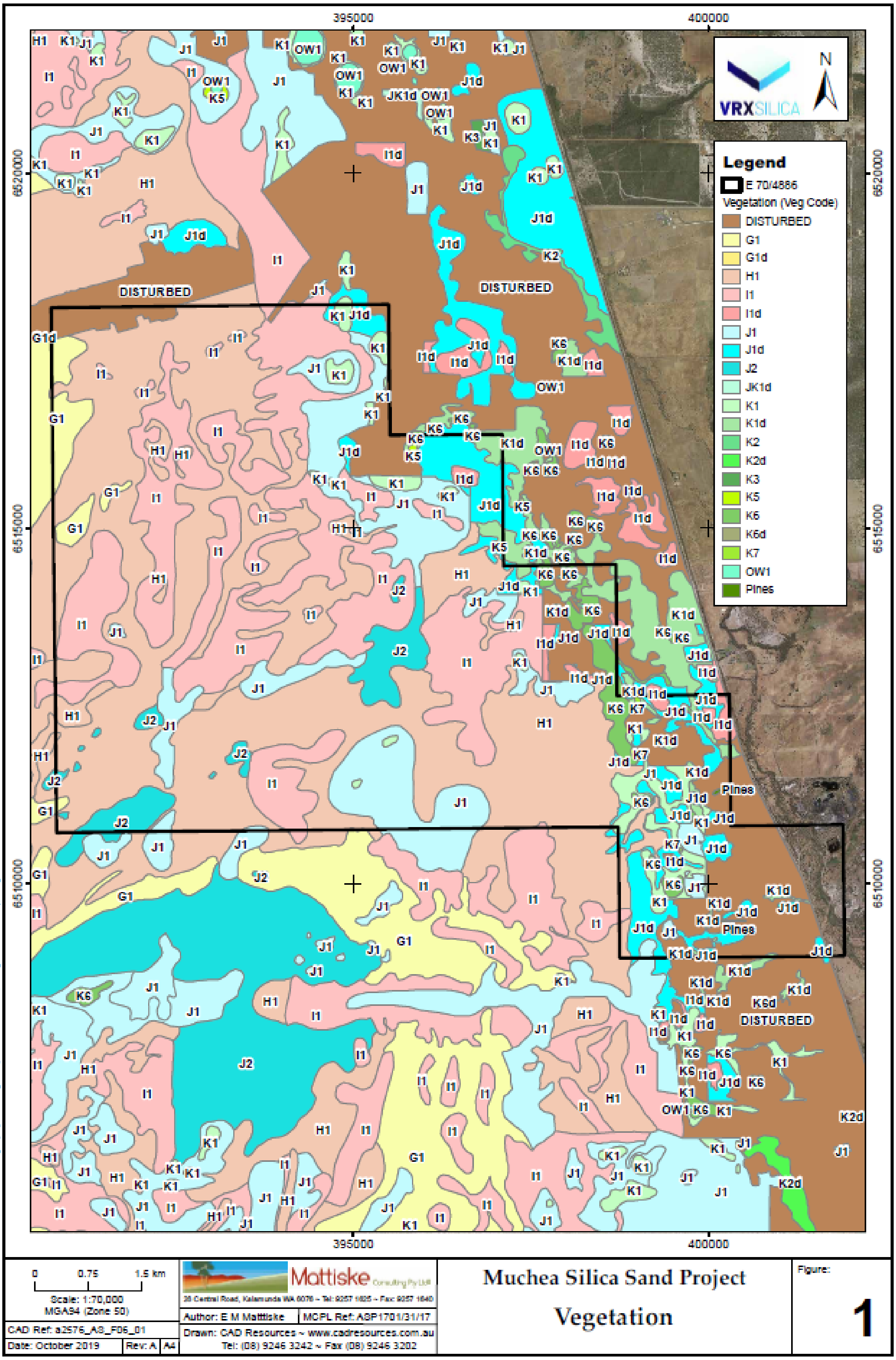

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Figure 37: Mattiske vegetation-type mapping on Muchea project area

Other Significant Vegetation

A 500 m wide strip along the western edge of the Muchea Project area falls within Gnangara State Forest and Yeal Nature Reserve, which is part of Gnangara Park and part of Bush Forever Site 380-Rosella Rd Bushland. Gnangara Park is vested in the Conservation and Parks Commission (Sonneman & Brown 2008).

The Bush Forever site contains, or is inferred to contain, the FCTs 5-Mixed shrub damplands, 21c-Low-lying *Banksia attenuata* woodlands or shrublands, 22-*Banksia ilicifolia* woodlands, 23a-Central *Banksia attenuata-Banksia menziesii* woodlands, and 23b-Northern *Banksia attenuata-Banksia menziesii* woodlands (Western Australian Planning Commission 2000). The Priority Areas for the Muchea Project do not encroach on Yeal Nature Reserve, but are within 1 km of the eastern edge of the Nature Reserve.

The Timaru Nature Reserve is located approximately 2 km to the northeast of the northeast corner of the Priority Areas. The reserve was established to protect the TEC "Shrublands and woodlands on Perth to Gingin Ironstone Association of the Swan Coastal Plain" (Sonneman & Brown 2008), which possibly may extend along the northeastern boundary of the Muchea Project area.

11.4.2 Discussion and Conclusions

Of the 26 conservation significant species with potential to occur in the Muchea Project area, 25 were likely to be flowering over the months this survey was conducted (Table 31), and rainfall during the winter preceding the survey was within 10 % of the long-term average, so there should have been little variation in flowering times from those expected. It was noted in the desktop assessment that the majority of potential threatened and priority flora species identified prior to this survey preferentially occupy habitats located topographically lower and to the east of the Muchea Project area. No threatened or priority flora species were found during this survey. In larger surveys conducted within Banksia woodland of the Gnangara Mound in 2002 (Mattiske Consulting Pty Ltd 2003) and 2017 (Mattiske Consulting Pty Ltd 2018), only two species (*Jacksonia sericea* – P3, now P4; *Conostephium minus* – P4, currently not listed) of priority flora, respectively, were recorded. This implies that the parameters that led to those 26 conservation significant species being assessed as having the potential to occur in the area may be too broad.

The species accumulation curve indicated that approximately 75 % of the flora species potentially present within the Muchea Project area and 77% within the Priority Areas were recorded. If rainfall for the winter preceding a further survey is near average, then the survey should take place a little later in spring (i.e. September-November), as there are twice as many potential threatened and priority flora species in peak flower in November than in August (Table 31).

Few weed species (seven) were encountered during this survey. However, three of these have an Ecological Impact Ranking of 'High' and/or Invasiveness ranking of 'Rapid'. These species, *Gladiolus caryophyllaceus, Hypochaeris glabra* and *Ursinia anthemoides* subsp. *anthemoides* were found in one, three and ten sites respectively. All but one of the sites is along the eastern edge of the Muchea Project area and hence closer to areas of disturbance. The low coverage of introduced species is reflective of the Excellent-Pristine condition of the bushland.

The vegetation communities interpreted to occur in the survey area were defined using statistical analysis of species composition along with site vegetation descriptions and topography. All communities aside from M are very similar in species composition, and it is possible that larger groupings of communities could have been made. The seven communities defined in this report are reflective of their general species composition, topographical situation and also aerial photograph characteristics.

Analysis of data collected during this survey along with data from the Gibson et al. (1994) regional database of FCTs showed that most of the vegetation in the Muchea Project area aligns with the FCT 23b 'Northern *Banksia attenuata-Banksia menziesii* woodlands'. The exception to this is vegetation community M, which is situated almost entirely outside the Priority Areas; the sites in this community align more closely with FCT 21c 'Low lying *Banksia attenuata* woodlands or shrublands'.

Two FCTs, 4 and 23b, overlap with the Mattiske Consulting Pty Ltd SVTs K1 (wetter sites) and G1 and/or H1 (sandier sites) (Mattiske Consulting Pty Ltd 2002). The vegetation communities interpreted in this

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survey correspond in species composition with SVTs G1, H1, I1 and K1 and generally align with the dune slope positions of the SVTs.

One TEC and two PECs are interpreted to be present in the Muchea Project area, and correspond closely with the Gibson et al. (1994) FCTs. The TEC '*Banksia* Woodlands of the Swan Coastal Plain' is interpreted to cover the entire Muchea Project area. It encompasses the two PECs 'Low lying *Banksia attenuata* woodlands or shrublands ('floristic community type 21c')' and 'SCP Northern *Banksia attenuata* – *Banksia menziesii* woodlands ('floristic community type 23b')'. The only exceptions to this may possibly be along the northeastern edge of the survey area, which may instead be part of the TEC 'Shrublands and Woodlands on Perth to Gingin ironstone (Perth to Gingin ironstone association) of the Swan Coastal Plain', which relates to FCT 8. These TECs and PECs also relate, but less obviously due to differences in scale, to the Mattiske Consulting Pty Ltd (2002) SVTs.

The proportion of regional vegetation proposed to be cleared in the Priority Areas (< 1 % for all measures) may seem insignificant; however, as noted in the conservation advice for the Banksia Woodlands of the Swan Coastal Plain TEC (DotEE 2016), this ecological community has been "very heavily cleared and modified, and now exists as mostly very small and highly fragmented patches". The geographic extent of the Banksia Woodlands TEC over the Swan Coastal Plain is estimated to have declined by 50-60 % since Pre-European time. Only approximately 81,800 ha of the TEC were estimated to exist in reserves in 2016, which is around 24 % of the estimated extent of the TEC. The greatest ongoing threat to the existence of the TEC is clearing and fragmentation, including mining of silica sands (DotEE 2016). Other threats include dieback diseases, invasive species, fire regime change, hydrological degradation, climate change, grazing, decline in pollinating and seed dispersing fauna, and loss of key *Banksia* species.

11.5 Fauna

The objectives of investigations to date are to: identify fauna values; review impacting processes with respect to these values and the proposed activity; and provide recommendations to mitigate these impacts.

The methods used for this assessment are based upon the general approach to fauna investigations for impact assessment. The impact assessment process involves the identification of fauna values, review of impacting processes and, where possible, preparation of mitigation recommendations.

This approach to fauna impact assessment has been developed with reference to guidelines and recommendations set out by the Western Australian Environmental Protection Authority (**EPA**) on fauna surveys and environmental protection, and Commonwealth biodiversity legislation (EPA 2002; EPA 2004). The EPA proposes two levels of investigation that differ in the approach to field investigations, Level 1 being a review of data and a site reconnaissance to place data into the perspective of the site, and Level 2 being a literature review and intensive field investigations (e.g. trapping and other intensive sampling). The level of assessment recommended by the EPA is determined by the size and location of the proposed disturbance, the sensitivity of the surrounding environment in which the disturbance is planned, and the availability of pre-existing data.

The following approach and methods are divided into three groupings that relate to the stages and the objectives of impact assessment:

Desktop assessment. The purpose of the desktop review is to produce a species list that can be considered to represent the vertebrate fauna assemblage of the project area based on unpublished and published data using a precautionary approach.

Field investigations. The purpose of the field investigations is to gather information on this assemblage: confirm the presence of as many species as possible (with an emphasis on species of conservation significance), place the list generated by the desktop review into the context of the environment of the project area, collect information on the distribution and abundance of this assemblage, and develop an understanding of the project area's ecological processes that maintain the fauna. Note that field investigations cannot confirm the presence of an entire assemblage, or confirm the absence of a species. This requires far more work than is possible in the EIA process. For example, in an intensive trapping survey, How and Dell (1990) recorded in any one year only about 70% of the vertebrate species found over three years. In a study spanning over two decades, Bamford

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et al. (2010) has found that the vertebrate assemblage varies over time and space, meaning that even complete sampling at a set of sites only defines the assemblage of those sites at the time of sampling.

Impact assessment. Determine how the fauna assemblage may be affected by the proposed development based on the interaction of the project with a suite of ecological and threatening processes.

11.5.1 Desktop Assessment

Information on the fauna assemblage of the survey area was drawn from a wide range of sources. These included state and federal government databases and results of regional studies. Databases accessed were the Atlas of Living Australia (ALA), the WA Department of Biodiversity, Conservation and Attractions (DBCA) NatureMap (incorporating the Western Australian Museum's FaunaBase and the DBCA Threatened and Priority Fauna Database), BirdLife Australia's Birdata (Atlas) Database (BA), the EPBC Protected Matters Search Tool and the Bamford Consulting Ecologists (BCE) Database. Information from the above sources was supplemented with species expected in the area based on general patterns of distribution. Sources of information used for these general patterns were:

- Frogs: Tyler et al. (2000) and Anstis (2013);
- Reptiles: Storr et al. (1983, 1990, 1999 and 2002) and Wilson and Swan (2013);
- Birds: Blakers et al. (1984); Johnstone and Storr (1998, 2004), Barrett et al. (2003) and Menkhorst et al. (2017);
- Mammals: Menkhorst & Knight (2004); Churchill (2008); and Van Dyck and Strahan (2008).

Sources of information used for the desktop assessment:

- Atlas of Living Australia (ALA 2019): Records provided by collecting institutions, individual collectors and community groups (29° 40' 10''S, 115° 10' 41''E – plus 20 km buffer).
- NatureMap (DBCA 2019): Records in the WAM and DPaW databases. Includes historical data and records on Threatened and Priority species in WA (29° 40' 10''S, 115° 10' 41''E – plus 20 km buffer).
- BirdLife Australia Birdata (Atlas Database): Records of bird observations in Australia, 1998-2018 (29° 40' 10''S, 115° 10' 41''E – plus 20 km buffer).
- EPBC Protected Matters: Records on matters of national environmental significance protected under the EPBC Act (29° 40' 10''S, 115° 10' 41''E – plus 20 km buffer).

Previous fauna surveys

BCE has conducted multiple fauna surveys at Muchea and nearby areas. These surveys have included monitoring, targeted fauna assessments and a level 2 fauna assessment. Other surveys conducted by BCE further afield will be used as background information only to inform potential species lists compiled during desktop studies. Species records from these studies are contained in the Naturemap database which was consulted as part of the desktop study. In addition, BCE maintains a detailed database and annotated species lists that were available for reference as part of the desktop study. Some of the BCE records pre-date Naturemap. Previous reports consulted for background information include Harris et al. (2008), Metcalf and Bamford (2008), Bamford (2009), Bamford (2012), Everard and Bamford (2014), Bamford et al. (2015) and Bamford and Chuk (2015-17). Some of these studies were undertaken within 1km of the project area; others within about 10km.

Nomenclature and taxonomy

As per the recommendations of EPA (2004), the nomenclature and taxonomic order presented in this report are based on the Western Australian Museum's (WAM) Checklist of the Fauna of Western Australia 2016. The authorities used for each vertebrate group were: amphibians (Doughty et al. 2016a), reptiles (Doughty et al. 2016b), birds (Johnstone and Darnell 2016), and mammals (Travouillon 2016). In some cases, more widely-recognised names and naming conventions will be followed, particularly for birds where there are national and international naming conventions in place (e.g. the BirdLife Australia working list of names for Australian Birds). English names of species where available

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are used throughout the text; Latin species names are presented with corresponding English names in tables in the appendices.

Interpretation of species lists

Species lists generated from the review of sources of information are generous as they include records drawn from a large region and possibly from environments not represented in the survey area. Therefore, some species that were returned by one or more of the data searches will be excluded because their ecology, or the environment within the survey area, meant that it is highly unlikely that these species will be present. Such species can include, for example, seabirds that might occur as extremely rare vagrants at a terrestrial, inland site, but for which the site is of no importance.

Species returned from the databases and not excluded on the basis of ecology or environment are therefore considered potentially present or expected to be present in the survey area at least occasionally, whether or not they were recorded during field surveys, and whether or not the survey area is likely to be important for them. This list of expected species is therefore subject to interpretation by assigning each a predicted status in the survey area.

The status categories used are:

- **Resident:** species with a population permanently present in the survey area;
- **Migrant or regular visitor:** species that occur within the survey area regularly in at least moderate numbers, such as part of annual cycle;
- **Irregular Visitor:** species that occur within the survey area irregularly such as nomadic and irruptive species. The length of time between visitations could be decades but when the species is present, it uses the survey area in at least moderate numbers and for some time;
- **Vagrant:** species that occur within the survey area unpredictably, in small numbers and/or for very brief periods. Therefore, the survey area is unlikely to be of importance for the species; and
- **Locally extinct:** species that would still be present but has not been recently recorded in the local area and therefore is almost certainly no longer present in the survey area.

These status categories make it possible to distinguish between vagrant species, which may be recorded at any time but for which the site is not important in a conservation sense, and species which use the site in other ways but for which the site is important at least occasionally. This is particularly useful for birds that may naturally be migratory or nomadic, and for some mammals that can also be mobile or irruptive, and further recognises that even the most detailed field survey can fail to record species which will be present at times, or may be previously confirmed as present. The status categories are assigned conservatively. For example, a lizard known from the general area is assumed to be a resident unless there is very good evidence that the site will not support it, and even then it may be classed as a vagrant rather than assumed to be absent if the site might support dispersing individuals.

11.5.2 Field Investigation Methodology and Personnel

The survey area was visited on 18 November 2018 by Dr Mike Bamford (BSc Hons. Ph.D. (Biol.)), Dr Wes Bancroft (BSc Hons. Ph.D. (Zool.), Sarah Smith (Bsc. (Biol.) and Peter Smith (Dip. Ag. Sc.). Mike Bamford and Katherine Chuk - B. Sc. (Zool.) Hons. prepared a report.

During the site inspection as much as possible of the site was visited, habitat observations were made in order to develop descriptions of Vegetation and Substrate Associations (VSAs), and opportunistic fauna observations were recorded when relevant to the survey. Access to the site was good from the Brand Highway via the sealed Timaru Road.

Survey Limitations

The EPA Guidance Statement 56 (EPA 2004, now EPA 2016) outlines a number of limitations that may arise during surveying. These survey limitations are discussed in the context of the BCE investigation of the survey area in Table 34.

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Potential Survey Limitation	BCE Comment
Level of survey.	Level 1 (desktop study and site inspection). Survey intensity was deemed adequate due to the scale of the project and the amount of data available in the region.
Competency/experience of the consultant(s) carrying out the survey.	The ecologists have had extensive experience in conducting fauna surveys and have conducted several fauna studies within the immediate region.
Scope. (What faunal groups were sampled and were some sampling methods not able to be employed because of constraints?)	The survey focussed on vertebrate fauna and fauna values.
Proportion of fauna identified, recorded and/or collected.	All vertebrate fauna observed were identified. Extensive desktop information allowed for a robust predicted species list to be developed.
Sources of information e.g. previously available information (whether historic or recent) as distinct from new data.	Abundant information from databases and previous studies.
The proportion of the task achieved and further work which might be needed.	The survey was completed and the report provides fauna values for the project area.
Timing/weather/season/cycle.	Timing is not of great importance for level 1 investigations.
Disturbances (e.g. fire, flood, accidental human intervention etc.) that affected results of survey.	None
Intensity. (In retrospect, was the intensity adequate?)	All major VSAs were visited and significant species habitat and traces were identified.
Completeness (e.g. was relevant area fully surveyed).	Site was fully surveyed to the level appropriate for a level 1 assessment and for the proposed impact. Fauna database searches covered a 20 km radius beyond the survey area boundary. Detailed field investigations covered the VSAs present.
Resources (e.g. degree of expertise available in animal identification to taxon level).	Field personnel have extensive experience with fauna and habitat in the region.
Remoteness and/or access problems.	There were no remoteness/access problems encountered.
Availability of contextual (e.g. biogeographic) information on the region.	Regional information was available and was consulted.

Table 34: Survey Limitations

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Fauna values within the survey area can be summarised as follows:

Fauna assemblage. Moderately rich but incomplete with some species locally extinct. Assemblage is typical of the Lesueur Sandplains subregion. Notable for a rich reptile assemblage and high proportion of non-resident birds, many of which are nectarivorous and exploit seasonal abundance of nectar and pollen from the species-rich flora.

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Species of conservation significance. Few species of high conservation significance are present or expected, but the Carnaby's Black-Cockatoo is important, with known roost sites nearby and the species very likely to be a regular foraging visitor to the project area. The locally significant Rufous Fieldwren and Rainbow Bee-eater are almost certainly present, with the bee-eater a breeding visitor. The Western Ground Parrot may be locally extinct but because of its very high conservation significance (with the only known wild population estimated as <150 birds; A. Burbidge pers. comm.), the slight possibility of the species being extant in the general area is important.

Vegetation and Substrate Associations (**VSAs**). The survey area supports few but distinct VSAs, all of which are mostly intact. All are very extensive regionally.

