

Appendix L
Champions Quarry
Marketing Assessment



Champions Quarry Marketing Assessment

19 August 2009

For Reavill Farm Pty Ltd

Tucki Hills Pty Ltd

19 August 2009

Jeff Champion
Reavill Farm Pty Ltd and Tucki Hills Pty Ltd,
Hazlemount Lane,
Tucki NSW 2480A

Dear Jeff,

RE: Marketing Assessment Report

Attached is the final report entitled Marketing Assessment Champions Quarry as requested.

For and on behalf of AVKO Mining Pty Ltd

A handwritten signature in black ink, appearing to read 'Alan Robertson', followed by a long, sweeping horizontal line that extends to the right.

Alan Robertson
Principal Engineer FAusIMM, MMICA, MIOQ

EXECUTIVE SUMMARY

Following discussions over the past year between Mr Jeff Champion, Coffey Mining and AVKO Mining (following my transfer from Coffey Mining to AVKO Mining), I have completed a marketing assessment of Champions Quarry, located at Tuckurimba, approximately 16 km south of Lismore in Northern New South Wales. The existing quarry has an approved annual extraction of 29,000 m³ (64,000 t) and project approval is currently being sought under provisions of Part 3A of the Environmental Planning and Assessment Act (EPA, 1979), for increasing the production to 250,000 t/a.

This marketing study has involved the following process to reach its conclusions:

- A site visit and overview of the working quarry and drill cores (Coffey Geotechnics, 2007) from the proposed extraction area. Another sample of screened sand was taken from the on-site screen and this is being further investigated.
- A review of laboratory analysis of drilled core and material sampled from the quarry working area and a determination of the types of material that can be supplied from Champions Quarry.
- Examination and assessment of a sample of the grey sandstone drill core.
- A review of the supply and demand for quarry materials in the Lismore/Ballina Region and surrounds.
- A Strengths, Weaknesses, Opportunities and Threats (SWOT) Analysis was completed in regard to quarry marketing.

AVKO Mining is impressed by all aspects of the overall staged approach and culture associated with the growth of the quarry by the management of Champions Quarry. This includes a developing internal capability in quarry operations, environmental management (including experience in farming), processing and marketing.

The following are the key conclusions from the marketing assessment.

1. Mineral Resource.

This is assessed, based on the core drilling programme as 5.4 Mm³ – approx 12 Mt (JE Siemon, 2008 Appendix C of Coffey Geotechnics Report) and is made up of overburden (7.4%), general fill (35.2%) and slightly weathered sandstone (57.4%). This Resource could provide up to 50 years production, dependent on the product split and associated demand. As the quarry is developed it will be advantageous to further investigate the composition of the Resource in terms of material quality and location of sandstone types within the Resource. For example, from the core data, AVKO Mining assesses that the sandstone classified as “Very High Strength” represents approximate 40% of the hard and very hard sandstone volume, this volume being interspersed with medium and lower strength material. This approach may assist in the Quarry Design Plan and future excavation methods of the harder sandstone at a lower depth.

2. Current Operations.

The current operations are relatively low key with an excavator, loader, water truck, tip truck and mobile Fintec Striker screen on site. The operations are well managed with a capacity to produce up to 1,000 t/day of fill or roadbase material and this includes blending of local basalt material. Recent screening production has been limited due to heavy rains. Under the current approval, the operations could easily handle a local supply contract of up to 64,000 t/a. The greatest limiting factor to production under the current Development Approval (DA) is the limited space on the

existing quarry floor. The current operations also have some available material to supply landscaping stone and stone for boulder walls.

3. Future Operations.

Production capacity should be increased to 250,000 t/a when the Part 3A approval is obtained and the necessary infrastructure installed. This may require a processing design based on essentially wet feed to a trommel and wet processing of the sand (including product centrifuging to remove moisture and recycle water) similar to the process at Southern Pacific Sands (Bribie Island) and Emerald Quarries (Emerald). AVKO Mining recommends that future marketing addresses the optimum product split to optimise income from the quarrying operations. This requires uniform extraction of the Resource in the form of overburden, general fill, engineered fill, washed sand and sandstone products. This may require further quality assessment of the sandstone component as it appears some of the material is of extremely high quality.

4. Review of Material Quality.

The Material Assessment Report (Coffey, 2007) outlines the potential products from the Resource, based on limited material testing. Gradings of quarried material supplied and tested by Coffey indicate that there is a significant percentage of coarse aggregate (approx 25% plus 2mm) which is significantly higher than the coarse content of the finer coastal sands. Ultimately the product size depends on the excavation process as well as the efficiency of washing and screening. Further testing will be required in this regard. It is recommended that the core from one borehole be “sacrificed” for further testing to provide more data on potential material types with depth.

5. Champions Quarry Products.

AVKO Mining believes that further testing of the sandstone core will confirm the potential products described in the Material Assessment Report (Coffey, 2007) and potentially identify further products. Current and future products include:

- Washed sand.
- Roadbase and select roadbase using select sandstone product and imported basalt (RTA Specification DGS and DGB).
- Engineered fill (CBR 30).
- Bricklayers sand (loam).
- General sandstone fill.
- Topsoil.
- Landscaping boulders and Type “A” and “B” for engineered walls.
- Aggregate products (concrete aggregates) from identified high strength sandstone layers.

6. Further Material Testing.

AVKO Mining recommends further testing of sand and of core from a specific borehole. Although previous testing has confirmed that washed sand is suitable for the concrete and asphalt market, further testing will indicate likely gradings, colour and free silica content and thus the suitability to the “medium value” and “high value” sand market.

7. Product Demand, Competition and Potential Market Position for Champions Quarry.

Significant research has been completed by Champions Quarry and Environmental Resource Management (ERM) in regard to local demand and competition in the Far North Coast Region. This includes Resource estimates and production rates of competitors, local prices and population

growth. AVKO Mining has used this and other data to rank Champions Quarry as a long term producer of quarry products within the region. Key issues are:

- The Far North Coast Region in general and the Lismore/Ballina Region in particular is principally basalt and has limited sand quarries.
- There is a distinct lack of washed sand for the concrete and asphalt markets in the Lismore/Ballina Region.
- There is a distinct lack of suitable sandstone for blending with basalt to provide RTA specification DGS and DGB blended road base for the region.
- There are limited sources of dimension stone and sandstone boulders.
- There is a distinct lack of Australian Standard bricklayer's sand in the region since Broken Head Quarry ceased production in 2007.
- There are no licensed quarries for topsoil sales in the area.
- Some quarries appear to be extracting more than their licence allows.
- Some quarries are operating illegally or have been closed down by Local or State Government Departments.

The potential ability of Champions Quarry to supply washed sand, select roadbase, engineered fill and other sand products to regular markets and to major projects in the Lismore/Ballina Region will have a major effect on the growth of the quarry. This study has identified that Champion's Quarry is probably the largest potential resource of regional significance of washed sand and sandstone available for approval in the Lismore/Ballina Region of New South Wales. Most competitive operations are located on limited resources or have longer term operational (including environmental) problems.

8. **Overall Conclusions.**

The proposed expansion of Champions Quarry, when approved, will provide a unique high quality sandstone resource for the Far North Coast Region. The Quarry will provide a wide range of washed sand and sandstone derived products for the civil construction industry, particularly in the Lismore/Ballina Region. The type of products will depend on:

- Optimisation of the site product to target 100% utilisation of material extracted. This reduces the need to stockpile waste material and lowers the product cost.
- Optimisation of product value. The project has the potential to target an average ex-bin price of \$30/t once high strength to very high strength sandstone production commences. Waste from dimension stone and boulder extraction can be used for "value added" products.
- Existing and future local demand for products.

AVKO Mining predicts that Champions Quarry should reach a production capacity of 250,000 t/a within three to five years of the approval of the Part 3A Application and following implementation of the necessary infrastructure for larger scale extraction.

The SWOT Analysis indicated that expansion of the Champions Quarry is associated with low risk in the current financial climate.

9. **Overall Recommendations.**

After approval of the Part 3A AVKO Mining recommends as follows:

- Installation of a sand washing plant and associated dam infrastructure as a matter of priority to ensure Champions Quarry establishes itself as a supplier of washed sand in the region.
- Further tests of washed sands from the quarry and core samples to determine the mix of sands which can be produced.
- Tests on sections of the hard to very hard core from one hole for Unconfined Compressive Strength (UCS), Modulus of Rupture, Flexural Strength, Absorption, Sodium Sulphate Soundness Loss and Specific Gravity. This is for the purpose of determining the suitability of the high strength to very high strength sandstone as a dimension stone.
- Tests of the residue material as a potential aggregate.

AVKO Mining also recommends, after approval of the Part 3A further correlation of the resource to the potential product stream as follows:

- Identification of the relationship between the stratigraphy, fracturing and the rock types (and potential products) with depth.
- Use of the Measure While Drilling concept to gain additional material information and build a three dimensional block model of the Resource which will assist in future quarry design and scheduling based on in-situ material quality.



Alan Robertson
Principal Engineer FAusIMM, MMICA, MIOQ
19 August 2009

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1. INTRODUCTION

1.1 Background

At the request of Jeff Champion, Alan Robertson Principal Engineer of AVKO Mining Pty Ltd, Brisbane (AVKO Mining) has completed a Marketing Assessment of Champions Quarry located off Wyrallah Road at Tuckurimba 16 kilometres south of Lismore in Northern New South Wales.

Alan Robertson previously worked as Principal Mining Engineer for Coffey Mining Pty Ltd, Brisbane (Coffey Mining) and has had significant experience in marketing assessments and valuations for a number of sand and sandstone projects on the east coast of Australia. These include a number of sandstone projects in the Helidon and Warwick regions, Glenreagh Sandstone (west of Coffs Harbour), and sand and gravel projects located at North Stradbroke Island (Riverside Industrial Sands), Beachmere (Southern Pacific Sands), Emerald (Emerald Quarries) and Roma (Yuleba Silica Sands).

In terms of marketing, the primary local area of market influence for Champions Quarry includes part of the Far North Coast Region as follows:

- Lismore City Council
- Ballina Shire Council to the east.
- Byron Shire Council mainly Byron Bay and Suffolk Park.
- Richmond Valley Shire Council to the south and west.
- Kyogle Shire Council to the north-west.

This marketing catchment represents a projected population (2009) of 155,523 based on projected growth on 2006 figures of 1.9%/a.

1.2 History of Champions Quarry

A sandstone quarry has been in operation on the site since approximately 1959. The Quarry was originally operated by the old Gundurimba Shire Council, then following amalgamations, Lismore City Council until the 1980's. In the mid 1990's the New South Wales State Government licensing of quarries restricted Champions Quarry to an existing use rights status of 5,000 m³/a (11,000 t/a) with no lateral expansion. In 2006 Lismore City Council granted DA 2005/99 allowing for an annual extraction of up to 29,000 m³/a (approximately 64,000 t/a). The current quarry occupies an area of 2ha. A Part 3A Application has been lodged with the New South Wales Department of Planning for an increase in annual production to 250,000 t over approximately 15 ha. The proposal also involves two 40 megalitre water storage and recycling dams and a sand washing plant.

2. RESOURCE DESCRIPTION

2.1. Site Geology

The material on site comprises part of the Kangaroo Creek Formation, described as quartz sandstone and conglomerate, which outcrops over a large area extending from near Coffs Harbour north to the Queensland border. The sandstone rock mass dips approximately 2 degrees to 5 degrees to the west north-west. There are some overlying basalt rocks on the site but these are limited to an area west of the proposed quarry expansion area. There is a thin clay soil veneer above RL50m inside the proposed expansion area. The weathered basalt is responsible for the yellow to brown colouring of the sand produced on the site. This will change to greyish white as the deeper material is extracted. Core recovery and continuous core length from diamond drilling at Champions Quarry is confirmed in the Coffey Geotechnics 2007 report.

