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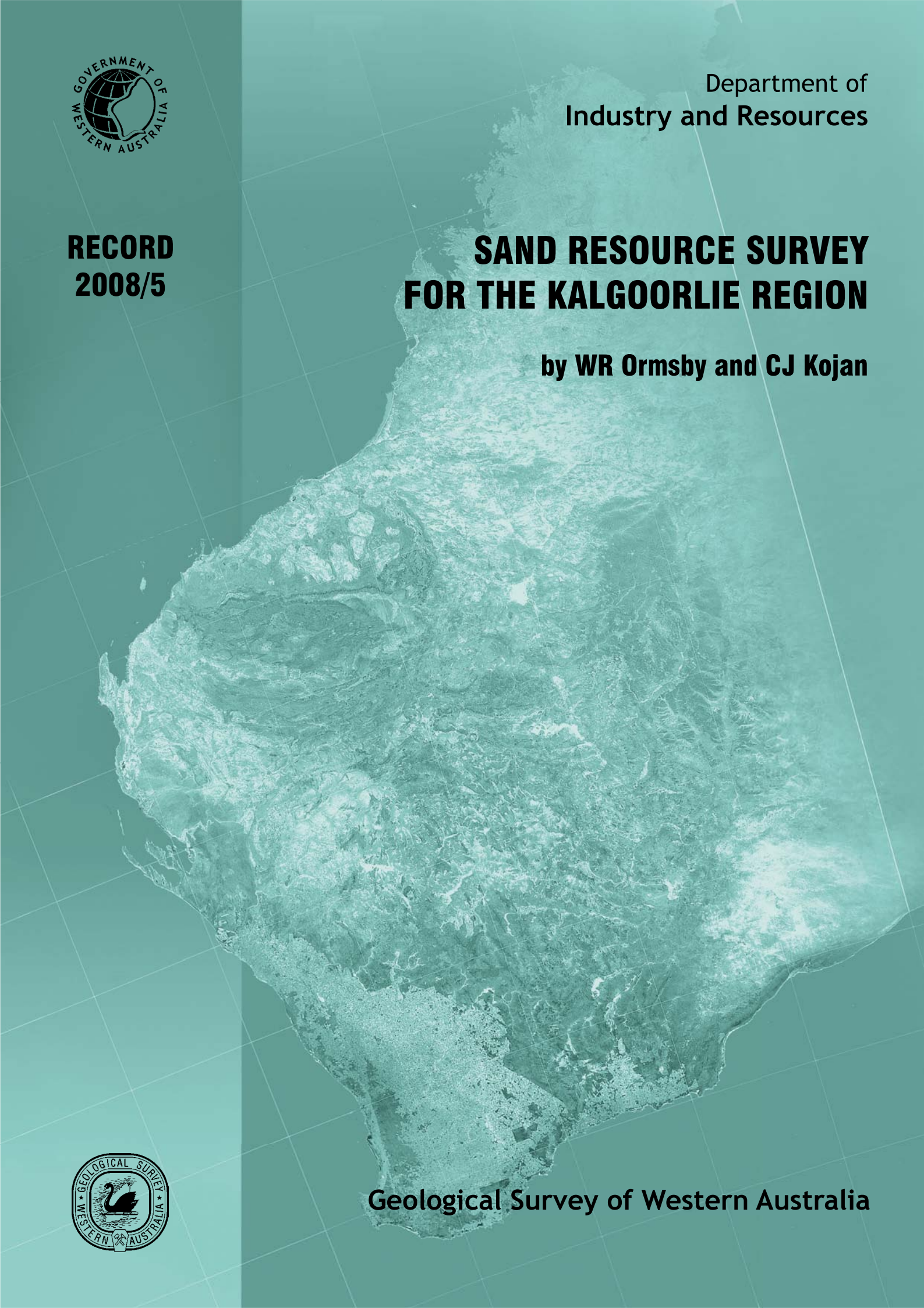
2008/5

SAND RESOURCE SURVEY FOR THE KALGOORLIE REGION

by WR Ormsby and CJ Kojan



Geological Survey of Western Australia

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA

Record 2008/5

SAND RESOURCE SURVEY FOR THE KALGOORLIE REGION

by
WR Ormsby and CJ Kojan

Perth 2008

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Sand resource survey for the Kalgoorlie region

by

WR Ormsby and CJ Kojan

Abstract

The Basic Raw Materials Strategy report for the Goldfields–Esperance Region in 1997 identified the need for basic raw material studies in the Kalgoorlie region. The survey was prompted by a perceived lack of good-quality sand, combined with increased demand for concrete sand, and issues relating to access of sand resources in conservation reserves and mining tenements held for other commodities.

Sand in the Kalgoorlie region is used in the construction industry as a fine-grained aggregate in the manufacture of concrete and shotcrete. Shotcrete is used in underground mining for improving the stability of rock surfaces. Other uses for sand include bricklayer's sand, plaster sand, and fill sand for general construction purposes. Higher quality concrete sand must meet stringent specifications and is currently mined at two locations and transported up to 100 km to Kalgoorlie. Construction sand, suitable for most purposes including concrete, mortar, and fill is currently being mined from eight other locations, mostly situated 40 to 70 km southwest and west of Kalgoorlie.

The present survey has mapped and sampled areas of sand resource potential within about 100 km of Kalgoorlie. Based on geology and mode of occurrence, three broad categories of sand have been identified, namely lakeside dune sand, yellow sand, and brown sand. Sampling and testing has identified four classes of sand quality ranging from concrete sand to silty sand, suitable for a range of uses.

Regionally, the area west and south of Coolgardie is considered to be the most prospective for all types of construction sand and associated gravel. A large area between 75 and 110 km west of Kalgoorlie (north of Woolgangie) has been identified as a potential long-term supply of construction sand and gravel for Kalgoorlie and the wider Goldfields region.

KEYWORDS: Yilgarn Craton, Kalgoorlie–Boulder, Coolgardie, building sands, construction materials, grain size analysis, industrial sand mining, sand pits, Landsat, regolith, mapping, sampling, resource assessment.

Introduction

Background

The need for a Basic Raw Materials (BRM) Strategy for the Kalgoorlie sub-region was identified in May 1997 by government and industry representatives involved in the preparation of the Goldfields–Esperance Regional Planning Strategy (GERPS). The Strategy was initially intended to cover the occurrence and availability of sand, gravel, clay, hard rock (aggregate), and limestone within 100 km of the City of Kalgoorlie–Boulder.

As stated in Section 3.6.2 of the final GERPS report (Western Australian Planning Commission, 2000): 'Basic raw materials are essential for local road and building foundation construction as well as for cement and concrete manufacture. The extent and nature of BRM in the region is not fully known'. The GERPS report refers in Section 5.5.1 to a Mineral Resources and Basic Raw Materials Strategy, and states: 'The preparation of basic raw materials plans for key areas in the region identifying adequate resources for the future development, principally of Kalgoorlie–Boulder, ….is recommended. Such studies will benefit community and industry by providing the basis for protection from inadvertent sterilization of important BRM or construction materials resources by other land uses, including mineral development. They will allow rational, orderly extraction of the basic raw material resources and provide both producers and users with confidence of assured supply.'

Funding for a basic raw material survey in the Kalgoorlie region was contributed by the former Ministry for

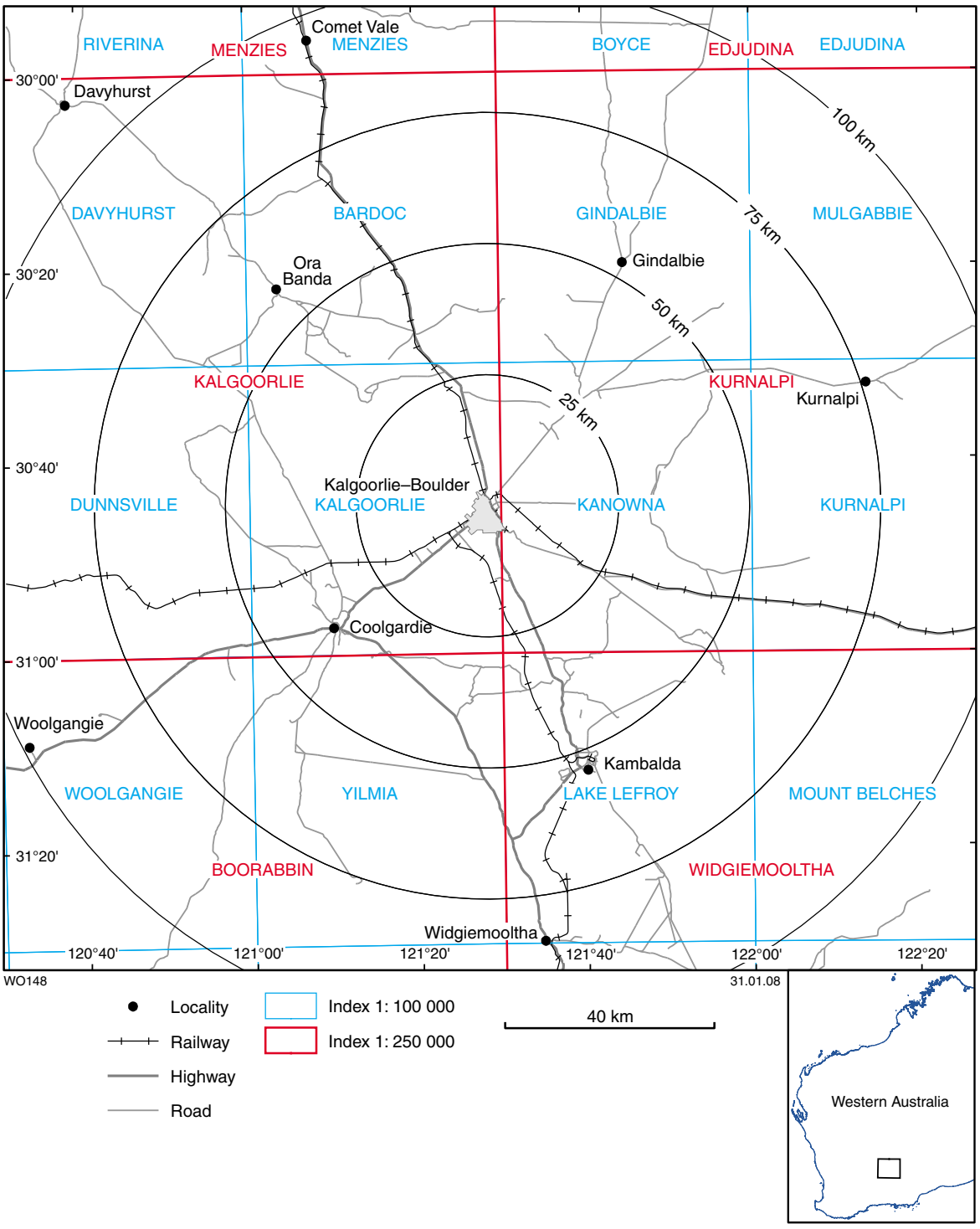

Figure 1. Infrastructure, index maps, and distance from Kalgoorlie–Boulder for the area covered by the Kalgoorlie sand resource study

Planning, Department of Resource Development (now Department of Industry and Resources), Department of Conservation and Land Management (now Department of Environment and Conservation), Main Roads (Department for Planning and Infrastructure), Pioneer Concrete, and the then Department of Minerals and Energy. This survey of sand resources covering the Kalgoorlie region (Fig. 1) arose from a combination of funding constraints, the perception of a lack of good quality sand resources close to the City of Kalgoorlie–Boulder, a marked increase in demand for concrete sand, and issues in accessing sand resources in conservation reserves and areas subject to mining tenements for other commodities.

The primary aim of the survey was to map and sample the significant sand resources of the Kalgoorlie region,

and particularly to identify sources of higher quality construction sand. This information will form the basis for strategic land-use planning in the Kalgoorlie region to ensure the long-term supply of construction sand for the Goldfields.

Sand uses and specifications

Sand is used widely in the construction industry as a fine-grained aggregate for concrete, bricklayer's sand (sand for general purpose mortar), plaster sand and as fill sand for general use in subdivisions for housing and industrial development, and for protecting water, gas, electrical and telecommunication pipelines and conduits. A significant use is as a flux in the production of high-grade nickel matte at the Kalgoorlie Nickel Smelter. Other uses of sand in the Kalgoorlie area include the use of general purpose or fill sand for fixating liquid waste before disposal, and the use of red loam (red silty sand) for use in garden beds.

The sand used at the Kalgoorlie Nickel Smelter is obtained from BHP Billiton's mining leases at Mount Burges, northwest of Coolgardie and is reported as silica sand for mining royalties and statistical purposes. All other sand mined in the region is considered to be construction sand. It is estimated that about half of the total of almost 190 000 tonnes (t) of construction sand production reported for 2006 was used for concrete. A large and growing part of concrete sand production is used in shotcrete to improve the stability of rock surfaces in mines. Shotcrete is the term used for mortar or concrete that is pneumatically projected at high velocities onto a surface.

Different specifications are required for each type of use. The most stringent specification applies to concrete sand that needs to meet certain criteria relating to size fraction and the content of deleterious material such as clay, organic matter, sulfate and chloride. In practice, it may be difficult to locate sufficient quantities of sand meeting the Australian Standard (AS2758.1–1998) for concrete (Standards Australia, 1998), and a lower specification may be used, depending on the end use of the concrete and the scope for modifying the concrete mix.

The quantity of silt, and particularly clay material, is the most critical criteria for concrete sand. The minus 75 µm (<0.075 mm, i.e. silt and clay) fraction as determined by Australian Standard AS2758.1–1998 is the first screening test for concrete quality sand. This Standard specifies a range of 0 to 5% passing minus 75 µm and requires that the sand be graded as per the requirements of the AS1289 3.6.1 test.

Specifications for bricklayer's or general purpose mortar sand and plaster sand should, strictly speaking, meet similar size fraction specifications to those established for concrete sand. The British Standard Specifications for these uses are described in Smith and Collis (1993). Biggs (1979) reports that natural samples of bricklayer's sand in the Perth area are generally too fine to conform to the British Standard Specification but this is not considered a problem and can be largely overcome by removing the undersize fraction by screening and through the use of additional amounts of cement.

The practice in some Kalgoorlie pits is similar to that in Perth in that major suppliers of bricklayer's and plaster sand screen, or screen and wash, the sand to obtain satisfactory products without necessarily conforming to the British Standard Specifications for these materials. Both bricklayer's and plaster sand sold in the Kalgoorlie area are described as containing clay.

Sand production

Construction sand is currently being mined from ten separate project areas in the Kalgoorlie region. These are all located on Crown Land, as shown in Plate 1, and hence are covered by Mining Leases under the *Mining Act 1978*. Most sand for concrete (including shotcrete) is obtained from Readymix's Widgiemooltha and Comet Vale pits, located about 75 km south and north of Kalgoorlie respectively. Some sand for concrete is also obtained from projects west of Kalgoorlie including Mount Burges and Grosmont. Most sand for mortar, fill or other purposes is obtained from the seven projects/pits located southwest and west of Kalgoorlie. Most of these pits are located between 42 and 70 km from Kalgoorlie.

Total production of construction sand reported to the Department of Industry and Resources for calendar year 2006 was 189 924 t. Annual construction sand production for the period 1986 to 2006 is shown in Figure 2. Production is highly cyclical, reflecting the activity levels of the gold and nickel mining industries that underpin the local economy. Demand for sand is currently strong reflecting the current demand for these metals. In particular, there is a strong demand for shotcrete for use in underground mining and a current requirement for large amounts of concrete sand and fill sand for infrastructure projects and for residential and industrial site development.

Sand royalty and prices

Sand in the Kalgoorlie region is generally considerably more expensive than the equivalent products in the Perth region. As all sand in the Kalgoorlie region is mined from Crown Land under the Mining Act, it is subject to a royalty, currently $0.42/dry tonne, increasing to $0.50/t by 1 July 2009 if produced for construction purposes. 'Silica' sand has a higher royalty rate of $0.68/dry tonne, increasing to $0.80/t by 1 July 2009.

Approximate prices for the main sand types used in the construction industry are as follows:

- Fill sand ranges from about $5/t collected at the pit, to $15–20/t for bulk orders delivered in Kalgoorlie. Small quantities of fill sand purchased in Kalgoorlie cost $15–30/t;
- Plaster sand and bricklayers sand costs around $5–10/t collected at the pit and $25–40/t for both bulk orders delivered in Kalgoorlie and for small amounts sold retail;
- Concrete sand costs about $25/t for sand collected at the pit to $35/t for sand delivered to batch plant operators in Kalgoorlie.