Patterns of biodiversity. Within the survey area all VSAs, aside from a small disturbed area in the north-west, are intact and likely to support a high level of species richness. VSA3 may support some aquatic and wetland-associated species not found in VSAs 1 and 2 due to the seasonal presence of water. VSAs 1 and 2 are likely to support a high diversity of terrestrial species, with VSA1 notably important for conservation significant species such as Carnaby's Black-Cockatoo.

Key ecological processes. The main processes which may affect the fauna assemblage are likely to be local hydrology, the fire regime and the presence of feral predators.

11.5.3 Conclusion and Recommendation

Because of the fairly continuous and undisturbed habitat surrounding the survey area, potential impacts are mostly considered to be minor or negligible. Potential impacts of greatest concern to fauna include:

- Loss of habitat
- mortality during clearing
- habitat fragmentation (drainage line)
- roadkill due to increased traffic
- impacts of feral species
- hydrological change
- altered fire regimes
- light

Recommendations to manage potential impacts include:

- Referral to the Department of Energy and the Environment under the EPBC Act for impact on >1ha of moderate to high forging value vegetation for Carnaby's Black-Cockatoo.
- Undertake baseline surveys (bird censusing and systematic sampling of small, terrestrial vertebrates) to provide data for the assessment of the effectiveness of post-mining rehabilitation. Rehabilitation is assumed as a standard part of the mining process.
- Conduct aural surveys for the Western Ground Parrot to see if the species persists in the broader area. In the unlikely event that it is confirmed to be present, even within 5-10km, discussions will need to be held with DBCA regarding management actions for this species.
- Conduct survey for Mallee fowl mounds before clearing.
- During clearing operations, investigate options for fauna rescue to reduce direct mortality.
- Clearing is likely to increase feral species activity (particularly Fox, Cat and Goat). Waste management to reduce increase in feral species and control of pre-existing feral species (particularly Fox and Cat) would provide further benefit. Survey lines and access tracks should be rehabilitated as soon as they are no longer needed as these re utilised by feral fauna.
- Minimising clearing where possible and progressively rehabilitate where practical after mining.
- Minimise impact on the drainage line, and manage ground water if the project may impact groundwater levels.

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- Minimise disturbance. Night time operations and lighting are of particular concern and lighting should be directed away from bushland areas.
- Fire management measures should be implemented to prevent extensive fires affecting the project area or surrounding landscapes. Ideally this would protect infrastructure and contribute to a regional approach to fire management.

11.6 Groundwater

Water is required for processing at Muchea with groundwater resources being considered the most likely and reliable source. The water demand is approximately 500 ML/yr at the Muchea site. In order to meet these water requirements, there will be need for a groundwater licence from the Department of Water and Environmental Regulation (**DWER**).

This document provides a scoping level of hydrogeological assessment that reviews the regional hydrogeology, development constraints, potential borefield layout and design considerations, and the likely approval process within the DWER.

11.6.1 Physiography

The VRX Silica tenement E70/4886 is situated upon the Swan Coastal Plain, Figure 38, which is up to about 32 km wide in this part of the plain. Several geomorphic units occur parallel to the coast, with the tenement located upon the eastern margin of the Bassendean Dunes adjacent to the Pinjarra Plain in the east.

The Bassendean Dunes form an area of undulating eolian sand plain which accumulated as a series of shoreline and dune deposits. The Bassendean Dunes form the eastern portion of the Gnangara Mound. The Pinjarra Plain is a flat alluvial plain of alluvial clay at the base of the Dandaragan and Darling Plateaus, which is approximately 4 km wide in this area.

Surface elevation of the tenement area rises from around 55 m AHD in the east over the Pinjarra Plain, to around 70 m AHD through the central portion and reaching about 76 m AHD in the western portion. Dune ridges reach almost 100 m AHD. The area is covered by native vegetation, except for the eastern margin which is cleared for grazing.

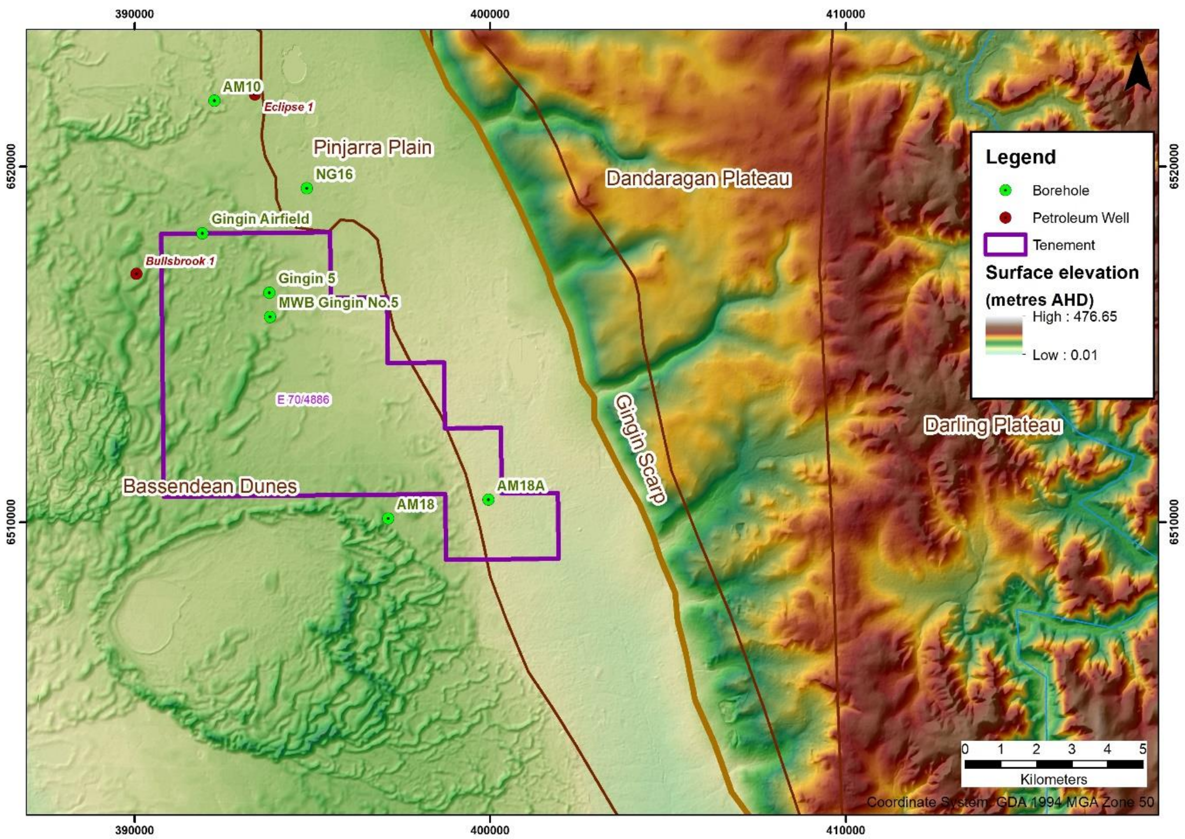

Figure 38: Physiography

11.6.2 Geology

Geology of the Project area is described in the hydrogeological reports 'Hydrogeology and groundwater resources of the Perth region, Western Australia' (Davidson, 1995) and 'Perth regional aquifer modelling system (PRAMS) model development: Hydrogeology and groundwater modelling' (Davidson and Yu, 2006). The report 'Northern Perth Basin: Geology, hydrogeology and groundwater resources' (Department of Water, 2017) is also relevant although its coverage extends south only to Gingin. In addition, geological data is available from several water bores in the area of the tenement obtained from the Department of Water and Environmental Regulation's website Water Information Reporting, and a couple of exploratory petroleum wells.

This area lies within the central Perth Basin, which contains a succession of Quaternary to Permian age deposits up to a total of approximately 12,000 m thick. A summary of the geological succession for the Quaternary to Middle Jurassic is provided in Table 35, which covers a depth to approximately 3,000 m that includes the Yarragadee Formation, Otorowiri Formation, Leederville Formation and Superficial Formations.

Yarragadee Formation

The Yarragadee Formation is present beneath the entire tenement area conformably below the Otorowiri Formation of the Parmelia Group. In the exploratory petroleum well Bullsbrook No.1 (Osborne et al., 1973) just west of the Project area, the Yarragadee Formation was 2,647 m thick, while it is 2,660 m thick in Eclipse No.1 (Thornton, 2003) 3.9 km north of the tenement. The Yarragadee Formation is a fluvial deposit consisting predominantly of weakly to moderately cemented sandstone, with interbedded siltstone, shale and claystone.

Four sub-units are identified within the Yarragadee Formation based on palynological ages and the lithological portions of sand compared with finer-grained sand, silt and clay (Department of Water, 2017). These are informally referred to as units A, B, C and D in ascending order. Units A and C are predominantly sand, while unit B contains approximately 50% siltstone and shale, and Unit D can comprise in excess of 80% fine-grained sediments.

In Bullsbrook No.1, Unit D extends to 1 095 m depth, which is highly argillaceous to about 300 m depth. Below this depth, it has a lithology dominated by fine to very coarse-grained sand, but contains abundant shale/claystone, siltstone and clayey sandstone through much of the interval as indicated by the downhole gamma-ray log. There is a greater portion of sandstone within Unit C below 1,095 m to 1,968 m in Bullsbrook No.1, while Unit B extends to 2 310 m and Unit A (base of Yarragadee Fm) to 2,807 m depth.

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Period	Epoch	Stratigraphy	Max Thickness (m)	Lithology
Quaternary	Pleistocene	Superficial Formations		
		Bassendean Sand	60	Sand, minor silt and clay
		Guildford Clay	?10	Clay, sandy clay and clayey sand
Neogene	Pliocene	Yoganup Formation	10	Sand
		Ascot Formation	20	Sand, clay and limestone
Cretaceous	Late	Coolyena Group		
		Poison Hill Greensand	14	Sandstone and clay, glauconitic
		Gingin Chalk	8	Chalk, sandy and glauconitic
		Molecap Greensand	43	Sandstone, glauconitic
	Early	Leederville Formation		
		Pinjar Member	70	Sandstone, siltstone and shale
		Wanneroo Member	250	Sandstone, with lesser siltstone and shale
		Mariginiup Member	130	Sandstone, siltstone and shale
		Parmelia Group		
		Carnac Formation	-	Shale/claystone, siltstone
Jurassic	Late	Jervoise Sandstone	-	Sandstone, clayey sandstone, siltstone and claystone
		Otorowiri Formation	120	Shale/claystone, siltstone, sandstone
	Late / Middle	Yarragadee Formation	2,700	Sandstone, clayey sandstone, siltstone and shale/claystone

Table 35: Stratigraphy in the Gingin Project area (Quaternary to Jurassic)

Parmelia Group

The Parmelia Group shallows and thins toward the western margin of the tenement, Figure 39, with the base elevation interpreted to go from below -700 m AHD in the south-east to above -200 m AHD in the north-west (Davidson, 1995; Davidson and Yu, 2006). In the Muchea area, potentially three formations comprise the Parmelia Group, which are in ascending order; Otorowiri Formation, Jervois Sandstone and Carnac Formation (Department of Water, 2017). Siltstone and shale are predominant within the Otorowiri and Carnac Formations, which contain minor thin beds of fine-grained sandstone, and are fluvial to lacustrine deposits. The Jervoise Sandstone (also referred to as the Parmelia Sandstone by Davidson and Yu (2006) comprises fluvial fine to coarse-grained feldspathic sand with some siltstone and shale beds. Sandstone is predominantly medium grained with a weak kaolinitic or siliceous cement.

Within the Project area, the Otorowiri Formation is potentially overlain unconformably by the Leederville Formation over the full area, although it is possible that areas of Jervoise Sandstone may be present. Petroleum exploration well Eclipse 1 located north of the tenement intersected all three formations, including; 113 m of Otorowiri Formation over 248 to 361 m depth, 83 m of Jervois Sandstone between 165 m and 248 m depth, which is overlain by the Carnac Formation possibly up to 70 m depth.

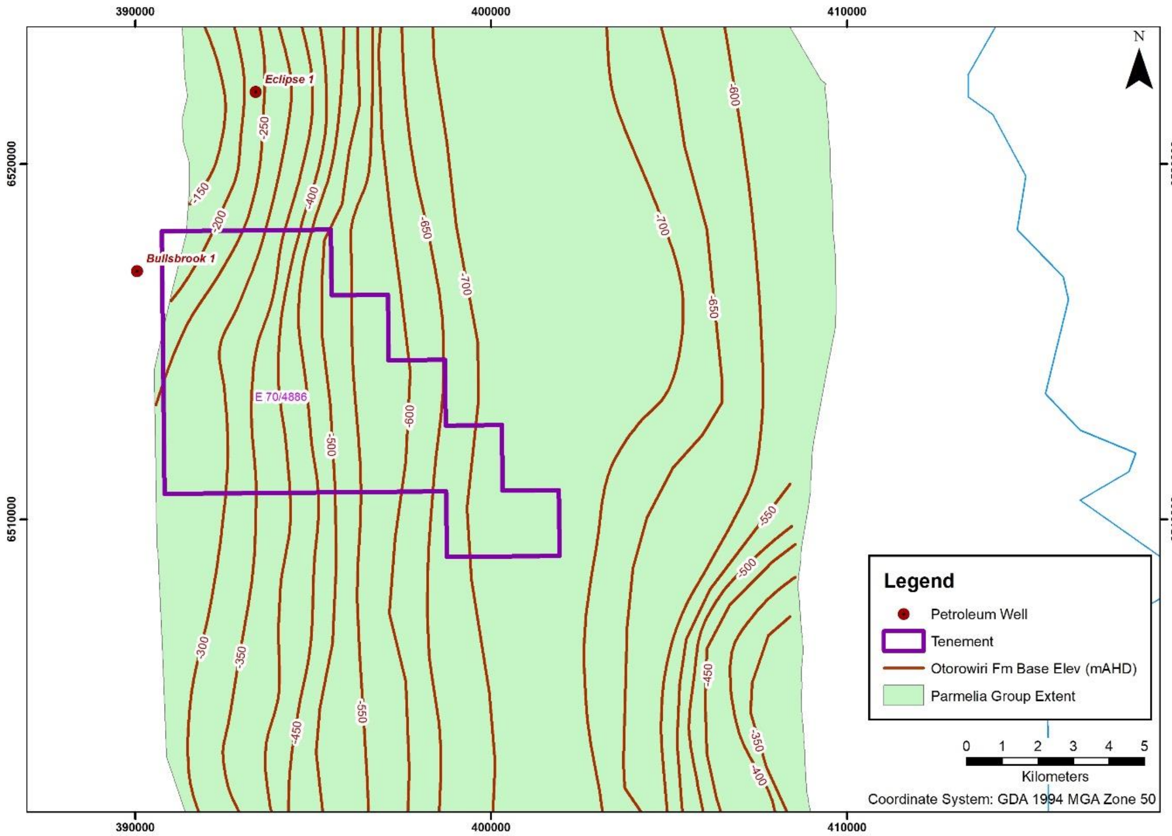

Figure 39: Extent and base elevation of the Parmelia Group Otorowiri Formation (after Davidson, 1995).

Leederville Formation

Leederville Formation is present beneath the entire Project area unconformably overlying the Parmelia Group. It was deposited in a fluvio-deltaic to shallow marine environment, comprising discontinuous, interbedded shale/claystone, siltstone, clayey sandstone and sandstone. The sandstone is weakly to moderately consolidated, fine-grained and fine to coarse-grained, coloured pale grey to grey.

Figure 40 shows the base elevation of the Leederville Formation, which is mapped as deepening from an elevation of -150 m AHD at the north-western portion of the tenement to about -500 m AHD at the south-eastern end. It has a maximum intersected thickness in the area of 388 m in AM18A in the south-east of the tenement.

Three member units are identified within the Leederville Formation, which are in ascending order; Mariginiup Member, Wanneroo Member and Pinjar Member. The Mariginiup Member is mostly fine-grained or fine to very coarse-grained sandstone with abundant clayey sandstone, claystone and siltstone beds. It is overlain by the Wanneroo Member which is mainly fine to very coarse-grained, weakly consolidated sandstone. At the top of the formation, the Pinjar Member consists of interbedded sandstone, siltstone and shale.

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The Mariginiup Member is present beneath the tenement, thinning from around 130 m in the SE to about 20 m in the NW. The Wanneroo Member is also present beneath the entire area, with a maximum thickness of about 250 m in the east which thins to about 150 m at the western margin. In monitoring bore AM18A, 222 m of the Wanneroo Member was intersected (Davidson, 1995). The Pinjar Member thins from a maximum thickness of about 70 m in the eastern portion, pinching out beneath the western part of the tenement. AM18A intersected a 41 m interval of Pinjar Member.

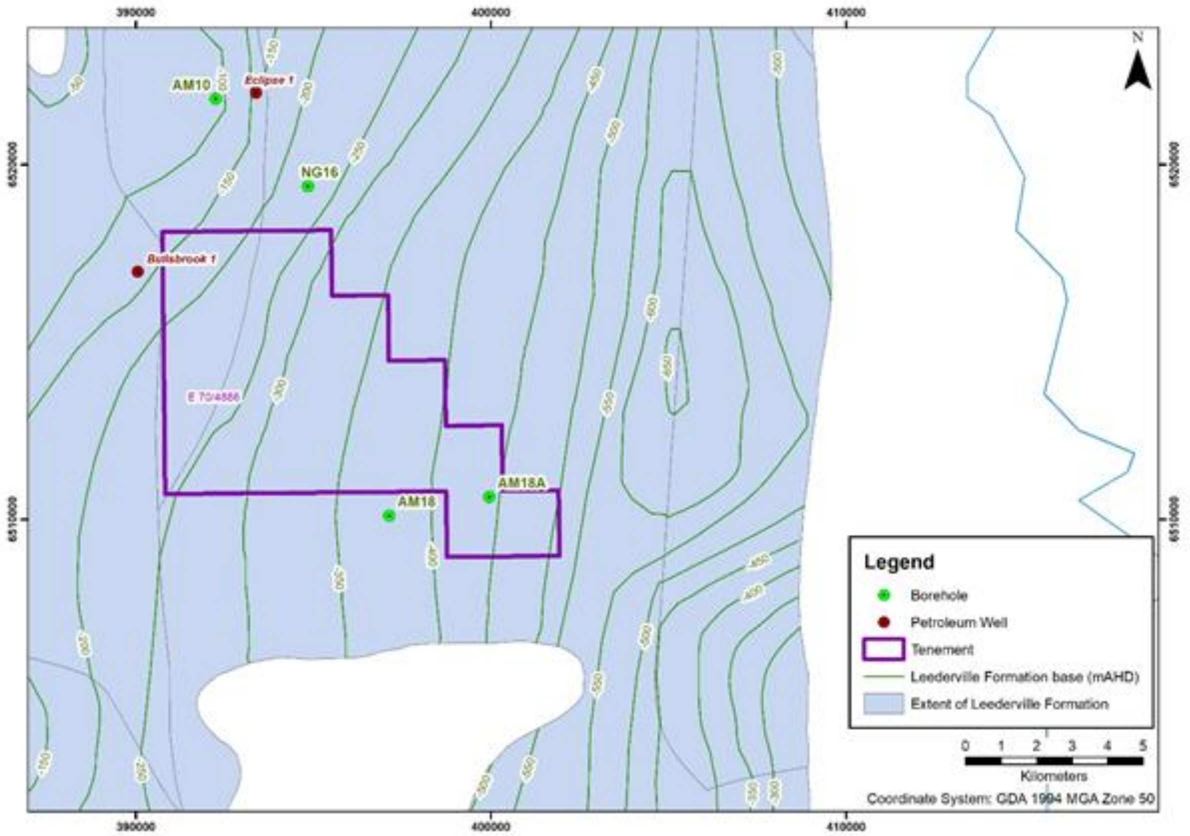

Figure 40: Extent and base elevation of the Leederville Formation
(after Davidson and Yu, 2006).

Coolyena Group

Late Cretaceous sediments belonging to the Coolyena Group are present sub-cropping the Superficial Formations about the south-eastern portion of the tenement. It comprises, in ascending order, the Molecap Greensand, Gingin Chalk and Poison Hill Greensand. The lithology is predominantly highly glauconitic clayey sandstone, with fossiliferous marine chalk present in the Gingin Chalk. It has a total intersected thickness of 65 m in AM18A, but the formations are absent within about 500 m west of the borehole.

Superficial Formations

The Swan Coastal Plain is underlain by a sequence of Quaternary and Pliocene sedimentary deposits, summarised in Table 35, that unconformably overlie a gentle, westward sloping erosional surface over the Leederville Formation, Figure 41. Base of Superficial Formations is at about 15 to 20 m AHD elevation on the tenement, with a thickness mostly around 50 to 60 m, but it thins to the eastern margin where it may be around 35 m.