2.2. Review of Material Quality

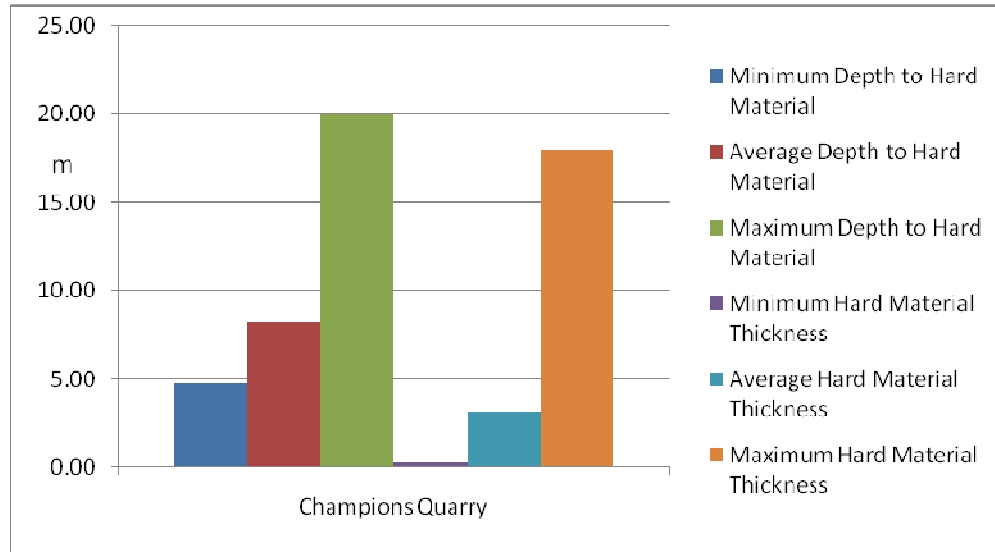
AVKO Mining has reviewed the technical data provided (Coffey Geotechnics, 2007) and makes the following observations:

- Fine and coarse sand is present on the site.
- The material is also suitable for structural or engineering fill.
- The material has a good Californian Bearing Ratio (CBR) for sandstone.
- The Plasticity Index (PI) of the yellow sandstone is excellent for roadbase and engineered fill.
- Parts of the yellow sandstone are suitable for bricklayers loam (sand).
- The grey sandstone is high to very high strength and clean and will be excellent for washed sand and other high value products.
- The material tested was from the existing workings and bore samples.
- Limited tests on the hard to very hard material were completed.
- More data can be obtained from the geotechnical logs of the boreholes.
- UCS tests on the core samples will assist with future planning.

AVKO Mining is of the opinion that detailed analysis of the geotechnical data and further testing of core material will provide significantly more information for quarry planning and potential product identification. AVKO Mining has reviewed the core logging and has assessed the percentage of high strength to very high strength material within the harder zones at depth. AVKO Mining assesses that the sandstone classified as "Very High Strength" represents approximate 40% of the hard and very hard sandstone volume, this volume being interspersed with medium and lower strength material. Figure 2.1 shows the averaged data for the boreholes within the proposed quarry area. APPENDIX 2-A shows the data analysis.

This approach may assist in the Quarry Design Plan and future excavation methods.

Figure 2.1: Details of High to Very High Strength Within Resource Boundary



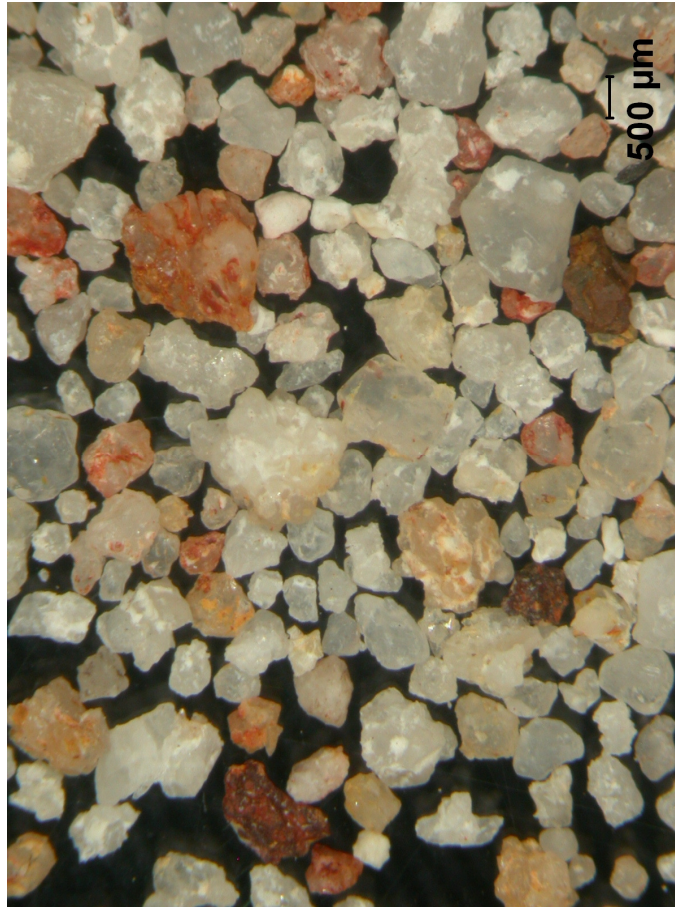
AVKO Mining had a sample of screened sand washed and the oversize from a 300 mm screen has been photographed under high magnification. A typical photograph is shown in Figure 2.2. Observations are:

- Confirms fine and coarse sand present.
- The sand particles or grains are described as “sub angular” to “sub rounded”.
- A number of the quartz particles are white.
- Overall a good size, colour and shape range of particles.

At a later stage in the project further testing and analysis of the material and project planning could involve:

- Preparation of a 3D contour model which can plot major bedding spacings (which determine the thickness of boulders or dimension stone or pavers that may be directly extracted), location of interbedded materials eg clays (and their quantities). This model should correlate specific stratigraphic layers identified in the core data.
- Selection of sections the hard to very hard core from one hole for Unconfined Compressive Strength (UCS), Modulus of Rupture, Flexural Strength, Absorption, Sodium Sulphate Soundness Loss and Specific Gravity. This is for the purpose of determining the suitability of the high strength to very high strength sandstone as a dimension stone.
- X-Ray Diffraction to determine the silica and accessory minerals content of unwashed and washed sand. A sample has been forwarded to Brisbane laboratory for analysis.
- Further drilling of the resource. AVKO Mining has an Atlas Copco D9C SmartRig which can identify rock types based on the drilling characteristics for the material types. The process is called Measure While Drilling and requires drilling parallel to an existing cored hole for “calibration” of the drilling parameters against the material types.

Figure 2.2: Photograph of Fine Sand Particles (+300 microns)



It is important to correlate the tested properties with the potential product range. Parameters include:

- The silica content of the sand, confirmed at approximately 84%.
- The material size shows a good range of fine and course particle size.
- Deleterious materials within the product (some materials eg clays provide improved PI for roadbase, engineer fill and bricklayers loam).

3. MARKET ASSESSMENT

3.1. Introduction

In assessing the Champions Quarry operations in the Far North Coast Region the following key issues have been identified.

- The Far North Coast Region in general and the Lismore/Ballina Region in particular is principally basalt and has limited sand and sandstone quarries.
- There is a distinct lack of washed sand for the concrete and asphalt markets in the Lismore/Ballina Region.
- There is a distinct lack of suitable sandstone for blending with basalt to provide RTA specification DGS and DGB blended road base for the region.
- There is a distinct lack of Australian Standard bricklayer's sand in the region since Broken Head Quarry ceased production of bricklayer's sand in 2007.
- There are no licensed quarries for topsoil sales in the Lismore/Ballina Region.
- Some quarries appear to be extracting more than their licence allows.
- Some quarries are operating illegally or have been closed down by Local or State Government Departments.

3.2. Champions Quarry Product Description

The resource at Champions Quarry is extremely important and unique to the region for the following reasons:

- It is a sandstone resource in what is basically a basalt region.
- Most of the coastal and river bed sands possess round particles and are less valuable than the sought after fractured face sands, described as sub-rounded to sub-angular (found at Champions Quarry) required for strength for the concrete market.
- Generally, sources of washed sand provide either fine sand or coarse sand. Champions Quarry product analysis shows both fine and coarse sands are present on site.
- Most coastal sands and hinterland sandstone possess little or no Plasticity Index (PI) Rating. PI is necessary for products such as high quality roadbase, blended roadbase, certified engineered fill and bricklayer's loam. The resource at Champions Quarry shows consistent PI in the yellow sandstone.
- The Champions Quarry resource possesses an excellent combination of Californian Bearing Ratio (CBR) for strength, a high level of fines, excellent

PI, zero reactivity (wet to dry) and the product has self cementing properties – all qualities not present in basalt products and rarely found in sandstone in the region. These qualities are required for roadbase, RTA specification blended roadbase and certified engineered fill and are currently lacking in supply in the Lismore/Ballina Region

Accordingly, Champions Quarry would be able to efficiently and economically supply a large range of important products to the region.

3.3. Demand for Sandstone Quarry Products in the Far North Coast Region

The area of consideration for marketing is the greater area of the Far North Coast Region (excluding the Tweed Shire Council and Clarence Valley Council). Table 3.1 shows the population of these local government areas (Census 2006 Update) projected to 2009. AVKO Mining assesses the annual demand for sand related products (including washed sand, certified engineered and general fill, roadbase, bricklayers sand and specialty sand products) in this region to be 3 t - 4 t/capita. The remaining consumer demand is for aggregates used in concrete, road aggregates and construction projects and this annual demand for the region is assessed at 4 t – 5 t/capita.

Table 3.1: Population of Local Government Areas in Far North Coast Region

Local Government Area	1996	2001	2006	2009 Projected
Lismore City	43,551	43,064	44,225	46,794
Ballina Shire	34,650	38,159	40,266	42,605
Byron Shire	26,620	29,689	30,635	32,415
Richmond Valley Shire	20,861	21,183	22,172	23,460
Kyogle Shire	9,919	9,817	9,686	10,249
TOTAL	135,601	141,912	146,984	155,528

Note: 2009 figures are projected bases on 1.9% annual growth from 2006.

Note: Tweed Shire and Clarence Valley Council areas are excluded as they are outside the area of consideration because of cartage distances and other suppliers.

Based on the above numbers, the demand for sand and sand products in the Far North Coast Region, excluding Tweed Shire and Clarence Valley Shire, is currently approximately 470,000 t/a - 620,000 t/a

3.4. Market Segmentation

A typical market segmentation by area of customer activity for extractive industry operators in the market area is as follows:

- Local sales (non –account sales, COD)
- Manufacturers (concrete, asphalt, filler media)

- Re-sellers (landscape yards, trucking firms)
- Developers (subdivisions)
- Civil contractors (housing, commercial, major projects)
- Subcontractors (builders, landscapers)
- Local Government (infrastructure, recreation)
- Others (agriculture, swimming pool filter sands, foundry sands, golf course sands)

3.5. Potential Markets for Champions Quarry

3.5.1. Distance to Potential Markets

Table 3.2 shows the distance to markets for a number of population centres from Champions Quarry within Lismore City Council, Ballina Shire, Byron Shire, Richmond Valley Shire and Kyogle Shire.