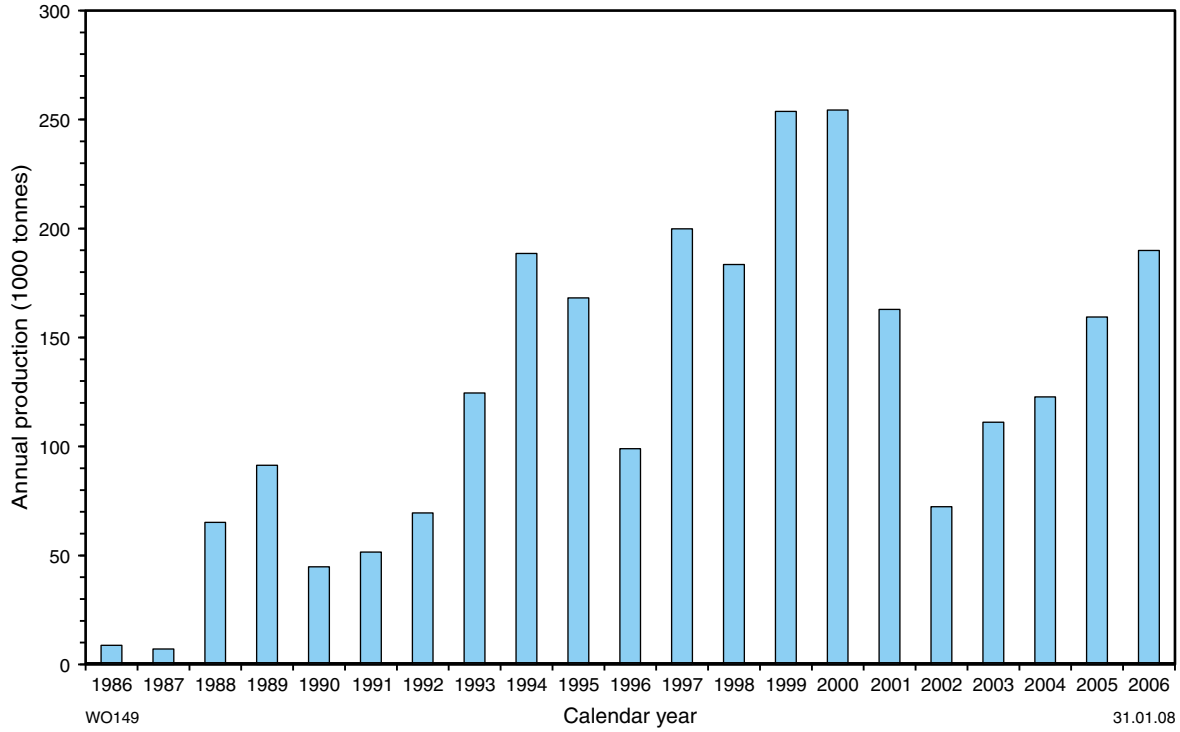

Figure 2. Reported Kalgoorlie region construction sand production from mining tenements for the period 1986 to 2006 highlighting the rapid increase in production in the 1990s

Previous work

The survey area has previously been mapped by the Geological Survey of Western Australia (GSWA) in the 1960s and 1970s resulting in the publication of 1:250 000-scale maps and explanatory notes for BOORABBIN (Sofoulis,1963), KALGOORLIE (Kriewaldt, 1969), KURNALPI (Williams, 1973), and WIDGIEMOOLTHA (Sofoulis, 1966). Most of the survey area was subsequently remapped in more detail by the GSWA in the 1980s and early 1990s and a series of 1:100 000 geological maps and explanatory notes were published: BARDOC (Witt and Swager, 1989), DAVYHURST (Wyche et al., 1992), DUNNSVILLE (Swager, 1994a), GINDALBIE (Ahmat, 1995a), KALGOORLIE and YILMIA (Hunter, 1993), KANOWNA (Ahmat, 1995b), KURNALPI (Swager, 1994b), LAKE LEFROY (Griffin and Hickman, 1988a), MOUNT BELCHES (Painter and Groenewald, 2001), MULGABBIE (Morris, 1994). The 1:100 000-scale mapping formed the basis for second edition 1:250 000-scale maps and explanatory notes for BOORABBIN (Hunter, 1991), KALGOORLIE (Wyche, 1998), KURNALPI (Swager, 1996), and WIDGIEMOOLTHA (Griffin and Hickman, 1988b).

Regolith* mapping — the mapping of surficial deposits of geologically recent origin including sand, clay and laterite — was carried out by Gozzard (1988) on the DUNSVILLE and KALGOORLIE 1:100 000-scale maps. Swarnecki (2005) published a detailed regolith survey centered on Kalgoorlie that covered four 1:50 000-scale maps. Much of this data was collected between 2000 and 2004 as part of the GSWA's Urban and Development Areas Geology Mapping Projects.

Riganti et al. (2003) completed a reinterpretation of the regolith for the existing 1:100 000-scale map coverage of the Eastern Goldfields based on Landsat images. The revised regolith mapping dataset and accompanying Record form part of the East Yilgarn digital database first released in 2003 and subsequently updated (Geological Survey of Western Australia, 2007a).

The East Yilgarn digital database also incorporates data from the survey area on former and operating mines from the GSWA MINEDEX database, and on mineral occurrences from the GSWA WAMIN database. The Inventory of Abandoned Mine Sites (Geological Survey of Western Australia, 2007b) includes detailed information on BRM pits as well as abandoned mine-related features within the high priority areas covered by that project. All of these databases contain information relevant to sand resources in the survey area and were used in this survey.

An assessment of the silica sand potential of selected sand deposits and occurrences within the survey area was carried out by Abeysinghe (2003) as part of a larger survey of silica resources encompassing the entire State. Sampling was undertaken in the Stewart Siding, Queen Victoria Rock, Mount Burges and Goongarrie (Comet Vale), Lake Lefroy, and Widgiemooltha areas in May and June 2000. Samples were tested for particle size distribution and analysed for SiO_2, Al_2O_3 and Fe_2O_3.

* Regolith is the layer of unconsolidated rock material that overlies bedrock.

Sand resource mapping method

Fieldwork for this survey was generally restricted to areas within 15 km of sealed and graded roads and within sand covered areas shown on the GSWA's 1:250 000-scale and 1:100 000-scale maps. Mapping utilized colour Landsat images and Global Positioning System to delineate potential sand resource areas, and sampling assisted in assessing the suitability of such areas for concrete sand. Existing sand mining operations were also visited and discussions were held with industry owners, operators, and local and state government officers based in Kalgoorlie.

Sand resource geology

The entire survey region is underlain by Archean greenstone and granitic rocks of the Yilgarn Craton that formed mainly between about 3.05 and 2.62 Ga (Cassidy et al., 2006). The greenstone includes metamorphosed mafic and ultramafic rocks, metasedimentary and felsic rocks which can be constructed into a general stratigraphy for the Kambalda and Ora Banda areas (Swager et al., 1995). The entire sequence has been subjected to a number of deformations resulting in a general north-northwesterly structural trend and an anastomosing network of regional scale faults. The granitic rocks include granitic gneiss, and various generations of granites which range in age from synchronous with emplacement of the felsic volcanics to post-tectonic (Groenewald et al., 2000).

Sand in the region can be divided into two main types: yellow–orange sand overlying granitoids, and red–brown sand overlying greenstones adjacent to playa lakes.

The yellow–orange sand (hereafter yellow sand), typically overlies higher topography (Fig. 3). Yellow sand occurs most commonly in the upland granite area to the west of Coolgardie and in the Woolgangie to Davyhurst area where it is found on a north-northwest trending linear range of hills (Fig. 3). Its mode of occurrence suggests a residual origin resulting from in situ weathering of the underlying granites (Carroll, 1939). Nevertheless, this sand is commonly found to be underlain by, and possibly transitions vertically to a ferruginous gravel (Fig. 4). Gravel deposits are commonly found beneath a thin veneer of sand (less than 1 m thick) adjacent to thicker accumulations of yellow sand, such as at Mount Burges and Kangaroo Hills.

Areas of surfical yellow sand include those mapped as Cenozoic sands (*Czs*) on the 1:100 000 geological map series and also those commonly shown as 'R_I-SI' in the East Yilgarn database. Field inspection has demonstrated that many areas mapped as surficial sands are in fact gravelly sand at the surface, or transition to gravelly sand at shallow depths. Yellow sand is mapped on Plate 1 where deposits are interpreted as thicker sand accumulations of potentially economic significance (generally greater than 1 m). In some cases this has been supported by hand auger sampling or by direct observation of pits or previous drilling. This evidence indicates that most yellow sand deposits of potential economic significance are probably between 2 and 5 m thick (Fig. 5), reaching a maximum of about 10 m thick. Typical yellow sand is yellow–orange in colour, reddish in part, fine to coarse grained, poorly to moderately sorted, subrounded, and subangular in part.

A Landsat image processed to define the interband ratios 5/7, 4/7, 4/2 (Tapley and Gozzard, 1992) was particularly useful in this survey for highlighting and refining the areas of yellow sand. The ratio image was complemented by orthophotographs, other Landsat images and field inspections. Another useful tool for identifying areas of potentially economic significance is the Shuttle Radar Topography Mission (SRTM) data. Processing of these data resulted in topographic images using a 90 m by 90 m pixel size. Elevation, aspect, slope, and other derivative images were generated to highlight subtle changes in the regional topography. Empirically, in areas of known yellow sand, there appears to be a correlation of thicker sand deposits with either local topographic highs and large-scale sand dunes (e.g. Mount Burges; Fig. 6), or with broad, 'smooth' basin topography (e.g. Kangaroo Hills, Fig. 7).

Red–brown to brown sand (hereafter brown sand), occurs around the margins of, and within, playa lakes that occupy the depressions in the landscape and shows an association with mapped paleochannels, particularly immediately to the north, south and east of Kalgoorlie, and also around Lake Lefroy. Brown sands commonly occur as elongate dunes adjacent to the playa lakes where, with the exception of the area immediately south of Kalgoorlie, they are preferentially better developed on the southeastern margins of these lakes. The brown sand dunes occur adjacent to, and at least in part overlie gypsiferous or kopi dunes, and normally attain a thickness of only 1 to 2 m. Despite their close association with kopi dunes, the brown sand dunes normally appear to contain little if any gypsum. This is supported by a number of sulfate analyses which are typically returned less than 100 ppm sulfate (Appendix 1). The mode of occurrence of the brown sand is indicative of a depositional, possibly earlier fluvial, and later wind blown (eolian) origin. Typical brown sand is red–brown to brown (Fig. 8) very fine to fine grained and silty, medium to coarse grained in part, poorly to moderately sorted, and subangular to subrounded. Fine pisolitic ironstone grains are common.

The areas covered by mixed brown sand and kopi dunes have normally been mapped as *Cztd* on the GSWA 1:100 000- and 1:250 000-scale geological maps. These form the basis of mapping of the brown sand areas in this survey. Detailed mapping by Gozzard (1988) subdivided the brown sand areas on the DUNNSVILLE and KALGOOLIE 1:100 000 sheets into morphological features. The subdued lunette topography (*Qgt*), lunette (*Qgl*), and sinuous dune (*Qga*) of Gozzard (1988) all correlate with brown sand dunes, but also can apply to kopi dunes. The sand sheet (*Qgs*) of Gozzard (1988) may be suitable for sand supply in part, but is commonly less than one metre thick and may contain intermixed gravel. Later regolith mapping by Swarnecki (2005) in the Kalgoorlie–Kanowna area included potential resources of brown sand in both sand dune (*Ee*), and part of eolian sandplain (*Es*) units. Regolith mapping in the East Yilgarn database (Geological Survey of Western Australia, 2007a) includes potential resources

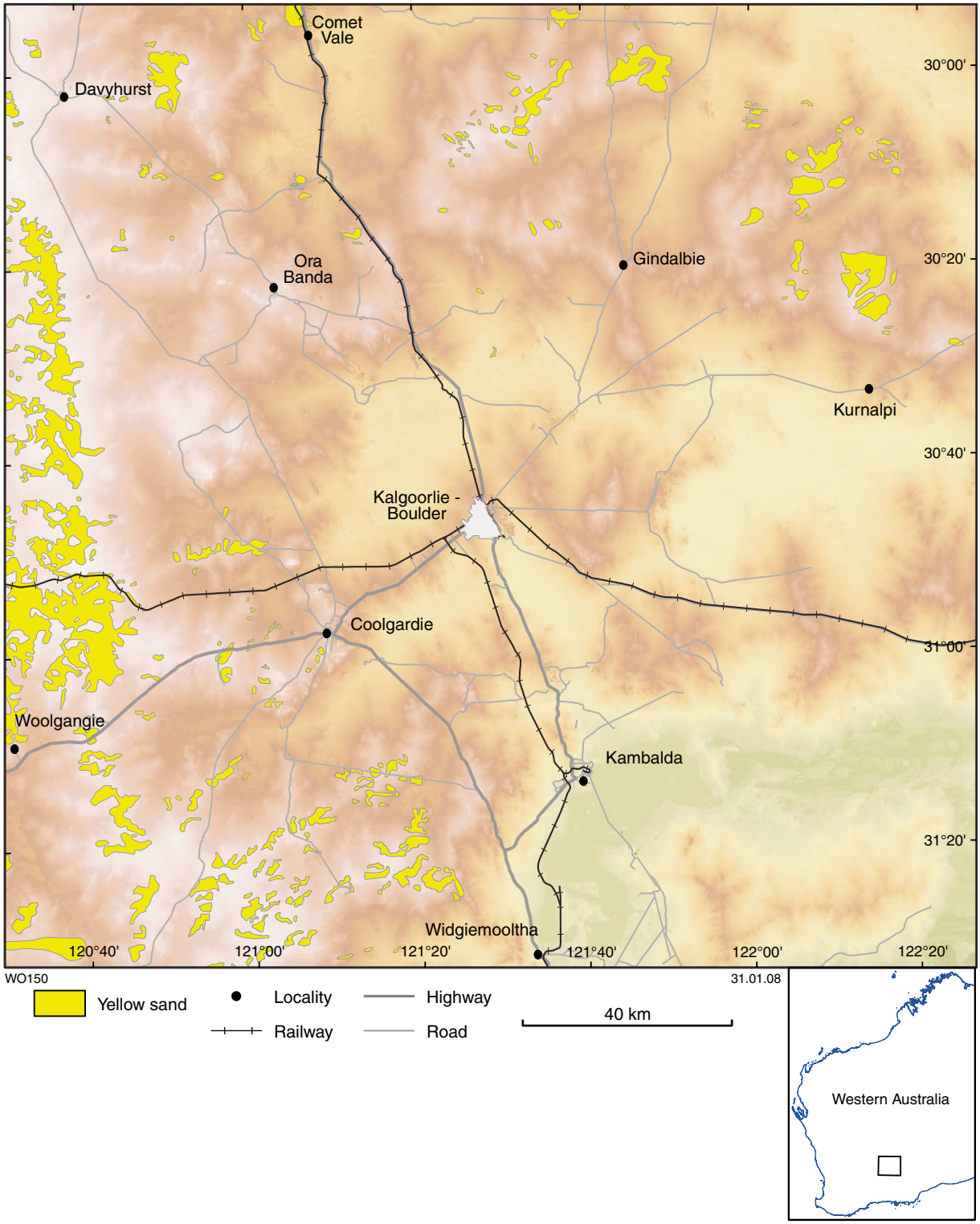

Figure 3. Elevation, shaded from SRTM data. Whitish hues highlight the highest elevations whilst yellow and green hues occupy lower elevations that are associated with playa lakes. Yellow sand (shaded) preferentially overlies topographic highs

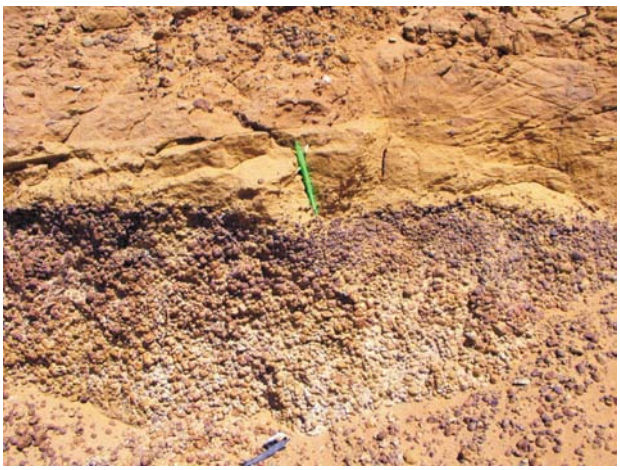

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Figure 4. About 0.3 m of yellow sand with minor ferruginous gravel overlying ferruginous gravel with minor sand matrix in the Grosmont pit area about 14 km west-southwest from Coolgardie (MGA $_{33}$13350E $_{65}$64700N)

of brown sand variously in the lake mixed (*Lm*), and lakeside deposits (*Ld*), but these both can also include kopi deposits, and unsuitable thin and/or gravelly sand sheet material, and together approximate the *Cztd* units of earlier mapping.

In practice, detailed mapping of the occurrence of the numerous individual or groups of dunes of brown sand is not warranted on the scale of this survey, but can readily be carried out on a local-scale using aerial photographs or orthophotographs. The red–brown colour of these dunes contrasts markedly with the much paler, whitish hues of the adjoining kopi dunes. Within about 25 km of Kalgoorlie, the majority of the brown sand dunes were mapped as *Ee* by Swarnecki (2005).

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Figure 5. Yellow sand at Logans pit, located about 20 km northwest of Widgiemooltha (MGA $_{35}$0320E $_{65}$27290N). Scale auger rod is 1 m long

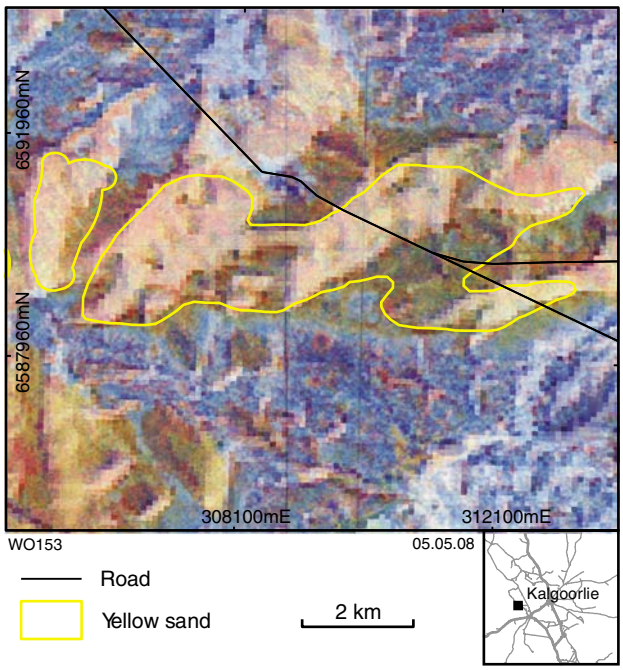


Figure 6. Interpreted yellow sand boundary, Mount Burges area, about 21 km northwest of Coolgardie. Image comprises the interband ratios 5/7, 4/7, 4/2 from Landsat data, overlying two SRTM-derived images emphasising ridgelines as red lines, drainages as blue lines, and relief topography with illumination from the northwest. Pixilation is due to the 90 m resolution of the SRTM data

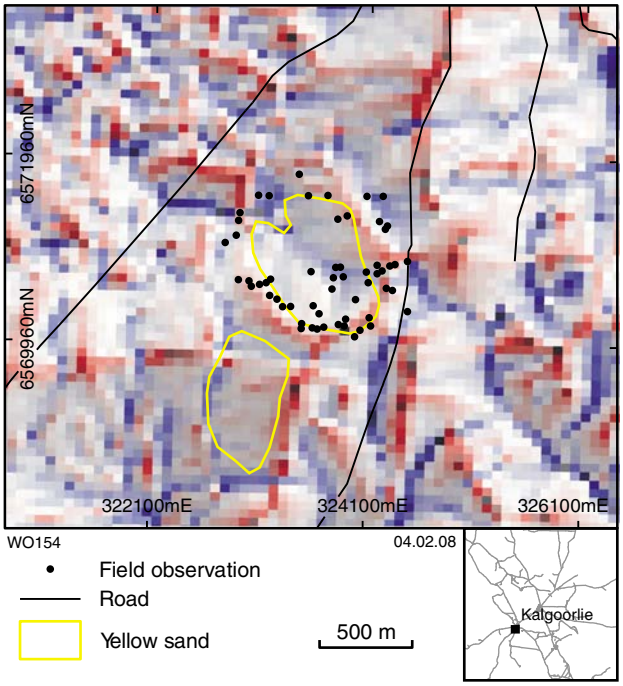


Figure 7. Multi-layered SRTM-derived images showing the occurrence of yellow sand in a basin-like topographic setting at Kangaroo Hills, about 3.5 km southwest from Coolgardie. Ridgelines are shown as red lines, and lower elevations are blue. Relief topography is illuminated from the northeast. Pixilation is due to the 90 m resolution of the SRTM data

WO155 04.02.08

Figure 8. Brown sand at Leeks pit, located about 24 km north-northwest of Kalgoorlie (MGA 346380E 6619500N). Scale auger rod is 1 m long

In addition to the two main sand types, a third category of yellow-coloured lakeside sand dunes has been identified in the Lake Lefroy region. These dunes occur preferentially on the southern and eastern margins of the lake and contain some of the best-quality sand in the Kalgoorlie region.