The Superficial Formations comprise the Pliocene-aged Ascot Formation and Yoganup Formation, the overlying Bassendean Sand, and east of the tenement by the Guildford Formation.

The Ascot Formation consists of hard to friable calcarenite with coarse to medium grained sands, coloured dark grey with phosphate nodules present toward the base. It is 5 m thick (46 to 51 m) in NG16, and possibly present in Gingin 5OB below 45 m depth (45 to 59 m) and AM18 from 64 m (64 to 69 m).

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The Yoganup Formation comprises shoreline deposits of fine to coarse-grained quartz sand with minor clay and concentrations of heavy minerals, present extending westward of the Gingin Scarp. It possibly does not extend as far west as bores on the tenement with lithological logs.

Overlying the Ascot Formation is the Bassendean Sand, which is a shallow marine, shoreline and fluvial deposit of fine to medium and coarse-grained unconsolidated sand about 50 m thick. In AM18, 64 m of Bassendean Sand is present, with 45 m present in Gingin 5OB and 39 m in NG16.

Guildford Clay is present beneath the Pinjarra Plain and relatively thin intervals possibly extend into the eastern portion of the tenement where it may interfinger with the Bassendean Sand at the eastern limit of the Bassendean Dunes. It comprises clay and sandy clay with lenticular beds of very fine to coarse-grained sand but does not appear to be present within holes drilled in the central portion of the tenement.

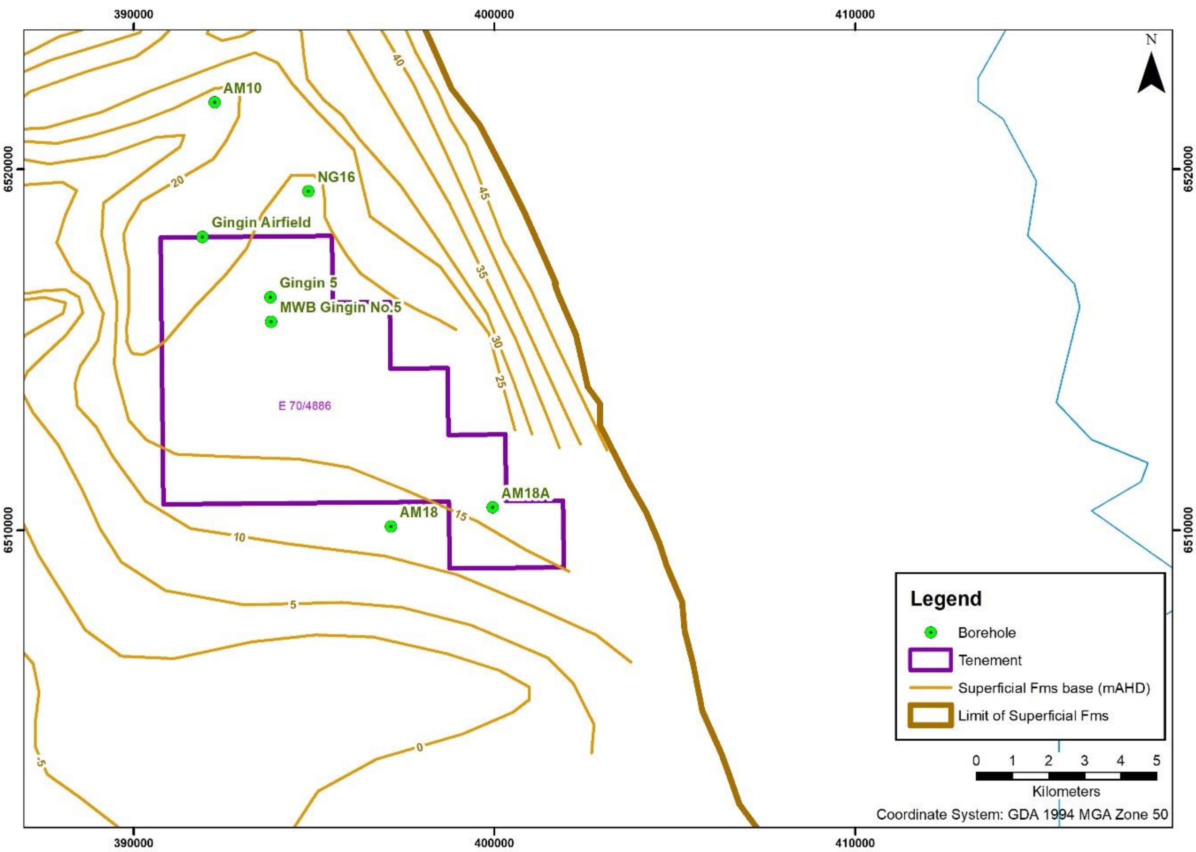

Figure 41: Extent and base elevation of the Superficial Formations (after Davidson, 1995).

11.6.3 Hydrogeology

Groundwater aquifers are formed by the Superficial Formations, Leederville Formation and Yarragadee Formation, which form the Superficial aquifer, Leederville aquifer and Yarragadee aquifer respectively. The Otorowiri Formation of the Parmelia Group forms an aquitard hydraulically separating the Leederville aquifer from the deeper Yarragadee aquifer in the tenement area. A schematic hydrostratigraphic profile is shown in Figure 42 which represents the anticipated succession of geological and aquifer units for the central portion of the Muchea tenement.

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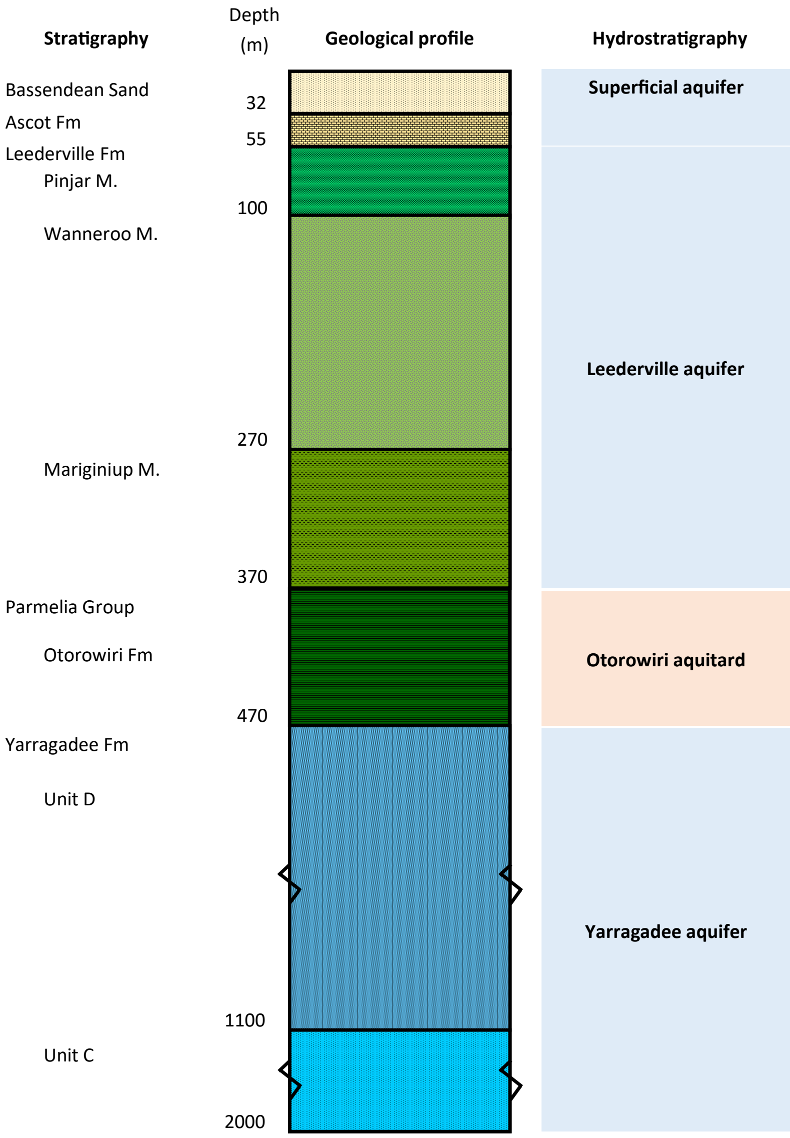

Figure 42: Schematic hydrostratigraphy representative of the central part of Muchea tenement E70/4886.

Superficial aquifer

The Bassendean Sand and Ascot Formation together form the main units of the Superficial aquifer beneath the tenement, which comprise a permeable, unconfined aquifer. Figure 43 shows the watertable elevation about the tenement, which is situated upon the crest of the Gnangara Mound. The watertable elevation is at about 60 m AHD beneath the tenement, which declines to the west and south-east of the tenement. There is a saturated aquifer thickness of about 40 m, with the watertable depth approximately 10 m below ground surface. Groundwater is recharged by the infiltration of rainfall, and flow is down the hydraulic gradient westward toward the coast and eastward to the Pinjarra Plain where it feeds into Ellen Brook.

Both Bassendean Sand and Ascot Formation are permeable units of the Superficial aquifer. The hydraulic conductivity can range between about 10 and 50 m/day (Davidson and Yu, 2006), with large bore yields possible from the aquifer of 1 000 to 2 000 kL/day. Guildford Clay in the eastern portion of the Superficial Formations is principally a low permeability clayey sand with a hydraulic conductivity possibly in the range of 0.4 to 1 m/day (Davidson, 1995).

Beneath most of the tenement, groundwater salinity within the Superficial aquifer is very low. It contains less than 250 mg/L Total Dissolved Solids (TDS) beneath the western portion, increasing to brackish levels of about 1 500 mg/L beneath the Pinjarra Plain. The distribution of groundwater salinity within the Superficial aquifer is shown by Figure 44, which is adapted from Davidson (1995).

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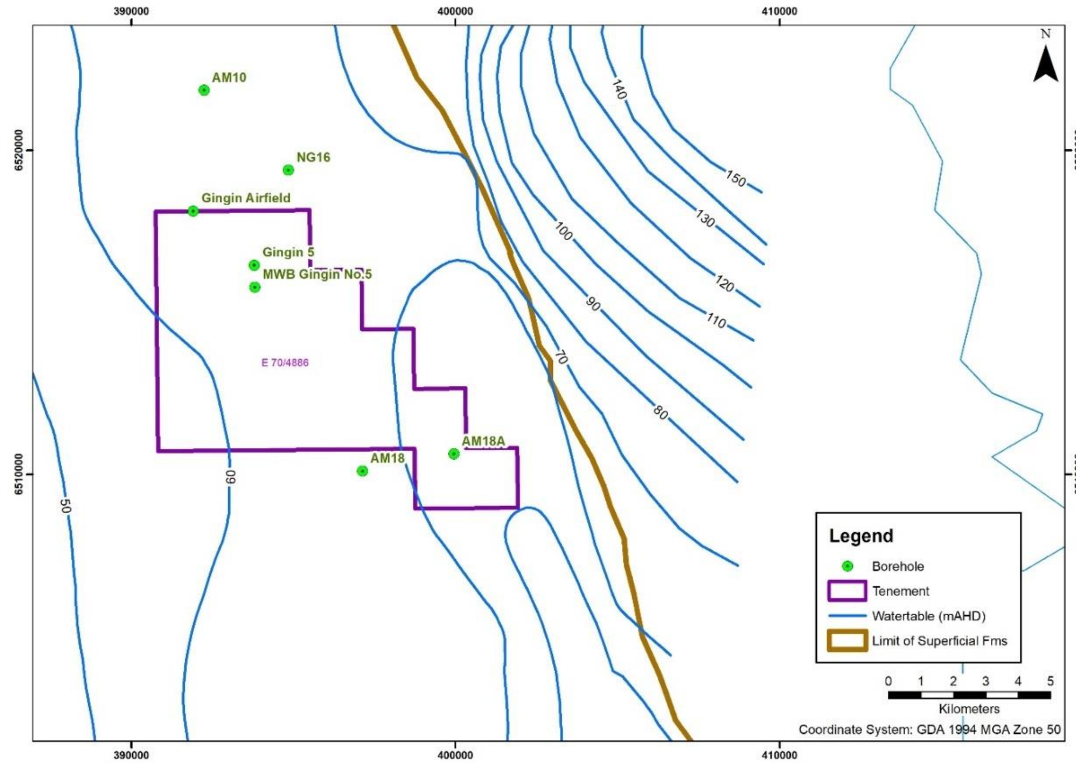

Figure 43: Watertable elevation.

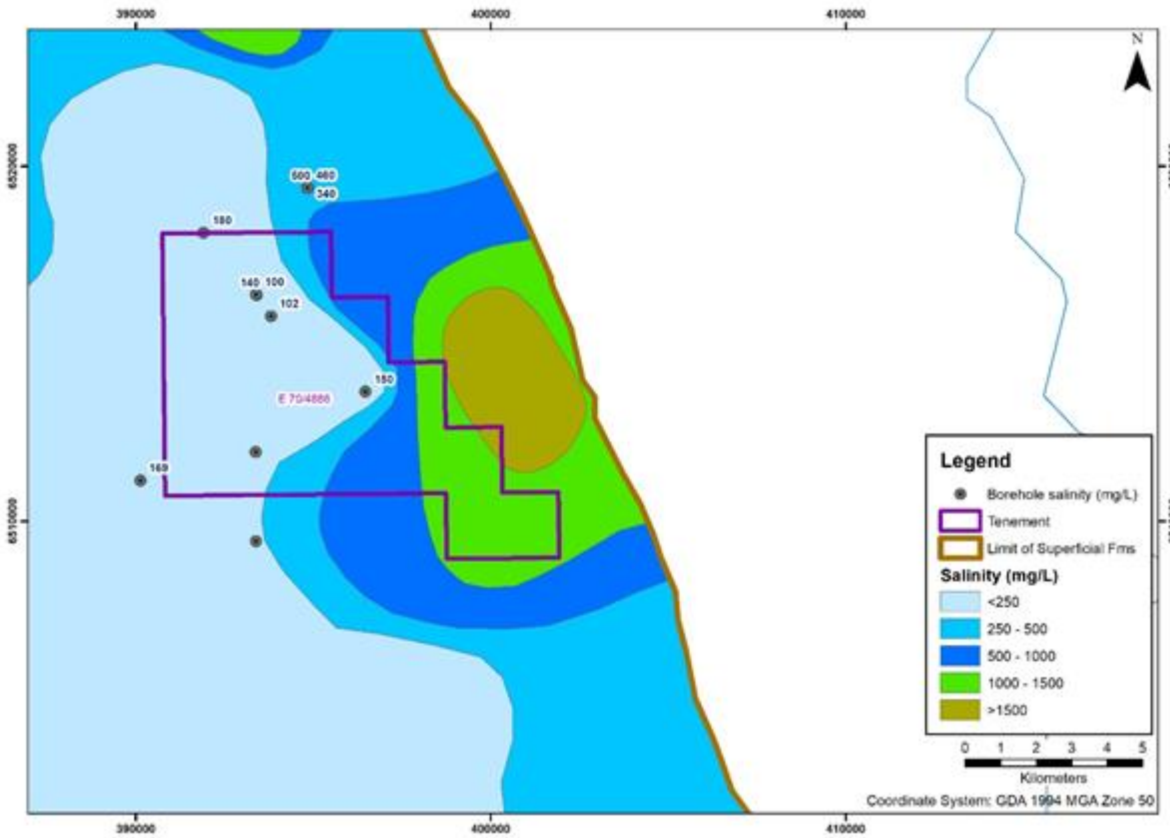

Figure 44: Groundwater salinity within the Superficial aquifer (after Davidson, 1995).

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Leederville aquifer

The Leederville aquifer comprises the three members of the Leederville Formation (Pinjar, Wanneroo and Mariginiup), while the Jervoise Sandstone may also be considered part of the aquifer where present directly below the Leederville Formation. Shale/claystone beds confine the aquifer. The thickest and most permeable portion of the aquifer is made up by the Wanneroo Member, from which bore yields of several thousand kilolitres per day are possible. Sandstone intervals are likely to have an average hydraulic conductivity of around 10 to 20 m/day (Davidson, 1995; Department of Water, 2017). However, the more clayey and silty Pinjar and Mariginiup Members will have a significantly lower permeability, with an average hydraulic conductivity probably less than 1 m/day, while the Jervoise Sandstone is less than 2 m/day (Davidson and Yu, 2006).

Groundwater is recharged to the aquifer over the Dandaragan Plateau, and by downward leakage from the Superficial aquifer over the coastal plain. Groundwater flow within the aquifer passes south-southwest from beneath the Dandaragan Plateau. The potentiometric head declines from about 50 m AHD to 40 m AHD across the tenement.

Groundwater in the Leederville aquifer has a salinity of less than 500 mg/L TDS within the upper portion, but this increases to around 1,000 mg/L through the lower part. In AM18, groundwater salinity is less than 500 mg/L to 210 m depth, then increases close to 1,000 mg/L about the base of the aquifer. NG16A contains groundwater with 340 mg/L TDS at the very top of the Leederville aquifer, and AM10, 3.7 km north of the tenement, yielded water with a salinity of 230 mg/L in upper portion of the aquifer.

Yarragadee aquifer

A major regional aquifer extending over the central to northern Perth Basin is contained within the Yarragadee Formation, which is confined below the Otorowiri Formation or Leederville Formation in this part of the basin. It is a permeable aquifer, with an average value for hydraulic conductivity of about 12 m/day found from a large number of pumping tests throughout the central – northern Perth Basin (Department of Water, 2017). The higher clay content of Unit D results in a much lower permeability through this portion of the aquifer, which has an average hydraulic conductivity of 0.7 m/day determined in the Cataby area (Department of Water, 2017).

Large yields of up to 6 000 kL/day are possible from water production bores screened over thick sand intervals (Johnson and Commander, 2006). Bore yields are likely to be significantly less from Unit D, which is present beneath the tenement extending to in excess of 1,000 m depth.

Groundwater recharge to the Yarragadee aquifer is by downward leakage from the overlying Superficial aquifer beneath the Yeal Nature Reserve west of Gingin, and via flow from the Leederville – Parmelia aquifer emerging from the Dandaragan Plateau, although this probably does not occur until west of the Otorowiri Formation extent (west of the tenement). There is direct infiltration of rainfall over the Arrowsmith Region north of Cataby (from 100 km N-NW of tenement) where the Yarragadee Formation outcrops, although this water probably does not flow south to the Muchea area. Groundwater flow is southward within the Yarragadee aquifer, with a potentiometric head of around 40 m AHD beneath the tenement.

Groundwater within the Yarragadee aquifer beneath the tenement is brackish, decreasing from around 3,000 mg/L about the eastern portion, to less than 1,000 mg/L at the western end (based on mapping by Davidson, 1995). There is a general increase in salinity with depth, at least below about 1,500 m depth as seen in Bullsbrook 1. Potentially groundwater salinity may decrease downward passing from Unit D into the upper portion of Unit C, before increasing again down through Unit C. In AM10, groundwater was found to contain 1,620 mg/L TDS from the upper portion of the aquifer (286 – 291 m depth).

11.6.4 Development constraints

The Department of Water and Environmental Regulation were contacted to provide advice on water availability and development considerations for proposed sand mining applications in the groundwater protection area. Below are the key aspects for consideration and discussion in moving forward with the project.

11.6.5 Water quality protection

The most significant constraint to groundwater abstraction in the Muchea Project area is the Gnangara Mound, which contains substantial fresh groundwater resources and provides a large portion of the water supply for Perth. In order to protect these groundwater resources, the Department of Water and Environmental Regulation have proclaimed groundwater protection areas that cover the most sensitive parts of the groundwater system.

The highest level of groundwater protection has a P1 classification, which reduces down to P2 and P3 protection areas in less critical and sensitive areas. Figure 45 shows the groundwater protection area for the eastern part of the Gnangara Mound and highlights there is a reasonable amount of the tenement area covered by the P1 groundwater protection area (shown in orange). Most of the area is classified as P1, except for a few small areas on the edge of the GPA which are P2 (pale brown; 15, 21, 11a, 20).