Table 3.2: Distance from Champions Quarry to Local Markets

From	To	Distance
Champions Quarry	Alstonville	25.6km
Champions Quarry	Ballina	38km
Champions Quarry	Broadwater	17km
Champions Quarry	Byron Bay	66.5km
Champions Quarry	Casino	35km
Champions Quarry	Evans Head	26.8km
Champions Quarry	Kyogle	64.4km
Champions Quarry	Lismore	16km
Champions Quarry	Woodburn	16.8km

The following needs to be taken into account when considering the “maximum radius” for which sale of product from Champions Quarry is competitive:

- Product availability – is a similar product available in the required quantity within close proximity eg 15–30 km?
- The product value – is the product priced competitively for the distance it needs to travel? For example, haul distance is not an issue for dimension stone and boulders (worth \$1800/load) which may be transported up to 250 km while fill and low value products may be limited to a 30-40 km haul distance
- Greenhouse Gas Emissions associated with transport.

Whilst Champions Quarry is within approximately 60 km of all of the above market centres, supply of low cost material will be concentrated on areas within a radius of 16–40 km of the Quarry. This will minimise the delivered cost of the product,

eliminate local duplication of product into the market place and minimise Greenhouse Gas Emissions. The centres which Champions Quarry has identified for washed sand, premium roadbase and certified engineer fill are Lismore, Alstonville, Ballina, Casino, Evans Head, Woodburn and the upgrade of the Pacific Highway from Ballina to south of Woodburn. These are all within a 16–40 km radius of Champions Quarry.

Higher value products such as bricklayers sand, specialty sands and dimension stone can be sold into more distant markets at an economically viable price.

3.5.2. Potential Market – Washed Sand for Concrete Plants and Asphalt Plants

Potential markets for Champions Quarry's washed sand include concrete and asphalt plants. The list of these plants appears below:

Concrete Plants

Boral – Alstonville, Ballina, Casino, Evans Head and Lismore

Cemex – Ballina, Byron Bay, Casino and Lismore

Hanson – Ballina, Byron Bay and Lismore

The above plants are each licensed to produce 13,000-25,000 m³ of concrete per annum. The individual plants produce between 65 and 75 m³/h. Based on the maximum annual output for each plant, this equates to 300,000 m³ of concrete per annum for the defined part of the Region. A cubic metre of concrete weighs approximately 2.35 tonnes and contains approximately 800-900 kg of sand (natural or manufactured).

In some regions where sand is in short supply and cartage distances affect price, manufactured sand comprises up to 50% of sand requirements. However, at or approaching 50% of manufactured sand, concrete experiences workability and rheology problems. Concreters are strongly opposed to using concrete in which there is over 50% of manufactured sand. There are no artificial sand manufacturing plants in the region. The closest plants are Coffs Harbour to the south (Cemex) and Nerang (QLD) to the north (Hanson's). In our region Boral uses no artificial sand, whilst Hanson's import 50% of their sand needs as artificial sand from Nerang, since the closure of Broken Head Quarry.

Therefore the sand demand is assessed at:

12 concrete plants x 25,000 m³/a:

= 300,000 m³/a x 0.85 t sand/m³

= 255,000 t/a fine and coarse sand required in the Region for the concrete plants.

Asphalt Plants

Two asphalt plants exist in the Lismore/Ballina Region as follows:

Boral – Gap Road, Alstonville

Northern Rivers Quarry and Asphalt – Nimbin Road, Blakebrook (Lismore City Council)

These two plants are said to produce approximately 30,000 t of asphalt each per annum although Boral has a license for up to 100,000 t/a. Sand comprises 17% of asphalt. Therefore, approximately 10,000 t of sand is required annually by the two plants, based on a total of only 60,000t/a of asphalt.

Therefore the natural sand demand in the region for concrete plants (12) and asphalt plants (2) is of the order of 265,000 t/a, with only up to 60,000 t/a of local supply currently available.

Main suppliers of natural (washed) sand are:

- Boral Sand (Swan Bay) 30,000 t/a approved washed sand extraction.
- South Ballina Sand Quarry (Bill Allen) 30,000 t/a fine sand.
- Broken Head Quarry currently has an Order from NSW Department of Planning not to operate for Non-Compliance from 31 January 2009.
- The remainder of the sand must come from Nerang (QLD) and the Lower Tweed which results in long road haul distances of up to 150 km plus.

If Broken Head Quarry is included in the above scenario, it is obvious that there is still a major shortfall of washed sand in the Region. Therefore there is an opportunity for Champions Quarry to supply washed sand into the following markets:

- Some of the 12 concrete plants located at 6 locations which include Alstonville, Ballina, Byron Bay, Casino, Evans Head and Lismore.
- The two asphalt plants Northern Rivers Quarry and Asphalt at Blakebrook and Boral at Alstonville.

3.5.3. Potential Market – Roadbase and Engineered Fill

As has been stated in other sections in this report, the predominant quarry material available in the Lismore/Ballina Region is basalt. However basalt on its own, does not perform well as roadbase. Basalt is normally deficient in fines, lacks PI (a plasticity rating to bind it) and if it is present (as clay) it is normally reactive (wet and dry). The sandstone material found at Champions Quarry possesses all the qualities lacking in basalt.

In the Northern Rivers Region, the RTA has long endeavoured to overcome the difficulties of using raw basalt by blending with other quarry products. Recently the

RTA has tested Champions Quarry sandstone roadbase and confirmed that if blended with basalt, it provides a premium roadbase which meets the RTA Northern Region Specifications for DGS and DGB roadbase.

Recently, Lismore City Council has commenced using Champions Quarry product for blending with their basalt from Blakebrook Quarry.

There are significant opportunities for the use of Champions Quarry sandstone material for both sub grade fill and for final grades of road base, on its own or blending with basalt for RTA specification works. This is particularly so in the Lismore/Ballina Region, now that Broken Head Quarry is not operational and had been a major supplier of this material in the past, and because of the increased emphasis on distance travelled and Greenhouse Gas Emissions.

Champions Quarry is also uniquely placed to provide Structural or Engineered Fill (AS 3798-2007) as confirmed by Coffey Geotechnics letter dated 23rd April 2007.

This provides enormous opportunities for Champions Quarry for building projects, Pacific Highway upgrades and similar infrastructure projects..

Volumes for the above projects will vary greatly from year to year however, the availability of this type of material is critical to the region, especially if Governments are keen to reduce Greenhouse Gas Emissions via shorter transport distances for major infrastructure and roadwork projects, and contain costs.

3.6. Potential Sandstone Products

Initial investigations into the “Very High Strength” sandstone core by AVKO Mining indicate that this material may be suitable for dimension stone. This assumption is based on:

- The high density of the core (2.46 g/cc).
- The high unconfined compressive strength (UCS) of a sample at approx 42 m depth. The value measured was 73 MPa.
- The high surface finish of a cut section of core indicating suitability to polishing.

A summary of the UCS data is shown in Table 3.3.

Table 3.3: UCS Test Data – Sandstone Core Sample

Height	13.363	cm
Radius	2.5905	cm
Aspect Ratio	2.58	
Volume	281.73	cc
Density	2.46	g/cc
Weight	693.34	g/cc
Area	21.08	sq mm
Force	153.6	kN
UCS	0.07	kN/mm ²
UCS	0.0001	Pascals
UCS	72.85	MPa
	1Pa	1N/m ²

Initial indications are that the crushed aggregate from the “Very High Strength” sandstone may be suitable as a replacement for the larger material component of road base (as an alternative to imported basalt). Extraction within upper levels of the current approved area has already identified a small proportion of landscaping boulders.

3.7. Competition for Champions Quarry

Figure 3.1 shows the location of Champions Quarry with respect to a number of other quarries in the region. The quarries shown in yellow are either basalt quarries (which are not detailed), or small sand and sandstone quarries or small existing use rights quarries with very limited output, several of these supplying filling sand as distinct from washed sand for the concrete and asphalt market. The three quarries shown in pink are quarries which are within 60 km of Champions Quarry and supply or are capable of supplying washed sand for the concrete and asphalt markets. These quarries are documented below.

Operational and Past Operational Washed Sand Quarries

Boral Sand Swan Bay - approximately 30,000 t/a. This material is extracted out of the Richmond River and is the amalgamation of three old river bed leases. This quarry supplies a significant amount of Boral's washed sand needs for their concrete batching plants. This product is wholly used by Boral. Due to the district's shortage of washed sand AVKO Mining does not consider the Swan Bay operations a threat because of the restricted annual volume and sole use by Boral.

South Ballina Sand Quarry – 50,000 t/a. This quarry is operated by Bill Allen and was approved for 12 years under a Part 3A Variation in 2009 by the NSW Department of Planning. It is a limited resource of approximately 600,000 t. The quarry provides fine sand only for the concrete market, mainly in Ballina. Due to the

district's shortage of washed sand AVKO Mining does not consider the South Ballina operation a threat because of the limited production of fine sand only.

Broken Head Quarry – Broken Head Quarry is currently in doubt. Broken Head Quarry has an approved annual production of approximately 140,000 t under its Consent No DA 97/0465 determined by the Minister of Planning in May 1999 and modified in April 2000. It had operated for many years prior to that as Batsons Quarry. In October 2008 Broken Head Quarry had an Order placed on it by the NSW Department of Planning to construct a major intersection on Broken Head Road by 31 January 2009 or cease operating. As the intersection has not been constructed, it is assumed that the future of the Broken Head Quarry is in doubt. This is unfortunate as this quarry provided washed sand for the concrete and asphalt plants in the region (approximately 30,000-40,000 t/a), roadbase, engineered fill and until 2007 was the region's sole supplier of bricklayer's sand. AVKO Mining does not consider the possibility of Broken Head Quarry reopening to be a threat because of the distance (60 km) away from Champions Quarry and the considerable need for washed sand in the region.

Other Sand and Sandstone Quarries

Several sand and sandstone quarries or existing use rights quarries exist in the region. They are not generally considered a threat to Champions Quarry as most of them only sell filling sand or very small amounts of other sand products.

Newmans Quarry 1 (Originally known as Robinsons Quarry) – 10 km south west of Woodburn. This quarry DA was approved by Richmond Valley Shire Council in 1997 for approximately 30,000 m³/a. The owners commenced illegally selling a large volume of bulk sub-grade fill material into the Ballina Bypass in 2007. The quarry had a shut down order placed on it by Richmond Valley Shire Council in 2008, which was not a good start to the Part 3A background paper which was lodged by the operators with the NSW Department of Planning on 17 October 2007. No Environmental Assessment (EA) has yet been lodged with the Department of Planning. The Part 3A will lapse unless the EA is lodged within 2 years of the background paper (now known as a Preliminary Environmental Assessment) being lodged. If the Part 3A process was recommenced on the above quarry, AVKO Mining does not see it as a major threat. The material is very hard dry sandstone, requires blasting and crushing for production, lacks PI and the property has no known water storage sites or approvals for dams for a sand washing plant. Accordingly the product probably would not produce certified engineered fill or bricklayers sand (because of a lack of PI) but could produce bulk fill to the Pacific Highway upgrade. The site suffers a disadvantage of cartage distance over Champions Quarry to the main Lismore/Ballina Region.

Newmans Jackybulbin Quarry Jackybulbin Road, Tabbimobile off the Pacific Highway. Comprises several old existing use right quarries granted amended consent by the Land and Environment Court in January 1999 to DA No 1997/111 (Maclean Shire Council) now Clarence Valley Council. Three separate areas with

multiple cells interspersed over 880 acres, one area for 100,000 t rock PA and two areas for 100,000 t each PA for bulk fill and sand. Very complicated conditions of consent. Approximately 70 km south of Ballina, obviously cartage distance limits competitiveness in the Lismore/Ballina Region.