Although these dunes appear to be genetically related to the brown sand that occurs along other parts of the shoreline, and in more distal areas, they are a distinctly different colour (much more comparable with the yellow sand), are markedly less silty, and tend to occur in higher dunes from about three to greater than six metres high. The reasons for these differences are unclear, but may be related to reworking of brown sand. Lakeside dune sands are typically yellow (Fig. 9), predominantly fine to medium grained, moderately sorted, and subrounded to subangular.

WO156 04.02.08

Figure 9. Lakeside dune sand at the Widgiemooltha pit, located about 15 km northeast of Widgiemooltha (MGA 372330E 6528230N)

They occur within the area mapped as *Cztd* on the 1:100 000 map sheet (Griffin and Hickman, 1988a), and were also normally depicted as dune trend lines. The delineation of these dunes in this survey was accomplished by a combination of field inspection, sampling, previous GSWA mapping, orthophotography and highlighting invididual dunes on SRTM-derived topographic images.

Sand sampling and testing

A total of 192 sand samples each comprising 2–3 kg of material were collected by various methods including shovel samples of sand heaps and stockpiles, vertical channel samples taken down sand-pit faces or railway cuttings, and hand auger samples where pits or other exposures are lacking. Individual channel and auger samples generally represent 1 to 1.5 vertical metres sampled. Maximum vertical thickness sampled was 5 m.

Samples were submitted to specialist material testing laboratories to assess their suitability for concrete. CSR-Readymix and Benchmark Laboratories carried out the testing of the samples from the two field work programs.

The required tests for the evaluation of a natural sand intended for use in concrete are discussed in Australian Standard 2758.1–1998 (Standards Australia, 1998). Although full compliance testing would require eight individual tests, CSR-Readymix recommended that initial screening tests involving grading (particle size distribution test), colour, and clay/silt determination be undertaken for the quick identification of potentially suitable material. CSR-Readymix also advised that the only additional tests warranted are the chloride and sulfate analyses on the basis that their technical data indicates that sand from the Kalgoorlie–Boulder region will always meet the target limits for the remaining tests.

Results for all testing are listed in Appendix 1. In total, 192 samples were tested for particle size analysis to Australian Standard AS1289 3.6.1 (Standards Australia, 1995), organic impurities to AS1141.34 (Standards Australia, 1997a) and percentage clay/silt determination AS1141.33 (Standards Australia, 1997b). Also, 45 of these samples were tested for chloride and sulfate to Australian Standard AS1012.20 (Standards Australia, 1992). Where multiple samples were collected from the same locality, the results were averaged, weighted by sample length, and are also listed in Appendix 1. All sample localities are shown on the sand resource survey map (Plate 1).

Sand test results and classification

The three mapped categories of sand — yellow sand, brown sand, and lakeside dune sand have distinctly different size fraction distributions as shown (Figs 10–13). The standard deviation curves show that the brown sand (Fig. 10) has the highest variability in grain sizes between samples, whilst the yellow sand (Fig. 11) and lakeside dune sand (Fig. 12) have considerably less variation. The steeper curve for the lakeside dune sand (Fig. 13) indicates

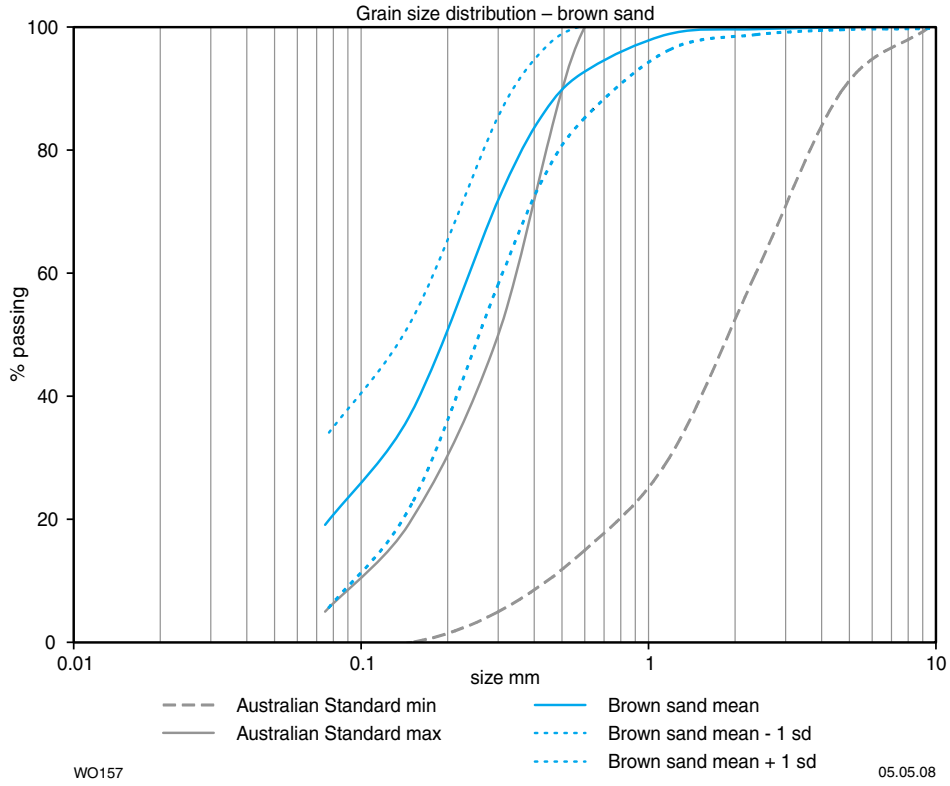


Figure 10. Mean grainsize distribution and standard deviation for brown sand (45 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

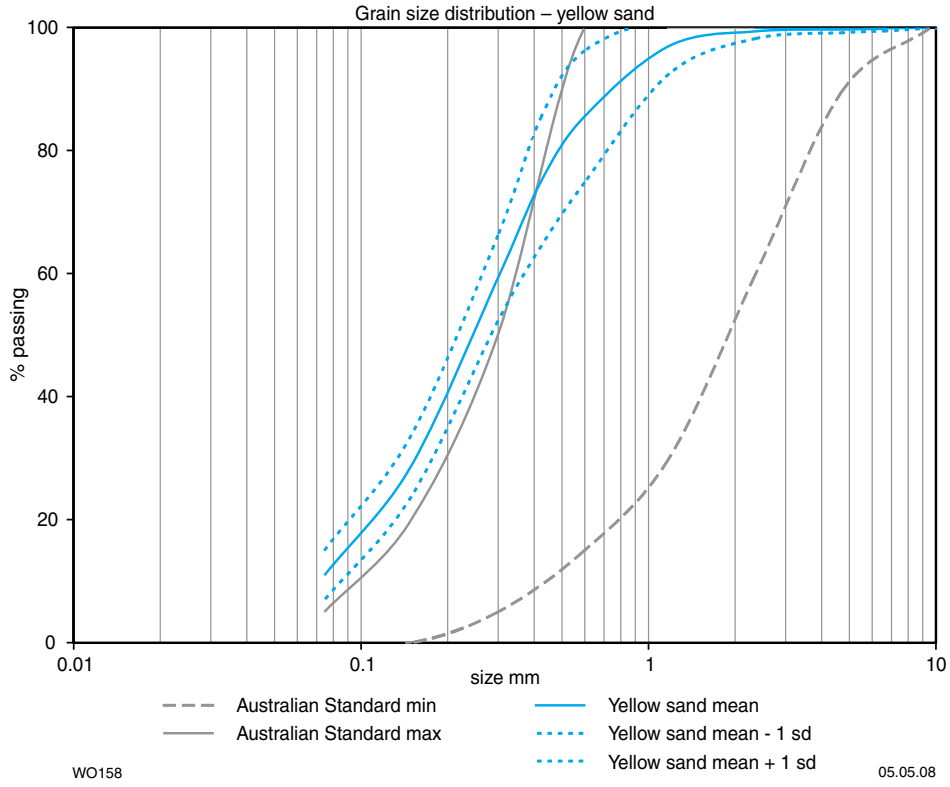


Figure 11. Mean grainsize distribution and standard deviation for yellow sand (64 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

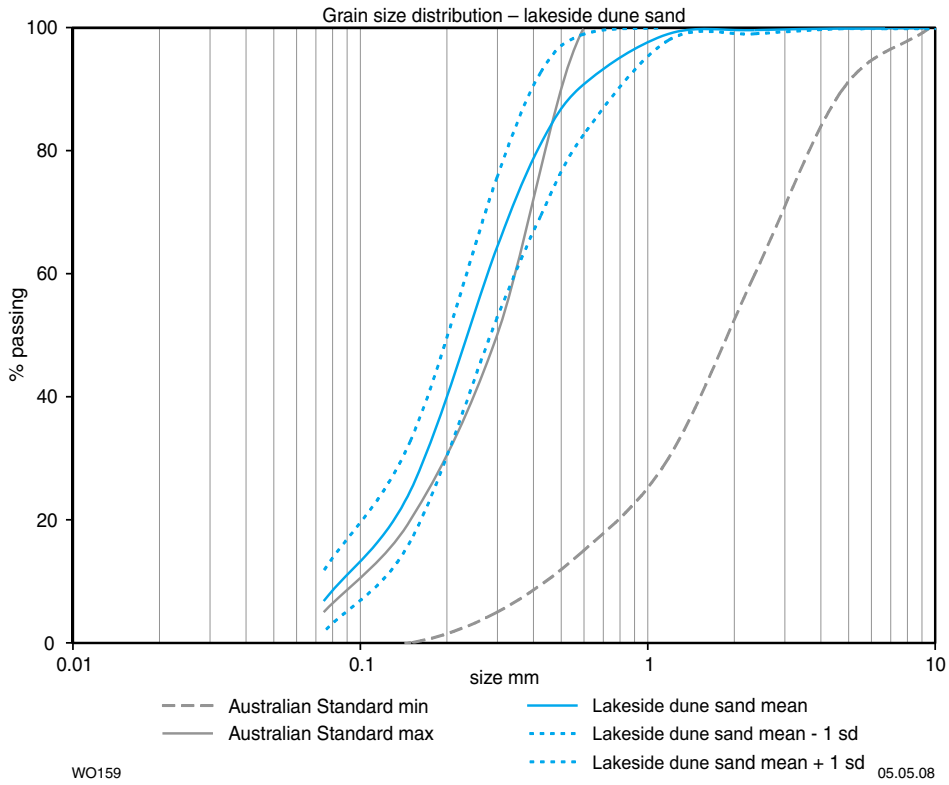


Figure 12. Mean grainsize distribution and standard deviation for lakeside dune sand (11 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

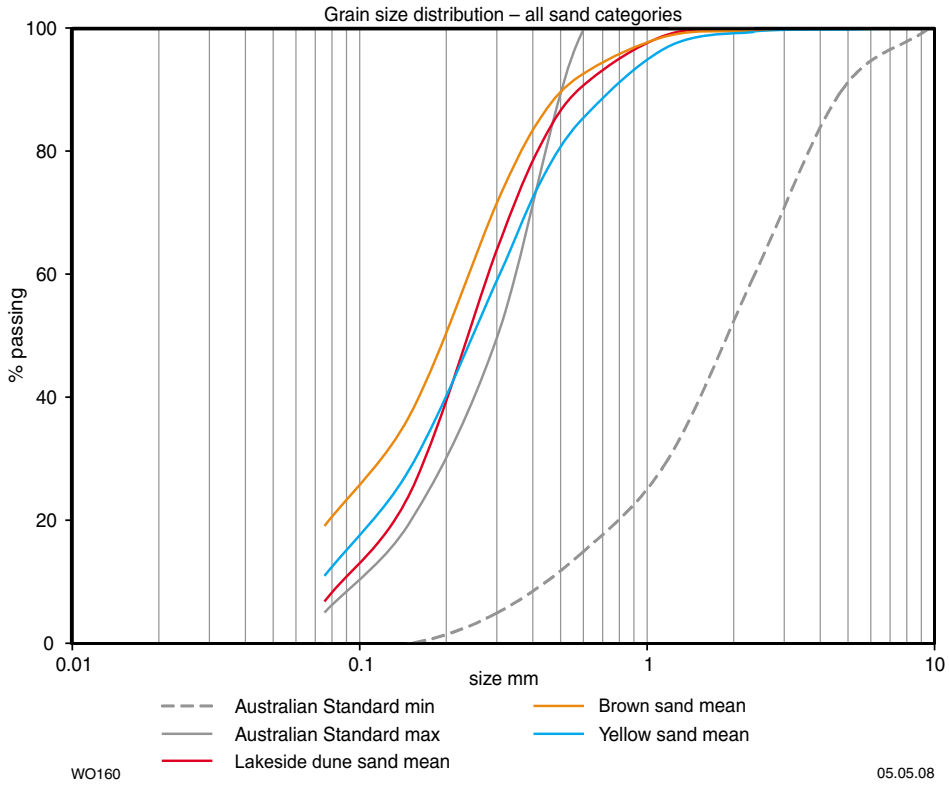


Figure 13. Comparison of the mean grainsize distribution for all sand categories compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

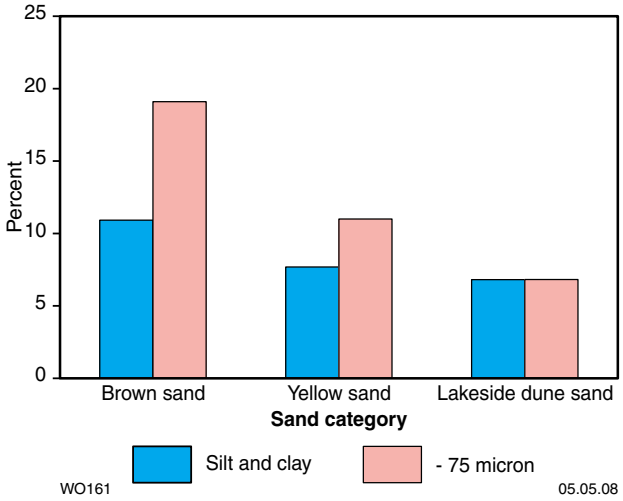


Figure 14. Mean fine fractions for the three sand categories measured by percentage silt and clay determination (AS1141.33), and percentage passing minus 75 µm sieve (AS1289 3.6.1)

that it is better sorted than the other sands which have similar profiles. Notably, the brown sand has the highest silt fraction with a mean of 19.1% passing minus 75 µm (Fig. 14), and is best described as a silty sand, making it suitable only for fill in most cases. Whilst both the yellow sand and lakeside dune sand are also relatively fine-grained with respect to the Australian Standard 2758-1–1998 (Standards Australia, 1998) for concrete sand, they are of significantly better quality than the brown sand.

Only five of the yellow sand samples and four lakeside dune samples notionally meet the Australian Standard for concrete sand with respect to particle size analysis (with 0 to 5% passing minus 75 µm size fraction), and are consequently termed concrete sand in this survey (Fig. 15). The silt and clay fractions as determined by the settling method (AS1141.33) for these samples vary from 1.8% to 7.9% and average 4.4%. Concrete standard AS2758.1 also specifies a minus 2 µm (notionally clay) fraction of less than 1% as specified from Australian Standard test no. 1141.13. This test was not carried out on any of the samples. Only three concrete sand samples were analysed for chloride and sulfate, resulting in 400 to 481 mg/kg and <100 to 304 mg/kg respectively. These limited analyses indicate suitability for plain concrete only, but are insufficient to be representative.

Samples with the concrete sand classification occur within yellow sand to the north and northeast of Kalgoorlie, including Comet Vale, and within lakeside dune sand along parts of the southern shores of Lake Lefroy (Fig. 16). Sand mining has been taking place at both the Lake Lefroy (Widgiemooltha) and the Comet Vale localities since the 1980s. North of Kalgoorlie, two other samples that technically meet the concrete sand specification were obtained from occurrences of creek bed alluvial sand (sample no. 193207) and paleochannel sand (sample no. 165749), both of which are only available in limited quantities.