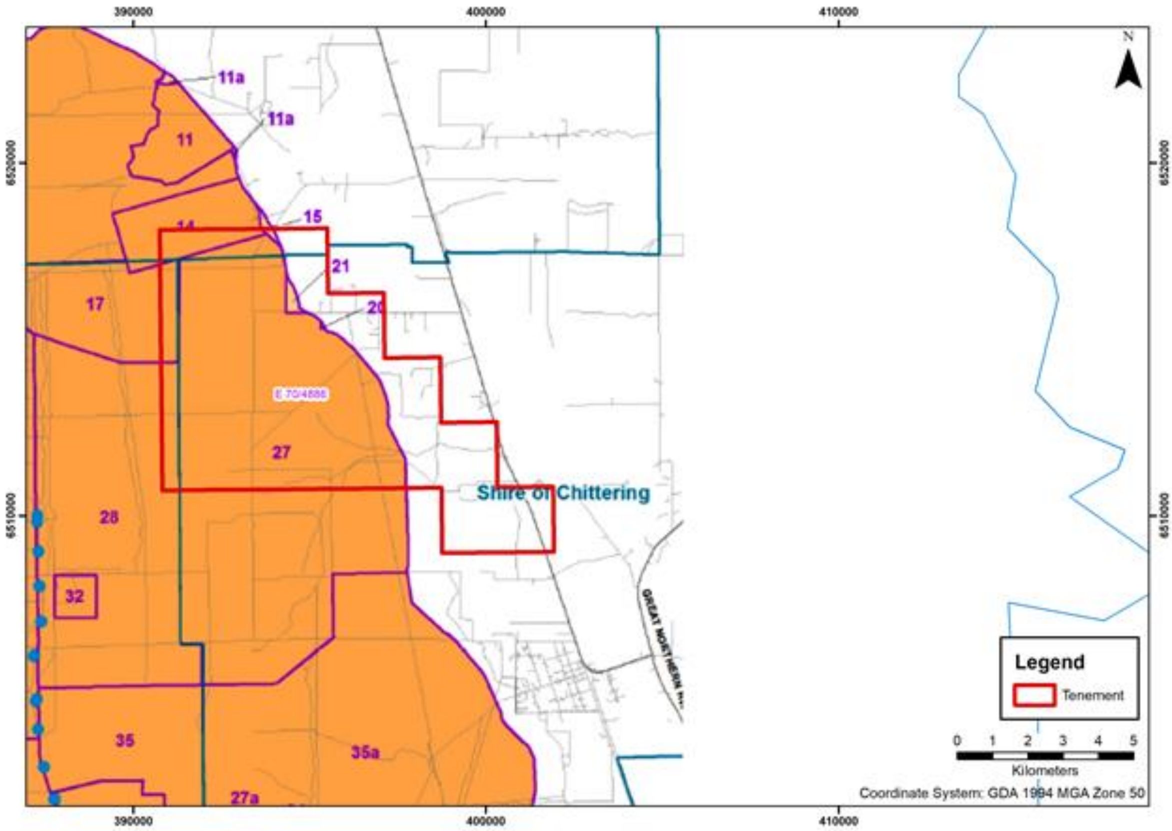

Figure 45: Groundwater protection area for tenement.

In accordance with Water Quality Protection Note No. 25 - Land use compatibility tables for public drinking water source areas (DWER, 2016) sand mining is compatible with conditions in a P1 area. As such, sand mining is generally considered to be appropriate provided best management practices are used and any approval conditions imposed by the decision-making authority are met.

In advising the DMIRS, the DWER supports exploration subject to the following;

- No ground disturbing activities are to occur within Well Head Protection Zones - the tenement is east of any Well Head Protection Zones so this condition can be met.
- In the absence of an approved Water Management Plan or Fuel Management Plan, there should be no fuel storage or refuelling within the P1 area. This can be managed as any fuel storage can be located outside of the P1 area.
- Drilling should be conducted in accordance with Minimum construction requirements for water bores in Australia (National Uniform Drillers Licensing Committee, 2012) to prevent contamination of the public drinking water source. This is a standard practice and may involve grouting, gravel-packing or backfilling exploration holes – this should be discussed and agreed with DWER.

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- In accordance with Guidelines for protection of surface and groundwater resources during exploration (Department of Mines and Petroleum, 2002) adequate decommissioning of bores is required to prevent contamination of the water source. This is a standard practice and may involve grouting, gravel-packing or backfilling exploration holes – this should be discussed and agreed with DWER.

In terms of the future mining proposal, DWER recommends that a Water Management Plan (WMP) is prepared. The WMP must include, but not be limited to; groundwater levels, depth of excavation / clearance above water table (a minimum of 3 meters from the Year 2000 maximum groundwater levels is required in the Gnangara Groundwater Area), water requirements and supply, fuel and chemical management, stormwater management, wastewater management, pre and post development monitoring, site closure and rehabilitation.

The WMP should be prepared in accordance with relevant DWER Water Quality Protection Notes (WQPN) and guidelines including;

- Statewide policy no. 1: Policy and guidelines for construction and silica sand mining in public drinking water source areas (updated January 2018)
- WQPN 10: Contaminant spills – emergency response
- WQPN 15: Extractive industries near sensitive water resources
- WQPN 25: Land use compatibility tables for public drinking water source areas
- WQPN 56: Tanks for fuel and chemical storage near sensitive water resources
- WQPN 65: Toxic and hazardous substances
- WQPN 84: Rehabilitation of disturbed land in PDWSAs
- Water Quality Protection Guidelines for Mining and Mineral Processing (No. 1 – 11)

It is likely that DMIRS will generally condition the Mining Proposal approval with a condition for a Water Management Plan. The development of a WMP will need to be discussed with Preston Consulting as to the best approach for its development and submission.

11.6.6 Sand mining excavation depth

As part of the Water Management Plan, it will be necessary to demonstrate that depth of excavation or clearance above watertable will be a minimum of 3 meters from the Year 2000 maximum groundwater level. The AHD of the watertable in the superficial aquifer in 2000 was about 64 m AHD in the north towards the airfield and about 61.5 m AHD in the central / southern portion.

Bore hydrographs are shown in Figures 46 to 48 for three monitoring bores in the area – GG5 (6516373mN, 393411mE), GC20 (6513302mN, 393410mE) and PM2 (6511955mN, 393388mE). In all cases, the depth to watertable in 2000 is more than 14 m bgl, hence, any sand extraction would have to be limited to about 11m bgl.

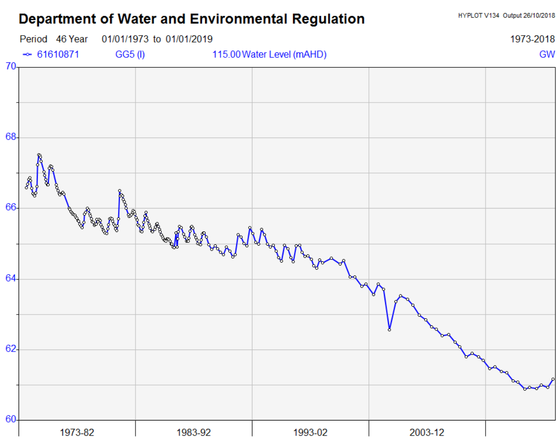

Figure 46: Bore hydrograph for GG5(I)

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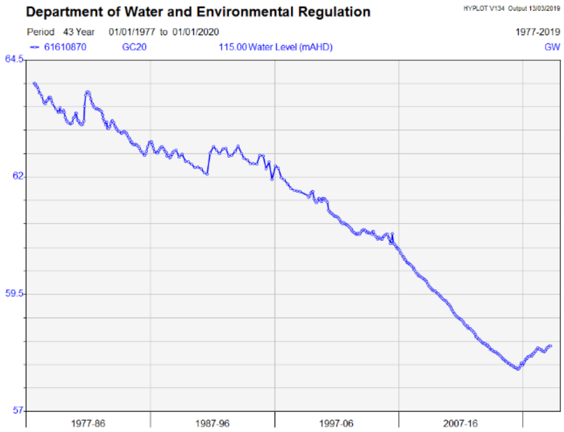

Figure 47: Bore hydrograph for GC20

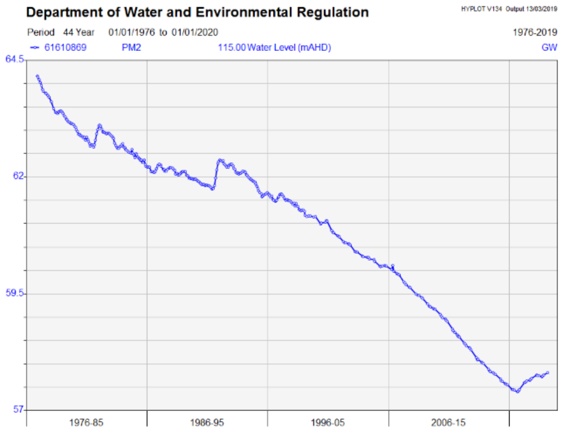

Figure 48: Bore hydrograph for PM2

11.6.7 Water availability

Access to the Leederville and Yarragadee aquifers is limited to only 50ML/yr and only under extenuating circumstances, as outlined in the Policy on accessing the Leederville and Yarragadee aquifers in Perth (Department of Water, 2006). Even though the Water Register suggests that there is water available from the Leederville and Yarragadee groundwater resources, it is all assigned to Public Water Reserve (**PWR**) and is not available for general licensing. Temporary access to the PWR is managed under Operational policy 5.01 - Managing water reserved for use by drinking water service providers.

As such, it will be necessary to consider groundwater options in the Gingin Groundwater Area to the east of the tenement. All aquifers in the Gingin Groundwater Area are fully allocated; hence, there is no available allocation and there will be need for either groundwater trading and/or land acquisition with a groundwater entitlement. Some form of land acquisition will be required and will need to be further assessed.

11.6.8 Conveyance of groundwater resources

The only option to access processing water within the tenement area will be water conveyance from the Gingin Groundwater Area into the eastern portion of the tenement area (east of the P1 protection area). If this is not possible, it will be necessary for the development of a processing facility outside the Gnangara Groundwater Area.

Any conveyance of groundwater resources into the Gnangara Groundwater Area will require a comprehensive impact assessment. The risk in the eastern portion of the tenement outside of the P1 area will be low and may be manageable. Inside the P1 area, the high-quality (ie low salinity) of groundwater will require considerable assessment and will be considered by DWER as a high risk of contaminating the groundwater resource.

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11.7 Social factors

11.7.1 Population Centres

The nearest population centres are Muchea and Gingin, which are approximatley 12km and 14km, respectively, from the Project via Brand Highway. The nearest inhabitants are more than 500m from the boundaries of the Project area.

The Company will source labour requirements from these two population centres.

11.7.2 Land Ownership and Use

The entire project is located on vacant, unallocated Crown Land.

The Company has a Mining Lease application (MLA70/1390) which is wholey within granted Exploration License E70/4886. The Mining Lease application and Exploration Licenses are held by Wisecat Pty Ltd a 100% owned subsidiary of VRX.

The Project area is predominately native vegetation but with cleared tracks used by a variety of stakeholders. The Company has been able to use these tracks to access areas for exploration and sampling.

11.7.3 Socio-economic Context

The project can provide significant benefits to the State through very long-term employment and Royalties and locally provide employment and contract opportunities.

The Project will also use the under-utilised rail system and potentially significantly increase exports through the Kwinana Bulk Terminal.

11.7.4 Potential Development

Once the Project has reached an expected production rate and quality of final product the Company can consider further downstream processing of silica sand in to glass products.

Any further processing will have to consider the logistics of transporting both raw material and final products and the economic imperative of supplying a potential domestic and international market.

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12 Project Implementation

12.1 Staged Construction

The Project will have two stages of construction. Initially the Project will require the construction of the processing facility and the remote feeder station. Mining will initially include an excavation and trucking component to remove up to 2 million tonnes of sand to establish a level route corridor for the ultimate conveyor system.

Implementation of the Project in 2 stages will minimise upfront capital costs and enter the market in a more sustainable and less disruptive Manner.

This staged approach will support the planned ramp up of production as the plant will initially operate for up to 2 years at 1 million tonnes per year as the project allows for silica sand products to be introduced to the glass making and foundry industries in Asia before maximising production at 2 million tonnes per year.

12.2 Implementation Plan

The Company will complete detailed mining and processing scheduling before commencing construction of the processing plant. Fortunately, the scheduling detail is made significantly simpler due to the consistency of the ore source which will also reflect in the consistent quality of the final products.

The Implementation plan for the Project will depend on:

- Final approvals for mining
- Final offtake contract for at least 1 million tonnes per year
- Definitive Feasibility Study
- Financing of construction and working capital
- Construction
- Commencement of mining and processing

12.3 Contracting Strategy

The Company will own, operate and maintain the feeder station, processing operations and manage the project operations.

The Company will however contract the supply of mining and power supply equipment.

12.4 Early Engineering

The Company has undertaken preliminary engineering within 10% capital cost estimates and power requirements for the processing plant (CDE Global) and the feeder and trommel stations, pumping and conveyor system (ProjX).

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The processing plant is designed for 300 tonnes per hour throughput (2 million tonnes per year) and will produce up to 3 separate silica sand products.

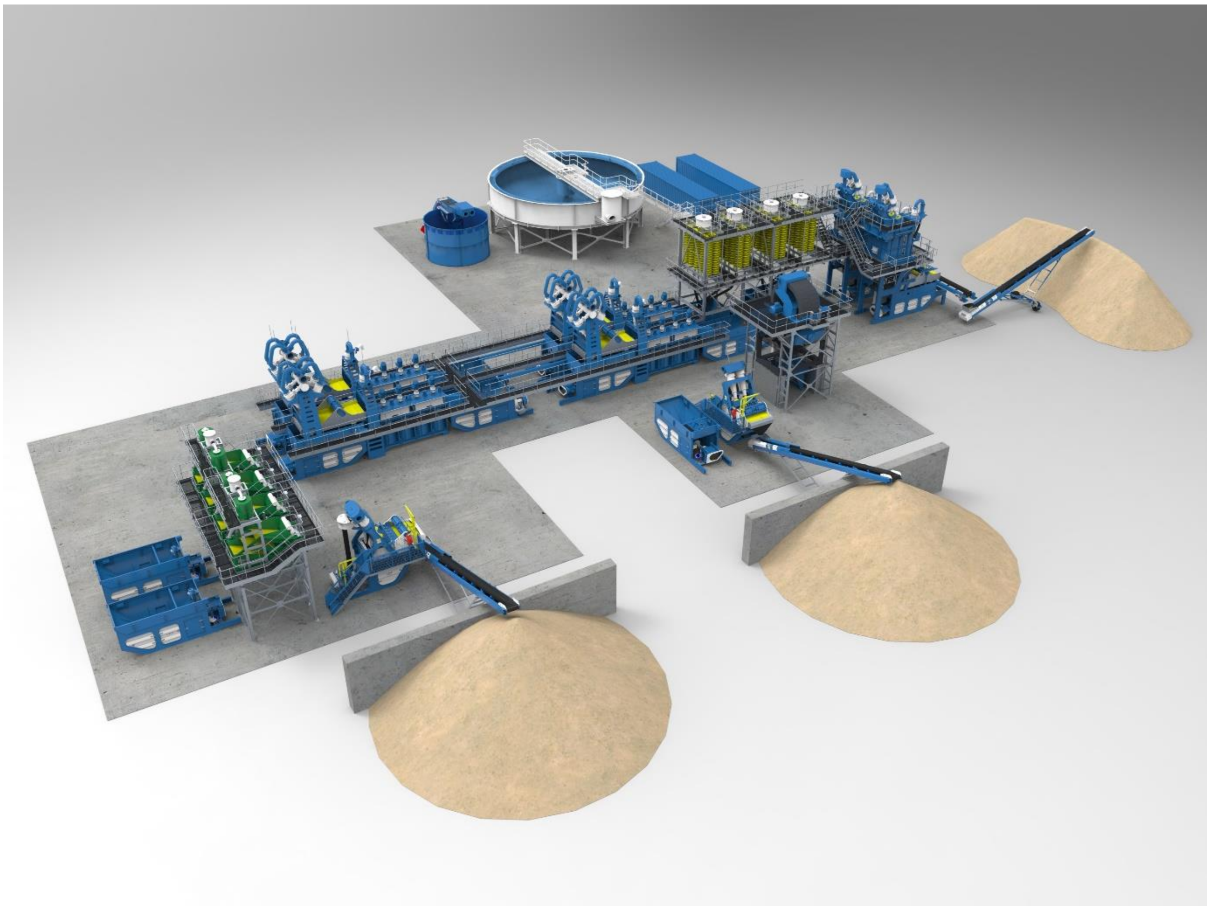

Figure 49: Processing Plant General Arrangement

The feeder station will take ore feed from a front end loader, with a conveyor to transport feed to a trommel which will screen feed to 3 mm before pumping to the processing plant.

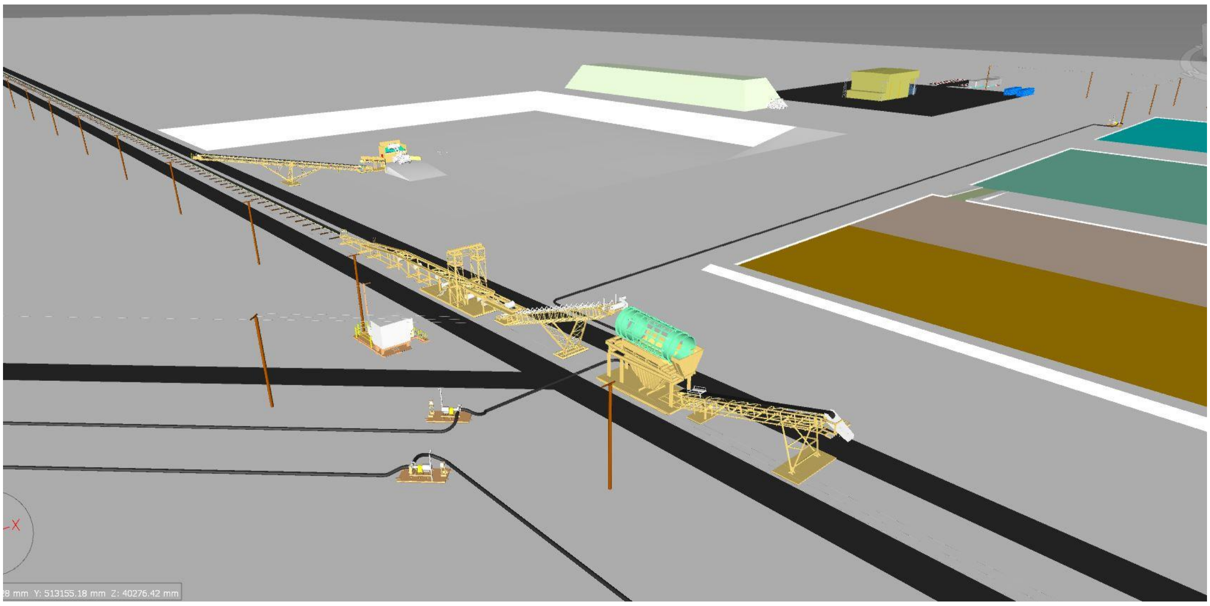

Figure 50: Feeder and Trommel Arrangement

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12.5 Detailed Engineering

The Company will undertake detailed engineering to confirm final designs before construction. Detailed engineering will commence following a final Board decision and will complete the critical path associated with the timely construction of the Project.

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13 Operational Readiness

VRX will develop a comprehensive risk-based program to ensure VRX has the requisite capability and systems to operate the Muchea project successfully from day one.

This approach will commence with a thorough enterprise-wide risk assessment and identification of the standards, controls and systems which will be required to mitigate these risks through the life of the operation. The outcome is an intellectual architecture comprising of well thought, thorough and effective operating systems, which will be designed to ensure operational readiness and logical prioritisation of the project's many moving parts.

The process will be detailed and involve a higher level of operational systems design than is typically undertaken by single asset sponsors for new projects of this scale. This is done primarily due to the high bar of performance that VRX has set for the project and the strong business imperative to have the asset predominantly run and operated by persons living locally. In addition, VRX recognizes that the bulk silica sand mining industry is an emerging industry in WA and thus has fewer established practices and less depth of expertise than is typical in other sectors of the mining industry.

The key aims of this approach are:

- To rigorously and effectively manage the project execution and the project start up and ramp-up to full capacity, thereby avoiding operational start-up dip.
- To align the Company with ISO 9000 quality compliance through effective controls and management of those controls governing product quality.
- To control the scope of roles within the Company and to manage the amount of discretion that people have in their roles so that they are positioned to focus on the project outcomes.
- To facilitate role clarity and enabling effective decision making, successful team work, and accountability.
- To achieve the Company's vision of being "a globally significant silica sand producer, who is recognised for our great quality of products produced safely and ethically".
- To achieve the Company's planned localisation targets and strategy, which will provide sustainable business opportunities and jobs for locals, and a sense of ownership of the asset within the district.
- To minimise the dependence on expensive contracting resources.
- To drive safety, productivity and product quality through an in-built and inherent business improvement mindset.
- To enable the most efficient management of the asset in a global market, with all the inherent challenges involved in managing markets and cultures.

13.1 Company Values

A set of company values has been firmly established within VRX that will underpin the operational strategy of the Company.

Safety: All of us have an equal right to go home safely.