Lennox Head Sand Pit – small pit supplying filling sand near Lennox Head in a Potential Acid Sulphate Soil area.

AMA Sand Pit – small pit supplying filling sand near Lennox Head in a Potential Acid Sulphate Soil area.

Campbells Quarry Broadwater – small pit supplying filling sand.

Doonbah Quarry – small dredge supplying filling sand near Evans Head.

3.8. Potential New Quarries

- Ramtech (Pottsville): Fine Construction Sand 200,000 t/a (acid sulphate – requires lime addition). Development Approval well progressed. Up to 200,000 t/a concrete sand and poor quality mortar sand. This potential quarry lies outside the radius of completion for low value products.
- Glenreagh Sandstone (Kangaroo Creek Sandstone): Variable Sandstone and Sand Products – located 130 km from Champions Quarry. Not competitive for low value sand products into the Far North Coast Region.
- Cudgen Lakes Sand Extraction Project (Cudgen-Tweed Region): Fine sands and loams.-located 130 km from Champions Quarry. 7.5 Mt resource. Competitive into northern section of the Far North Coast Region.

3.9. Sustainability Issues

The proximity of Champions Quarry to Lismore means that truck haul distances of fill and roadbase materials are significantly reduced when compared to haulage from most other sources. For a truck and dog hauling material, the likely production of greenhouse gases is based on the truck fuel economy and the annual distance hauled. For Champions Quarry, it is assumed that 30 t capacity truck and trailers are used and these average 2 km/L and the emission of CO₂ is 2.7t CO₂-e/kL

If, based on an annual production rate of 250,000 t/a, an average haul distance of 30 km was saved due to the closer proximity of the quarry to the markets, a total of 394 t of Greenhouse gases would be saved each year.

In addition, the energy (Bond Work Index) (BWI) or Crushing Work Index (CWI) required to crush the sandstone is significantly less than that for the local basalts. The CWI for the harder sandstone would be 40% or less when compared to basalt (fresh basalt would be 20 – 25 kWh/t and sandstone would be 10 – 15 kWh/t). In terms of concrete sands, natural sands or sands derived from sandstone make

significantly better concrete sand than sands artificially produced from crushing rock because:

- The grains are generally less angular than manufactured sands and cause the concrete to flow better.
- Most authorities specify a maximum limit of manufactured sand in concrete blends.
- There is a significant amount of energy required to produce manufactured sands.

3.10. Marketing Risk Associated with Champions Quarry

Table 3.4 shows a Strengths Weaknesses, Opportunities and Threats (SWOT) Analysis for Champions Quarry.

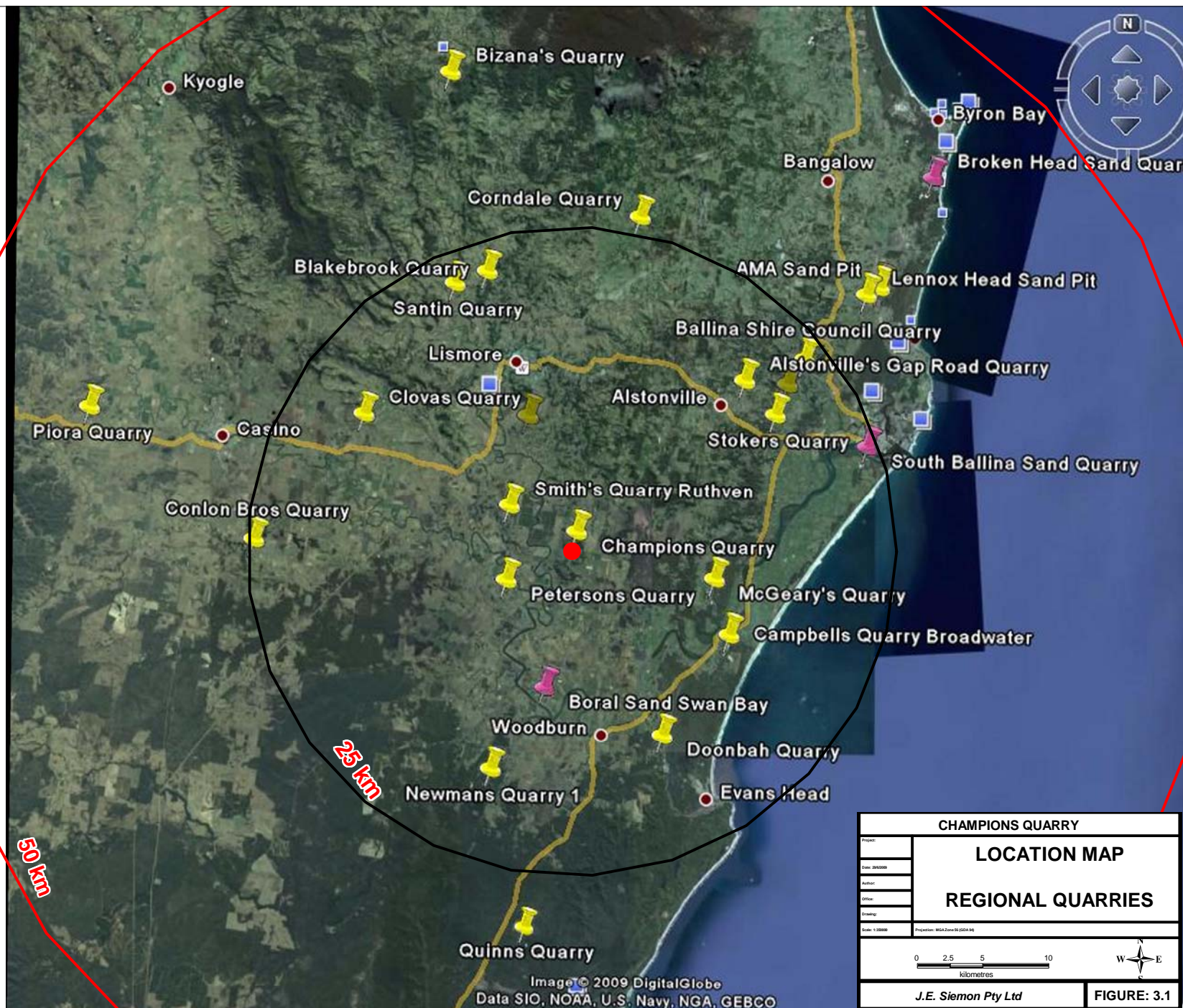


Table 3.4: SWOT Analysis for Champions Quarry

<p style="text-align: center;">Strengths</p> <ul style="list-style-type: none"> – Resource of regional significance – Large sandstone resource (rare in area) – 50 year supply at 250,000 t/a – Large potential product range – Close to markets – Completed EIS & received recommendation for approval from Local & State Gov't Departments – Part 3A application lodged – Established quarry access road & new intersection – Abundant water resource and approvals – Two generations of family in business & marketing – Family culture towards developing quarry – Knowledge of the local area & market – Small quarry operation on site since 1959 – Low sulphate environment (coastal sands high sulphate) – Champion family has established local koala corridors 	<p style="text-align: center;">Weaknesses</p> <ul style="list-style-type: none"> – Restricted existing quarry floor area – Current limited production level – Material quality not fully assessed – Unable to supply full range of products until Part 3A approval
<p style="text-align: center;">Opportunities</p> <ul style="list-style-type: none"> – Major infrastructure projects in region (Pacific Hwy) – Opportunity to supply washed sand to up to 14 local concrete and hotmix plants – Opportunity to produce coarse and fine sand – Potential to increase product range (eg dimension stone) – Product value adding – Potential ownership of local landscape supply business 	<p style="text-align: center;">Threats</p> <ul style="list-style-type: none"> – Part 3A Quarry expansion not yet approved (2010?) – Some organised opposition to quarry expansion – Commencement of Glenreagh sandstone project 130 k away at Coffs Harbour (high value products only) – Possible expansion of Newmans Quarry south-west of Woodburn

3.11. Value of Sand Products

AVKO Mining assesses the value of sand products in three categories. These depend on colour quality and sizing and include:

- **Low Value Sand.** This sand is valued at less than \$30/t (ex-bin) and includes most extractive industry products ranging from fill/overburden to loams, bedding sands blended sands with basalt as quality road base as well as concrete sands. A typical quarry selling these sands would have an average ex-bin price of \$15-\$20/t.
- **Medium Value Sand.** This sand value category is for sands meeting specific “tight” specifications based on sizing, colour is generally in the range \$30-\$60/t and includes foundry sand, bulk filtration sand, quality bricklayer’s “fatty” loams and golf course sand. A typical quarry that produces say 10% of its products as medium-value sands can raise its average selling price from \$20/t to \$24/t.
- **High Value Sand.** This is the specialty sand category and prices can range in excess of \$90/t depending on grading (some sands may be a specific size eg 1mm – 2mm), colour and silica content. These include silica flours (usually ground in a ceramic lined ball mill), specialty fine sands for ceramics and bagged sands such as filter sands, mortar sands, gap-filler sands and other sands. To produce high value sand, expensive equipment such as up-current classifiers, screening systems and packaging systems are required. One of the quarry operations with a high ex-bin price due to the sale of high value sand is Yuleba Silica Sands (near Roma) where the average ex-bin price is reported to be in excess of \$90/t.

3.12. Potential Products from Champions Quarry

These products and the associated local pricing are outlined in Table 3.5. Details of the products are provided in APPENDIX 3-A. APPENDIX 3-A also shows the specifications (sand sizing) for a range of potential sand products for Champions Quarry. The sand sizing (grading) specifications for a particular product may be met by:

- Washing to meet silica content requirements.
- Screening and/or blending to meet grade requirements.
- Crushing and screening of “Very High Strength” material to meet sizing requirements.

Table 3.5: Potential Products from Champions Quarry

Material Type	Density	Available on Site	Ex-Bin Price (\$/t)	Wholesale Price (\$/t)	Comments
Washed Concrete Sand	1.6	Yes, not available at present	\$20 - \$24	\$20 - \$24	Washed sand to specifications
Roadbase		Yes	\$14 - \$16	\$14 - \$16	Price dependant on specifications
Blended Roadbase DGS	1.8	Sandstone is but requires basalt	\$20 - \$24	\$20 - \$24	Price non certified to certified stockpiles
Blended Roadbase DGB	1.8	Sandstone is but requires basalt	\$24 - \$28	\$24 - \$28	Price non certified to certified stockpiles
Engineered Fill	1.7	Yes	\$16 - \$20	\$16 - \$20	Dependent on specifications and certification
Bricklayers Sand	1.7	Yes	\$25 - \$28	\$25 - \$28	Better (fatter) than coastal sands
General Fill Overburden	1.7	Yes	\$8 – \$10	\$8 – \$10	Unscreened
Filler sand (Asphalt)	1.6	Yes	\$20 - \$24	\$20 - \$24	Washed sand to specifications
Bedding Sand	1.7		\$14 - \$18	\$14 - \$18	Screened
Topsoil	1.5	Yes	\$20 - \$25	\$20 - \$25	Screened material- may blend in fines from screening
Sandstone Boulders A Grade	2.2-2.4	Yes, not available at present	\$60-\$65	\$60-\$65	Located at depth in Resource
Sandstone Boulders B Grade	2.2	Yes, limited	\$30 - \$35	\$30 - \$35	Currently minor quantities only- increase value by rocksaw cutting
Dimension Stone	2.4	Yes, not available at present	\$1,000	\$600 - \$800	Located at depth in Resource – requires further testing

4. REFERENCES

Coffey Geotechnics, 2007. Suitability of Quarried Sandstone Material. Facsimilie dated 24 April, 2007.