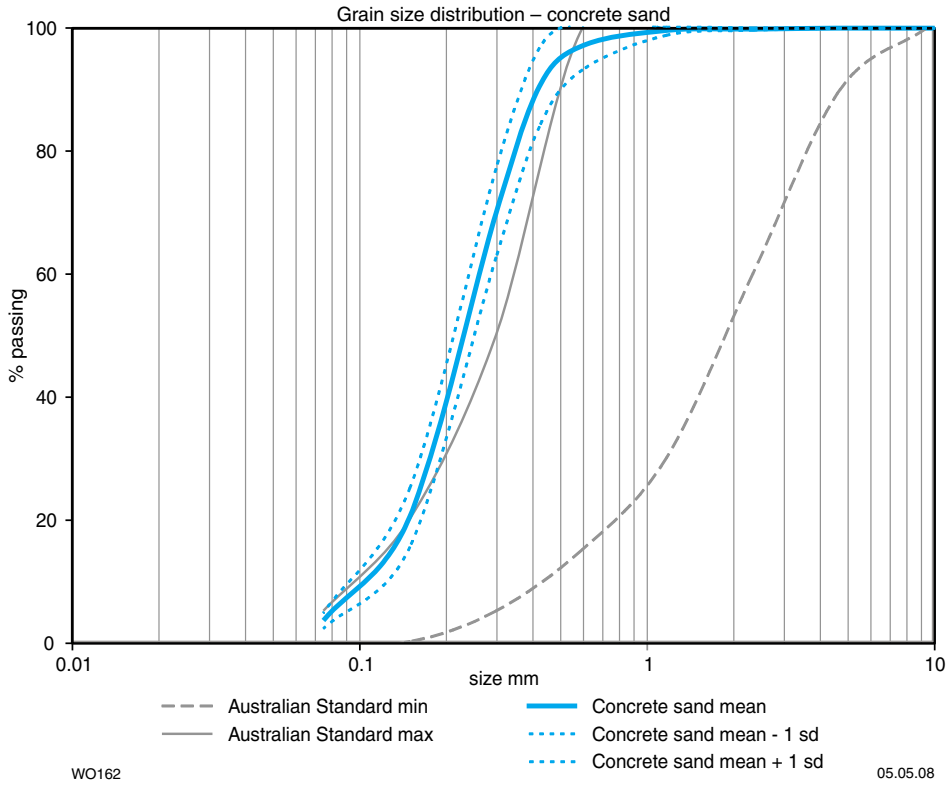


Figure 15. Mean grainsize distribution and standard deviation for concrete sand (9 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

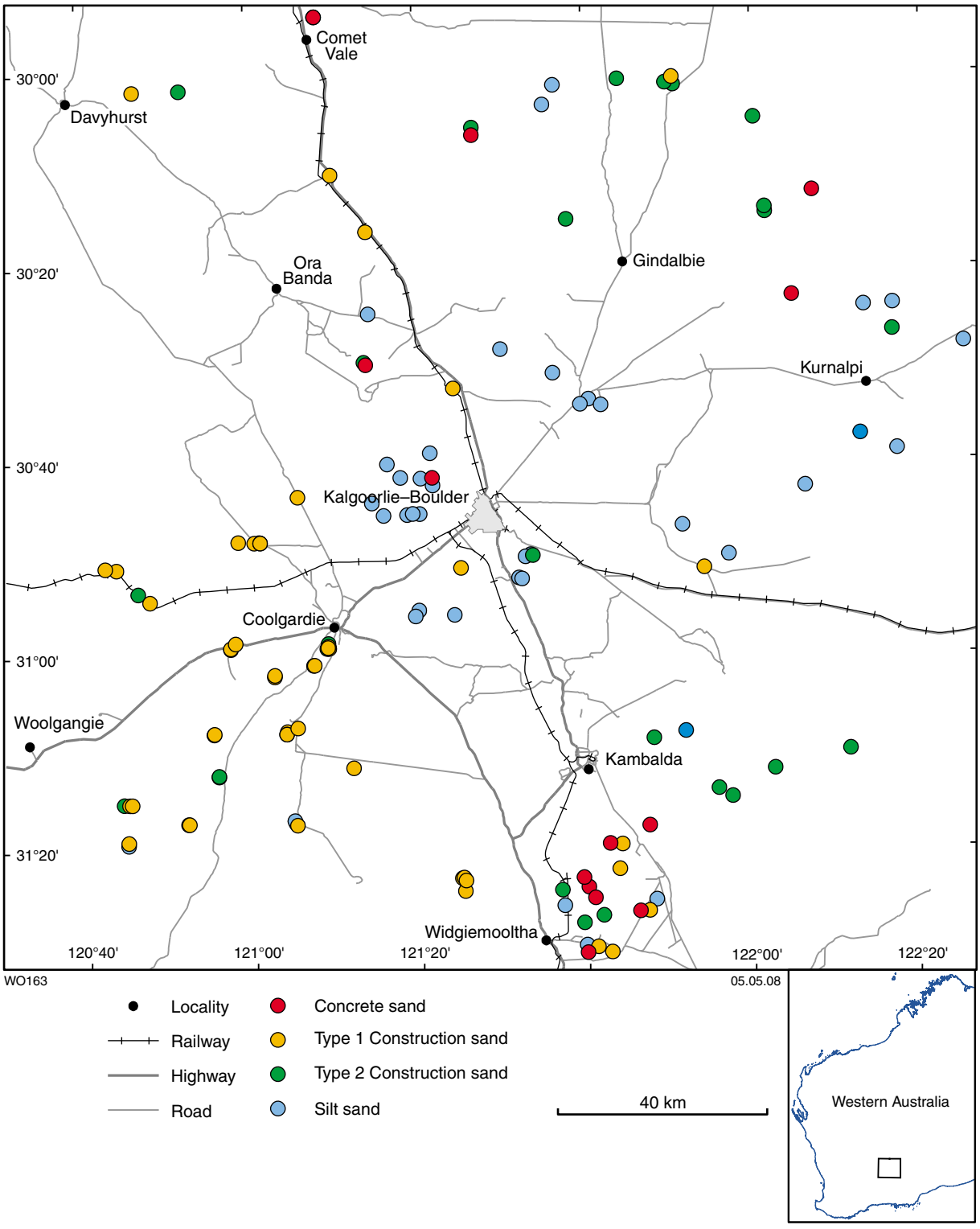


Figure 16. Distribution of the four sand quality classifications adopted in this study based upon test work on 192 samples. Concrete sand is the highest quality sand, and silty sand is the lowest quality

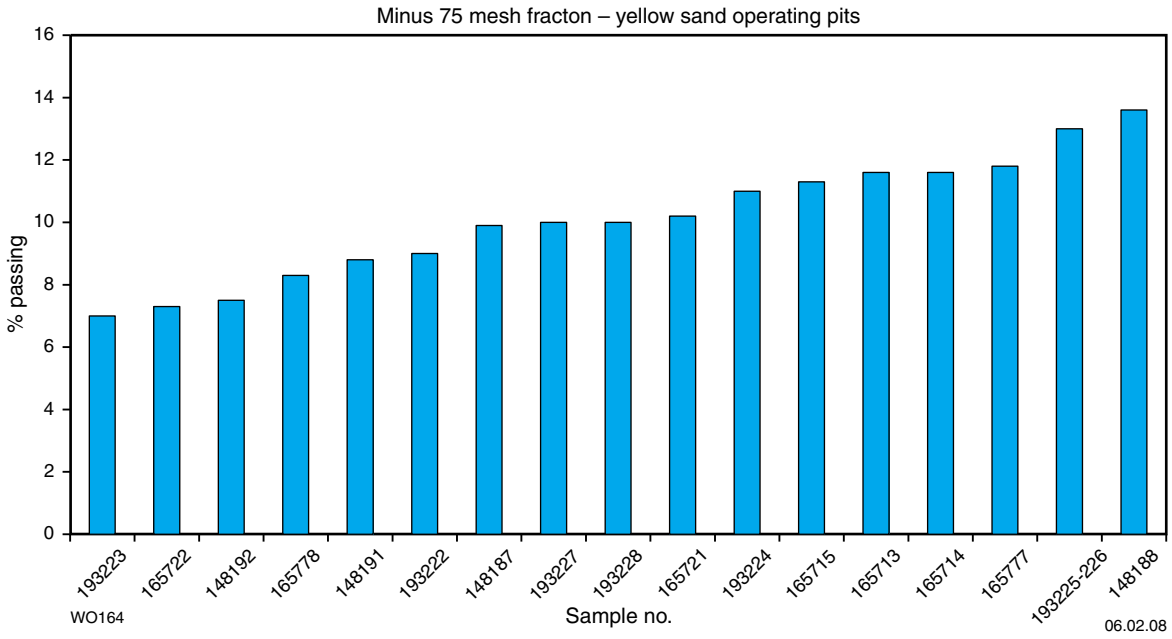


Figure 17. Minus 75 mesh fraction for all yellow sand operating pit samples other than Comet Vale

All of the remaining yellow sand samples from operating pits located to the west, southwest, and south of Kalgoorlie returned sand size fractions of 5% to 14% passing minus 75 µm (Fig. 17). These operations source sand for a variety of purposes including concrete sand. The silt and clay content (measured using AS1141.33 test method) of all yellow sand and lakeside dune sand samples with size fractions of less than or equal to 14% passing minus 75 µm can be divided into two groups around the value of 7.5% silt and clay (Fig. 18) which approximates the upper limit of silt and clay from the concrete sand samples.

Yellow and lakeside dune sand samples with size fractions of 5% to 14% passing minus 75 µm were divided into two types:

- Type 1 construction sand has silt and clay values ranging between 0% and 7.5%, and can be suitable for concrete purposes as evidenced by several currently operating pits returning samples of silt and clay within this range. This type of construction sand occurs mainly to the south and west of Kalgoorlie (Fig. 16) and accounts for the majority of operating sand pits in the survey area.

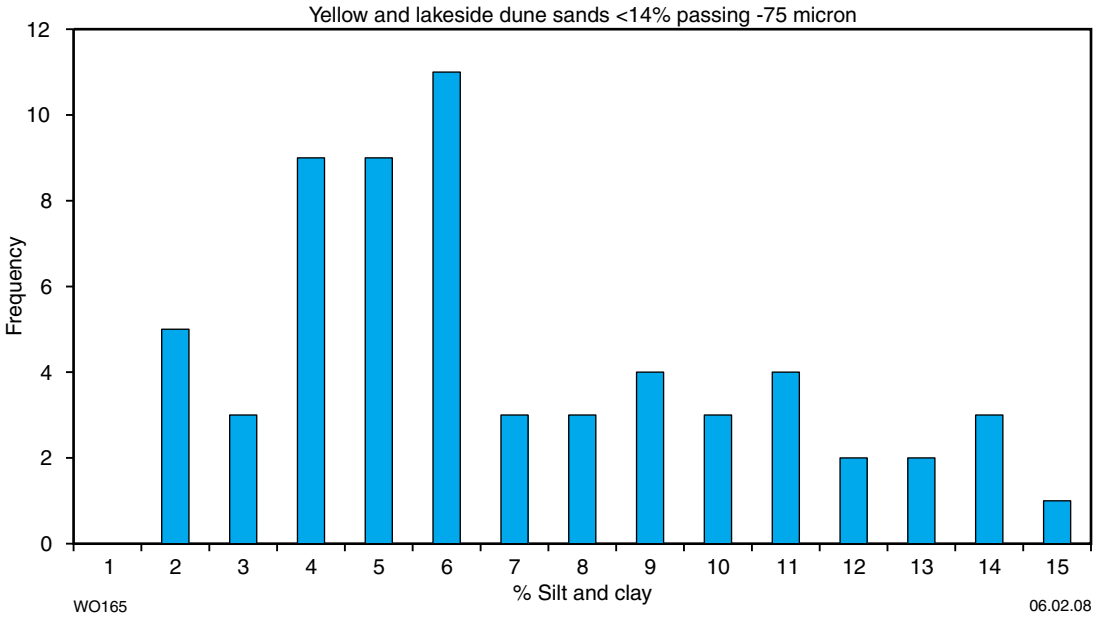


Figure 18. Frequency distribution of the silt and clay content (using AS1141.33 test method) for all minus 75 mesh fraction samples of yellow sand and lakeside dune sand (62 samples)

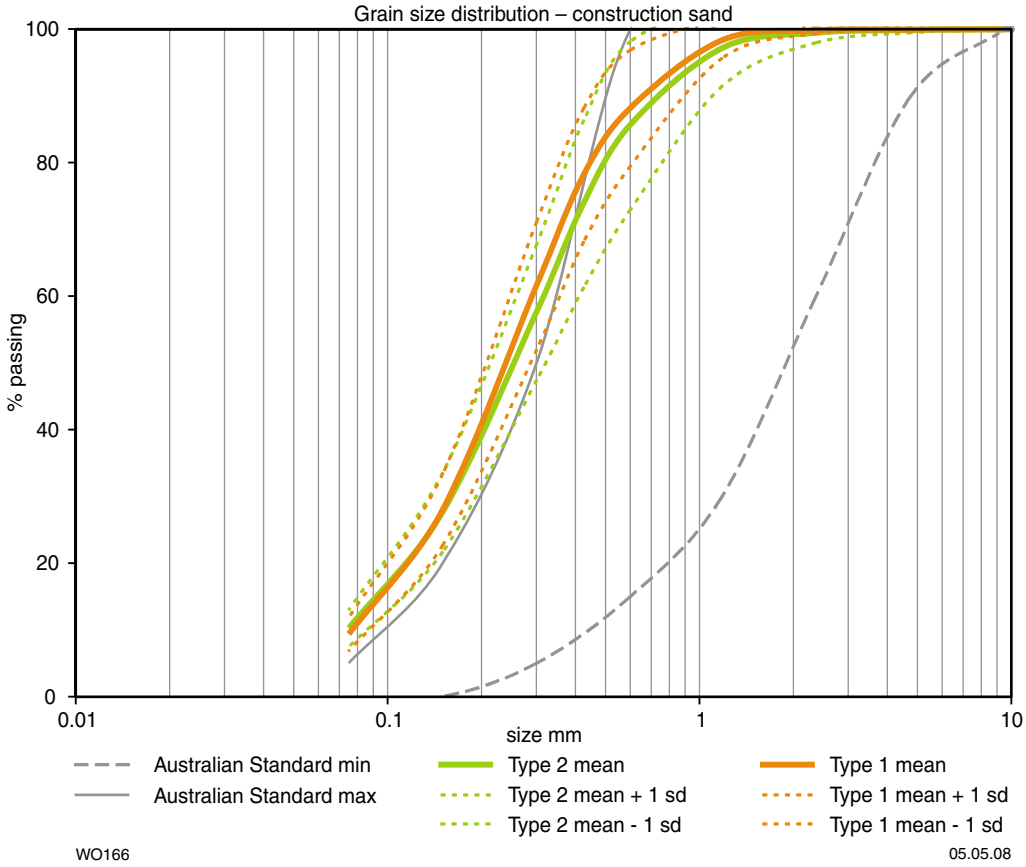


Figure 19. Mean grainsize distribution and standard deviation for type 1 construction sand (44 samples) and type 2 construction sand (28 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

- Type 2 construction sand has silt and clay values of between 7.5% and 15%, and is more likely to be suitable for uses other than concrete. This category of construction sand occurs mainly to the northeast and southeast of Kalgoorlie (Fig. 16).

Despite differences in the silt and clay contents using method AS1141.33, both types 1 and 2 construction sands have very similar size distribution profiles as determined by method AS1289 3.6.1 (Fig. 19). Type 1 construction sand is marginally better sorted than type 2 construction sand. Twenty-three type 1 (Fig. 20) and only three type 2 construction sand samples were analysed for chloride and sulfate. All results were within the ranges suitable for concrete purposes, although five of the type 1, and one of the type 2 samples were only suitable for plain concrete due to high chloride content (maximum of 516 mg/kg for a composite sample).

The remaining samples returned test results in excess of 14% passing minus 75 µm, and/or had silt and clay contents exceeding 15%. These are classified as silty sand in this survey. The vast majority of silty sands occur within the brown sand, playa lake associated areas to the north, south and east of Kalgoorlie (Fig. 16). Figure 21 shows that silty sands are unlikely to be suitable for concrete purposes due to their very fine grain size, and they have by far the highest variability in grain size distribution between samples, and are the most poorly sorted of all the sand classifications, making them best suited for fill sand purposes.

Figure 22 shows the main differences between the concrete sand, construction sand and silty sand classifications. Concrete sand is the best sorted, but on average over 97% is finer than 600 µm (0.6 mm), whereas the other classifications are less well sorted, resulting in a larger proportion of coarse sand (>600 µm).

Discussion

Whilst the sand sampling classification scheme (i.e. concrete sand, type 1 and type 2 construction sand, and silty sand) is a useful way of characterizing the different sand qualities in the survey area, the data remain indicative only because of the limitations of sampling methods and sample density. Figure 16 shows some overall patterns in sand quality, but it also highlights the spatial variability in sampling results. Because of these constraints, spatial patterns in sand prospectivity are best assessed by integrating the sand sampling results with the three broad sand categories: lakeside dune sand, yellow sand, and brown sand. Four geographical regions with different broad sand quality characteristics have been interpreted for the Kalgoorlie region (Fig. 23). They are discussed in

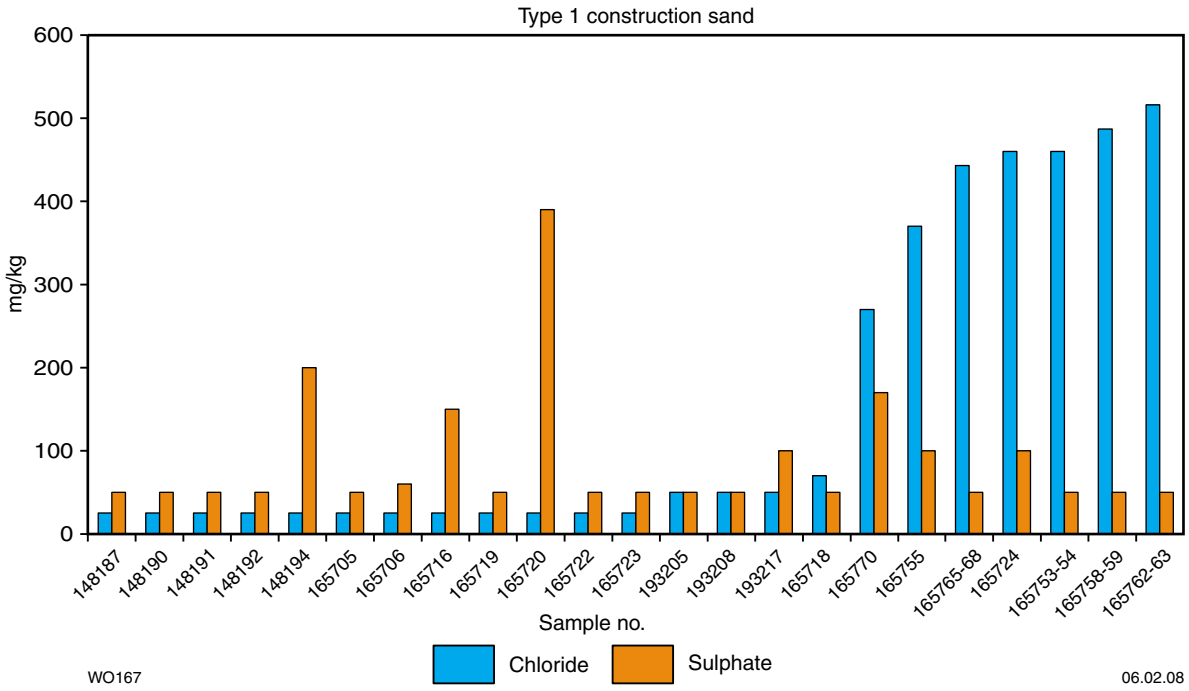


Figure 20. Chloride and sulfate assay results for type 1 construction sand using method AS 1012.20