Team Work: We achieve superior results by working together.

Accountability: We are accountable to our family, our community and our colleagues – do them proud, give it your best.

Respect: We are a diverse organisation who respect each other.

Stakeholders: Our stakeholders measure our success – our customers, our investors and our community all have expectations of us.

13.2 Operational Strategy

VRX is staffed by experienced mining and mineral industry veterans. Our experienced team has a clear opportunity to provide a fresh approach to operations of a Western Australian Silica Sand mining and processing facility, and a global marketing function, with best operating and management practice supported by an Australian (Perth) head office governance team.

The Muchea mine and processing facility will be operated by a predominantly local workforce and an experienced leadership team. This strategy will create a high level of government and local community support.

To ensure the Project is run safely and will reliably produce an on-specification product at nameplate capacity and cost from day one, a robust suite of management systems and operating standards will be developed jointly by an early recruited leadership team and the Perth head office, and will be implemented during commissioning.

Capable local operational staff will be recruited with sufficient lead time to be fully trained in the operation of mine and plant with emphasis on the key controls and expectations by which their performance will be measured.

There will be early recruitment of key management and technical roles for the express purpose of developing and implementing the management systems, and then training the operating staff in the lead up to operations.

The design of the organisation structure and operational systems will be fit for purpose striking the right balance between the required level of governance and operating efficiency which will ensure sustained performance of safe, efficient, on specification operational delivery through the life of the project.

13.3 Risk Based Approach

An operational readiness will be developed using a strong risk-based approach. The lesson from other projects is that where there is a failure to fully understand and prepare for operational risks early, projects are exposed to significant value loss arising from production shortfall, out of specification product, and cost increases, collectively referred to as "start-up dip". In addition, there is often a high level of safety and environment incidents.

Project risk workshops identify the following key project risks:

- failure to achieve project financing
- failure to achieve project permitting and land compensation arrangements
- project cost overrun or delay resulting in significant dilution of value for existing shareholders
- excessive working capital requirements for the project and possible loss of market niche for VRX's high value silica sand products, due to:
  - inadequate orebody knowledge or unexpected complexity
  - inadequate operational preparedness and capability resulting in out of specification product
  - product logistics delays
  - sales and marketing issues - production issues
- loss of government or community support for the project
- health, safety and environmental (HSE) risks.

These risks will be captured in a detailed risk register. The approach will be to prepare mitigation strategies accordingly.

Risk controls will be identified for all risks, comprising:

- mitigation actions to be completed prior to commencement of operations
- operational standards and management systems which will govern operations and mitigate risks through the life of the project.

Risk mitigation actions include:

- Specific studies to ensure full anticipation of technical, quality, reliability and environmental issues.

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- Engagement of specialist consultants to advise on critical technical, marketing and government and community aspects of the project.
- Design reviews to ensure engineering controls are included in plant design.
- Specific obligations to include in third-party contracts that will be critical to safety, environment, production and product quality.
- Definition of infrastructure upgrades and government co-commitments.
- Establishment of project control for construction management.
- Planned and targeted early recruitment and training.

On-going control of risk through the life of the operation will be through effective implementation of standards and management systems.

In particular, the controls for HSE risks will be documented in a set of HSE standards and systems which collectively define the Health, Safety and Environment Management System (HSEMS) for the project. The HSEMS, consists of a set of Health and Safety standards, Environment standards, and systems which are critical to effective HSE management. This will provide a comprehensive risk management framework for the project.

13.4 Development of Operational Readiness Plan

Risk mitigation actions will be prioritised and sequenced into a comprehensive work plan for operational readiness. The work plan will also include completion of the design of standards and systems in a prioritised way and implementing these as required for the project construction phase and for the operations phase of the project.

The operational readiness project plan will have clear links to the financing, permitting, and construction project plans.

13.5 Implementation of Operational Readiness Plan

The operational readiness plan will be implemented by an early recruited operations team, supported by expert consultants where required, and with a Project Management Office (PMO) function to track and report on status throughout. The recruitment schedule is aligned with the operational readiness plan to ensure timely implementation of key roles to complete the work plan tasks. The clear remit of early recruited roles will be to build the organisational systems and to have their teams fully operationally-ready at start of operation.

A readiness methodology will be used to support key aspects of the implementation including coaching and training on standards and systems design, access to a comprehensive library of checklists and requirements from equivalent operations design, and executive leadership advice where required.

There is a close relationship between the operational readiness plan and the human resources strategy for the project. In particular, the design of the standards and systems will provide clear role clarity for all operations positions. The training and development of personnel recruited into leadership roles will include training in standards and systems design methodology and in the style of leadership required of VRX managers at all levels to ensure that the management systems are effectively utilised.

14 Human Resources

Where possible the Company will source employees from the local communities of Gingin and Muchea.

The skills required to operate this type of mining equipment and processing are well represented within the Western Australian mining industry personnel.

The Company will operate and maintain the feeder and processing equipment but contract the power generating equipment and mining operations equipment and relevant personnel.

Where possible the Company will preferentially offer opportunities to local Indigenous operators.

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15 Operating Cost Estimate

Operating costs have been determined from either first principles or contract budget submissions and estimates and estimated on 1 million tonnes per year throughput, with expected unit cost savings if throughput is increased as anticipated to potentially 2 million tonnes per year.

Operating costs are divided amongst the follow categories of expenditure:

- administration
- mining
- processing
- product handling, and
- royalties and marketing.

15.1 Administration

Administration costs are estimated on adequate site management with a project manager and deputy, two vehicles, site services including offices and ablutions, lease rents and rates and site insurances.

Total costs estimated at an average A$0.47 per tonne processed.

15.2 Mining

Section 6 sets out the unique and flexible mining and rehabilitation method proposed for the Project to maximise production and the recovery of rehabilitated mined areas.

For the first 3 years the equipment list will be 1 dozer with a scythe ripper, interchangeable front mounted mulcher or push blade, 4 front end loaders (**FEL**), one with a modified bucket to be used in the rehabilitation process for sod recovery and replacement, one to be used in excavation from a working face to 2 x 6 wheel drive 20 tonne articulated trucks and 1 FEL to load from a stockpile to a feeder trommel.

This fleet will operate for 12 hours per day at a rate of up to 1 million tonnes per year until an adequate level route is established with a continuous 15 m high and 1.5 km long operating face and a caterpillar type feeder conveyor is installed. This will take up to 3 years and excavate 3 million tonnes of material. This will eliminate the requirement for the 2 trucks and 1 FEL.

The reduced fleet can increase operating times to 24 hours per day to increase the throughput to 2 million tonnes per year.

A water cart may be required during the hotter months if any dust is generated.

Production and cost estimates are based on budget wet hire contract rates and estimated operating times for each piece of equipment as required. Labour, fuel and maintenance costs are included in the contract rates.

Total costs estimated at an average A$3.99 per tonne processed.

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15.3 Processing

Figure 51 illustrates the proposed processing circuit for the Project.

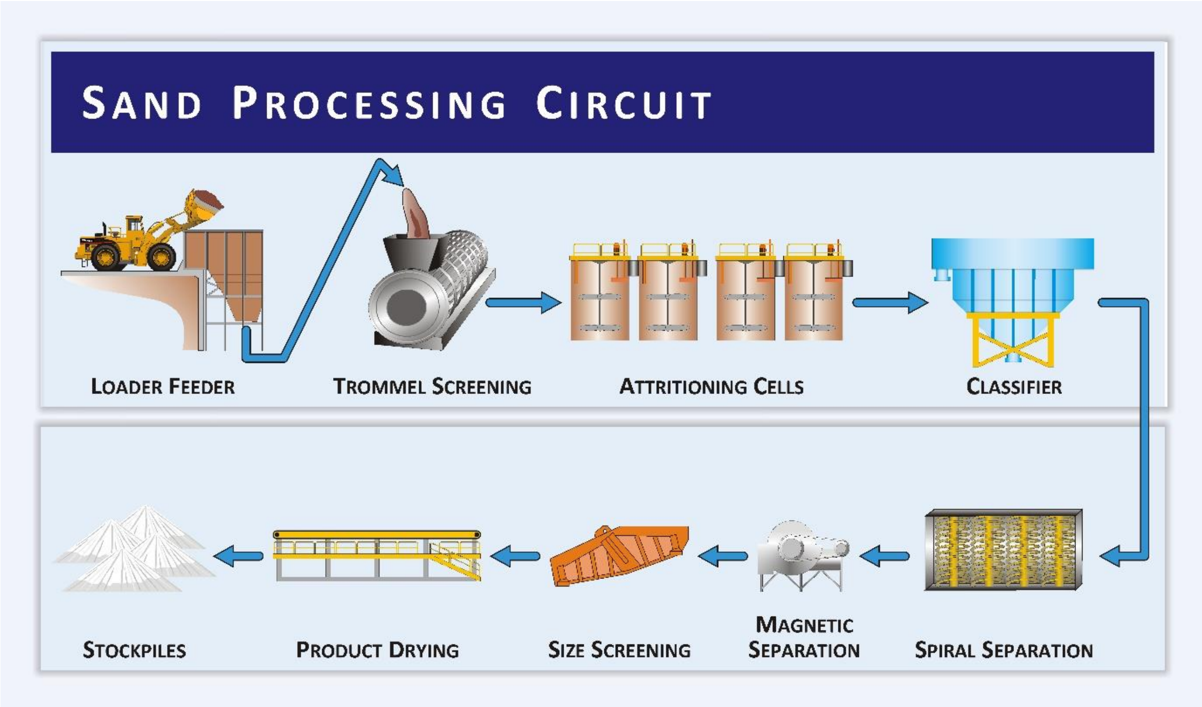

Figure 51: Sand Processing Circuit

Processing barrier limits include the initial production feeder that transfers to the rotating drum trommel screen which in turn will screen organic material from the ore feed and add water to a slurry feed of 30% by weight.

Costs include the power and water required to pump the slurry to the processing plant and the plant operations. These costs are based on engineering power and water estimated requirements and industry standard unit costs. Further engineering estimates are used for the maintenance requirements for all the processing equipment but generally based on 5% of the initial capital cost per year.

Costs also include labour costs of processing and maintenance personnel.

Overall this type of processing is very similar to the mineral sands wet concentrators with well-established maintenance schedules and routines in Western Australia.

Total costs estimated at an average A$7.49 per tonne processed.

15.4 Product Handling

15.4.1 Estimated Costs

Product handling costs include the loading of rail cars, rail transportation to the Kwinana Bulk Terminal and handing costs for ship loading. Sales prices are based on FOB Incoterms on the basis of a loaded ship (see Section 15.4.2 for further information).

Estimated costs are based on multiple submitted contract rates for rail and port operations.

Total costs estimated at A$19.10 per tonne processed.

15.4.2 Incoterms

International commercial trading terms are referred to as "Incoterms" and relate to the point at which ownership changes hands. They inform the parties what to do with respect to carriage of the goods from buyer to seller. They also explain the division of costs and risks between the parties.

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Typical terms are:

FOB - Free On Board

This term means that the seller delivers when the goods pass the ship's rail at the named port of shipment. This means the buyer has to bear all costs and risks to the goods from that point. The seller must clear the goods for export. This term can only be used for sea transport.

CFR - Cost and Freight

This term means the seller delivers when the goods pass the ship's rail in the port of shipment. The seller must pay the costs and freight necessary to bring the goods to the named port of destination, but the risk of loss or damage, as well as any additional costs due to events occurring after the time of delivery, are transferred from seller to buyer. The seller must clear goods for export. This term can only be used for sea transport.

CIF - Cost, Insurance, Freight

The seller delivers when the goods pass the ship's rail in the port of shipment. The seller must pay the cost and freight necessary to bring goods to named port of destination. Risk of loss and damage is the same as CFR. The seller also has to procure marine insurance against the buyer's risk of loss/damage during the carriage. The seller must clear the goods for export. This term can only be used for sea transport.

CIP - Carriage and Insurance Paid

This term means that the seller delivers the goods to the carrier nominated by them but the seller must in addition pay the cost of carriage necessary to bring the goods to the named destination. The buyer bears all costs occurring after the goods have been so delivered. The seller must clear the goods for export. The seller also has to procure insurance against the buyer's risk of loss or damage to the goods during the carriage. This term may be used irrespective of the mode of transport (including multimodal).

15.5 Royalties and Marketing

Estimated royalties are based on the existing rate for the State Royalty (which is reviewed every 5 years), with an allowance for an expected negotiated Native Title party royalty based on production tonnes and a further industry standard agent's fee for marketing and sales of exported products. Australian Silica Pty Ltd retains a Net Production Royalty of 1%.

Total costs estimated at A$1.69 per tonne processed.

15.6 Total Operating Costs

Total net direct cash cost (**C1**) per tonne processed is estimated as follows:

	$/t
Administration (site management)	$0.47
Mining (inc excavation and rehab)	$3.99
Processing (inc power,water and maintenance)	$7.49
Product Handling (inc loading, rail and port)	$19.10
Royalties and Marketing	$1.69
Total Cash Costs of Production	$32.74

* Australian dollars

16 Capital Cost Estimate

CDE Global has provided VRX with a cost estimate for a 2 million tonne per annum (Mtpa) processing plant which, due to its modular nature, is a detailed proposal and accurate to ±15% in pricing. Table 36 sets out a summary of this cost estimate.

Processing Plant Costs ± 15%

	CDE Quote GBP	$AUD
Mechanical Equipment, lighting, wiring, pipework	£6,800,000	$12,716,000
WHIM Module (optional)	£700,000	$1,309,000
Installation & commissioning Labour	£1,100,000	$2,057,000
Crane Hire and EWP's	£400,000	$748,000
Freight (C.I.F Fremantle) (65 containers)	£420,000	$785,400
Contingency (5% of mech.)	£340,000	$635,800
Total	£9,760,000	$18,251,200

Table 36: Summary of quote details for processing plant
(exchange rate of 1GBP = 1.87AUD)

Further testwork is underway to finalise the requirements for the magnetic separation component. This is not anticipated to materially affect the costs.

The Company has commissioned a cost estimate for the feeder, trommel and pump station from a local engineering company ProjX, Table 37.

	Total before contingency	Contingency	TOTALS
Local Infrastructure	$3,290,000	$658,000	$3,940,000
Feed bin, conveyor and feed bin over overland conveyor inc components and power supply	$656,681	$131,336	$780,000
Overland conveyor including purchase, refurbishment and power supply	$637,127	$127,425	$760,000
Trommel, pump and feed pipeline including power supply	$4,927,848	$985,570	$5,910,000
Ancilliary equipment, dams, bore water supply and power supply	$2,643,090	$528,618	$3,170,000
	$15,100,244	$2,265,037	$14,560,000

Table 37: Summary of quote details for feeder, trommel and pump station

The Project metrics have depreciated all of the capital cost at 15% per year.

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17 Marketing

Globally, silica sand is in a growth phase due to increasing demand from the construction sector, with both volume and value having increased worldwide. Sales of silica sand experienced a compound annual growth rate of approximately 8.7% in value terms from 2009 to 2016, with a market value of US$6.3 billion. This was due to its applications across a range of industries, including glass making as well as foundry casting, water filtration, chemicals and metals, along with the hydraulic fracturing process.

Accelerations in construction spending and manufacturing output worldwide are expected to drive growth in important silica sand-consuming industries, including the glass, foundry and building products sectors. Significant growth is projected for the hydraulic fracturing market as horizontal drilling for shale oil and gas resources expands, largely in North America.

The Asia-Pacific region is expected to remain the largest regional consumer of industrial sand through 2025, supported by the dominant Chinese market. The country's container glass industry will drive further silica sand sales, supported by rising production of glass bottles, particularly in the alcoholic beverage sector including wine and beer.

In India, foundry activity has shown strong growth, driven by the production of sand moulds to manufacture metal castings. Indonesia will also register strong growth in silica sand sales through 2022, supported by rapid advances in the output of glass products and metal castings, combined with increased hydraulic fracturing activity.

Outside of the Asia-Pacific region, demand for silica sand in North America is forecast to rise at a faster annual pace than any other regional market. The US and Canada will lead regional growth, driven by expansion in the countries' respective hydraulic fracturing segments. Strength in US oilfield activity will boost demand for sand proppants, as will increases in the number of fracturing stages per well.

Consumption of silica sand in Western Europe is projected to see more modest annual gains through 2020, although such growth will mark a rebound from the declines registered during 2008 to 2015. Recoveries in building construction and manufacturing activity, including a turnaround in flat glass output, will stimulate renewed demand for industrial sand in the region. (Source: Ceramic Industry Website – Reference A)

17.1 Silica Sand Markets

High-grade silica sand is a key raw material in the industrial development of the world, especially in the glass, metal casting, and ceramics industries. High-grade silica sand contains a high portion of silica (over 99% SiO_2) and is used for applications other than construction aggregates. Unlike construction sands, which are used for their physical properties alone, high-grade silica sands are valued for a combination of chemical and physical properties. Global consumption of industrial silica sand is expected to climb 3.2% per year through 2022. Asia Pacific growth is higher than global growth and is expected to be around 5-6% per year. Ongoing economic and infrastructure development in the Asia/Pacific region will drive growth, as will hydraulic fracturing activity in North America. Frac sand will be used increasingly in Asia Pacific in future years but unlikely to match the use in North America where 100 million tonnes are used annually.

17.1.1 Glassmaking

Silica sand is the primary component of all types of standard and specialty glass. It provides the essential SiO_2 component of glass formulation; its chemical purity is the primary determinant of colour, clarity and strength in glass. Industrial sand is used to produce flat glass for building and automotive use, container glass for foods and beverages, and tableware. In its pulverised form, ground silica is required in the production of fibreglass insulation and for reinforcing glass fibres. Specialty glass applications include test tubes and other scientific tools, incandescent and fluorescent lamps.

Over the past 20 years, growth in glass demand has exceeded GDP growth and continues to grow at circa 5% per annum.

The Asia Pacific region has dominated the glassmaking industry for some time and Australia is uniquely positioned to supply this increasing demand.

The Company continues to monitor the various markets for silica sand for glass making and the foundry industry via market specialists and contacts within the industry.

17.1.2 Specialty Markets

Metallurgical Uses

In metal production, silica sand operates as a flux to lower the melting point and viscosity of slag to make them more reactive and efficient. Lump silica is used either alone or in conjunction with lime to achieve the desired base/acid ratio required for purification of final metals. These base metals can be further refined and modified with other ingredients to achieve specific properties such as greater strength, corrosion resistance or electrical conductivity. Ferroalloys are essential in specialty steel production. Industrial sand is used by the steel and foundry industries for de-oxidation and grain refinement.

Chemical Production

Silicon-based chemicals are found in thousands of everyday applications ranging from food processing to soap and dye production. In this case, SiO_2 is reduced to silicon metal by coke in an arc furnace, to produce the Si precursor of other chemical processes. Industrial sand is the main component in chemicals such as sodium silicate, precipitated silica, silicon tetrachloride and silicon gels. These chemicals are used in products such as household and industrial cleaners, in the manufacture of fibre optics and to remove impurities from cooking oil and brewed beverages.

Paint and Coatings

Paint formulators select micron-sized industrial sands to improve the appearance and durability of architectural and industrial paint and coatings. High purity silica produces critical performance properties such as brightness and reflectance and colour consistency. In architectural paints, silica fillers improve tint retention, durability, and resistance to dirt, mildew, cracking and weathering. Low oil absorption allows increased pigment loading for improved finish colour. In marine and maintenance coatings, the durability of silica imparts excellent abrasion and corrosion resistance.

Ceramics

Ground silica is an essential component of the glaze and body formulations of all types of ceramic products, including tableware, sanitary ware and floor and wall tile. In the ceramic body, silica is the skeletal structure onto which clays and flux components attach. The SiO_2 contribution is used to modify thermal expansion, regulate drying, contain shrinkage and improve structural integrity and appearance. Silica products are also used as the primary aggregate to provide high temperature resistance to acidic attack in industrial furnaces.

Filtration and Water Production

Industrial sand is used to filter water to become drinkable. It is also necessary in the processing of wastewater and the production of clean water from wells. Uniform grain shapes and grain size distributions produce efficient filtration bed operations (including multimedia) for the removal of contaminants from wastewater to provide potable water. As silica is chemically inert, it will not degrade or react when it comes in contact with acids, contaminants, volatile organics or solvents. Silica is used as packing material in deep-water wells to increase yield from the aquifer by expanding the permeable zone around the well screen and by preventing the infiltration of fine particles from the formation.

Fibreglass including optical fibres

Washed, correctly sized and dry sorted, the silica sand from the Projects can potentially be targeted for high-grade applications in the glass industry. The main export destination countries for these types of products are China, Japan, Taiwan and Korea.