Coffey Geotechnics, 2007. Champions Quarry Material Assessment in Proposed Expansion Area.

ERM, 2009. Champions Quarry Expansion Preliminary Environmental Assessment.

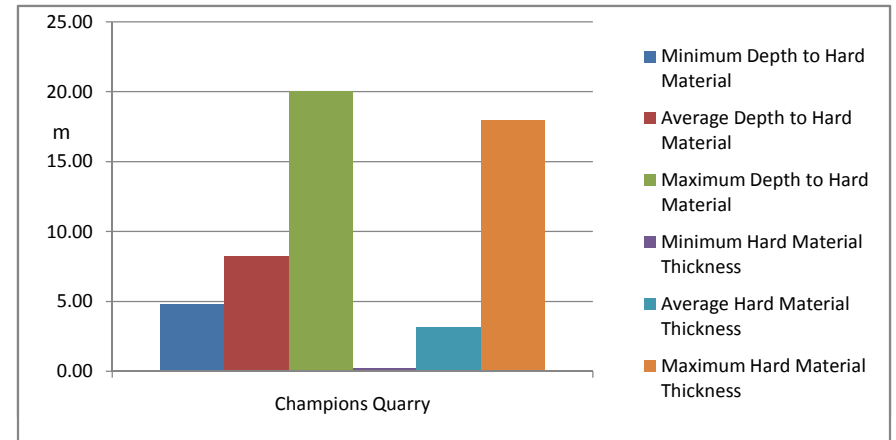
APPENDIX 2-A
Borehole Strength Data

Borehole No.	Total Depth	Estimated Strength						RQD %
		High			Very High			
		Start	Finish	Length	Start	Finish	Length	
1	20.3	20.05	20.3	0.25				65%
Cumulative Percentage				0.25 1%			0 0%	
2	20.3	6.05	7.5	1.45				62%
2	20.3	8.05	12.3	4.25				95%
2	20.3				12.3	15.6	3.3	96%
2	20.3	19.5	20.3	0.8				100%
Cumulative Percentage				6.5 32%			3.3 16%	
3	21.65				5	6.1	1.1	86%
3	21.65	6.1	6.9	0.8				86%
3	21.65				6.9	9.5	2.6	100%
3	21.65	9.5	11.6	2.1				94%
3	21.65				11.6	12.9	1.3	94%
3	21.65	12.9	13.8	0.9				0%
3	21.65				18.2	20.9	2.7	77%
Cumulative Percentage				3.8 18%			7.7 36%	
4	42.3	4.8	8.2	3.4				90%
4	42.3				17.3	23.7	6.4	100%
4	42.3	23.7	24.2	0.5				100%
4	42.3				24.3	42.3	18	95%
Cumulative Percentage				3.9 9%			24.4 58%	
5	41.6				11.5	12.6	1.1	98%
5	41.6	13.2	13.8	0.6				98%
5	41.6				13.8	18.7	4.9	97%
5	41.6	18.7	19.6	0.9				100%
5	41.6				19.6	25.2	5.6	95%
5	41.6				25.6	34.5	8.9	100%
5	41.6	34.5	36.5	2				100%
5	41.6				36.5	38.7	2.2	100%
5	41.6	38.7	39.6	0.9				99%
5	41.6				39.6	41.6	2	99%
Cumulative Percentage				4.4 11%			24.7 59%	
6	21.95				8	8.8	0.8	95%
6	21.95				11.2	21.95	10.75	99%
Cumulative Percentage				0 0%			11.55 53%	

Note: outside boundary
Note: outside boundary
Note: outside boundary
Note: outside boundary

Champions Quarry

Minimum Depth to Hard Material	4.80
Average Depth to Hard Material	8.27
Maximum Depth to Hard Material	20.05
Minimum Hard Material Thickness	0.25
Average Hard Material Thickness	3.14
Maximum Hard Material Thickness	18.00



Note: outside boundary
Note: outside boundary

APPENDIX 3-A
Potential Champions Quarry Products

This database was prepared by A Robertson and M. Oleniuk (both previously of Coffey Mining Pty Ltd). Intellectual property belongs to Alan Robertson of AVKO Mining. It should only be used as a guide to identify if Champions Quarry can meet product grading specifications for certain sand sizes and types.

In the case of Champions Quarry, the analysis represents material as "quarried" with limited processing.

As Champions Quarry develops, there will be an upgrade in processing (eg crushing/washing) and this will lead to a change in material sizing and quality.

For each product type spreadsheet, the suitability of Champions Quarry sand is discussed.

The following is an explanation of each spreadsheet

- Inputs** This is the grading data obtained from analysis of Champions Quarry products
The red shaded columns are not used because they include imported basalt for roadbase material
It is not necessary to combine all of the inputs when examining a sand product from screening and matching it against a product specification
Each standard grading curve is transferred to the Prodsiz spreadsheet and this spreadsheet also shows the "combined grading". This can represent the bulk sizing.
- Prodsiz** This spreadsheet shows the overall suitability of the quarried product, either natural or screened, to meet product grading specifications
The following are the components of this spreadsheet:
Vertical Scale - Size Range of Product: This is a log scale showing the grading ranges for a particular product.
Horizontal Scale: This scale is a pseudo linear scale which shows the percentage of silica in the sand product.
Segment **ABCD** indicates the potential products that may be achieved from Champions Quarry. Where the lines overlap the product specs Champions sizing is unsuitable.
The percentage size distribution column shows the combined sizing of the gradings supplied by Champions Quarry. This will change with processing.
Note: If a sand of specific size is taken out, this limits the gradings for other products.
- Sieve Sizes** These are the conversions, dependent on the type of screens used. Generally use AS screen size (mm and microns)
- Product Specifications**
Road Base (Unbound): Specifications shown are for Type 1, 2 and 3 for Old Main Roads. Screened Champions Quarry material meets lower gradings but there is a shortfall of Higher grading sizes.
Note: Specifications depend on PI, shrinkage, degradation factor and other parameters. By blending crushed basalt (upper sizes), specifications can be met.
Cover Aggregates: Specifications can not be met by current products.
Note: Specifications for certain cover aggregates may be met by crushing and shaping the high strength sandstone (70 Mpa plus).
Dense Asphalt. This product may be achieved by washing, screening and blending to achieve the design gradient curve..
Mastic Asphalt. This product has a large proportion of 8mm -10mm sizing which would need to be manufactured from hard sandstone.
Open Graded Asphalt. As above.
Fine Gap: Screened Champions sand should meet this specification.
Concrete/Bedding: Natural Champions product meets general grading specification.
Mortar sand: Screened -5mm product with fines (for PI) will meet specification.
Golf Course Sand: Screened Champions OK on sizing but will not meet colour (may be select areas)
Shotcrete Sand: Screened Champions Quarry Sand with fines removed will meet specifications.
Locomotive Sand: Washed and dried Champions fine sand should meet specifications.
Glass Sand: Champions sand would not meet purity requirements.
Oil Frac Sand: Needs further investigation

A. S.	Sample Number
Sieve Size	A7708
75	
53	
37.5	
26.5	
19	
9.5	
4.75	100
2.36	95
1.18	83
0.6	56
0.425	41
0.3	26
0.15	17
0.075	14

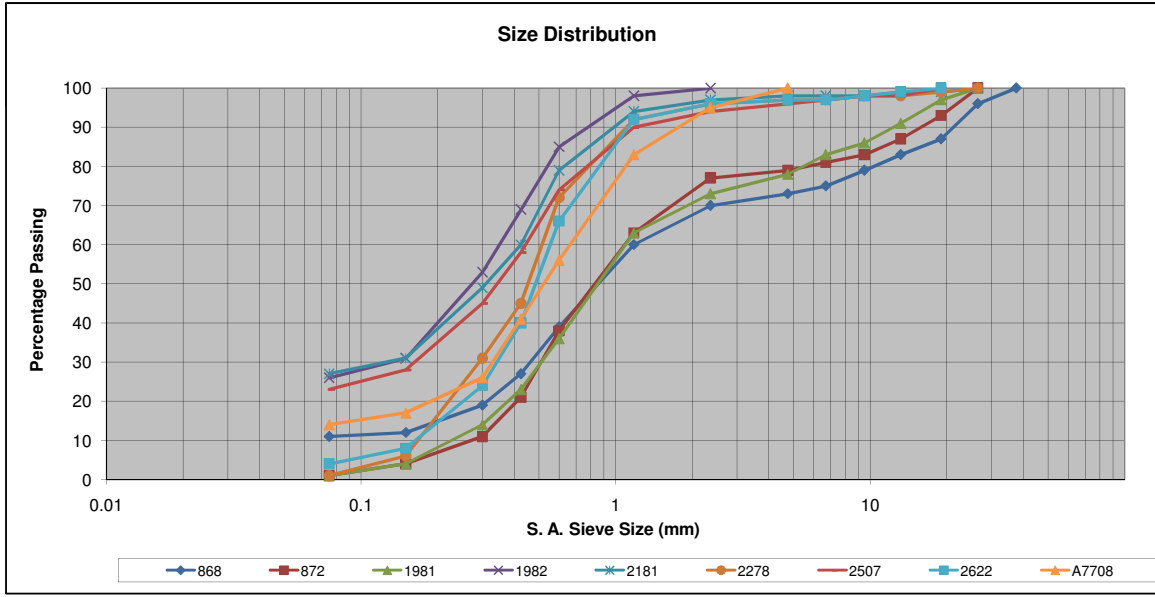
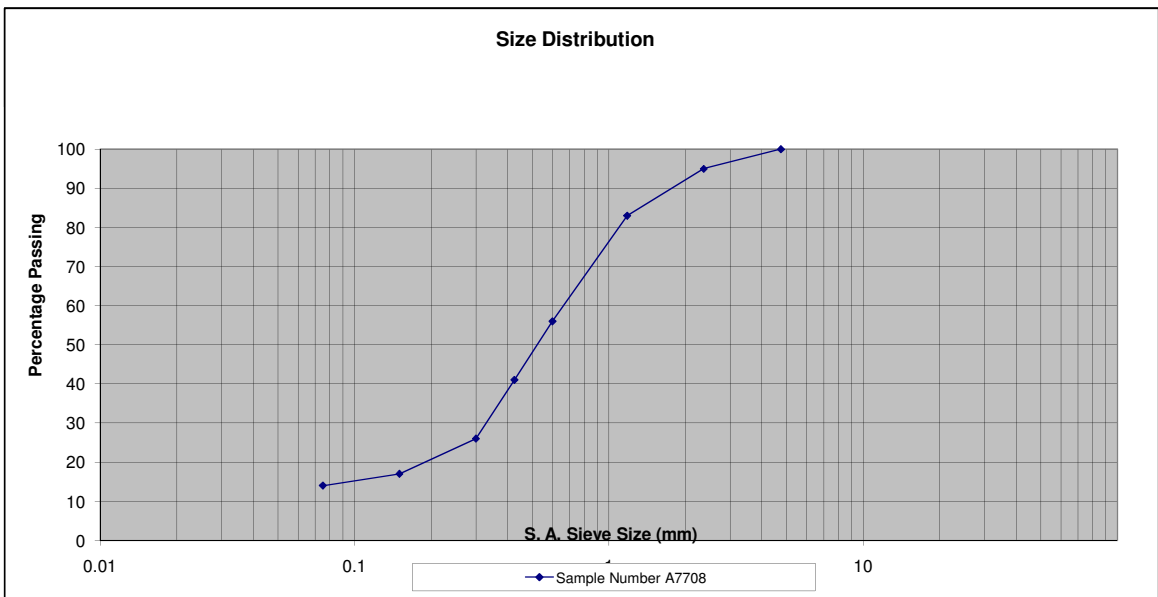
SIZING DATA SUPPLIED BY CHAMPIONS QUARRY