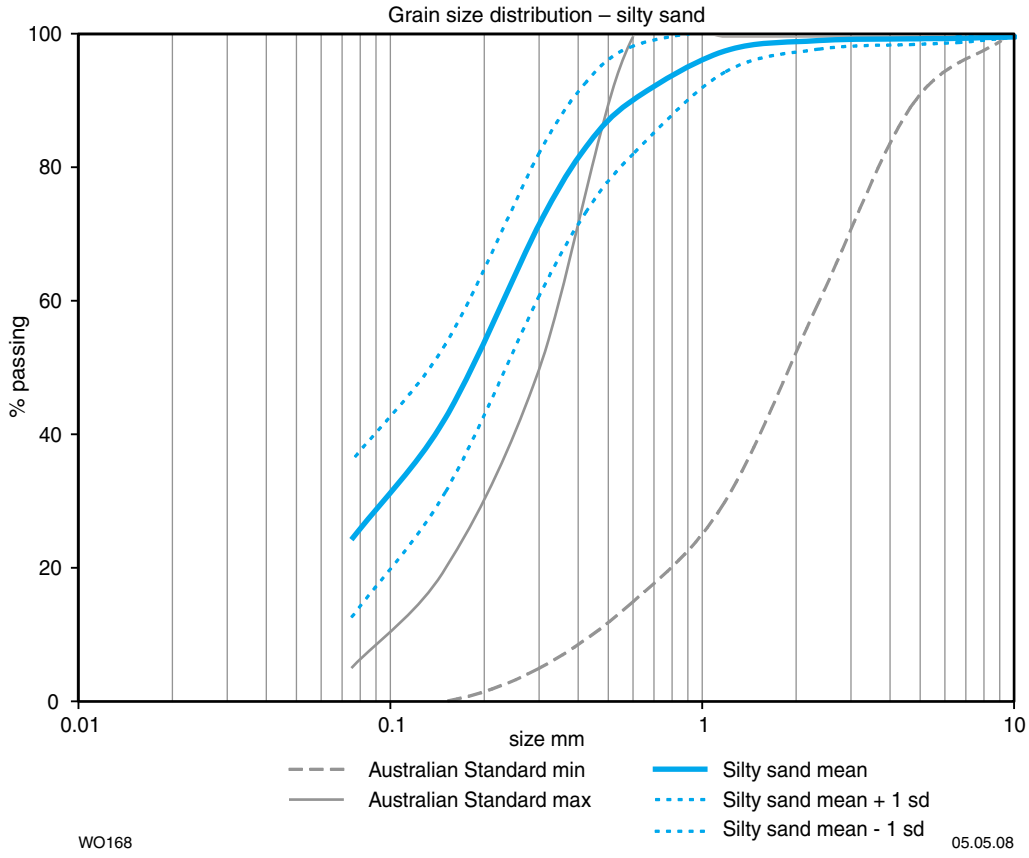


Figure 21. Mean grainsize distribution and standard deviation for silty sand (46 samples) compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

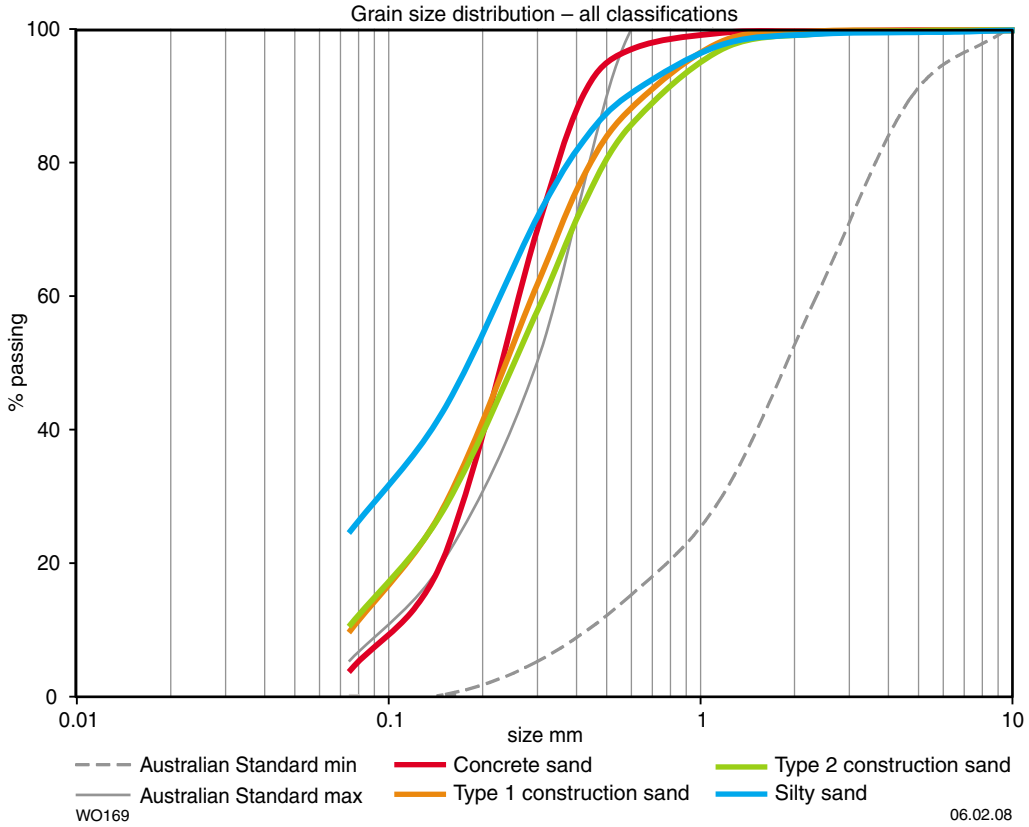


Figure 22. Comparison of the mean grainsize distribution for all sand classifications compared to the Australian Standard AS 2758.1.1998 for concrete aggregate

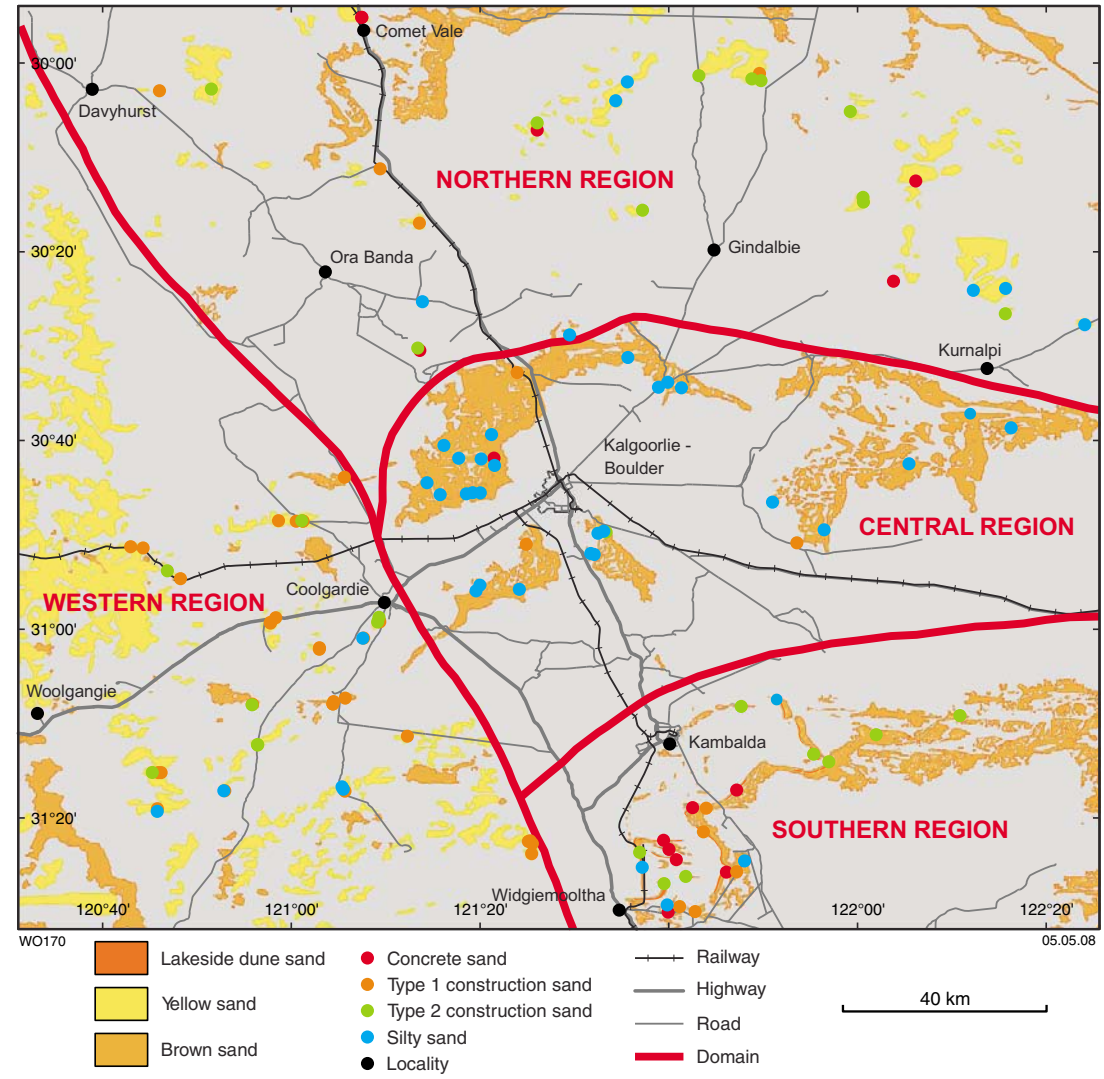
order of decreasing prospectivity for locating large new sources of construction sand.

The western region covers most of the outer western hemisphere of the survey area, and consists almost entirely of yellow sand associated with granitoids in areas of relatively high topography. Notable exceptions are brown sands associated with playa lakes at Gnarlbine and Kunanalling. Most operational sand pits in the Kalgoorlie survey area are located in the Western region, and 70% of the samples tested from this region were classified as Type 1 construction sand (Fig. 24). The combination of comparatively low variability of sand quality, and the vast quantities of sand in this region, results in it having the lowest overall exploration risk for obtaining long-term supplies of sand suitable for most construction purposes. The most prospective area occurs from about 10 to 65 km north of Woolgangie, and from about 75 to 110 km west of Kalgoorlie. This area actually extends beyond the western limit of this survey, and more sampling and mapping is required to fully define the area, and to confirm the sand quality. As the yellow sand commonly overlies ferruginous gravel, this area is also prospective for associated gravel.

The southern and northern regions both have a significant proportion of higher quality concrete sand (Fig. 24). Of these two areas, the southern region represents the lowest exploration risk as the sampling consistently showed that both the concrete sand and type 1 construction sand are closely associated with the well-defined lakeside dune sand areas. One sand pit is operating in this region at Widgiemooltha. The remainder of the southern region consists of brown sand associated with playa lake deposits with test results classified as lower quality type 2 construction sand and silty sand.

Sampling in the northern region showed a much greater variability in sand quality on a district scale. All samples were collected from within the yellow sand which overlies granitoids in areas of relatively high topography, and forms the majority of mapped sand occurrences in this region. The high variability in sampling results, the majority of which were of the poorer quality type 2 construction sand classification, represents a higher exploration risk than for the western and southern regions. Hower, the sand pit operational at Comet Vale that returned concrete sand quality test results indicates that there is some potential for additional sand supplies from this region.

The playa lakeside sediments closest to Kalgoorlie all fall within the central region. Poor-quality brown silty sand dominates this area (Fig. 24) and consequently the exploration potential for construction sand is low. The close proximity of some of these sands to Kalgoorlie has resulted in a number of abandoned sand pits, presumably mainly sourcing sand for fill and garden purposes. The two concrete sand quality samples from this domain were obtained from a creek bed and paleochannel sand. The latter sand source has not been thoroughly examined in this survey which focuses upon surface deposits.



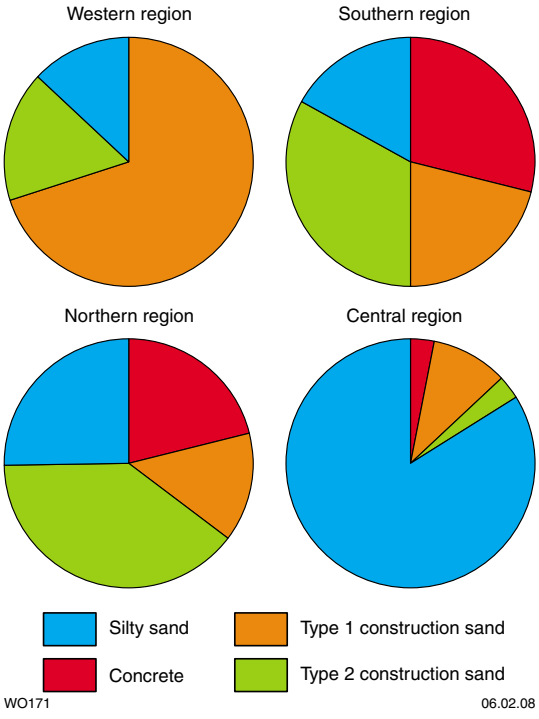


Figure 23. **(above) The four regions defined in this study on the basis of sand category and sample test result classifications**

Figure 24. **(left) Proportion of samples with the various sand classifications based upon the sample test results for the four regions shown in Figure 23**

Paleochannels provide another potential source of sand, although overburden depth and possibly clay content could detract from the viability of any operation. Two of the three better quality samples with a type 1 construction sand classification were obtained from the former Douglas Lake and Leeks silica sand mining pits. Whilst the Douglas Lake pit is depleted, the Leeks pit has some limited potential for further resources. The third type 1 construction sand result was obtained from a near surface, shovel sample located at the southwestern end of Lake Yindarlgooda, and may not be representative of the area.

Conclusions

The majority of sand within 100 km of Kalgoorlie is very fine grained with respect to the Australian Standard for fine concrete aggregate. Almost all sand within 40 km of Kalgoorlie has a high silt and/or clay content and therefore is unsuitable for concrete purposes.

The best-quality known concrete sand is located in the Comet Vale (northern region) and Widgiemooltha (Southern Region) areas, 100 km to the north and 100 km (by road) to the south of Kalgoorlie respectively. Both of these areas currently have operating pits, located close to the major highway. At current rates of mining, the sand resources within the existing leases will be exhausted within approximately 20 years. There are other potential resources of concrete sand within a few kilometres of both these operations. Access to these resources is constrained by a conservation reserve proposal (Comet Vale) and by mining tenements held by gold and nickel mining companies (Widgiemooltha). Potential exists for similar quality resources in a number of localities located similar distances to the northeast of Kalgoorlie (northern region), but the exploration risk in these areas is higher, and transport routes are not as well established over much of this area.

The majority of operational sand pits and resources are concentrated to the southwest of Kalgoorlie and west of Coolgardie in the western region. Operational pits in this area are located between 40 and 75 km from Kalgoorlie, and produce sand of sufficient quality for a range of construction purposes, including concrete. Some of these pits, together with nearby areas, will be able to provide adequate sand supply for Kalgoorlie in the short to medium term, possibly longer, if there are no other land access constraints. Overall, the western region is considered to be the most prospective, and hence lowest risk area for large quantities of construction sand. There is potential for vast quantities of construction sand in the area to the north of Woolgangie more than 75 km west of Kalgoorlie, and extending further west of the survey area. This area has access to both the transcontinental railway line and the Great Eastern Highway, and has the potential to supply construction sand to Kalgoorlie, the wider Goldfields region, and possibly beyond. In the long term when closer sources of suitable quality sand are either depleted or denied through land access constraints, this area may become a viable source.