Suppliers need to work with the customers and or distributors in each key market to provide the required tonnages of suitably specified high grade sand delivered in container loads, or bulker bags and that the sand would be delivered from the site to a port facility. Final delivery is often in pneumatic tanker or bulker bags. Some large producers have on-site grinding facilities using flint pebbles as media.

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17.1.3 Container Glass

The introduction and use of lightweight containers is critically dependent upon the glass forming technologies available for their manufacture. For many years, 'blow-blow' technology was the dominant glass bottle forming process. However, more recently 'narrow neck press and blow' (NNPB) has become the dominant technology for the production of lightweight bottles. Superior dimensional control and consistency available from NNPB allows lighter bottles to be produced without compromising fitness for purpose or market appeal. The current NNPB process inevitably has limitations on the minimum bottle weight which can be achieved, this also being critically dependent on bottle design and volume.

17.2 Market Risk

A key challenge for industrial minerals projects is not meeting market specifications. The silica sand market has specifications for parameters such as purity (e.g. SiO_2 content) in addition to tight specifications for trace elements such as Fe and Ti and Cr in the glass industry.

Failure to meet specifications may result in selling the products at discounted rates, or indeed not finding markets at all.

Other risks for silica sand may include particle size distribution and physical strength (crush resistance) as in the case of proppants for the oil industry.

Industrial minerals are generally considered to be bulk commodities and are therefore susceptible to distance to market and transport costs; therefore, logistics may pose a risk to supplying markets.

17.3 Glassmaking Silica Sand Pricing

Chemical Composition (%)

Product	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	CaO	MgO	K_2O	May 2019 Price FOB
F80	99.95	0.02	0.008	0.030	0.005	0.001	0.004	US$38-55 (A$54-79) per DMT FOB Kwinana
F80C	99.95	0.02	0.005	0.030	0.005	0.001	0.004	
F150	99.8	0.07	0.015	0.035	0.020	0.001	0.004	
F200	99.9	0.06	0.02	0.030	0.010	0.001	0.020	

Table 38: Glassmaking Silica Sand Pricing

Particle Size **Sieve Opening / µm retained**

Product	850	600	425	300	212	150	106	75	53
F80		0.5%	49%	50%	0.5%				
F80C	9.0%	90.0%	1.0%						
F150				0.5%	88%	11%	0.5%		
F200		0.5%	30%	40%	21%	8%	0.5%		

Table 39: Glassmaking Silica Sand Particle Sizes

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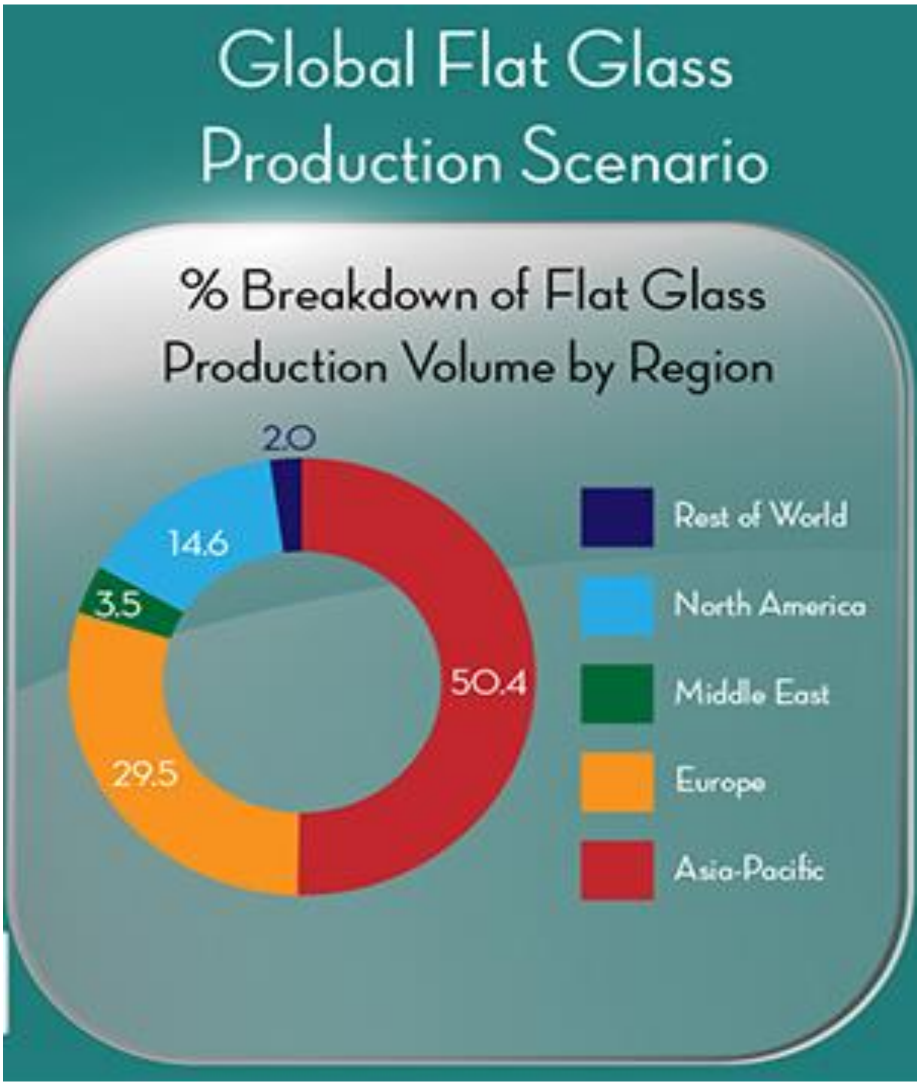
17.4 Glassmaking Silica Sand Demand

The Asia Pacific region has dominated the glassmaking industry for some time and Australia is uniquely positioned to supply this increasing demand.



Asian Silica Sand Markets

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Use	Spec	Market in Asia	Growth in Asia
Float (Plate) Glass	99.5% SiO2	60 - 65Mt	5% - 6%
Container Glass	99.5% SiO2	70 - 75Mt	5% - 6%
Cover Glass (Solar Panels)	99.5% SiO2 & Low Fe	5 - 6Mt	+30%
Smart Glass (Ultra Clear)	99.5% SiO2 & Low Fe	1 - 2Mt	5% - 6%
Specialist Glass (Thin Screen)	99.7% SiO2	500 - 600 kt	+10%

Table 40: Asian Silica Sand Markets
Source: Stratum Resources

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Asian Growth Sectors

- Increase in Automobile Production
- Rebound in Building Construction Activity
- Rising Demand for Energy Efficient Windows
- Strong Demand for Fabricated Flat Glass Products
- Use of Glass in Solar Thermal Panels & Photovoltaic Modules
- Expanding Applications of Glass in Healthcare & Electronics Sectors
- Demand for Glass Products with Solar Control & Impact Resistance Features

Year / Country	2017a	2018a	2019e	2020f	2021f	2022f	2023f	2024f	2025f
China	0.89	1.9	2.4	2.8	3.4	3.6	4.2	4.4	5.6
Japan	1.16	1.18	1.2	1.3	1.3	1.4	1.4	1.5	1.5
South Korea	1.05	0.94	1.2	1.3	1.4	1.5	1.6	1.6	1.7
Taiwan	1.42	1.47	1.5	1.5	1.6	1.6	1.7	1.7	1.7
Philippines	0.35	0.49	0.51	0.53	0.6	0.6	0.7	0.7	0.8
Thailand	0.19	0.15	0.17	0.2	0.3	0.3	0.4	0.4	0.5
Subtotal (rounded)	**5.6**	**6.13**	**6.9**	**7.6**	**8.6**	**9**	**10**	**10.3**	**11.8**

Table 41: Silica sand estimated demand in selected Asian countries Mt to 2025

Source: ITC Trade map, Stratum estimates. A-actual, e-estimate, f-forecast

Product requirements will be based on SiO_2 content, other impurities and particle size distribution. There are many and varied requirements generally dependent on the final product.

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18 Financial

Based on the capital and operating cost estimates a financial model was developed for the purpose of evaluating the economics of the Project.

18.1 Key Assumptions

The financial analysis for the Project has been undertaken based on the following key assumptions:

Currency	Australian dollars *Sales contracts in Asia for silica sand are invariably based $US and a A$0.70 exchange rate has been applied*
Project life	25 years Total Probable Ore Reserve alone supports a 9-10 year project. Mining will occur solely from the Probable Ore Reserve during this period. There is a reasonable expectation that with further close spaced drilling the existing Inferred Mineral Resource would convert to Indicated Mineral Resource and subsequently Probable Ore Reserve. This will increase the mine life to well in excess of this time period, however the model is conservatively restricted to 25 years. See Section 5.4 for further information.
Depreciation	15% rate on capital
Corporate tax rate	27% on taxable profit
Production	Steady state of production from Probable Ore Reserves over life of mine, with the first 2 years at 1 Mt per year and thereafter at 2 Mt per year *The Company has currently expressions of interest and letters of intent to purchase 3.5 Mt per year of Muchea products and expects further interest once these products are made available to the market*
Shares on Issue	404,318,617
NPV estimation discount rates	Standard financial modelling conducted at both 10% and 20% discount rates. *The 20% rate is generally above standard reporting rates but demonstrates that the Project is still financially robust at this higher rate*
Capital cost	Based on estimates ±15% from engineering companies with extensive experience in sand separation
Operating costs	A$32.74 C1 costs, including royalties *Based on first principles and current rates for equipment*
Sales revenue	US$38-55 (A$54-79) per dry metric tonne dependent on product type, product quality, contract terms and quantity *Revenue is constant based on current prices and ignores any projected growth in prices*
Maximum debt	A$30 million
Borrowing rates	12%
Accounts receivable	30 days
Accounts payable	30 days
Plant maintenance	5% of capital cost per year
Environmental bond	A$500,000 *May be substituted by the WA Department of Mines, Industry Regulation and Safety's "Mining Rehabilitation Fund"*
Capex contingency	20%
Recoveries	Muchea-F80 Glassmaking 48% Muchea-F80C LCD 20% Muchea-F150 Glassmaking 20% *Recoveries are based on CDE testwork at ±5%*

18.2 Project Metrics

The production target incorporates the maiden Probable Ore Reserve of 18.7 Mt @ 99.9% SiO_2 with 14.6Mt @ 99.9% SiO_2 within the Mining Lease application area (see Section 5.3) as well as a portion of the Inferred Mineral Resource of 61.4 Mt @ 99.6% SiO_2 (see Section 5.4).

The maiden Probable Ore Reserve is estimated from the Indicated Mineral Resource only. This constitutes approximately 30% of the estimated total production target (in terms of processed tonnes of silica sand) over the 25 year mine life for the Project BFS. It provides sufficient tonnage for the first 9-10 years of mining operations. Mining from the area of the Probable Ore Reserve only supports a 9-10 year mine life and the Company intends to mine solely from the Probable Ore Reserve during that period. Section 5.4 sets out details of the proposed mine plan.

Summary results from the financial model outputs are set out in Table 42. The first column shows outputs when aggregated with the Inferred Mineral Resource and the second column shows outputs from the Probable Ore Reserve only. Muchea is a viable project whether or not the Inferred Mineral Resource area is included in the analysis.

	Muchea (Inc. Inferred)	Muchea (Reserve Only)
Post Tax, ungeared NPV_{10}	$337,900,000	$180,500,000
Post Tax, ungeared NPV_{20}	$146,400,000	$104,600,000
Post Tax, ungeared IRR	96%	96%
Payback period (yrs) (post tax) (ramp up rate)	2.3	2.3
Exchange Rate US$/A$	$0.70	$0.70
Life of Mine (yrs) (Scope of BFS Study)	25	15
Total Sales (initial 25 years) no escalation	$3,345,000,000	$1,011,000,000
EBIT	$1,540,000,000	$447,000,000
Cashflow after finance and tax	$1,123,000,000	$321,000,000
Shares on Issue	404,318,617	404,318,617
EPS after tax (per year)	$0.11	$0.09
Capex (2 mtpa)	$32,820,000	$32,820,000
Capex contingency (inc)	20%	20%
Life of Mine C1 costs, FOB Kwinana (inc royalties)	$32.74	$33.84
Tonnes Processed (initial 25 years) (Mt)	54	16
Production Target (Mt) (BFS Study)	(25 years) 48.3	(9-10 years) 14.6
Probable Ore Reserves @ 99.9% SiO_2 (Mt)	18.7	18.7
Ore Reserve life (yrs)	9-10	9-10
JORC Resources (million tonnes)	208	208

Table 42: Project Metrics

Notes:

1: Steady state of production over life of mine. Life of mine based on the Inferred Mineral Resource (see Section 5.4) and maiden Probable Ore Reserve in the first column and the maiden Probable Ore Reserve in the second column. Throughput of 1Mtpa increasing to 2Mtpa in year 3 (see Section 18.3). Assumes 88% recovery rate from tonnes processed (see Table 20).

2. There is a low level of geological confidence associated with inferred mineral resources and there is no certainty that further exploration work will result in the determination of indicated mineral resources or that the production target itself will be realised.

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3. The Probable Ore Reserve and the Inferred Mineral Resource underpinning the above production targets have been prepared by a Competent Person in accordance with the requirements of the JORC Code 2012.
4. Refer to Section 18.1 for underlying assumptions.
5. A life of mine production profile is set out in Section 18.3.
6. A sensitivity analysis is set out in Section 18.4.
7. All figures are presented in Australian dollars, unadjusted for inflation
8. Rounding errors may occur.

18.3 Production Profile

The maiden Probable Ore Reserve constitutes approximately 30% of the estimated total production target (in terms of processed tonnes of silica sand) over the 25 year mine life for the Project BFS. It provides sufficient tonnage for the first 9-10 years of mining operations. The Company intends to mine solely from the Probable Ore Reserve during that period (see Figure 52).

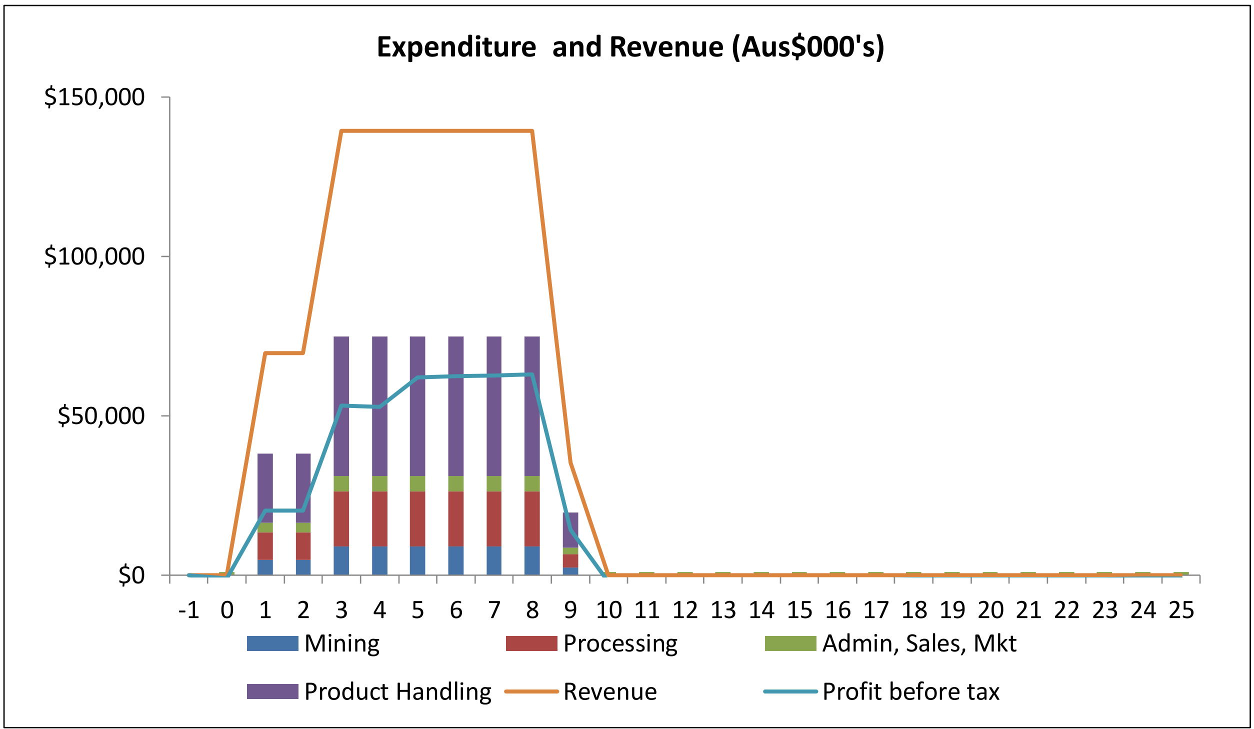

Figure 52: Production Expenditure and Revenue
(First 9-10 years of mine life)

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Taking into account the Indicated and Inferred Mineral Resource (see Section 5.2) the Company expects the mine life to increase to at least 25 years (see Figure 53).

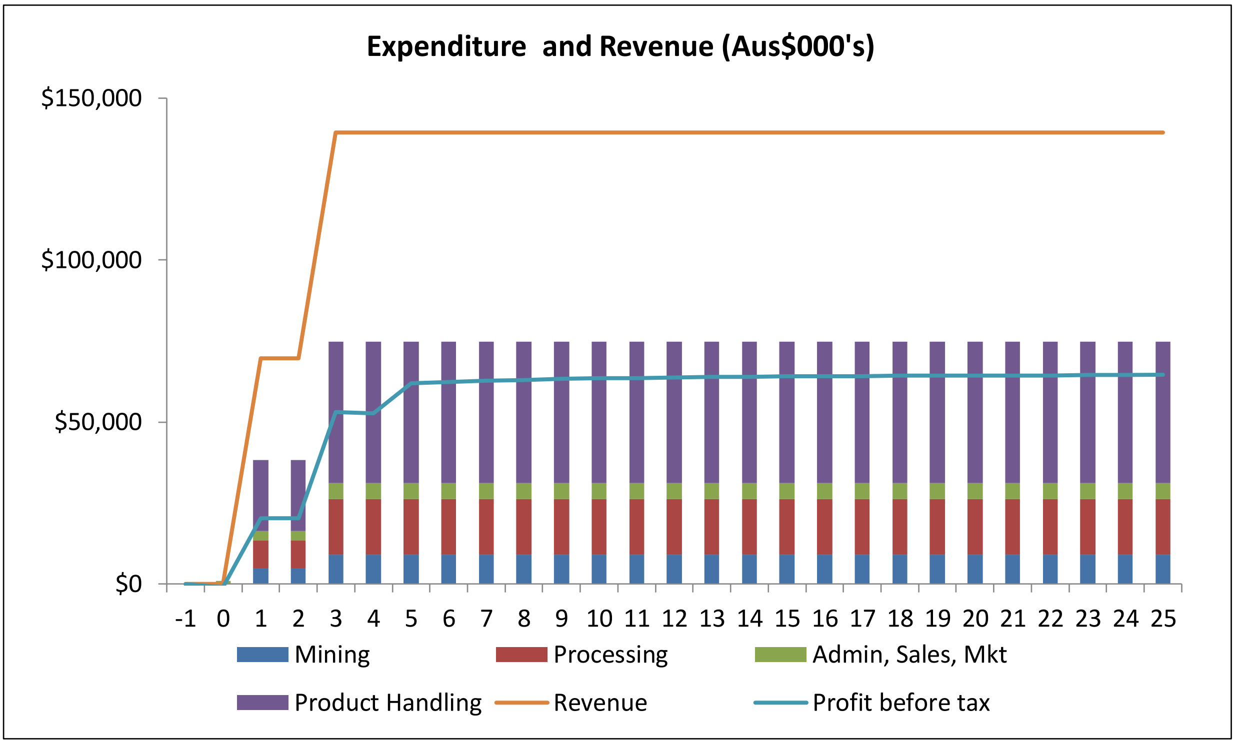

Figure 53: Production Expenditure and Revenue (mine life of 25 years)

18.4 Sensitivity Analysis

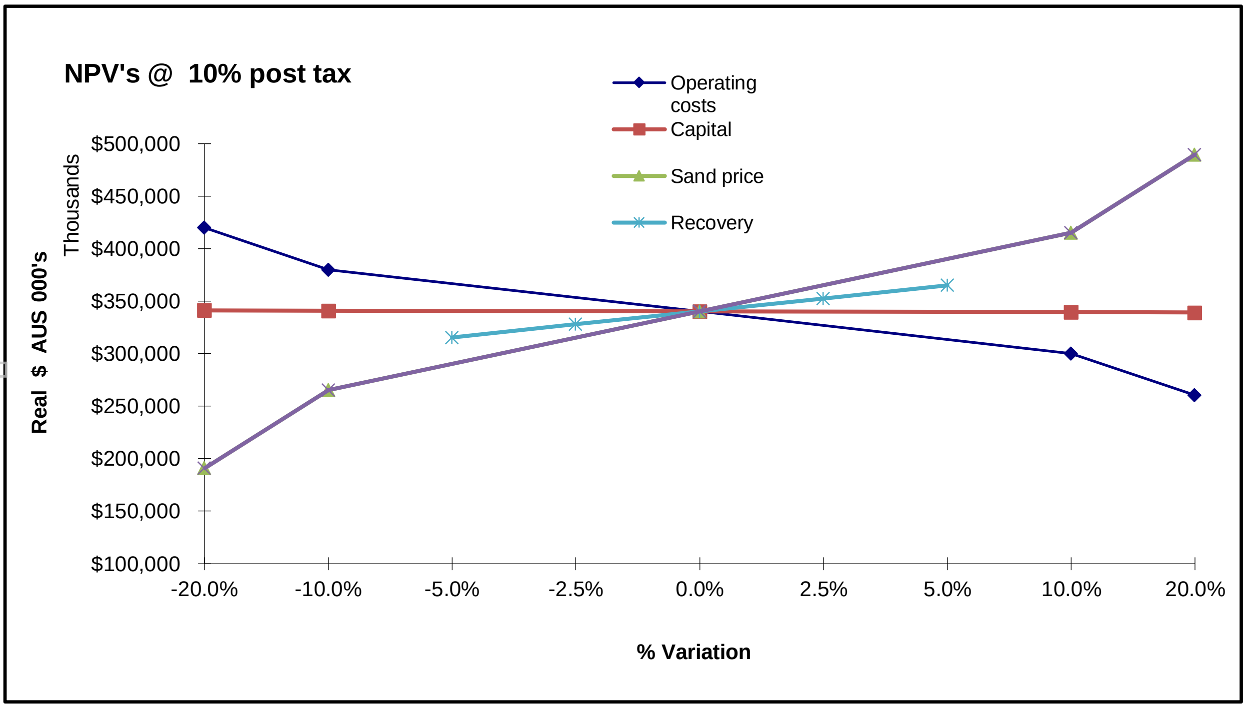

Figure 54: Sensitivity Analysis

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19 Resources and Reserves JORC Tables

19.1 JORC Code 2012 Edition Table 1 Section 1

Sampling Techniques and Data

(Criteria in this section apply to all succeeding sections.)