These sizings not used as they include imported material

A. S.	Sample Number												
Sieve Size	A7708	868	872	1981	1982	2181	2278	2506	2507	2508	2509	2622	Average
37.5		100											100
26.5		96	100	100		100	100	100		100	100		100
19		87	93	97		99	99	100	100	100	100	100	98
13.2		83	87	91		99	98	88	98	91	90	99	92
9.5		79	83	86		98	98		98			98	91
6.7		75	81	83		98	97	49	97	68	76	97	82
4.75	100	73	79	78		98	97		96			97	90
2.36	95	70	77	73	100	97	96	20	94	39	36	96	74
1.18	83	60	63	63	98	94	92		90			92	82
0.6	56	39	38	36	85	79	72		74			66	61
0.425	41	27	21	23	69	60	45	7	58	17	18	40	36
0.3	26	19	11	14	53	49	31	5.5	45	14	14	24	25
0.15	17	12	4	4	31	31	6		28			8	16
0.075	14	11	1	1	26	27	1	3.5	23	8	7	4	11
0.0135								2		6	5.5		5

CHAMPIONS QUARRY SPECIFICATION SHEET

SAND & GRAVEL SIZING AND PRODUCT SPECIFICATIONS

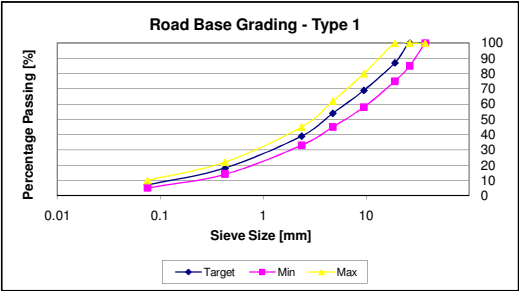
[illegible]

Sieve Size Conversion

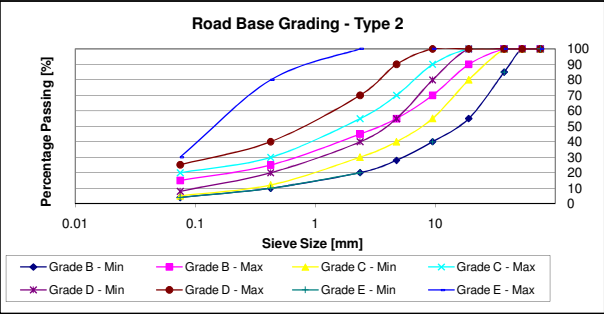
U.S. MESH	INCHES	MICRONS	MILLIMETERS
3	0.265	6730	6.73
4	0.187	4760	4.76
5	0.157	4000	4
6	0.132	3360	3.36
7	0.111	2830	2.83
8	0.0937	2380	2.38
10	0.0787	2000	2
12	0.0661	1680	1.68
14	0.0555	1410	1.41
16	0.0469	1190	1.19
18	0.0394	1000	1
20	0.0331	841	0.841
25	0.028	707	0.707
30	0.0232	595	0.595
35	0.0197	500	0.5
40	0.0165	400	0.4
45	0.0138	354	0.354
50	0.0117	297	0.297
60	0.0098	250	0.25
70	0.0083	210	0.21
80	0.007	177	0.177
100	0.0059	149	0.149
120	0.0049	125	0.125
140	0.0041	105	0.105
170	0.0035	88	0.088
200	0.0029	74	0.074
230	0.0024	63	0.063
270	0.0021	53	0.053
325	0.0017	44	0.044
400	0.0015	37	0.037

Road Base Grading - Unbound Pavements

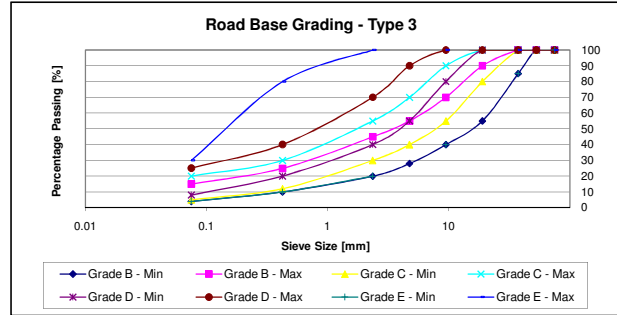
Type 1 Unbound Material			
AS Sieve Size [mm]	Percentage by Mass Passing		
	Target	Minimum	Maximum
37.5	100	100	100
26.5	100	85	100
19	87	75	100
9.5	69	58	80
4.75	54	45	62
2.36	39	33	45
0.425	18	14	22
0.075	7	5	10



AS Sieve Size [mm]	Percentage by Mass Passing							
	Grading B		Grading C		Grading D		Grading E	
	Min	Max	Min	Max	Min	Max	Min	Max
75	100	100	100	100	100	100	100	100
53	100	100	100	100	100	100	100	100
37.5	85	100	100	100	100	100	85	100
19	55	90	80	100	100	100	40	100
9.5	40	70	55	90	80	100	20	100
4.75	28	55	40	70	55	90	10	100
2.36	20	45	30	55	40	70	4	100
0.425	10	25	12	30	20	40	10	80
0.075	4	15	5	20	8	25	4	30



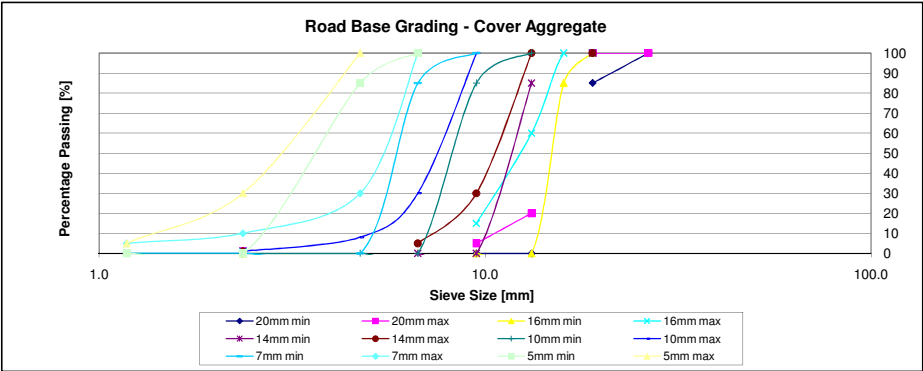
AS Sieve Size [mm]	Percentage by Mass Passing							
	Grading B		Grading C		Grading D		Grading E	
	Min	Max	Min	Max	Min	Max	Min	Max
75	100	100	100	100	100	100	100	100
53	100	100	100	100	100	100	85	100
37.5	85	100	100	100	100	100	40	100
19	55	90	80	100	100	100	20	100
9.5	40	70	55	90	80	100	10	80
4.75	28	55	40	70	55	90	4	30
2.36	20	45	30	55	40	70		
0.425	10	25	12	30	20	40		
0.075	4	15	5	20	8	25		



Cover Aggregate						
AS Sieve Size [mm]	20 mm	16mm	14mm	10mm	7mm	5mm

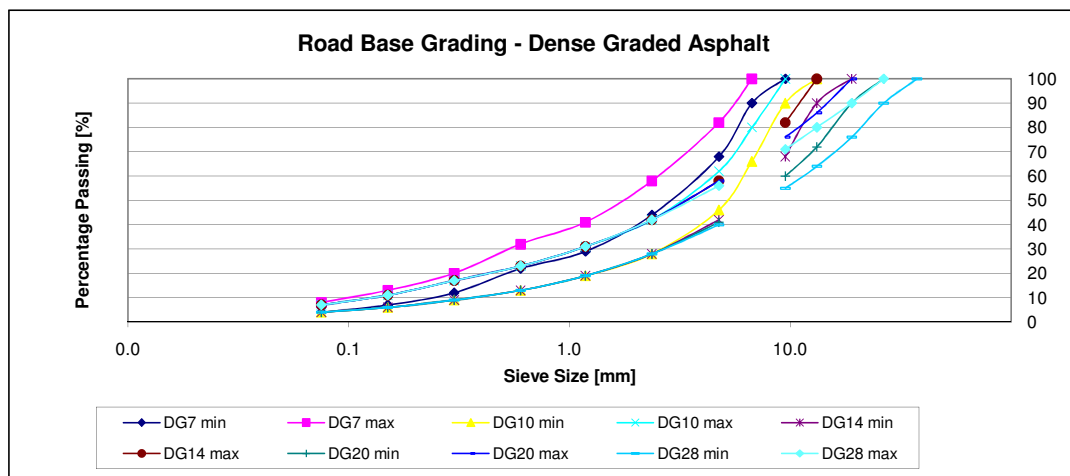
Road Base Grading - Cover Aggregate

AS Sieve Size (mm)	Percentage Passing by Mass for Each Nominal Size											
	20mm		16mm		14mm		10mm		7mm		5mm	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
26.5	100	100										
19.0	85	100	100	100	100	100						
16.0			85	100								
13.2	0	20	0	60	85	100	100					
9.50	0	5	0	15	0	30	85	100	100			
6.70					0	5	0	30	85	100	100	
4.75							0	8	0	30	85	100
2.36	0	1	0	1	0	1	0	1	0	10	0	30
1.18									0	5	0	5



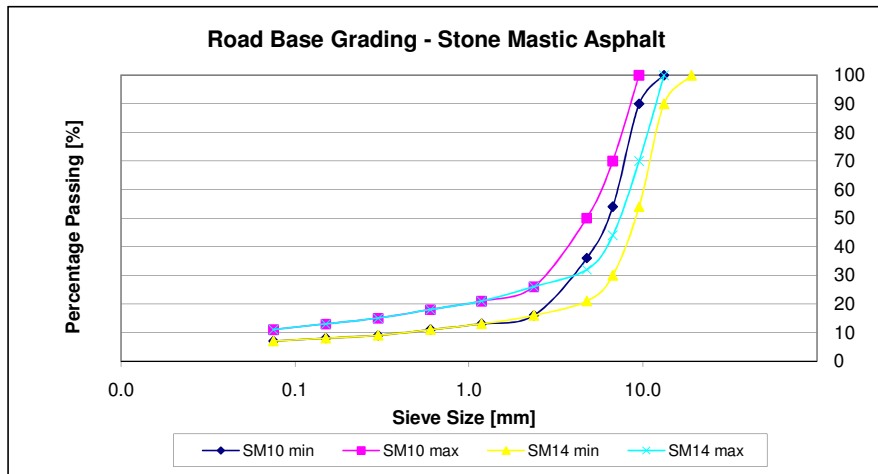
Road Base Grading - Dense Graded Asphalt Pavements

AS Sieve Size [mm]	Percentage Passing by Mass for Each Nominal Size									
	DG7		DG10		DG14		DG20		DG28	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
37.5									100	
26.5							100		90	100
19.0					100		90	100	76	90
13.2			100		90	100	72	86	64	80
9.5	100		90	100	68	82	60	76	55	71
6.7	90	100	66	80						
4.75	68	82	46	62	42	58	41	58	40	56
2.36	44	58	28	42	28	42	28	42	28	42
1.18	29	41	19	31	19	31	19	31	19	31
0.60	22	32	13	23	13	23	13	23	13	23
0.30	12	20	9	17	9	17	9	17	9	17
0.15	7	13	6	11	6	11	6	11	6	11
0.08	4	8	4	7	4	7	4	7	4	7