Acknowledgements

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Appendix 1

Sample locations, descriptions, test results and classification

GSWA	East MGA	North MGA	Deposit	Location	Situation	Status	Sample type	Sample interval	Colour	Description
148187	323922	6570342	KA1	Kangaroo Hills	Sand pit	Operating	Channel	0 – 1.8	Light brown	sand
148188	323772	6570342	KA1	Kangaroo Hills	Sand pit	Operating	Auger	0 – 1.6	Light brown	sand
148189	321113	6567098	YL1	Kangaroo Hills	Sand plain	na	Auger	0 – 2.0	Light brown	sand
148190	321257	6567127	YL1	Kangaroo Hills	Sand plain	na	Auger	0 – 1.8	Light brown	sand
148191	313812	6564817	YL2	Hasties (Boral)	Sand/gravel pit	Operating	Channel	0.5 – 3.0	Yellow brown	sand
148192	313827	6565097	YL2	Hasties (Boral)	Sand/gravel pit	Operating	Channel	0.5 – 3.0	Yellow brown	sand
148193	302687	6553747	WO1	Gnarlbine	Sand pit	Operating	Channel	0 – 2.5	Pink brown	sand
148194	302737	6553837	WO1	Gnarlbine	Sand pit	Operation	Channel	0–2	Pink brown	sand
148195	303757	6545867	WO2	North. of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
148196	303757	6545977	WO2	North of Victoria Rock	Sand plain	na	Auger	0 – 1.9	Yellow brown	sand
148197	298257	6536827	WO3	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
148198	298257	6536827	WO3	West of Victoria Rock	Sand plain	na	Cuttings	3–6	Yellow brown	sand
148199	298407	6536827	WO3	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
148200	287137	6540157	WO4	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
165701	286137	6540157	WO4	West of Victoria Rock	Sand plain	na	Auger	0 – 1.5	Yellow brown	sand
165702	287637	6540157	WO4	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
165703	287137	6533057	WO5	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
165704	287137	6532557	WO5	West of Victoria Rock	Sand plain	na	Auger	0–2	Yellow brown	sand
165705	316397	6554617	YL3	South of Kangaroo Hills	Old pit	Abandoned	Channel	0 – 1.7	Yellow brown	sand
165706	316297	6554157	YL3	South of Kangaroo Hills	Old pit	Abandoned	Channel	0 – 2.3	Yellow brown	sand
165707	316297	6554157	YL3	South of Kangaroo Hills	Old pit	Abandoned	Channel	0 – 0.8	Pink brown	sand
165708	318327	6537477	YL4	Quairnie Rock	Sand plain	na	Auger	0 – 1.9	Yellow brown	sand
165709	318117	6537927	YL4	Quairnie Rock	Sand plain	na	Auger	0 – 1.6	Yellow brown	sand
165710	318607	6537097	YL4	Quairnie Rock	Sand plain	na	Auger	0 – 1.5	Yellow brown	sand
165711	328947	6548027	YL5	Old railway	Old pit	Abandoned	Channel	0 – 2.3	Yellow brown	sand
165712	350197	6525357	YL6	Old railway	Sand plain	na	Auger	0 – 1.3	Yellow brown	sand
165713	305477	6569787	DU1	Ubini Sand	Sand pit	Operation	Channel	1–3	Yellow brown	sand
165714	305457	6569927	DU1	Ubini Sand	Sand pit	Operation	Channel	0.2 – 2.0	Yellow brown	sand
165715	306357	6570857	DU1	Ubini East/Shire	Sand pit	Operation	Channel	0 – 2.2	Yellow brown	sand
165716	290137	6578197	DU2	Transline	Old pit	Abandoned	Channel	0.3 – 2.5	Yellow brown	sand
165717	287877	6579697	DU2	Transline	Old gravel pit	Abandoned	Channel	0 – 1.3	Yellow brown	sand
165718	283706	6584087	DU3	Transline	Old gravel pit	Abandoned	Channel	0.2 – 3.5	Yellow brown	sand
165719	281596	6584277	DU4	Transline	Railway cut	na	Channel	2–4	Yellow brown	sand
165720	309477	6589797	KA2	Mount Burges	Rehab pit	Shutdown	Channel	0–2	Yellow brown	sand
165721	310587	6589847	KA2	Mount Burges	1998 pit	Operation	Channel	3 – 6.5	Pink brown	sand
165722	310587	6589847	KA2	Mount Burges	1998 pit	Operation	Shovel	0–3	Yellow brown	sand
165723	317462	6598567	KA3	Kunanalling SE/Dale	1998 pit	Shutdown	Shovel	0 – 1.5	Red	loam
165724	318337	6555307	YL7	South of Kangaroo Hills	Old pit	Abandoned	Channel	0 – 1.7	Pink brown	sand
165725	340507	6595877	KA4	White Dam	Old pit	Abandoned	Channel	0.2 – 2	Pink brown	sand
165726	338147	6595657	KA4	White Dam	Dune	na	Channel	1.0 – 2.0	Pink brown	sand
165727	338147	6595657	KA4	White Dam	Dune	na	Channel	2.0 – 3.0	Brown	loam
165726–27	338147	6595657	KA4	White Dam	Dune	na	Channel	1.0 – 3.0	Brown	loam
165728	333727	6595407	KA5	Kopai Lake	Dune	na	Auger	0 – 1.45	Pink brown	sand
165729	333727	6595407	KA5	Kopai Lake	Dune	na	Auger	1.45 – 2.45	Brown	loam
165728–29	333727	6595407	KA5	Kopai Lake	Dune	na	Auger	0 – 2.45	Brown	loam
165730	331467	6597727	KA6	Bullock Lake	Dune	na	Auger	0 – 1.45	Brown	sand and loam
165731	331467	6597727	KA6	Bullock Lake	Dune	na	Auger	1.45 – 2.45	Brown	loam
165730–31	331467	6597727	KA6	Bullock Lake	Dune	na	Auger	0 – 2.45	Brown	loam
165732	334207	6605077	KA7	White Flag Lake	Dune	na	Auger	0.3 – 1.45	Pink	sand
165733	334207	6605077	KA7	White Flag Lake	Dune	na	Auger	1.45 – 2.45	Pink	sand
165734	334207	6605077	KA7	White Flag Lake	Dune	na	Auger	2.45 – 3.45	Pink	sand
165732–34	334207	6605077	KA7	White Flag Lake	Dune	na	Auger	0.3 – 3.45	Pink	sand
165735	342837	6601287	KA8	Firebreak	Old sand pit	Abandoned	Auger	0 – 1.4	Brown	sand
165736	342837	6601287	KA8	Firebreak	Old sand pit	Abandoned	Auger	1.4 – 2.6	Brown	sand
165735–36	342837	6601287	KA8	Firebreak	Old sand pit	Abandoned	Auger	0 – 2.6	Brown	sand
165737	340537	6602527	KA9	North of Centre dam	Dune	na	Drillhole	0–2	Buff sand	sand
165738	340537	6602527	KA9	North of Centre dam	Dune	na	Drillhole	2.0 – 4.0	Pink white	sand
165739	340537	6602527	KA9	North of Centre dam	Dune	na	Drillhole	4.0 – 5.0	Medium brown	sand
165737–39	340537	6602527	KA9	North of Centre dam	Dune	na	Drillhole	0 – 5.0	Pink brown	sand
165740	336737	6602607	KA10	North of Centre dam	Dune	na	Auger	0 – 1.4	Pink brown	sand
165741	336737	6602607	KA10	North of Centre dam	Dune	na	Auger	1.4 – 2.4	Pink brown	sand
165742	336737	6602607	KA10	North of Centre dam	Dune	na	Auger	2.4 – 3.4	Pink brown	sand
165740–42	336737	6602607	KA10	North of Centre dam	Dune	na	Auger	0 – 3.4	Pink brown	sand
165743	342227	6607307	KA11	Horans Small Dam	Dune	na	Auger	0 – 1.4	Brown loamy	sand
165744	342227	6607307	KA11	Horans Small Dam	Dune	na	Auger	1.4 – 2.4	Brown loamy	sand
165745	342227	6607307	KA11	Horans Small Dam	Dune	na	Auger	2.4 – 3.4	Brown loamy	sand
165743-45	342227	6607307	KA11	Horans Small Dam	Dune	na	Auger	0 – 3.4	Brown loamy	sand
165746	340697	6577797	KA12	Brown Lake	Dune	na	Auger	0 – 1.4	Pink brown	sand
165747	340697	6577797	KA12	Brown Lake	Dune	na	Auger	1.4 – 2.4	Brown loamy	sand
165746-47	340697	6577797	KA12	Brown Lake	Dune	na	Auger	0 – 2.4	Pink brown	sand and loam
165748	340057	6576667	KA13	Brown Lake	Dune	na	Shovel	0 – 0.3	Dark brown	loam
165749	329837	6623607	KA14	Mount Pleasant	Manly stockpile	Stockpile	Shovel	20–22	Coarse white	sand
165750	329487	6624057	KA14	Mount Pleasant	Manly pit	Shutdown	Section	20 – 21.4	Coarse white	sand
165751	329487	6624057	KA14	Mount Pleasant	Manly pit	Shutdown	Section	21.4 – 22.4	White	clay and sand
165750–51	329487	6624057	KA14	Mount Pleasant	Manly pit	Shutdown	Section	20-22.4	White	clay and sand
165752	330137	6633157	BA1	Cawse	Scorpion pit	Operation	Channel	0-1.7	Red loamy	sand
165753	329377	6648532	BA2	Vettersburg	Stillman sand pit	C and M	Channel	2.0-3.0	Red brown	sand

% passing specific sieve sizes (mm)											Clay	Organics	Chloride	Sulfate	Class
13.2	9.5	6.7	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075	(%)		(mg/kg)	(mg/kg)	
–	–	–	–	100	99	96	85	64	33	9.9	3.8	pass	<50	<100	type 1
–	–	–	–	100	99	97	86	65	35	13.6	15.3	pass	<50	<100	silty sand
–	–	–	–	100	98	93	85	68	36	15.5	10	fail	<50	<100	silty sand
–	100	99	99	97	93	90	83	65	33	13.8	7.2	fail	<50	<100	type 1
–	–	–	–	100	99	86	73	60	31	8.8	3.8	pass	<50	<100	type 1
–	–	–	–	–	100	94	84	69	33	7.5	3.8	pass	<50	<100	type 1
–	–	–	–	100	99	84	70	50	27	12.2	13.4	pass	<50	<100	type 2
–	–	–	–	100	99	87	74	54	28	11.4	4.5	pass	<50	200	type 1
–	–	–	–	100	99	89	76	58	26	8.5	9.2	pass	<50	<100	type 2
–	–	100	99	96	95	73	61	51	28	11.4	12.5	fail	–	–	type 2
–				100	92	72	67	58	31	14.4	8.1	pass	–	–	silty sand
–	–	–	100	99	94	77	71	59	26	9.9	6.9	pass	–	–	type 1
–	–	–	–	100	95	73	68	58	30	13.9	6.4	pass	–	–	type 1
–	–	–	–	100	98	84	74	59	28	11.7	6.1	pass	–	–	type 1
–	–	–	100	99	92	77	69	56	29	13.7	10.9	pass	–	–	type 2
–	–	–	–	100	99	87	76	59	26	10.6	5.5	pass	–	–	type 1
–	–	–	–	100	98	82	72	57	26	10.5	3.9	pass	–	–	type 1
–	–	–	–	100	99	84	71	57	29	14.9	3.9	pass	–	–	silty sand
–	–	–	–	–	100	96	86	62	21	5.3	5.6	pass	<50	<100	type 1
–	–	–	–	100	99	88	75	52	19	6.4	3.7	pass	<50	<120	type 1
–	–	–	–	100	99	92	79	59	29	13.3	5.5	fail	–	–	type 1
–	100	99	99	98	88	71	66	59	36	16.8	6.5	fail	–	–	silty sand
–	–	100	99	99	88	73	66	58	34	15.8	6.7	fail	–	–	silty sand
–	–	100	99	99	86	64	58	52	30	13.7	6.3	fail	–	–	type 1
–	–	–	100	100	99	81	68	57	30	10	2	pass	–	–	type 1
–	–	–	–	100	99	89	78	55	26	11.7	7.5	fail	–	–	type 1
–	–	–	–	100	98	76	67	57	31	11.6	5.6	pass	–	–	type 1
–	–	–	100	100	96	70	62	55	31	11.6	6.2	pass	–	–	type 1
–	–	–	–	100	99	82	73	62	32	11.3	5.5	pass	–	–	type 1
–	–	–	–	–	100	91	77	55	24	7.7	6.2	pass	<50	150	type 1
–	–	–	100	99	82	56	51	44	25	10.6	10.6	fail	–	–	type 2
–	–	–	–	100	98	80	70	56	26	8	5.3	pass	70	<100	type 1
–	–	–	–	100	97	76	63	47	23	7.6	5.6	pass	<50	<100	type 1
–	–	–	–	100	97	78	66	52	25	7.6	4.6	pass	<50	390	type 1
–	–	–	–	–	100	94	82	62	29	10.2	4.8	pass	–	–	type 1
–	–	–	–	–	100	97	86	62	25	7.3	1.6	pass	<50	<100	type 1
–	–	–	–	–	100	91	78	53	18	6.8	6.9	pass	<50	<100	type 1
–	–	–	–	100	99	87	75	58	26	9.9	4.7	pass	460	<100	type 1
–	–	–	–	100	99	95	88	78	53	35.7	18.7	pass	–	–	silty sand
–	–	–	–	100	99	94	88	81	63	51.2	5.5	pass	–	–	silty sand
–	–	–	–	–	100	96	91	81	50	23.8	11.5	pass	–	–	silty sand
–	–	–	–	–	100	95	90	81	57	37.5	8.5	pass	–	–	silty sand
–	–	–	–	100	98	92	87	79	60	46	10.2	pass	–	–	silty sand
–	–	–	100	99	98	93	87	77	57	39.3	13.4	pass	–	–	silty sand
–	–	–	–	100	98	92	87	78	59	43.3	11.5	pass	–	–	silty sand
–	–	–	–	100	99	97	90	76	47	29.8	18.1	pass	–	–	silty sand
–	–	–	–	–	100	95	88	77	61	51.8	12.5	pass	–	–	silty sand
–	–	–	–	100	99	96	89	76	53	38.8	15.8	pass	–	–	silty sand
–	–	–	–	–	100	94	86	77	61	49.5	16.9	pass	–	–	silty sand
–	–	–	–	–	100	98	93	87	69	58.8	7.6	pass	–	–	silty sand
–	–	–	–	–	100	95	86	80	66	50	10	pass	–	–	silty sand
–	–	–	–	–	100	96	88	81	65	52.6	11.8	pass	–	–	silty sand
–	–	–	–	100	99	96	96	81	43	26.3	29.5	pass	–	–	silty sand
–	–	–	100	99	98	92	86	70	37	25.4	12.9	pass	–	–	silty sand
–	–	–	–	100	99	94	91	76	40	25.9	21.8	pass	–	–	silty sand
–	–	–	100	99	95	87	83	79	70	64.7	13.6	pass	–	–	silty sand
100	97	96	95	93	92	81	76	68	50	42.3	20	pass	–	–	silty sand
–	–	–	–	100	99	98	97	89	52	25.3	17.1	pass	–	–	silty sand
100	99	98	98	97	95	87	83	77	58	47.9	16.9	pass	–	–	silty sand
–	–	–	–	–	100	99	96	86	46	24.2	26.2	pass	–	–	silty sand
–	–	–	–	–	100	98	95	85	49	26.2	16.7	pass	–	–	silty sand
–	–	–	–	100	99	96	90	80	46	28	23.9	nd	–	–	silty sand
–	–	–	–	–	100	98	94	84	47	25.9	22.7	pass	–	–	silty sand
–	–	–	100	99	99	98	96	87	46	26.6	11.9	pass	–	–	silty sand
–	–	–	–	–	100	99	97	88	44	26.3	16.7	pass	–	–	silty sand
–	–	–	–	–	100	98	97	89	53	34.1	30.9	pass	–	–	silty sand
–	–	–	–	–	100	98	97	88	47	28.7	18.9	pass	–	–	silty sand
–	–	–	100	99	98	92	86	70	37	25.4	12.9	pass	–	–	silty sand
–	–	–	100	99	98	97	95	85	49	30.6	27.6	pass	–	–	silty sand
–	–	–	100	99	98	94	90	76	42	27.6	19.0	pass	–	–	silty sand
–	–	–	–	–	100	98	96	94	76	53.1	23.1	fail	–	–	silty sand
–	–	–	100	98	83	59	47	32	9	2.3	4.7	pass	460	<100	concrete
–	–	–		100	91	72	58	40	15	7	7.4	pass	400	<100	type 1
–	–	–	100	99	88	61	47	36	25	21.6	21.8	pass	–	–	silty sand
–	–	–	–	100	90	67	53	38	19	13.1	13.4	pass	400	<100	type 2
–	–	–	–	–	100	91	79	64	37	15.7	10.2	pass	–	–	silty sand
–	–	–	–	–	100	99	97	80	25	4.7	2.1	pass	400	<100	concrete

Appendix 1 (continued)