Criteria	Commentary
Sampling techniques	AC drilling samples are 1m down hole intervals with sand collected from a cyclone mounted rotary cone splitter, ~2-3kg (representing 50% of the drilled sand) was collected. Two sub-samples, A and B, of ~200g were taken from the drill samples. The remainder was retained for metallurgical testwork. Auger drilling samples are 1m down hole intervals with sand collected from a plastic tub which received the full sample, ~8kg, from the hole. The sand was homogenised prior to sub sampling, two sub-samples, A and B, of ~200g were taken from the drill samples. A bulk sample of ~5kg was retained for each 1m interval for metallurgical testwork. The "A" sample was submitted to the Intertek Laboratory in Maddington, Perth for drying, splitting (if required), pulverisation in a zircon bowl and a specialised silica sand 4 Acid digest and ICP analysis. All auger samples were weighed to determine if down hole collapse was occurring, if the samples weights increased significantly the hole was terminated to avoid up hole contamination. Due to the visual nature of the material, geological logging of the drill material is the primary method of identifying mineralisation.
Drilling techniques	Vertical NQ sized aircore drilling was completed by a Contract Drilling Company using a Landcruiser mounted Mantis 82 drill rig. A 100mm diameter hand screw auger was used to drill until hole collapse.
Drill sample recovery	Aircore Visual assessment and logging of sample recovery and sample quality Reaming of hole and clearance of drill string after every 3m drill rod Sample splitter and cyclone cleaned regularly to prevent sample contamination No relationship is evident between sample recovery and grade Hand Auger All material recovered from the hole is collected in a plastic drum and weighed, the weights are used to determine when the hole is collapsing, and drilling is terminated. No relationship is evident between sample recovery and grade
Logging	Geological logging of drill samples is done by the field geologist with samples retained in chip trays for later interpretation. Logging is captured in an excel spreadsheet, validated and uploaded into an Access database
Subsampling techniques and sample preparation	AC drill samples are rotary split 50:50 into a calico bag resulting in 2-3kg of dry sample, 2 x 200g sub-samples, A and B, are taken from the drill sample. The A sample is submitted to the laboratory and the B sample is retained for repeat analysis and QA/QC purposes. The bulk sample is retained for later metallurgical testwork. Auger drill material, ~8kg, is collected in a plastic tub and homogenised, 2 x 200g sub-samples, A and B, are taken from the drill material. The A sample is submitted to the laboratory and the B sample is retained for repeat analysis and QAQC purposes. A 5kg bulk sample is retained for later metallurgical testwork. The sample size is considered appropriate for the material sampled.

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Criteria	Commentary
	The 200g samples are submitted to the Intertek Laboratory in Maddington, Intertek use a zircon bowl pulveriser to reduce the particle size to -75um.
Quality of analytical data and laboratory tests	Samples were submitted for analysis to the Intertek Laboratory in Maddington in Perth WA. The assay methods used by Intertek are as follows: multi-elements are determined by a specialised four-acid digest including Hydrofluoric, Nitric, Perchloric and Hydrochloric acids in Teflon tubes. Analysed by Inductively Coupled Plasma Mass Spectrometry, silica is reported by difference. The assay results have also undergone internal laboratory QAQC, which includes the analysis of standards, blanks and repeat measurements. The Company has been validating a high-purity silica standard that was created for the Company by OREAS Pty Ltd. This was required as there is no commercial standard available for high purity silica sand. The standard was "round robin" assayed at several laboratory's in Perth prior to the commencement of drilling. The standard was then included in the drill sample submissions to Intertek, in sequence, on a ratio of 1:20. Field duplicate samples were submitted in a ratio of 1:20 and in addition to this Intertek routinely duplicated analysis from the pulverised samples in a ratio of 1:25. The number of QAQC samples therefore represents ~14% of the total assays. A full analysis of all the quality control data has been undertaken. This analysis validates the drill assay dataset and conforms with the guidelines for reporting under the JORC 2012 code.
Verification of sampling and analyses	Significant intersections validated against geological logging At Muchea, twinned holes AC Vs Auger were completed validate the robustness of hand auger as an appropriate method of testing the in-situ sand. Assay comparisons shown an acceptable correlation between the 2 drilling methods.
Location of data points	Auger drill hole locations were measured by hand-held GPS with the expected relative accuracy; GDA94 MGA Zone 50 grid coordinate system is used. Aircore drill holes have been surveyed by an RTK GPS system. The reduced level (RL) of the drilling collars is generated from LIDAR contour data obtained from the Department of Water, unless quality RTK GPS is available.
Data spacing and distribution	Initial drilling at Muchea holes were spaced 400-800m apart along existing tracks, auger holes were spaces ~800m apart along tracks with some off tracks. The recent drilling spaced holes 50m apart along the existing track. It is believed that due to the relatively low variability of assays between drill holes that the current spacing may be sufficient for the estimation of a Mineral Resource. No sample compositing (down hole) has been done.
Orientation of data in relation to geological structure	Sampling is being undertaken on aeolian sand dunes; the drill orientation is therefore considered appropriate.
Sample security	All samples are selected onsite under the supervision of VRX Geological staff. Samples are delivered to the Intertek laboratory in Maddington. Intertek receipt received samples against the sample dispatch documents and issued a reconciliation report for every sample batch.
Audits or reviews	There has been no audit or review of sampling techniques and data yet.

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19.2 JORC Code 2012 Edition Table 1 Section 2

Reporting of Exploration Results

(Criteria listed in the preceding section also apply to this section.)

Criteria	Commentary
Mineral tenement and land tenure status	All drilling has been within Tenement E70/4886, which is owned by Wisecat Pty Ltd a 100% owned subsidiary of VRX Silica Limited. The tenement was granted 27 March 2017 and all drilling was conducted on VCL.
Exploration done by other parties	Minor exploration for mineral sands has been completed by Tronox in the South Eastern corner of E70/4886 and has been excluded in any assessment by VRX.
Geology	Most economically significant silica sand deposits in Western Australia are found in the coastal regions of the Perth Basin, and the targeted silica sand deposits at Muchea are hosted by the Bassendean Sand, which extends over large areas of the Swan coastal plains of the Perth Basin. The term Bassendean Sand was introduced in 1972 (Playford, P. E., and Low, G. H. 1972. Definitions of some new and revised rock units in the Perth Basin: Western Australia. Geological Survey, Annual Report for 1971, p. 44–46) for the widespread unit of quartz sand extending over large areas of the coastal plain, from about 23 km north of Jurien, to about 15 km southwest of Busselton. Quartz grains of the Bassendean Sand are interpreted as being derived from granitic rocks in the Darling Range and have accumulated as shoreline and dune sands during two or more periods of relatively stable sea level, ranging from about 8 to 25 m above present sea level. According to published reports (e.g. GSWA Bulletin 21) the Bassendean Sand is typically clean, well rounded and well sorted; however, its physical, chemical, and mineralogical characteristics can vary. The sand is generally white near surface but at depth it is usually high in iron and yellow to brown in colour. The Bassendean Sand generally has little or no overburden and it is noted from a report by the Geological Survey of Western Australia (Bulletin 21) that a discontinuous layer (generally less than a metre thick) of relatively hard ferruginous material, known as ‘coffee rock’, may occur at depths ranging from less than a metre to about 15 m below the surface. The coffee rock was interpreted as having formed due to precipitation of Fe oxides and hydroxides from circulating iron-rich groundwater. Below this layer, the white sand can be quite thick, extending to a maximum of about 15 m (Abeysinghe, P. B., 2003. Silica Resources of Western Australia. Geological Survey of Western Australia, Mineral Resources Bulletin 21).
Drillhole information	A tabulation of the Aircore drill holes used in this MRE update included as an attachment to this announcement.
Data aggregation methods	Not relevant. Exploration results are not being reported. Mineral Resources and Ore Reserves are being disclosed (see Section 3 and 4).
Relationship between mineralisation widths and intercept lengths	Not relevant. Exploration results are not being reported. Mineral Resources and Ore Reserves are being disclosed (see Section 3 and 4).
Diagrams	Refer to figures within the main body of this report.
Balanced reporting	Not relevant. Exploration results are not being reported. Mineral Resources and Ore Reserves are being disclosed (see Section 3 and 4).
Other substantive exploration data	Geological observations are consistent with aeolian dune mineralisation Four, certified, dry in-situ bulk density measurements were completed at Muchea by Construction Sciences Pty Ltd using a nuclear densometer. The arithmetic average of these was used in the determination of the exploration targets. Groundwater was intersected in only a few holes that were drilled deeper deliberately to ascertain the position of the water table. The water table is typically below 15m depth.

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Criteria	Commentary
	The mineralisation is unconsolidated sand. There are no known deleterious substances at this time.
Further work	This report is included as part of a Bankable Feasibility Study and Maiden Ore Reserve which demonstrates that the Project is robust and achievable. The Project will now be progressed through the Government approval process, financing and into construction and the commencement of Operations.

19.3 JORC Code 2012 Edition Table 1 Section 3

Estimation and Reporting of Mineral Resources

(Criteria listed in the preceding section also apply to this section.)

Criteria	Commentary
Database integrity	Data used in the MRE is sourced from a Microsoft Access database. Relevant tables from the Microsoft Access database are exported to Microsoft Excel format and converted to csv format for import into Datamine Studio 3 software and Surpac software. Validation of the data imported comprises checks for overlapping intervals, missing survey data, missing analytical data, missing lithological data, and missing collars.
Site visits	The Competent Person for the VRX estimate is a full-time employee of the Company and has made multiple visits to all Project areas. The Competent Person (CP) for CSA Global estimate, Dr AJ Scogings, a representative of CSA Global visited the VRX warehouse in Perth and the Muchea site on 17 October 2018, addressing the following: Sample storage – originals, field duplicates, pulps, standards and chip trays are housed appropriately. Some chip trays were photographed by the CP as a check against Company photographs and geology logs. Geology – the CP noted that the Muchea tenements are underlain by unconsolidated white / off-white fine-grained silica sand. Drill collars – the CP recorded and verified several unmarked drill sites using hand-held GPS. Project location – several points such as road intersections were located and plotted in Google Earth™ to verify the tenement location. Auger drilling method – Mr David Reid of VRX demonstrated the Company's hand auger drilling and sampling method at location MA001. The CP was satisfied that, providing the sand is sufficiently damp and stable at the time of drilling, samples collected by this method are representative, relatively uncontaminated and hence suitable for use in a Mineral Resource estimate. Aircore drilling method – although this was not observed during the site visit, the CP is of the opinion that aircore drilling is an appropriate method for drilling and sampling sand deposits such as Muchea.
Geological interpretation	Silica sand mineralisation at Muchea are hosted by the Bassendean Sand, and the targeted silica sand deposits are the aeolian sand dunes that overlie the Pleistocene limestones and paleo-coastline.

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Criteria	Commentary
	Within the project area, data obtained from the Department of Agriculture soil mapping shows the Bassendean Sand covering the full extent of the modelled area. The geological modelling was completed based on this soil mapping data in conjunction with the auger and air core drill (AC) logging data. The Mineral Resource is estimated above a 3-d wireframe basal surface for the upper white silica sand layer. Based on analysis of the results from the drilling data this basal surface appears to nominally follow the topographic surface. Only the uppermost white silica sand layer has been modelled at this stage despite the evidence in the deeper AC holes for additional white silica sand and yellow sand layers occurring below. This is due to the limitations on the depth sampled from auger drilling, the variable depths of AC drilling, and the drill hole spacing making interpretation of the geological extents of the lower sand layers difficult. The modelled basal surface therefore does not necessarily represent the full sand layer thickness over parts of the auger drilled area. The modelled extents of the upper white silica sand layer are further limited to within the VRX nominated Muchea target area. The surface humus layer is typically about 300 mm thick. In consultation with VRX, CSA Global decided that the upper 500 mm (overburden) is likely to be reserved for rehabilitation purposes. This overburden surface forms the upper boundary of the estimated Mineral Resource and is depleted from the reported Mineral Resources. Over a small area in the central west of the modelled area, the surface white silica sand layer is overlain by a minor clay in white sand zone, defined by the Al_2O_3 content being nominally above 1%. The basal surface of this material has been modelled and it forms the upper boundary surface of the modelled white silica sand layer in this part of the model. This material has not been grade estimated and is not reported as part of the MRE. Assumptions have been made on the horizontal extents of the mineralisation based on the soil mapping data and the spacing and extents of the drilling information. A nominal maximum horizontal extrapolation limit of 400 m past known drill data points has been applied with the interpretation additionally constrained within the VRX nominated target. Although it is understood that the thickness of the upper white silica sand layers is likely to be more than current auger drilling depths over the areas of the modelled area covered only by auger drilling, the vertical extents have been nominally limited to the current auger drilling depths. Approximately 10% of the modelled mineralisation can be considered to be extrapolated. Alternative interpretations based on the currently available data are considered unlikely to have a significant influence on the global MRE. Continuity of geology and grade can be identified and traced between drillholes by visual and geochemical characteristics. Confidence in the grade and geological continuity is reflected in the Mineral Resource classification.
Dimensions	The modelled and classified extents of the upper silica sand layer material within the target area are roughly 7 km north to south, and on average roughly 3.5 km west to east. The modelled sand layer is roughly horizontal, with fairly low relief. The currently modelled thickness of the sands is on average about 4.5 m. The current modelling (limited by the drilling methodology in parts) shows the thickness ranging between about 14 m in the north east, thinning to a nominal 3 to 5 m through the centre where it appears to pinch out in the west in part, thickening to between 5 and 8 m in the south east, and is a nominal 3 to 5 m in the south west.
Estimation and modelling techniques	In the Auger area Ordinary Kriging (OK) was the selected interpolation method, with Inverse distance squared (IDS) used as a check estimate.

Criteria	Commentary
	Grade estimation was carried out at the parent cell scale, with sub-blocks assigned parent block grades. Grade estimation was carried out using a hard boundary. Statistical analysis on the 1 m downhole composited drillhole data to check grade population distributions using histograms, probability plots and summary statistics and the co-efficient of variation, was completed for the estimated grade variables. The checks showed there were no significant outlier grades in the interpreted sand layer that required top-cutting. In addition to SiO_2, the grade variables Al_2O_3, Fe_2O_3, LOI, and TiO_2 are estimated into the model. A volume block model was constructed in Datamine constrained by the topography, overburden layer, sand type zone, material depletion zone and target area limiting wireframes. Drilling has been completed at a nominal 400 m spacing along existing tracks, which are nominally between 400 m and 1,200 m apart, thus forming a somewhat irregular drilling pattern. Two pairs of close spaced (~<10 m) auger / aircore drill hole twin holes have been drilled, along with a further two pairs at roughly 100 m apart and a pair of auger holes ~35 m apart. Spatial (variogram) analysis was completed on SiO_2 from the 1 m drill composite samples, yielding a low relative nugget of 10%. No clearly preferred mineralisation trend direction was recognised from the variogram modelling with primary and secondary variogram directions modelled at 090° and 000° respectively. For both these directions the modelled two structure spherical models yielded the same ranges of 500 m to the first structure and 800 m to the second. Based on the sample spacing and validated by means of a kriging neighbourhood analysis (KNA), a parent block size of 200 m(E) x 200 m(N) x 4 m(RL) or nominally half the average drill section spacing, was selected for the model. Sub-cells down to 12.5 m(E) x 25 m(N) x 0.25 m(RL) were used to honour the geometric shapes of the modelled mineralisation. The search ellipse orientations were defined as being horizontal based on the overall geometry of the mineralisation and with reference to the variogram modelling study. The search ellipse was doubled for the second search volume and then increased ten-fold for the third search volume to ensure all blocks found sufficient samples to be estimated. The search ellipse dimensions of 650 m x 650 m x 10 m, have been optimised by means of the KNA. A minimum of 12 and a maximum of 24 samples, based on the KNA results, were used to estimate each parent block for both zones. These numbers were reduced for the second search volume to 12 and 20 samples and in the third search volume to 8 and 16 samples. A maximum number of five samples per drillhole were allowed. Based on the results from the KNA, cell discretisation was 3 (E) x 3 (N) x 4 (RL) and no octant-based searching was utilised. Model validation was carried out visually, graphically, and statistically to ensure that the block model grade reasonably represents the drillhole data. Cross sections, long sections and plan views were initially examined visually to ensure that the model grades honour the local composite drillhole grade trends. These visual checks confirm the model reflects the trends of grades in the drillholes. Statistical comparison of the mean drillhole grades with the block model grade shows reasonably similar mean grades. The IDS check estimate shows similar grades to the OK model, adding confidence that the grade estimate has performed well. The model grades and drill grades were then plotted on histograms and probability plots to compare the

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Criteria	Commentary
	grade population distributions. This showed reasonably similar distributions with the expected smoothing effect from the estimation taken into account. Swath or trend plots were generated to compare drillhole and block model with SiO_2% grades compared at 400 m E, 400 m N and 4 m RL intervals. The trend plots generally demonstrate reasonable spatial correlation between the model estimate and drillhole grades after consideration of drill coverage, volume variance effects and expected smoothing. The Aircore drilling area Mineral Resources were estimated using a polygonal area weighted analysis using equidistant polygons generated from the location of the Aircore drill holes. The down hole widths and grades were determined by visual and statistical analysis to determine the average grades in the volume defined by the polygons, where this extended below 3m above the year 2000 water table, this higher level was used. No reconciliation data is available as no mining has taken place.
Moisture	Tonnages have been estimated on a dry, in situ, basis. The sampled sand material was generally reasonably dry, with data collected from the density testing of seven intervals showing an average moisture content of 1.8%.
Cut-off parameters	No cut-off parameters have been applied, as the sand appears to be readily amenable to beneficiation to a suitable product specification through relatively simple metallurgical processes as demonstrated by initial reported metallurgical testing results.
Mining factors or assumptions	It has been assumed that this deposit will be amenable to open cut mining methods and are economic to exploit to the depths currently modelled. No assumptions regarding minimum mining widths and dilution have been made. No mining has yet taken place.
Metallurgical factors or assumptions	A composite aircore sample of 104 white, 45 brown and 4 coffee rock (sand) intervals from Muchea was tested in Ireland during 2018. The sample was screened at 4mm to remove oversize particles. The remaining material was then subjected to an attrition process followed by spiral and magnetic separation methods. Attrition testing was carried out a retention period of 5 minutes, with the sample washed after attritioning to remove any liberated fine particles. Spiral testing was then carried out with approximately 80kg of attritioned material, after which the samples then underwent wet magnetic separation to explore the possibility of reducing the magnetic mineral content. Chemical analysis showed a general decrease in the Al_2O_3. Processing, attritioning and washing the material removed the largest fraction of Al_2O_3. The spiral separation process produced samples where the largest fraction of Al_2O_3 was found in the heavy mineral fraction. Magnetic separation resulted in the largest fraction of Al_2O_3 being in the magnetic fraction. The results for Fe_2O_3 follow the same general trend as for Al_2O_3. The percentage fraction of SiO_2 in the samples increased during the test process. Attritioning and washing the material removed fines and silt, which increased the SiO_2 content. The spirals test produced samples where the largest fraction of SiO_2 was found in the light fraction. Magnetic separation indicated that the largest fraction of SiO_2 was in the middling fraction. Two composite samples of brown sand and two composites of coffee sand were submitted to a laboratory in Perth for preliminary process tests to assess amenability for upgrading the silica content and removing impurities. It was concluded that one of the samples, known as 'Brown #1', which had the highest initial SiO_2 content, also showed the best potential to be upgraded to glass grade. CSA Global is of the opinion that further process