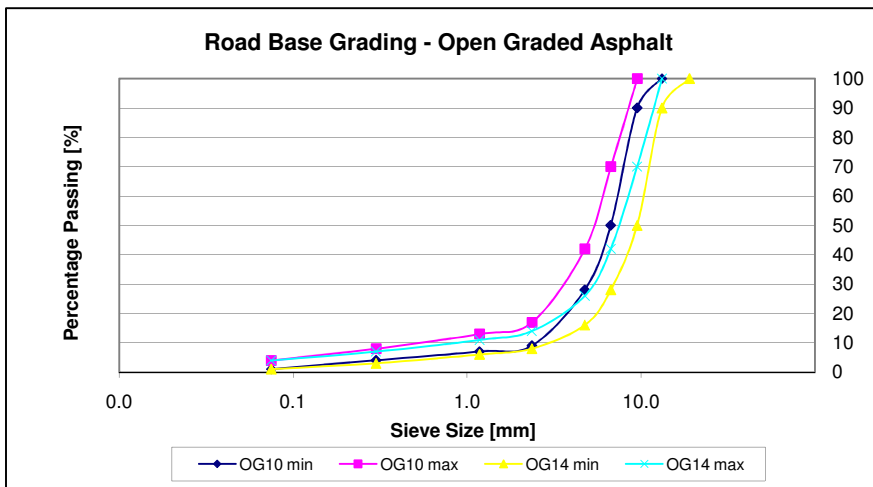
Road Base Grading - Stone Mastic Asphalt

AS Sieve Size [mm]	Percentage Passing by Mass			
	SM10		SM14	
	Min	Max	Min	Max
19.0			100	
13.2	100		90	100
9.5	90	100	54	70
6.7	54	70	30	44
4.75	36	50	21	32
2.36	16	26	16	26
1.18	13	21	13	21
0.60	11	18	11	18
0.30	9	15	9	15
0.15	8	13	8	13
0.075	7	11	7	11



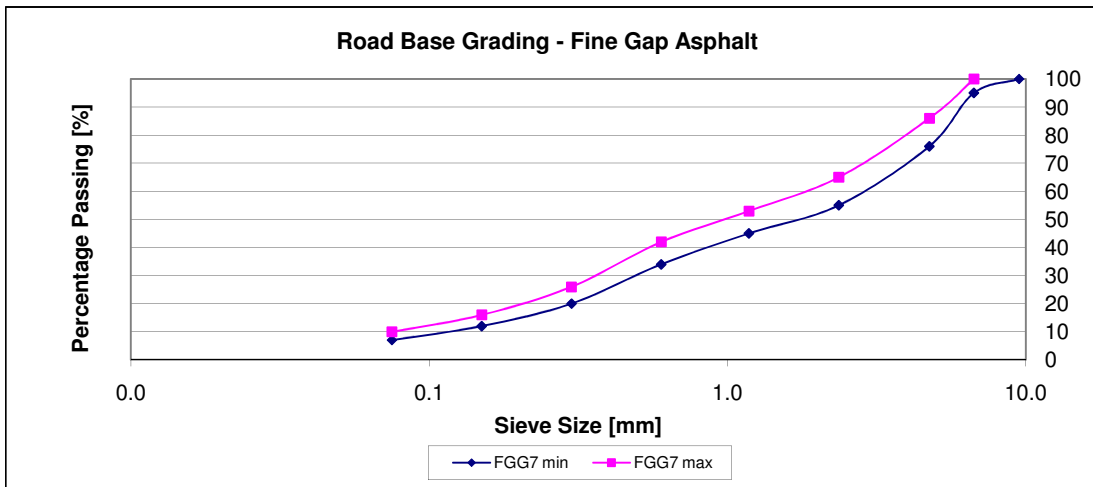
Road Base Grading - Open Graded Asphalt

AS Sieve Size [mm]	Percentage Passing by Mass			
	OG10		OG14	
	Min	Max	Min	Max
19.0			100	
13.2	100		90	100
9.5	90	100	50	70
6.7	50	70	28	42
4.75	28	42	16	26
2.36	9	17	8	14
1.18	7	13	6	11
0.30	4	8	3	7
0.075	1	4	1	4



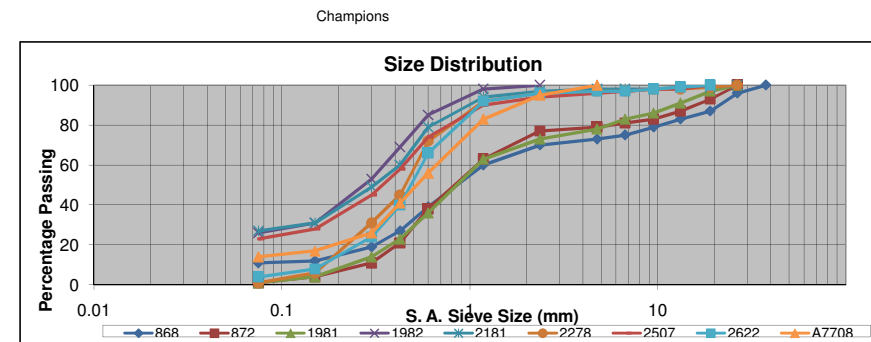
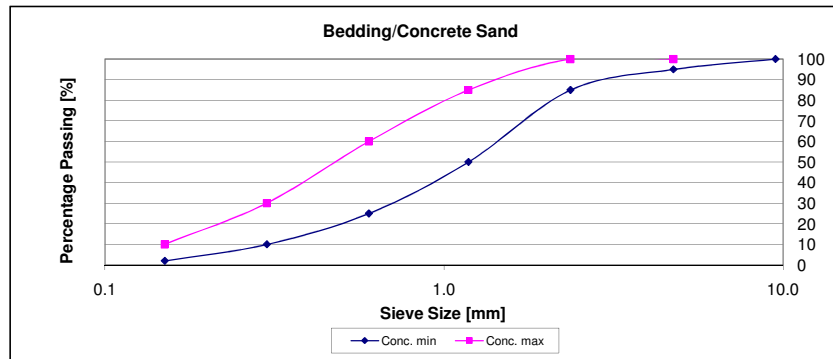
Road Base Grading - Fine Gap Graded Asphalt Pavements

AS Sieve Size [mm]	Percentage Passing by Mass	
	FGG7	
	Min	Max
9.5	100	
6.7	95	100
4.75	76	86
2.36	55	65
1.18	45	53
0.60	34	42
0.30	20	26
0.15	12	16
0.075	7	10



Bedding/Concrete Sand

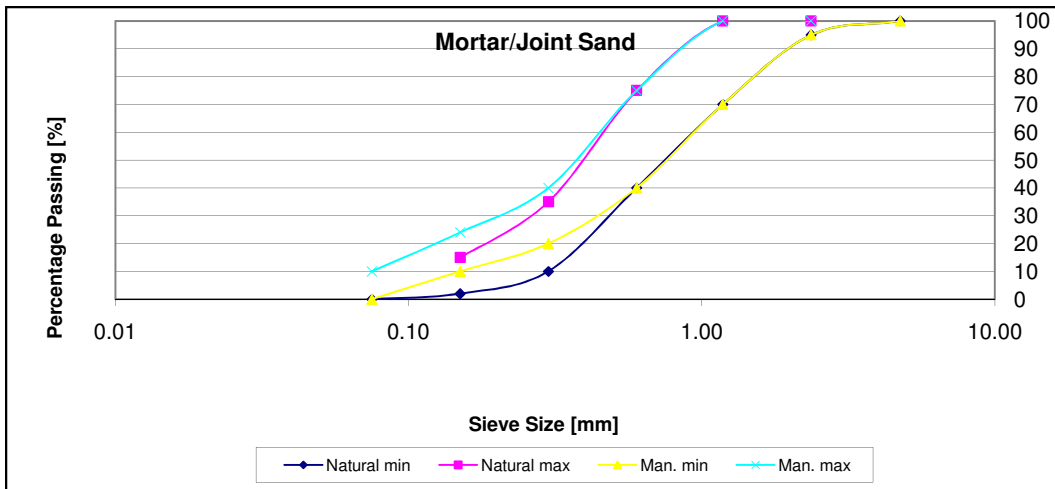
AS Sieve Size [mm]	Percentage Passing by Mass	
	ASTM C-33 Grading Requirements	
	Min	Max
9.5	100	
4.75	95	100
2.36	85	100
1.18	50	85
0.60	25	60
0.30	10	30
0.15	2	10



Mortar/Joint Sand

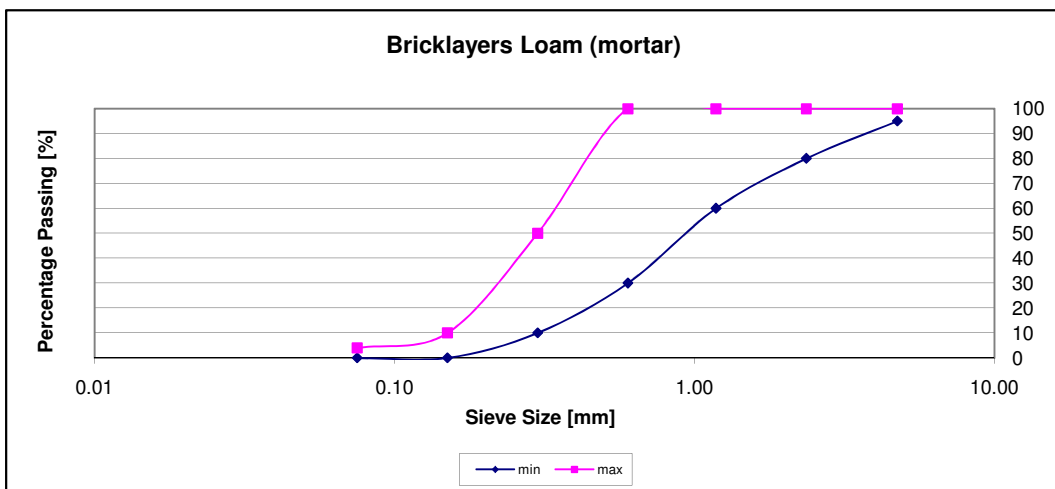
Joint Sand

AS Sieve Size [mm]	Percentage Passing by Mass			
	ASTM C-144 Grading Requirements			
	Natural Sand		Manufactured Sand	
	Min	Max	Min	Max
4.75	100		100	
2.36	95	100	95	100
1.18	70	100	70	100
0.60	40	75	40	75
0.30	10	35	20	40
0.15	2	15	10	24
0.075	0		0	10



Bricklayers Loam

AS Sieve Size [mm]	Percentage Passing by Mass	
	Min	Max
4.75	95	100
2.36	80	100
1.18	60	100
0.60	30	100
0.30	10	50
0.15	0	10
0.075	0	4