GSWA	East MGA	North MGA	Deposit	Location	Situation	Status	Sample type	Sample interval	Colour	Description
165754	329377	6648532	BA2	Vettersburg	Stillman sand pit	C and M	Channel	3-4.5	Red brown	sand
165753–54	329377	6648532	BA2	Vettersburg	Stillman sand pit	C and M	Channel	2-4.5	Red brown	sand
165755	322527	6659057	BA3	Canegrass	Sand pit	Abandoned	Channel	1.4-3	Red pisolitic	sand
165756	318917	6688636	ME1	Comet Vale	Readymix pit	Operation	Channel	1.5-2.3	Yellow brown	sand
165757	318922	6688641	ME1	Comet Vale	Readymix pit	Operation	Channel	0.5-1.8	Yellow brown	sand
165758	379407	6534657	LL1	West of LL causeway	Old sand pit	Abandoned	Channel	0.5-3	Pink brown	sand
165759	379407	6534657	LL1	West of LL causeway	Old sand pit	Abandoned	Channel	3-4.8	Pink brown	sand
165758–59	379407	6534657	LL1	West of LL causeway	Old sand pit	Abandoned	Channel	0.5-4.8	Pink brown	sand
165760	377107	6534727	LL1	West of LL causeway	Old sand pit	Abandoned	Channel	0.5-2.2	Orange brown	sand
165761	377107	6534727	LL1	West of LL causeway	Old sand pit	Abandoned	Channel	2.2-4	Orange brown	sand
165760–61	377107	6534727	LL1	West of LL. causeway	Old sand pit	Abandoned	Channel	0.5-4	Orange brown	sand
165762	378987	6530017	LL2	West of Foster mine	Sand pit	Abandoned	Channel	0.2-2.2	Pink brown	sand
165763	378987	6530017	LL2	West of Foster mine	Sand pit	Abandoned	Channel	2.2-4	Pink brown	sand
165762–63	378987	6530017	LL2	West of Foster mine	Sand pit	Abandoned	Channel	0.2-4	Pink brown	sand
165764	385957	6524397	LL3	South of St Ives mines	Costean	na	Shovel	0-2	Brown loamy	sand
165765	384657	6522267	LL4	Lake Lefroy pipeline	Dune	na	Auger	0-1.3	Orange brown	sand
165766	384657	6522267	LL4	Lake Lefroy pipeline	Dune	na	Auger	1.3-2.5	Orange brown	sand
165767	384657	6522267	LL4	Lake Lefroy pipeline	Dune	na	Auger	2.5-3.7	Orange brown	sand
165768	384657	6522267	LL4	Lake Lefroy pipeline	Dune	na	Auger	3.7-5	Orange brown	sand
165765–68	384657	6522267	LL4	Lake Lefroy pipeline	Dune	na	Auger	0-5	Orange brown	sand
165769	382927	6522157	LL4	Lake Lefroy Southeast	Dune	na	Channel	0-1.6	Pink brown	sand
165770	377777	6514367	CO1	Lake Lefroy Southeast	Dune	na	Channel	0-1	Orange brown	sand
165776	349607	6527757	YL6	Cybora	Costean	na	Channel	0-2.8	Yellow brown	sand
165777	349887	6527857	YL6	Cybora	Small pit	Abandoned	Channel	0-2	Yellow-orange	sand
165778	350277	6527337	YL6	Cybora main pit	Main pit	Operation	Channel	0-2.7	Yellow brown	sand
165779	373237	6526507	LL5	Lake Lefroy South	Dune	na	Auger	0-1.5	Orange brown	sand
165780	373237	6526507	LL5	Lake Lefroy South	Dune	na	Auger	1.5-2.9	Orange brown	sand
165781	373237	6526507	LL5	Lake Lefroy South	Dune	na	Auger	2.9-4	Orange brown	sand
165779–81	373237	6526507	LL5	Lake Lefroy South	Dune	na	Auger	0-4	Orange brown	sand
165782	374487	6524497	LL6	Lake Lefroy South	Dune	na	Auger	0-1.5	Yellow brown	sand
165783	374487	6524497	LL6	Lake Lefroy South	Dune	na	Auger	1.5-2.7	Yellow brown	sand
165784	374487	6524497	LL6	Lake Lefroy South	Dune	na	Auger	2.7-4	Yellow brown	sand
165782–84	374487	6524497	LL6	Lake Lefroy South	Dune	na	Auger	0-4	Yellow brown	sand
165785	376117	6521237	LL7	Lake Lefroy South	Dune	na	Auger	0-1.7	Red brown	sand
165786	376117	6521237	LL7	Lake Lefroy South	Dune	na	Auger	1.7-3	Red brown	sand
165785–86	376117	6521237	LL7	Lake Lefroy South	Dune	na	Auger	0-3	Red brown	sand
165787	372512	6519784	LL8	Lake Lefroy South	Dune	na	Auger	0 - 1.5	Pink brown	sand
165788	372512	6519784	LL8	Lake Lefroy South	Dune	na	Auger	1.5 - 2.7	Pink brown	sand
165789	372512	6519784	LL8	Lake Lefroy South	Dune	na	Auger	2.7 - 4	Pink brown	sand
165787–89	372512	6519784	LL8	Lake Lefroy South	Dune	na	Auger	0-4	Pink brown	sand
165790	368797	6522957	LL17	Lake Lefroy South	Low rise	na	Auger	0 - 1.4	Brown	loam
165791	368315	6525856	LL9	Lake Lefroy South	Dune	na	Auger	0 - 1.5	Orange brown	sand
165792	368315	6525856	LL9	Lake Lefroy South	Dune	na	Auger	1.5 - 2.7	Orange brown	sand
165793	368315	6525856	LL9	Lake Lefroy South	Dune	na	Auger	2.7 - 4	Orange brown	sand
165791–93	368315	6525856	LL9	Lake Lefroy South	Dune	na	Auger	0-4	Orange brown	sand
165794	373067	6515627	LL10	Lake Lefroy South	Dune	na	Auger	0 - 1.5	Orange brown	sand
165795	373067	6515627	LL10	Lake Lefroy South	Dune	na	Auger	1.5 - 3	Orange brown	sand
165794–95	373067	6515627	LL10	Lake Lefroy South	Dune	na	Auger	0-3	Orange brown	sand
165796	373247	6514207	LL11	Lake Lefroy South	Dune	na	Auger	0 - 1.5	Yellow	sand
165797	373247	6514207	LL11	Lake Lefroy South	Dune	na	Auger	1.5 - 2.8	Yellow	sand
165798	373247	6514207	LL11	Lake Lefroy South	Dune	na	Auger	2.8 - 4	Yellow	sand
165796–98	373247	6514207	LL11	Lake Lefroy South	Dune	na	Auger	0-4	Yellow sand	sand
165799	384477	6538247	LL12	East of Lake causeway	Dune	na	Auger	0 – 1.5	Orange brown	sand
165800	384477	6538247	LL12	East of Lake causeway	Dune	na	Auger	1.5 – 2.7	Orange brown	sand
133101	384477	6538247	LL12	East of Lake causeway	Dune	na	Auger	2.7 – 3.8	Orange brown	sand
165799–800 133101	384477	6538247	LL12	East of Lake causeway	Dune	na	Auger	0 – 3.8	Orange brown	sand
133102	391012	6556057	LL13	Lake Lefroy East	Dune	na	Auger	0 – 1.5	Orange brown	sand
133103	391012	6556057	LL13	Lake Lefroy East	Dune	na	Auger	1.5 – 2.9	Orange brown	sand
133102–03	391012	6556057	LL13	Lake Lefroy East	Dune	na	Auger	0 – 2.9	Orange brown	sand
133104	385057	6554637	LL14	Lake Lefroy North	Dune	na	Auger	0 – 1.5	Orange brown	sand
133105	385057	6554637	LL14	Lake Lefroy North	Dune	na	Auger	1.5 – 3	Orange brown	sand
133104–05	385057	6554637	LL14	Lake Lefroy North	Dune	na	Auger	0–3	Orange brown	sand
133106	397337	6545397	LL15	Lake Lefroy East	Dune	na	Auger	0 – 1.5	Orange brown	sand
133107	397337	6545397	LL15	Lake Lefroy East	Dune	na	Auger	1.5 – 2.6	Orange brown	sand
133106–07	397337	6545397	LL15	Lake Lefroy East	Dune	na	Auger	0 – 2.6	Orange brown	sand
133108	399927	6543937	LL16	Lake Lefroy East	Dune	na	Auger	0 – 1.5	Orange brown	sand
133109	399927	6543937	LL16	Lake Lefroy East	Dune	na	Auger	1.5 – 2.7	Orange brown	sand
133110	399927	6543937	LL16	Lake Lefroy East	Dune	na	Auger	2.7 – 3.8	Orange brown	sand
133111	399927	6543937	LL16	Lake Lefroy East	Dune	na	Auger	3.8 – 5	Orange brown	sand
133108–11	399927	6543937	LL16	Lake Lefroy East	Dune	na	Auger	0–5	Orange brown	sand
133112	407837	6549317	MB1	Lake Randell	Dune	na	Auger	0 – 1.5	Orange brown	sand
133113	421897	6553187	MB2	Lake Randell	Dune	na	Auger	0 – 1.5	Orange brown	sand
133114	421897	6553187	MB2	Lake Randell	Dune	na	Auger	1.5 – 2.6	Orange brown	sand
133115	421897	6553187	MB2	Lake Randell	Dune	na	Auger	2.6 – 3.8	Orange brown	sand
133113–15	421897	6553187	MB2	Lake Randell	Dune	na	Auger	0 – 3.8	Orange brown	sand
133116	398697	6589357	KA1	Lake Yindarlgooda	Dune	na	Shovel	0 – 0.5	Gypsiferous	silty sand
133117	412937	6602387	KU1	Lake Yindarlgooda	Dune	na	Auger	0 – 0.8	Buff	silty sand
133118	423197	6612298	KU2	Lake Yindarlgooda	Dune	na	Auger	0 – 1.5	Orange brown	sand
133119	430157	6609578	KU3	Lake Yindarlgooda	Dune	na	Auger	0 – 1.2	Brown	sandy silt

% passing specific sieve sizes (mm)											Clay	Organics	Chloride	Sulfate	Class
13.2	9.5	6.7	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075	(%)		(mg/kg)	(mg/kg)	
–	–	–	–	–	100	99	97	82	27	5.6	1.8	pass	500	<100	type 1
–	–	–	–	–	100	99	97	81	26	5.2	1.9	pass	460	<100	type 1
–	–	–	–	–	100	96	87	68	28	6.9	1.8	pass	370	100	type 1
–	–	–	–	–	100	98	88	63	18	3.4	2	nd	430	<100	concrete
–	–	–	–	–	100	97	85	64	22	5	1.8	nd	400	<100	concrete
–	–	–	–	–	100	94	86	75	42	12.1	7.4	pass	500	<100	type 1
–	–	–	–	–	100	95	87	73	35	6.6	1.9	pass	470	<100	type 1
–	–	–	–	–	100	94	86	74	39	9.8	5.1	pass	487	<100	type 1
–	–	–	–	100	98	91	84	72	32	4.3	3.8	pass	460	350	concrete
–	–	–	–	100	99	94	89	76	30	5.4	1.8	pass	500	260	type 1
–	–	–	–	100	99	93	87	74	31	4.9	2.8	pass	481	304	concrete
–	–	–	–	–	100	95	89	75	26	4.5	1.2	pass	530	<100	concrete
–	–	–	–	–	100	95	89	77	27	6.3	6.1	pass	500	<100	type 1
–	–	–	–	100	100	95	89	76	26	5.4	3.5	pass	516	<100	type 1
–	100	97	96	94	93	88	82	73	49	26.2	14.5	pass	–	–	silty sand
–	–	–	–	–	100	99	94	76	20	1.7	8.5	nd	200	<100	type 2
–	–	–	–	–	100	97	87	63	24	5.9	1.9	pass	480	<100	type 1
–	–	–	–	–	100	99	95	82	25	7.8	5.7	pass	500	100	type 1
–	–	–	–	–	100	99	93	68	21	6.6	3.3	pass	600	<100	type 1
–	–	–	–	–	100	99	92	72	22	5.4	4.9	pass	443	<100	type 1
–	–	–	–	–	100	98	95	83	37	4.6	3.8	pass	200	130	concrete
–	–	–	–	100	99	88	75	55	19	5.3	3.3	nd	270	170	type 1
–	–	–	–	100	98	84	76	64	35	12	5.7	pass	–	–	type 1
–	–	–	–	–	100	94	82	60	28	11.8	6	pass	–	–	type 1
–	–	–	–	–	100	98	90	67	28	8.3	5.5	pass	–	–	type 1
–	–	–	–	–	100	96	86	66	18	2.8	5.2	pass	–	–	concrete
–	–	–	–	–	100	92	81	58	14	2.7	6.1	pass	–	–	concrete
–	–	–	–	–	100	97	87	67	18	5	8.2	pass	–	–	type 2
–	–	–	–	–	100	95	85	63	17	3.4	6.3	pass	–	–	concrete
–	–	–	–	–	–	100	98	84	19	2.3	3.8	pass	–	–	concrete
–	–	–	–	–	–	100	97	78	17	0.8	6.1	pass	–	–	concrete
–	–	–	–	–	–	100	97	82	15	1	2.1	pass	–	–	concrete
–	–	–	–	–	–	100	97	82	17	1.4	3.9	pass	–	–	concrete
–	–	–	–	–	100	95	85	63	25	8.1	12.2	fail	–	–	type 2
–	–	–	–	–	100	97	84	64	29	8.5	11.8	pass	–	–	type 2
–	–	–	–	–	100	96	85	63	27	8.3	12.0	nd	–	–	type 2
–	–	–	–	–	100	90	72	49	15	5.2	7.8	pass	–	–	type 2
–	–	–	–	–	100	90	69	46	14	4	6.1	pass	–	–	concrete
–	–	–	–	100	99	93	79	62	25	9.2	11.3	pass	–	–	type 2
–	–	–	–	–	100	91	73	52	18	6.1	8.4	pass	–	–	type 2
–	–	–	100	98	97	83	72	61	37	20	12.8	pass	–	–	silty sand
–	–	–	–	–	100	92	78	60	22	6.9	12	fail	–	–	type 2
–	–	–	–	–	100	92	80	61	24	7.7	5.2	pass	–	–	type 1
–	–	–	–	100	98	94	81	64	28	9.3	8.7	pass	–	–	type 2
–	–	–	–	100	99	93	80	62	25	7.9	8.9	pass	–	–	type 2
–	–	–	–	–	100	97	92	79	36	10.5	17.5	pass	–	–	silty sand
–	–	–	100	99	99	98	95	87	42	22.3	11.9	pass	–	–	silty sand
–	–	–	–	100	100	98	94	83	39	16.4	14.7	pass	–	–	silty sand
–	–	–	–	–	100	99	89	63	18	3.4	9	pass	–	–	type 2
–	–	–	–	–	100	98	87	58	15	2.3	4	fail	–	–	concrete
–	–	–	–	–	100	98	90	64	15	2.3	7	pass	–	–	concrete
–	–	–	–	–	100	98	89	62	16	2.7	6.8	pass	–	–	concrete
–	–	–	–	100	98	89	80	61	19	1.6	4.2	pass	–	–	concrete
–	–	–	–	100	98	88	79	59	19	3.1	3.4	pass	–	–	concrete
–	–	–	–	100	98	89	77	59	22	3.7	4.3	pass	–	–	concrete
–	–	–	–	100	98	89	79	60	20	2.7	4.0	pass	–	–	concrete
–	–	–	–	–	100	87	73	55	21	6.2	15.5	pass	–	–	silty sand
–	–	–	–	100	99	88	75	55	18	4.4	14.8	pass	–	–	type 2
–	–	–	–	–	100	87	74	55	20	5.3	15.2	pass	–	–	silty sand
–	–	–	–	100	99	91	81	61	24	5.6	9.3	pass	–	–	type 2
–	–	–	–	100	99	92	81	63	28	6.8	10.2	pass	–	–	type 2
–	–	–	–	100	99	92	81	62	26	6.2	9.8	pass	–	–	type 2
–	–	–	–	100	99	84	74	64	24	4.4	7.3	pass	–	–	concrete
–	–	–	–	–	100	87	80	71	36	15.5	16.2	pass	–	–	silty sand
–	–	–	–	100	99	85	77	67	29	9.1	11.1	pass	–	–	type 2
–	–	–	–	100	99	69	52	36	11	3.5	9.2	pass	–	–	type 2
–	–	–	–	100	99	66	46	32	14	4.7	13	pass	–	–	type 2
–	–	–	–	100	98	64	46	33	13	6	12.5	pass	–	–	type 2
–	–	–	–	–	100	84	68	54	29	10.9	17.4	pass	–	–	silty sand
–	–	–	–	100	99	71	53	39	16	6.1	12.8	pass	–	–	type 2
–	–	–	–	–	100	99	95	84	47	11.3	10.9	pass	–	–	type 2
–	–	–	–	–	100	97	90	73	26	6.6	15.9	pass	–	–	silty sand
–	–	–	–	100	99	95	95	81	37	14.6	10.4	pass	–	–	silty sand
–	–	–	100	99	99	97	90	77	44	15.7	16.7	pass	–	–	silty sand
–	–	–	–	100	99	96	91	77	35	11.8	14.6	pass	–	–	type 2
–	–	–	–	100	97	91	85	79	60	43.7	10	pass	–	–	silty sand
–	–	–	–	–	100	97	93	87	50	27.8	17.8	pass	–	–	silty sand
–	–	–	–	–	100	99	96	83	37	13.7	24	pass	–	–	silty sand
–	–	–	–	–	100	97	91	78	44	22.7	18.4	pass	–	–	silty sand

Appendix 1 (continued)