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Criteria	Commentary
	testwork is required to verify whether the brown or coffee sands are amenable to purification and if so, which markets may be supplied. In the production of glass, there is both the need and requirement for silica to be chemically pure (composed of over 98% SiO_2), of the appropriate diameter (a grain size of between approximately 0.1 mm and 0.4 mm and with low iron content (less than approximately 0.04% Fe2O3). CSA Global is of the opinion that available process testwork indicates that product quality is considered favourable for eventual economic extraction and production of silica sand for glass markets. In addition, project location and logistics support the classification of the Muchea deposit as an industrial mineral Mineral Resource in terms of Clause 49 of the JORC Code.
Environmental factors or assumptions	No assumptions regarding waste and process residue disposal options have been made. It is assumed that such disposal will not present a significant hurdle to exploitation of the deposit and that any disposal and potential environmental impacts would be correctly managed as required under the regulatory permitting conditions. VRX has indicated that initial botanical studies are underway, and in the modelling the top 500 mm is reserved for rehabilitation purposes and is depleted from the model and is not reported.
Bulk density	Four, certified, dry in situ bulk density measurements were completed by Construction Sciences Pty Ltd using a nuclear densometer. The results from the four measurements are corrected based on the measured moisture factor. The mean dry in situ density result of 1.66 t/m^3 is used for all modelled material reported in the MRE.
Classification	Classification of the MRE was carried out accounting for the level of geological understanding of the deposit, quality of samples, density data, drillhole spacing and geostatistical parameters. The MRE has been classified in accordance with the JORC Code (2012 Edition) using a qualitative approach. All factors that have been considered have been adequately communicated in Section 1 and Section 3 of this Table. Overall the mineralisation trends are reasonably consistent over the drill sections. The MRE appropriately reflects the view of the Competent Person.
Audits or reviews	Internal audits were completed by CSA Global, which verified the technical inputs, methodology, parameters, and results of the estimate. No external audits have been undertaken.
Discussion of relative accuracy/ confidence	The relative accuracy of the MRE is reflected in the reporting of the Mineral Resource as per the guidelines of the JORC Code (2012). The Mineral Resource statement relates to global estimates of in situ tonnes and grade.

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19.4 JORC Code 2012 Edition Table 1 Section 4

Estimation and Reporting of Ore Resources

(Criteria listed in the preceding section also apply to this section.)

Criteria	Commentary
Mineral Resource estimate for conversion to Ore Reserves	The Mineral Resource Estimate (MRE) used as a basis for conversion to the Ore Reserve was provided by David Reid, a full time employee of VRX Silica as the Competent Persons on the Estimation and as the Competent Person on the Exploration Results and data collection. The Muchea Updated MRE used in this conversion is dated 17 June 2019. The Mineral Resources as reported inclusive of the Ore Reserves.
Site visits	The Competent Person, David Reid, is a full-time employee of VRX Silica and has made numerous site visits to Muchea. The following observations are applicable to this Conversion; The mining area is located between the towns of Muchea and Gingin Western Australia, 50km north of Perth. The area is access via the Brand Highway and the sealed Timaru Road. There are numerous existing tracks that also allow for alternative access. The population density is low, 968 persons in Muchea, and 852 persons in Gingin. There are a number of farming properties in the local area. The mining area is located on vacant crown land, VRX Silica has 100% ownership of the underlying mining tenure. The topographical is low to medium relict sand dunes covered in Banksia Woodlands. The proposed mining operation will excavate the sand from the surface to a level 3m above the year 2000 water table which varies in depth across the Project. The Indicated Resource extends into Freehold land, however a 200m buffer zone has been used for the boundary for mining, the sides of the mining depression will be graded at a 1:20 gradient. No ground water will be intersected during mining as the current water table is well below, +5m, where it was in the year 2000. Rainfall is expected to drain into the surrounding sand with little or no runoff that could defect the mining operation. The sand to be mined is unconsolidated and will not require blasting. All mining can be carried out by a wheeled front-end loader. There are no power lines or water lines in the mining area. There is a gas pipeline to the east of the mining area, however these will not be impacted during mining.
Study status	VRX Silica has finalised a Bankable Feasibility Study (BFS) for the Muchea Project. This Ore Reserve conversion is an integral part of the BFS and is therefore reported in conjunction here. The BFS has been completed to a +/-15% accuracy and demonstrates the project is robust and achievable.
Cut-off parameters	Only Indicated resources have been considered for conversion to Ore Reserves. The MRE defines one type of sand which has been demonstrated can be beneficiated to a saleable product via non-chemical means in a traditional sand processing plant. The MRE did not apply any cut-of grades during estimation as it simply modelled single type of sand, there is therefore no waste in the MRE. The MRE differentiated the top 500mm as “topsoil” and excluded it from the estimation as it was assumed it would be retained for rehabilitation purposes.

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Criteria	Commentary
Mining factors or assumptions	The mining method chosen for Muchea is a rubber wheeled front-end loader feeding into a 3mm trommel screen to remove organics. The undersize sand is slurried and pumped to a sand processing plant which is located proximal to the railway line to the Kwinana Bulk Terminal. After processing the silica sand is then loaded into railway trucks for bulk export from the Kwinana Bulk Terminal. The front-end loader was chosen due to the flexible nature of the machine combined with a high load rate and low material handling cost. Mining of the sand will extract to 3m above the year 2000 water table to the extents of the Indicated resource / Probable reserve. This level varies but is up to 11m below the current surface, on the periphery the ground will slope upwards at a 5% gradient. Mining will not excavate a hole and therefore there are no geotechnical requirements. Active mining faces will not exceed 5m, therefore face stability issues are not perceived to be an issue during mining. Pre-production drilling is unlikely to be required due to the low in-situ variation of the bulk sand resource, the aircore drilling used in the MRE is considered to be sufficient. 100% of the material in the mining area is considered to be sand that can be beneficiated to a saleable silica sand project. The top 500mm has been excluded from the MRE as it will be reserved for rehabilitation purposes. As there is no waste material, the recovery factor is considered to be 100% and ore loss therefore is considered to be 0%. Inferred Resources have not been included in the Ore Reserve Estimation. The BFS includes an assumption of mining a portion of Inferred Resource (30% of mined tonnage). • This ore is contiguous with the Indicated Resource and has been categorised as lower confidence based on wide spaced drilling. Drilling of the Indicated Resource is typically 50m spaced along existing tracks, whereas the Inferred Resource is drilled on a 400m along existing tracks. • There is sufficient drilling to assume geological and metallurgical continuity of the sand deposit. • There is negligible difference between the modelled sand in each category and it is believed an additional 1,500m of drilling would be required to upgrade the inferred resource category. The cost of this work is estimated to be in the order $250,000 (at current rates). It has not been completed purely for capital preservation reasons. • The Competent Person is confident the Inferred Resource will be converted prior to it being required in the mine plan. In designing the Mine Plan Pit, the Company has examined the restrictions and constraints on mining activities in the context of surrounding areas and the interests of stakeholders, and planned accordingly. To that end, the Mine Plan Pit ensures: • mining will not occur any closer than 100m to the Dongara to Pinjarra gas pipeline; • mining will not occur any closer than 200m to the boundary of any freehold land and will be at least 600m from the nearest house; and • the Mining Lease area does not intersect with the Gingin Airfield ground and mining will not occur any no closer than 250m to the boundary of the Gingin Airfield. In addition, mining will not occur under the flight lines to and from the airfield. These buffer zones are at least equal to, or are in excess of, industry practice and legislative requirements (if any). In addition, the eastern boundary of the Mine Plan Pit is contiguous with the FNA (see section 3) and does not intersect with any proposed conservation area under the Green Growth Plan. The Mine Plan Pit therefore is not impacted by any known exclusion areas.

Criteria	Commentary
	Infrastructure required will be office blocks, mining contractor workshop and associated facilities.
Metallurgical factors or assumptions	VRX Silica has completed a rigorous and extensive metallurgical testwork program. Bulk composite sample for Muchea were tested at the Nagrom Laboratory in Kelmscott, Perth and the CDE Global Laboratory in Cookstown, Northern Ireland. The testwork flowchart followed attritioning, spiral tests, magnetic separation and sizing and assay determination to determine a catalogue of saleable products that could be produced from the Muchea sand mineral resource. A full summary of the testwork is covered in Section 3 of this Table. The results of the testwork were used by CDE Global to complete an Engineering design and costing for a 300tph wet processing silica sand plant for Muchea. CDE Global is a world leader wet processing plant design and construction with over 1,300 projects delivered over the last 25 years. The silica sand plant utilises commonplace equipment and the process is well proven The sand will be processed through a traditional wet processing plant. A slurried sand will be delivered from the mine via a pipeline to the Plant which will be located proximal to the Moora–Kwinana Railway, with a rail connection direct to Kwinana Bulk Terminal. The process flow in the plant will be; • Sand slurry to a constant density tank, • Attrition Bank #1, deslime • Attrition Bank #2, deslime • Spiral gravity separation • Magnetic separation • Sizing screens to customer specifications The bulk testwork has allowed for generation of a catalogue of products that can be produced from the Muchea mineral resource. Three high value export products can be produced for the glassmaking market. The export products have been denoted as Muchea F80, Muchea F80C and Muchea F150. The testwork has determined the mass balance of the various particle sizes during processing and a recovery of each product can be estimated. The following recoveries are used in the conversion of mineral resources to ore reserves; **Product** / **Market** / **Recovery** Muchea F80 / Glassmaking / 48% Muchea F80C / LCD / 20% Muchea F150 / Glassmaking / 20% / **Total** / **88%** The Ore Reserve conversion is declared as a plant recovered tonnage and is represented by the chemical and physical compositions of the final products that are produced for export, or for the local market. An independent Technical Review by CSA Global on the Metallurgical Testwork to satisfy Clause 49 of the JORC 2012 code was included in the Maiden Mineral Resource Estimate.
Environmental	Environmental Characteristics of the Area The development is located: • Mining is 100% on Vacant Crown Land (VCL) • East of the Yeal Nature Reserve and State Forrest • West of Freehold land • South of Gingin Airfield • Approximately 25 km inland of the coast

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Criteria	Commentary
	• Mining is 100% on Vacant Crown Land (VCL) • West of Chandala Brook (Registered Aboriginal Heritage Site); and • Outside of World Heritage Areas, National Heritage Places, Ramsar Wetlands, Conservation Reserves or Commonwealth Marine Reserves. The Probable Ore Reserve is located within an area of deep Bassendean sands, leached o nutrients. The vegetation type is Banksia Woodlands. The topography is low to medium relict dunes. Assessment Process • Referral submission to DotEE; • Submission of Section 38 referral to WA EPA; • Seek an Accredited EPBC Act Assessment under the WA EP Act via an Environmental Review Document with public comment; • May required studies • Submission of Environmental Review Document Mitigation Strategies • Proposed Action lies within a large Development Envelope, allowing for the flexibility to target areas of lower significance to MNES • Disturbance will be kept to a minimum, up to 30 ha per year and 10 at any one time • Progressive rehabilitation using topsoil re-location to ensure topsoil and plants are translocated to previously mined areas • Conduct further surveys to identify Matters of National Environmental Significance • Use findings to steer the project and avoid MNES where possible There are no mine tailings storage requirements There are no waste dumps Processing requires no chemicals.
Infrastructure	The project is located within a development envelope bounded by Freehold Land to the east and the Yeal Nature Reserve and State Forrest to the West, and Gingin Airport to the North, the Southern boundary is the limit of tenure. Product will be loaded on rail for transportation to the Kwinana Bulk Terminal The project will require its own installed power and water infrastructure Labour will be sourced from the nearest towns (10-15kms) Muchea and Gingin There will be no accommodation installed at the mine site.
Costs	Operating costs Costs were determined from first principles and are estimated to include all costs to mine, process, transport and load product on to ships, including; • Mulching • Topsoil cut • Topsoil re-location • Excavation

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Criteria	Commentary
	• Plant Feed • Operating the trommel and pumping station • Processing • QA/QC • Power and Water • Administration • Product Handling • Train Feed and Transport • Port Storage • Ship Loading Product Quality • Multiple products will be differentiated during processing subject to required particle size distribution by screening • Recovery of products has been independently assessed by CDE Global, a world leading silica sand testing laboratory Commodity Prices • Commodity prices for VRX silica sand products have been determined by independent industry source Stratum Resources • The industry standard is that sales contracts are in US dollars • The exchange rate to convert to Australian dollars will be the prevailing at the time of payment • Subject to final quality produced the prices for the commodity will range from US$38 to US$55 per dry metric tonne Free on Board • There are no shipping cost estimates with all contracts to be based on FOB rates QA/QC • The company will undertake constant surveillance of product quality during production • An independent laboratory will be used to verify the product during loading on behalf of the buyer Royalties • The prevailing rate of Royalty due to the State is used in VRX economic assessments • The Royalty rate is per dry metric tonne ($1.17) and reviewed every 5 years with the next review due 2020 • A royalty rate has been negotiated with Native Title claimants and has been included in the project metrics. • Australian Silica Pty Ltd retains a Net Production Royalty of 1%.
Revenue factors	Revenue Revenue will be based on a negotiated per shipment basis per dry metric tonne FOB with payment by demand on an accredited bank Letter of Credit There are no other treatment, smelting or refining charges.
Market assessment	The Company has commissioned an independent assessment of the current market prices for proposed products by industry leader Stratum Resources The assessment includes projections for future demand and supply of Silica Sand The assessment concludes that there is a future tightening of supply suitable glassmaking silica sand with a commensurate increase in price

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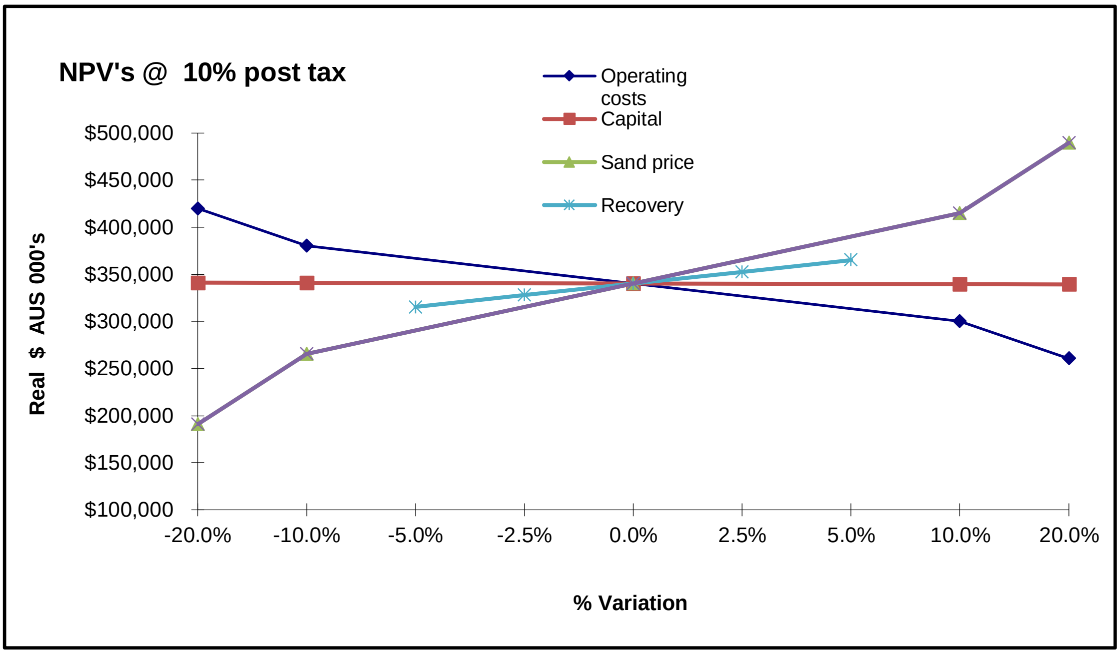
Criteria	Commentary
	Sales volumes have been estimated as a result of received Letters of Intent to purchase products
Economic	The Company economic analysis has calculated a 10% and 20% discounted ungeared post tax NPV The Company assessment has not escalated future product prices nor any inflation to operating costs The analysis has used a US$/A$ exchange rate of $0.70 Total probable Ore Reserve supports a 9-10 year project but there is a reasonable expectation



Criteria	Commentary
	that with further close spaced drilling the existing Inferred Resources would convert to Indicated Resources and Probable Reserves in excess of this time period, however the model is conservatively restricted to 25 years Tax rate used is 27% of profit Capital requirements are based on independent estimates Capital borrowings are based on a 12% borrowing rate Capital expenditure contingency is 20% of capital estimates Plant spares are estimated at 5% of capital value The economic analysis is most sensitive to the exchange rate and sales prices
Social	VRX made an application for a mining lease, M70/1390, on 14/01/2019. The application lies within the Whadjuk People native title claim boundaries (WAD242/11). The Company is currently in negotiations with the claimant group with respect to the mining lease application M70/1390. There is no reason to believe that an agreement will not be reached between the parties allowing for the mining lease to be granted. The Project is wholly on unallocated vacant crown land.
Other	There are no known obvious or naturally occurring risks that have been identified which could affect the project and no reason why the Company cannot gain all approvals to mine the project from the relevant Regulatory Bodies, both State and Federal.

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Criteria	Commentary
	The Company has received expressions of interest from 20 manufacturers across the Asia Pacific Region for various silica sand products in its published catalogue, including specific requests for Muchea products. The Company has made an application for a mining lease, M70/1390, on 14/01/2019 and there is no known reason why this lease will not be granted. A number of Letters of Intent to purchase the Projects proposed products have been received from potential customers.
Classification	Probable reserves are converted from Indicated resource materials. Because of the nature of the deposit (consistency, homogeneity, low variability) this is considered reasonable. 100% of the ore reserves are Probable.
Audits or reviews	The Ore Reserve estimate has been reviewed internally by VRX. No external reviews or audits have been undertaken on the Ore Reserve estimate.
Discussion of relative accuracy/ confidence	The Mineral Resource, and hence the associated Ore Reserve, relate to global estimates. To date there has been no commercial production, therefore no reconciliation can be made. A BFS if being finalised and the results of that study are available to the Competent Person. The BFS has been completed to a high level of detail and therefore the Competent Person can be confident the project is robust and produce positive economic benefit to the Company once in production. Sensitivity analysis made during the BFS process has indicated that the economics are most sensitive to the USD/AUD exchange rate. It is believed that the revenue model is sufficiently conservative to ensure a positive economic return.

19.5 JORC Compliance Statement

The information in this document that relates to Exploration Targets, Exploration Results, Mineral Resources, Ore Reserves and Production Targets have been extracted from the report(s) and announcements listed below.

Muchea Silica Sand Mineral Maiden Resource Estimate: CSA Global Mining Industry Consultants (October 2018)

Muchea Silica Sand Mineral Resource Estimate Update: David Reid, Geologist (June 2019)

Muchea Reserve Estimate: David Reid, Geologist (October 2019)

CDE Testing Report Revision 2: CDE Global (February 2019)

Desktop Assessment of Potential Flora, Vegetation and Fauna Values at the Muchea Project Area: Mattiske Consulting (March 2017)

Flora and Vegetation Assessment at the Muchea Project Area, Mattiske Consulting (October 2019)

Fauna Assessment for VRX Silica Muchea Silica Sand Project: Mike Bamford, Tim Gamblin, Andy McCreery and Natalia Huang, M.J. & A.R. Bamford Consulting Ecologists (November 2018)

Hydrogeological Feasibility Assessments Muchea Project: HydroConcept Consultants (March 2019)

Silica Sand Markets: Stratum Resources (July 2019)

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