Golf Course Sand

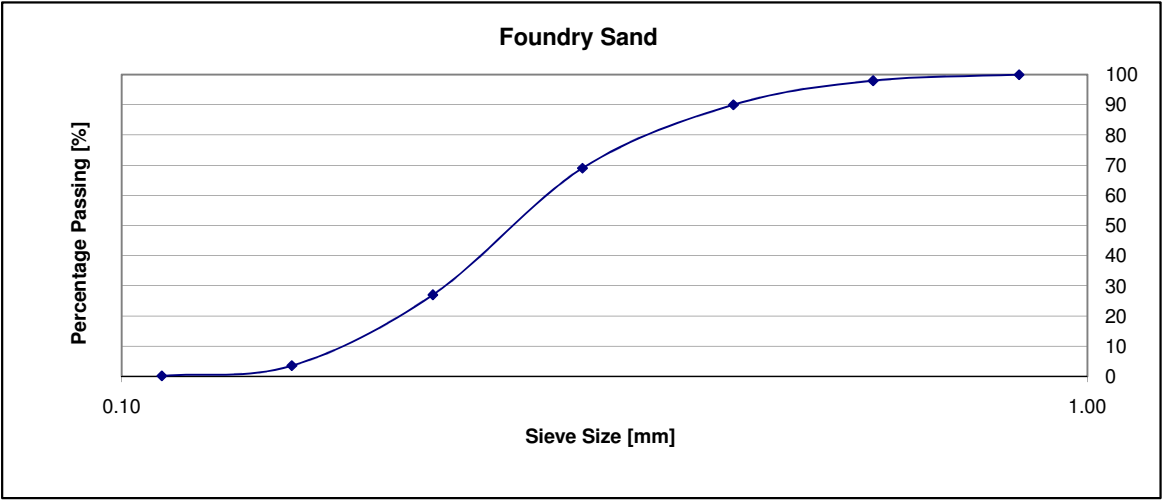
Golf Trap Sand		Pro White/Sure Play		Sure Play/Top Dressing		Kosse White	
AS Sieve Size [mm]	Percentage Passing by Mass	AS Sieve Size [mm]	Percentage Passing by Mass	AS Sieve Size [mm]	Percentage Passing by Mass	AS Sieve Size [mm]	Percentage Passing by Mass
	Min		Min		Min		Min
2.000	100	2.000	100	2.000	100	2.000	98.5
1.000	97	1.000	98	1.000	100	1.000	93.5
0.500	23	0.500	76	0.500	70	0.500	55.5
0.250	1	0.250	16	0.250	4	0.250	12.5
0.106	0	0.106	0	0.106	0	0.150	2.5
						0.053	0.5

Note: This data provided by U.S. Silica



Foundry Sand

AS Sieve Size [mm]	Percentage Passing by Mass
	Min
0.85	100
0.60	98
0.43	90
0.30	69
0.21	27
0.15	3.5
0.11	0.1



Gradation Limits for Shotcrete Aggregate

8:26 AM3/08/2009

ACI 506R - 90			
Sieve Size	Sieve Size [mm]	Gradation Range % Passing	
		High	Low
19mm	19	100	
12mm	12	100	
10mm	10	90	100
4.7mm	4.7	70	85
2.4mm	2.4	50	70
1.2mm	1.2	35	55
600micron	0.6	20	35
300micron	0.3	8	20
150micron	0.15	2	10

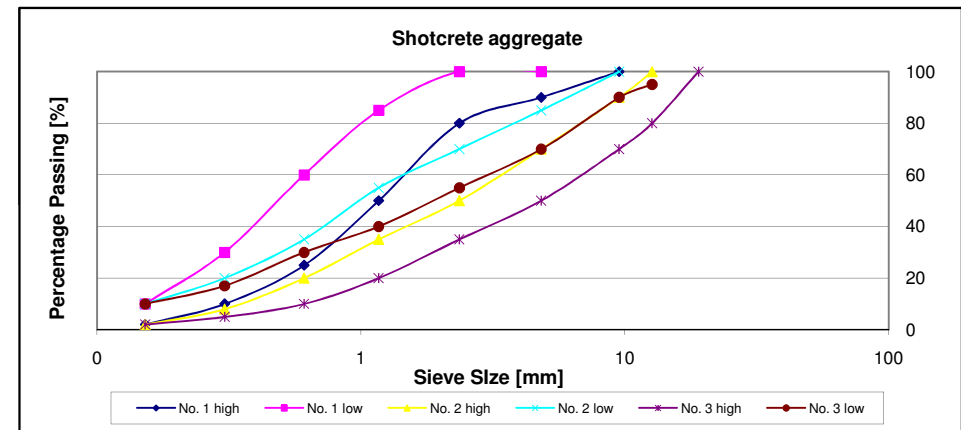
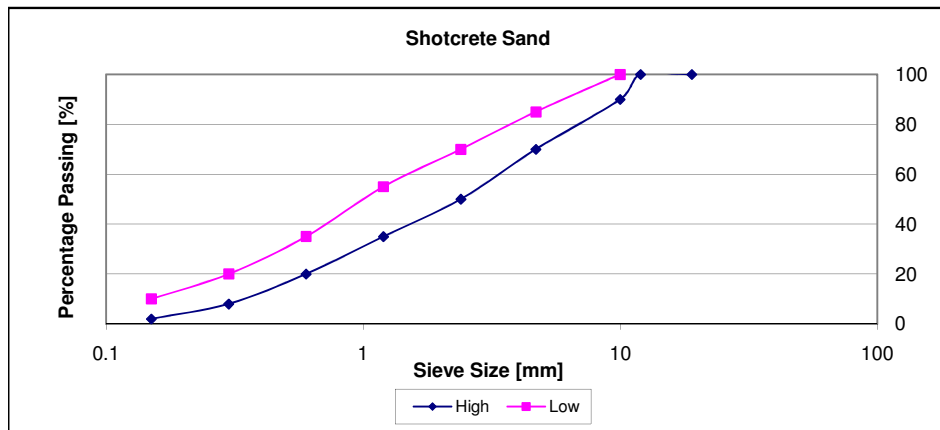
Sieve Size [in]	Sieve Size [mm]	ASTM C 33					
		No. 1		No. 2		No. 3	
		high	low	high	low	high	low
0.75	19					100	
0.5	13			100		80	95
0.375	10	100		90	100	70	90
0.19	4.8	90	100	70	85	50	70
0.093	2.4	80	100	50	70	35	55
0.046	1.2	50	85	35	55	20	40
0.024	0.6	25	60	20	35	10	30
0.012	0.3	10	30	8	20	5	17
0.006	0.15	2	10	2	10	2	10

Standards

AS 2758.1-1985 Aggregates and Rock for Engineering Purposes
AS 1141.32-1995 Methods for Sampling and Testing Aggregates
No Organic Matter
Less than 5% Loam or Silt

Lightweight shotcrete aggregate is most suitable for dry mix process

Lightweight aggregates have a particle density on a dry basis of less than 2.1 t/m³ and greater than or equal to 0.5 t/m³

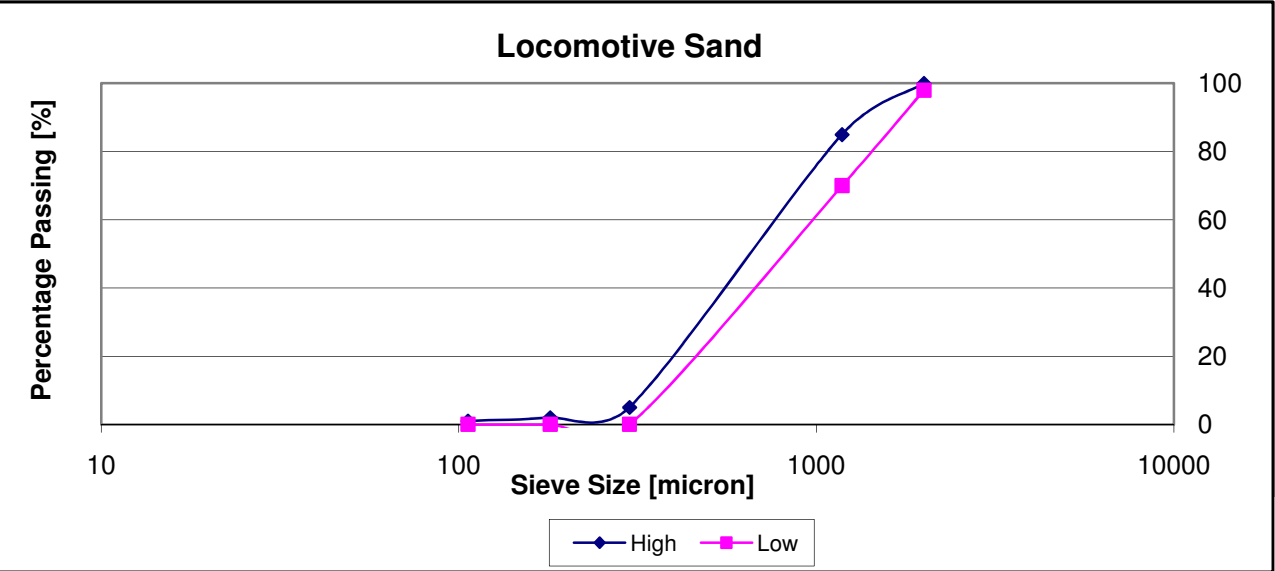


Gradation Limits for Locomotive Sand (Railway Grip)

Aggregate Gradation [mm]	Aggregate Gradation [micron]	Gradation Range % Passing	
		High	Low
2	2000	100	98
1.18	1180	85	70
0.3	300	5	0
0.18	180	2	0
0.106	106	1	0

Standards (Queensland Rail)

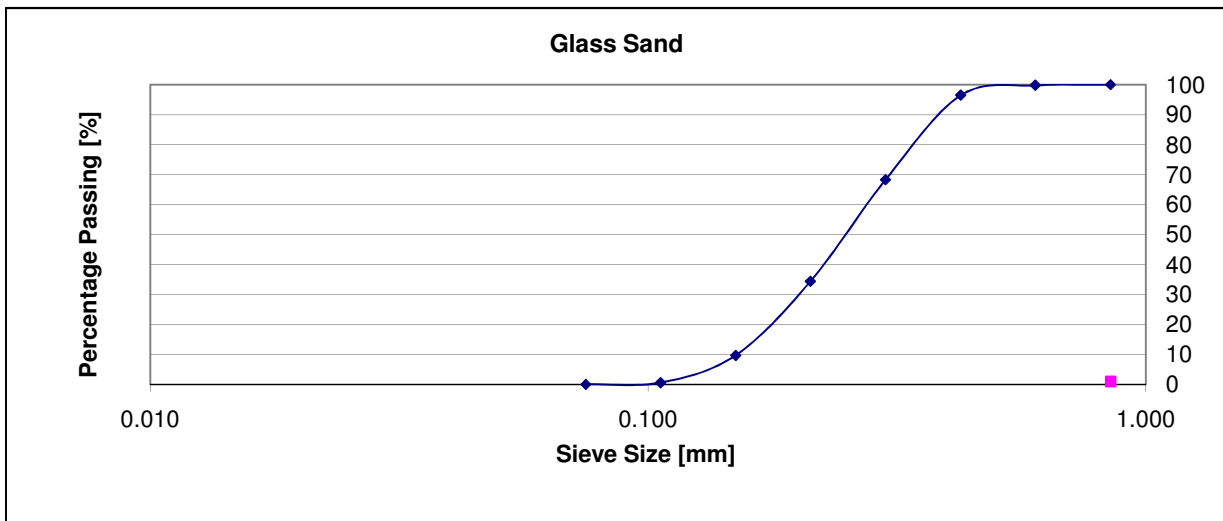
No Less than 95% Silica
Moisture content shall not exceed 0.5%
Must pass required cracking test



Glass Sand

AS Sieve Size [mm]	Percentage Passing by Mass	
	Min	
0.850	100	
0.600	99.8	
0.425	96.5	
0.300	68.3	
0.212	34.4	
0.150	9.7	
0.106	0.6	
0.075	0	

Note: Data provided by U.S. Silica



Oil Frac Sand

20/40 Oil Frac Sand

AS Sieve Size [mm]	Percentage Passing by Mass
	Min
1.180	100
0.850	99.8
0.600	79.8
0.500	39.8
0.425	5.8
0.300	0.3
0.000	0

Note: Data provided by U.S. Silica