GSWA	*East MGA*	*North MGA*	*Deposit*	*Location*	*Situation*	*Status*	*Sample type*	*Sample interval*	*Colour*	*Description*
133120	442527	6629838	MU1	Pinjin road	Sandplain	na	Auger	0 – 0.8	Yellow brown	sand
133121	429027	6631878	MU2	Old access track	Sandplain	na	Auger	0 – 1.25	Yellow brown	sand
133122	429057	6636848	MU3	Old access track	Sandplain	na	Auger	0 – 1.2	Brown	sand
133123	423567	6636428	MU4	Seismic line	Sandplain	na	Auger	0 – 1.5	Brown	sand
133124	423567	6636428	MU4	Seismic line	Sandplain	na	Auger	1.5 – 2.5	Brown	sand
133123–24	423567	6636428	MU4	Seismic line	Sandplain	na	Auger	0 – 2.5	Brown	sand
133125	410017	6638108	MU5	East of Kalpini	Dune	na	Auger	0 – 1.3	Orange brown	sand
133126	410017	6638108	MU5	East of Kalpini	Dune	na	Auger	1.3 – 2.4	Orange brown	sand
133125–26	410017	6638108	MU5	East of Kalpini	Dune	na	Auger	0 – 2.4	Orange brown	sand
133127	404787	6653558	MU6	Boundary fence	Sandplain	na	Auger	0 – 0.9	Orange brown	sand
133128	404697	6654478	MU6	Boundary fence	Sandplain	na	Auger	0 – 1.1	Orange brown	sand
133129	413647	6657758	MU7	Telecom tower	Dune	na	Auger	0 – 1.3	Yellow brown	sand
133130	413647	6657758	MU7	Telecom tower	Dune	na	Auger	1.3 – 2.3	Yellow brown	sand
133131	413647	6657758	MU7	Telecom tower	Dune	na	Auger	2.3 – 3.4	Yellow brown	sand
133129–31	413647	6657758	MU7	Telecom tower	Dune	na	Auger	0 – 3.4	Yellow brown	sand
133132	402387	6671258	GI1	Binti Binti	Dune	na	Auger	0 – 1.5	Orange brown	sand
133133	402387	6671258	GI1	Binti Binti	Dune	na	Auger	1.5 – 2.4	Orange brown	sand
133134	402387	6671258	GI1	Binti Binti	Dune	na	Auger	2.4 – 3.5	Orange brown	sand
133132–34	402387	6671258	GI1	Binti Binti	Dune	na	Auger	0 – 3.5	Orange brown	sand
133135	387137	6677158	GI2	Near Yarri road	Sandplain	na	Auger	0 – 1.5	Orange brown	sand
133136	385577	6677488	GI2	East of Carr Boyd	Sandplain	na	Auger	0 – 1.5	Orange brown	sand
133137	385577	6677488	GI2	East of Carr Boyd	Sandplain	na	Auger	1.5 – 2.5	Orange brown	sand
133138	385577	6677488	GI2	East of Carr Boyd	Sandplain	na	Auger	2.5 – 3.6	Orange brown	sand
133136–38	385577	6677488	GI2	East of Carr Boyd	Sandplain	na	Auger	0 – 3.6	Orange brown	sand
133139	386862	6678578	GI2	East of Carr Boyd	Sand pit	Small operation	Channel	0–1	Orange brown	sand
133140	376527	6678018	GI3	Donkey Rocks road	Sandplain	na	Auger	0 – 1.5	Orange brown	sand
133141	364357	6676658	GI4	Near National Park	Sandplain	na	Auger	0 – 1.5	Orange brown	sand
133142	364357	6676658	GI4	Near National Park	Sandplain	na	Auger	1.5 – 2.2	Orange brown	sand
133141–42	364357	6676658	GI4	Near National Park	Sandplain	na	Auger	0 – 2.2	Orange brown	sand
133143	362417	6672948	GI5	Near National Park	Sandplain	na	Auger	0 – 1.5	Orange brown	sand
133144	362417	6672948	GI5	Near National Park	Sandplain	na	Auger	1.5 – 2.7	Orange brown	sand
133145	362417	6672948	GI5	Near National Park	Sandplain	na	Auger	2.7 – 3.5	Orange brown	sand
133143–45	362417	6672948	GI5	Near National Park	Sandplain	na	Auger	0 – 3.5	Orange brown	sand
133146	349127	6668438	BA1	Near National Park	Dune	na	Auger	0 – 1.5	Yellow brown	sand
133147	349137	6667048	BA2	SW of National Park	Dune	na	Auger	0 – 1.35	Yellow brown	sand
133148	349137	6667048	BA2	SW of National park	Dune	na	Auger	1.35 – 2.4	Yellow brown	sand
133149	349137	6667048	BA2	SW of National Park	Dune	na	Auger	2.4 – 3.5	Yellow brown	sand
133147–49	349137	6667048	BA2	SW of National Park	Dune	na	Auger	0 – 3.5	Yellow brown	sand
133150	367262	6651587	GI6	West of Gindalbie	Dune	na	Auger	0 – 1.5	Orange brown	sand
133151	367262	6651587	GI6	West of Gindalbie	Dune	na	Auger	1.5 – 2.7	Orange brown	sand
133150–51	367262	6651587	GI6	West of Gindalbie	Dune	na	Auger	0 – 2.7	Orange brown	sand
133152	293537	6674147	DA1	Old Davyhurst track	Dune	na	Auger	3 – 4.5	Yellow brown	sand
133153	293537	6674147	DA1	Old Davyhurst track	Dune	na	Auger	4.5 – 5.4	Yellow brown	sand
133152–53	293537	6674147	DA1	Old Davyhurst track	Dune	na	Auger	3 – 5.4	Yellow brown	sand
133154	284697	6673657	DA2	Old Davyhurst track	Sandplain	na	Shovel	0 – 0.7	Yellow brown	sand
193201	359337	6584273	33561	Hannan Lake	Old sand pit	Abandoned	Channel	0 – 0.55	Red brown	silty sand
193202	359921	6584073	33562	Hannan Lake	Old sand pit	Abandoned	Channel	0 – 1.1	Red brown	silty sand
193203	361873	6588501	33571	Lakewood area	Old sand pit	Abandoned	Channel	0 – 1.4	Red brown	silty sand
193204	361468	6588663	33574	Lakewood area	Old sand pit	Abandoned	Channel	0 – 0.9	Red brown	silty sand
193205	348426	6585904	33588	Binduli area	Old sand pit	Abandoned	Channel	0–1	Red brown	silty sand
193206	339186	6595894	33639	White Dam area	Old sand pit	Abandoned	Channel	0 – 1.3	Red brown	silty sand
193207	342723	6602713	33660	North of White Dam	Creek bed	Creek bed	Shovel	0 – 0.3	Pink brown	sand
193208	346382	6619503	33668	South of Arrow Lake	Old sand pit	Abandoned	Channel	0 – 1.5	Red brown	silty sand
193209	371922	6617946	33685	North of Kanowna	Dune/sandplain	na	Auger	0–1	Red brown	clayey sand
193210	365116	6622717	33688	North of Kanowna	Dune	na	Auger	0–1	Red brown	silty sand
193211	365116	6622717	33688	North of Kanowna	Dune	na	Auger	1 – 1.2	Red brown	silty sand
193210–11	365116	6622717	33688	North of Kanowna	Dune	na	Auger	0 – 1.2	Red brown	silty sand
193212	355178	6626998	33691	North of Kanowna	Dune/sandplain	na	Auger	0 – 0.6	Red brown	silty sand
193213	370370	6616953	33697	North of Kanowna	Old sand pit	Abandoned	Channel	0.3 – 2	Red brown	silty sand
193214	374268	6616889	33701	North of Kanowna	Sandplain	na	Auger	0–1	Red brown	silty sand
193215	374268	6616889	33701	North of Kanowna	Sandplain	na	Auger	1 – 1.45	Red brown	silty sand
193214–15	374268	6616889	33701	North of Kanowna	Sandplain	na	Auger	0 – 1.45	Red brown	silty sand
193216	389923	6594689	33708	Lake Yindarlgooda	Dune	na	Shovel	0 – 0.2	Pale brown	silty sand
193217	394125	6586742	33711	Lake Yindarlgooda	Dune	na	Shovel	0 – 0.2	Pink brown	silty sand
193218	347379	6577071	33770	Smith Dam area	Sandplain	na	Auger	0–1	Red brown	clayey sand
193219	360491	6588226	33779	Lakewood area	Old sand pit	Abandoned	Channel	0 – 0.9	Red brown	silty sand
193220	375168	6515334	33792	Widgiemooltha	Sand pit	Shutdown	Channel	0 – 1.8	Orange	silty sand
193221	372300	6528262	33802	Readymix (central)	Sand pit	Operation	Channel	0–1	Orange	sand
193222	323798	6570731	33831	Kangaroo Hills	Sand pit (north)	Operation	Grab	–	Orange	silty sand
193223	323725	6570492	33834	Kangaroo Hills	Sand pit (west)	Operation	Grab	–	Orange brown	silty sand
193224	323552	6570311	33835	Kangaroo Hills	Sand pit (s'west)	Operation	Grab	–	Orange brown	silty sand
193225	323767	6571247	33885	Kangaroo Hills	Sand pit	Operation	Auger	0–1	Orange brown	silty sand
193226	323767	6571247	33885	Kangaroo Hills	Sand pit	Operation	Auger	1–2	Orange brown	silty sand
193225–26	323767	6571247	33885	Kangaroo Hills	Sand pit	Operation	Auger	0–2	Orange brown	silty sand
193227	310416	6589937	33896	Mount Burges pit	Sand pit (BHP)	Operation	Grab	–	Orange	silty sand
193228	306471	658964	33898	Mount Burges sand pit	Sand pit	Operation	Grab	–	Orange	silty sand

NOTES: na not applicable
C & M Care and maintenancde

% passing specific sieve sizes (mm)											Clay	Organics	Chloride	Sulfate	Class
13.2	9.5	6.7	4.75	2.36	1.18	0.6	0.425	0.3	0.15	0.075	(%)		(mg/kg)	(mg/kg)	
–	100	98	97	96	95	87	77	61	36	19.8	12.5	pass	–	–	silty sand
–	100	99	98	93	77	53	49	44	28	11.2	13	fail	–	–	type 2
–	100	99	99	99	95	75	64	56	38	20.1	19.2	pass	–	–	silty sand
–	–	100	99	99	93	71	63	54	33	17.6	8.3	fail	–	–	silty sand
–	–	–	–	100	94	77	69	62	41	22.2	8.2	pass	–	–	silty sand
–	–	100	99	99	93	73	65	57	36	19.4	8.3	nd	–	–	silty sand
–	–	–	–	–	–	100	98	79	25	6.5	9.5	fail	–	–	type 2
–	–	–	–	–	–	100	97	69	21	3.1	6.1	pass	–	–	concrete
–	–	–	–	–	–	100	98	74	23	4.9	7.9	nd	–	–	type 2
–	–	–	–	–	100	94	82	61	28	12	14.3	fail	–	–	type 2
–	–	–	–	100	99	85	67	55	27	9.8	10.7	fail	–	–	type 2
–	–	–	–	–	–	100	97	74	24	4.3	5.3	fail	–	–	concrete
–	–	–	–	–	–	100	98	75	21	3.2	5.8	pass	–	–	concrete
–	–	–	–	–	100	99	97	75	20	3.9	7.4	pass	–	–	concrete
–	–	–	–	–	–	100	97	75	22	3.8	6.1	pass	–	–	concrete
–	–	–	–	–	100	98	85	57	21	5.5	9.1	fail	–	–	type 2
–	–	–	–	–	100	99	86	58	25	7.2	9.1	pass	–	–	type 2
–	–	–	–	–	100	98	88	58	23	6.9	10.6	pass	–	–	type 2
–	–	–	–	100	100	98	86	58	23	6.4	9.6	pass	–	–	type 2
–	–	–	–	100	99	87	75	58	29	10.5	10.7	fail	–	–	type 2
–	–	–	–	100	99	83	71	59	31	13.1	5.1	pass	–	–	type 1
–	–	–	–	100	99	85	72	59	34	13.3	13.6	pass	–	–	type 2
–	–	–	–	100	99	86	74	60	34	15.7	10	pass	–	–	silty sand
–	–	–	–	100	99	84	72	59	33	14.0	9.0	pass	–	–	type 2
–	–	–	100	99	91	78	69	56	27	9.4	6.3	fail	–	–	type 1
–	–	–	–	100	96	75	66	56	31	13.5	9.1	fail	–	–	type 2
–	–	–	–	100	98	80	68	56	34	15.3	9.8	fail	–	–	silty sand
–	–	–	100	99	96	80	72	60	36	18.6	13.7	pass	–	–	silty sand
–	–	–	–	100	97	80	69	57	35	16.4	11.0	fail	–	–	silty sand
–	–	–	–	100	98	77	66	52	29	12.6	9.6	nd	–	–	type 2
–	–	–	–	100	98	82	72	60	36	18.6	10	pass	–	–	silty sand
–	–	–	100	99	98	83	71	59	39	20.6	17.4	pass	–	–	silty sand
	–	–	–	100	98	80	69	56	34	16.5	11.5	pass	–	–	silty sand
–	–	–	–	100	98	90	65	25	8.1	13.6	nd		–	–	type 2
–	–	–	–	–	–	100	99	78	11	2	3.9		fail	–	–	concrete
–	–	–	–	–	100	99	86	67	14	2.1	5.4	nd	–		–	concrete
–	–	–	–	–	–	100	99	80	17	2.4	4.8	pass	–	–	concrete
–	–	–	–	–	–	100	95	75	14	2.2	4.6	fail	–	–	concrete
–	–	–	–	–	100	84	66	51	29	10.8	12.5	pass	–	–	type 2
–	–	–	–	–	100	86	69	55	31	13.1	15.6	pass	–	–	silty sand
–	–	–	–	–	100	85	67	53	30	11.8	13.9	pass	–	–	type 2
–	–	–	–	–	100	98	79	52	18	4.1	9.8	fail	–	–	type 2
–	–	–	100	97	96	94	79	54	23	7.3	9.8	fail	–	–	type 2
–	–	–	100	99	99	97	79	53	20	5.3	9.8	fail	–	–	type 2
–	–	–	–	100	98	81	63	47	20	7	4.2	fail	–	–	type 1
–	–	–	–	–	100	96	89	75	36	17	8	pass	–	–	silty sand
–	–	–	–	–	100	98	93	80	35	15	9	fail	<100	100	silty sand
–	–	–	–	–	100	96	88	70	31	14	10	pass	–	–	type 2
–	–	–	–	–	100	92	83	68	37	20	10	pass	–	–	silty sand
–	–	–	–	–		100	98	83	35	12	6	pass	<100	<100	type 1
–	–	–	–	–	100	95	89	76	40	19	8	fail	<100	700	silty sand
–	–	100	99	96	84	59	48	30	4	1	4	pass	–	–	concrete
–	–	–	–	–	100	99	96	79	26	9	6	pass	<100	<100	type 1
–	–	–	–	100	99	96	88	73	47	35	nd	pass	–	–	silty sand
–	–	–	–	–	100	94	86	70	35	16	16	pass	–	–	silty sand
–	–	–	–	100	99	91	84	71	42	23	36	pass	–	–	silty sand
–	–	–	–	–	100	94	86	70	36	17.2	19.3	pass	–	–	silty sand
–	–	–	–	–	100	93	81	65	36	20	18	pass	<100	<100	silty sand
–	–	–	–	–	100	99	97	89	40	15	7	pass	–	–	silty sand
–	–	–	–	–	100	94	83	63	32	18	25	pass	100	100	silty sand
–	–	–	–	–	100	94	83	65	36	23	27	pass	–	–	silty sand
–	–	–	–	–	100	94	83	64	33	19.6	25.6	pass	100	100	silty sand
–	–	–	–	100	98	92	89	85	57	18	15	pass	–	–	silty sand
–	–	–	–	–	100	99	96	88	41	8	4	fail	<100	100	type 1
–	–	–	100	97	94	87	81	72	54	43	nd	pass	–	–	silty sand
–	–	–	–	–	100	96	86	66	31	15	8	fail	–	–	silty sand
–	–	–	–	100	98	86	77	67	41	12	3	pass	–	–	type 1
–	–	–	–	–	100	94	86	69	22	2	2	pass	<100	100	concrete
–	–	–	–	–	100	93	70	47	21	9	4	pass	–	–	type 1
–	–	–	–	–	100	97	83	61	28	7	4	pass	–	–	type 1
–	–	–	–	–	100	97	84	63	32	11	8	pass	–	–	type 2
–	–	–	–	–	100	89	70	52	27	11	8	fail	–	–	type 2
–	–	–	–	100	99	88	73	58	34	15	10	pass	–	–	silty sand
–	–	–	–	–	100	89	72	55	31	13.0	9.0	nd	–	–	type 2
–	–	–	–	–	100	93	79	61	30	10	10	pass	–	–	type 2
–	–	–	–	100	99	91	82	66	30	10	5	pass	–	–	type 1

ORMSBY, KOJAN

Sand resource survey for the Kalgoorlie region

RECORD 2008/5

This Record is published in digital format (PDF) and is available online at: www.doir.wa.gov.au/GSWApublications. Laser-printed copies can be ordered from the Information Centre for the cost of printing and binding.

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RESOURCE POTENTIAL FOR LAND USE PLANNING
SAND RESOURCE SURVEY
KALGOORLIE REGION

Geology

- Granitic rocks — granite and granitic gneiss of the Yilgarn Craton
- Greenstone — metamorphosed mafic, ultramafic, metasedimentary, and felsic rocks of the Yilgarn Craton

Sand category

- Lakeside dune sand — yellow sand, typically of concrete sand quality but variable; depositional; found on the southern and eastern margins of Lake Lefroy
- Yellow sand — yellow-orange sand, reddish in part; typically of Type 1 construction sand quality but variable; residual; preferentially overlies higher topography in granite and gneiss terrain as thicker sandplain or dunes
- Brown sand — red-brown to brown silty sand, typically poor quality; depositional; marginal to playa lakes and associated with paleodrainage in areas of low topography; sand dunes and sandplain intermixed with kopi dunes

Sand pit

- Ubini — Operating
- Vettersburg — Shutdown or care and maintenance
- Abandoned

Sand sampling classification

	Class	Specification	Use
●	Concrete sand	0–5% passing -75 micron (AS1289.3.6.1)	Concrete
●	Type 1 construction sand	5–14% passing -75 micron (AS1289.3.6.1), with 0–7.5% silt/clay (AS1141.33)	Concrete, mortar, fill
●	Type 2 construction sand	5–14% passing -75 micron (AS1289.3.6.1), with 7.5–15% silt/clay (AS1141.33)	Gardens, fill
●	Silty sand	>14% passing -75 micron or 5–14% passing 75 micron (AS1289.3.6.1), with > 15% silt/clay (AS1141.33)	Gardens, fill
148187	GSWA sample number	Refer to associated GSWA Record (in prep.) for all sampling results and classification details. Note sampling is indicative only. Further investigation is required to define specific resource quality.	

Sand region

- Sand region boundary

Region name	Characteristics
WESTERN	Predominantly yellow sand, lesser brown sand — mainly Type 1 construction sand
SOUTHERN	Brown sand and lakeside dune sand — highly variable quality on regional scale
NORTHERN	Predominantly yellow sand, lesser brown sand — highly variable quality on regional scale
CENTRAL	Brown sand — mainly silty sand of poor quality

- Highway
- Road
- Track
- Railway
- Kalgoorlie–Boulder city
- Townsite, locality, or place name
- Local government area boundary
- Playa/salt lake
- Paleochannel
- Sand mining lease (granted and pending)
- Freehold land (basic raw material extraction administered by Local Government)
- Existing conservation reserves (national parks, nature reserves, timber reserves, and conservation parks)
- Proposed conservation reserves
- Other Crown reserves

DATA DIRECTORY

Theme	Data Source	Data Currency	Agency
Geology	East Yilgarn 1: 100 000 Geological Information Series 1:500 000 interpreted bedrock geology of Western Australia	JAN 2007	Dept of Industry and Resources
Sand mining lease	TENGRAPH*	JAN 2007	Dept of Industry and Resources
Sand pit	MINEDEX* WAMIN	2006	Dept of Industry and Resources
Existing townsite boundary	TENGRAPH*	JULY 2003	Dept of Industry and Resources
Freehold land	TENGRAPH*	2006	Dept of Industry and Resources
Crown reserve	TENGRAPH*	2006	Dept of Industry and Resources
Proposed conservation reserves	DEC	2007	Dept of Environment and Conservation
Existing conservation reserves	DEC	2007	Dept of Environment and Conservation
Local government area boundary	Landgate	2006	Landgate
Topography	Landgate/GA	2006	Landgate/Geoscience Australia
Relief shading	NASA SRTM 90m Digital Elevation Data	2000	CentralSrve Group for International Agriculture Research – International Center for Tropical Agriculture (CIAT)

* CDWA and DoIR databases can be viewed online (www.doir.wa.gov.au/dotcustt/geoview_launch.asp) or can be downloaded from the GSWA Data and Software Centre (www.doir.wa.gov.au/GSWA/downloadcentre)

Compiled by WR Ormsby and CJ Kujan 2007

Cartography by S Mulligan

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Website www.doir.wa.gov.au. Email geological.survey@doir.wa.gov.au

The accommended reference for this map is:
ORMSBY, WR, and KUJAN, CJ, 2007, Sand resource survey, Kalgoorlie Region: Resource potential for land use planning (1:250 000 scale). Geological Survey of Western Australia.

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MOUNT MAGNET 2838	MULLAGI 3038	MELITA 3138	YERILLA 3238	LAKE CAREY 3338	MOUNT CELIA 3438
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1: 100 000 maps shown in black.
1: 250 000 maps shown in brown.

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Department of Industry and Resources

FRANCIS LOGAN, M.L.C.
MINISTER FOR ENERGY, RESOURCES, INDUSTRY, AND EXPORTS

Geological Survey of Western Australia

TIM GRIFFIN
EXECUTIVE DIRECTOR

SCALE 1:250 000

5000 0 5 10 15 20 25
Metres Kilometres

UNIVERSAL TRANSVERSE MERCATOR PROJECTION
HORIZONTAL DATUM: GEOCENTRIC DATUM OF AUSTRALIA 1994

Grid lines indicate 50 000 metre interval of the Map Grid Australia Zone 51

The Map Grid Australia (MGA) is based on the Geocentric Datum of Australia 1994 (GDA94)
GDA positions are compatible within one metre of the datum WGS84 positions.

GEOLOGICAL SURVEY OF WESTERN AUSTRALIA
SAND RESOURCE SURVEY
KALGOORLIE REGION
RESOURCE POTENTIAL FOR LAND USE PLANNING

FIRST EDITION 2007
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