Supply and Demand Profile of Geological Construction Materials

for the

Greater Sydney Region

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In conjunction with

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Terms and Definitions

The following key terms and definitions are commonly used throughout this report.

Asphalt is a mixture of crushed rock, sand, bitumen (hydrocarbons) and other specialist chemical binders used for surfacing of roads and hardstand areas – sometimes referred to as asphaltic concrete.

Cement is a manufactured powder used as a binder in concrete. It hardens in the presence of water. Portland cement, the most common cementitious material, is manufactured in cement works from raw materials such as limestone, clay, gypsum and sand.

Cementitious materials comprise cement and supplementary cementitious materials (see separate definition).

Coarse aggregates comprise crushed and sized rock from 5mm to 30mm in size used in concrete, asphalt and road surfacing.

Concrete is a building and construction material manufactured by combining crushed rock products, natural sand and cementitious materials with water.

Concrete Grade Fly Ash is fly ash that is suitable for use as a partial substitute for cement in the manufacture of concrete, being fine, medium, coarse or special grade fly ash as defined by Australian Standard AS3582.1.

Construction materials discussed in this Study comprise geological (naturally-occurring) materials referred to as extractive materials, cementitious materials comprising cement and supplementary cementitious materials (flyash and ground granulated blast furnace slag) and substitute construction materials that substitute for extractive materials (see separate definition).

Crushed rock products include a range of natural hard rocks or gravel that are crushed and screened to produce a range of fine and coarse aggregates. The fine fraction (<5mm) can be used to produce manufactured sand provided the rock type and processing methods are suitable. Emphasis is placed on "hard" rocks in order to distinguish those products from softer crushed sandstone products.

Extractive materials discussed in this Study are construction materials produced from geological resources comprising hard rock, sand, gravel or stone. They are used directly, or as raw materials in concrete and asphalt, for building homes, non-residential buildings and a wide range of infrastructure such as roads and railways, ports, utilities and water supply dams. The key extractive materials analysed and reported upon in this Study are crushed rock and natural sand products.

Extractive sites are those sites, also referred to as "quarries", that involve extraction and processing of geological materials to produce the size and grading of the materials required for use in the building and construction industries. This report preferentially refers to "quarries" which are synonymous with extractive sites.

Feeder Areas – Four geographic areas adjoining the GSR to the north, west, southwest and south that provide extractive materials to the GSR (see **Figure B**). Each feeder area comprises two or three Local Government Areas (LGAs). The Northern Feeder Area comprises the LGAs of Port Stephens, Lake Macquarie and Central Coast; The Western Feeder Area comprises the LGAs of Lithgow and Oberon; The South Western Feeder Area comprises the LGAs of Wingecarribee and Goulburn-Mulwaree; The Southern Feeder Area comprises the LGAs of Wollongong, Shellharbour and Kiama.

Fly ash is a waste by-product of the coal-burning process in power stations. It is primarily the non-combustible mineral component of coal and is obtained by separating fly ash particles out of the exhaust gas (flue gas) produced during the combustion of coal.

Fine aggregates comprise either naturally occurring sand or crushed rock <5mm in particle size.

Greater Sydney Region (GSR) – The Planning Region incorporating the North, Central, South, Central River City and West Planning Districts (see **Figure 1.1**).

Hard rock quarries are quarries that extract typically igneous rocks such as basalt, latite, granodiorite or rhyolite or some metamorphic rocks such as quartzite – all of which display high strength and durability characteristics and require blasting and crushing to produce the required crushed rock products.

Manufactured sand is fine aggregate produced from crushed rock that is used in concrete or asphalt as a replacement or partial replacement for coarse natural sand.

Natural sand is a naturally occurring material comprising loose grains (<5mm in size) of disintegrated or disaggregated rocks. Typically, coarse sand has grains from 2.4mm to 5mm in size, medium sand from 0.6mm to 2.4mm and fine sand the grains are generally less than 0.6mm.

Quarries are essentially sites where hard rock or natural sand is extracted and usually processed to produce a range of quarry products for use in the building and construction industries – also referred to as "Extractive Sites".

Raw materials is a broad term including extractive materials and other key ingredients such as cementitious materials (and their raw material constituents) used in the manufacture of concrete or asphalt.

Substitute construction materials within the Study refer to substitutes for extractive materials (i.e. crushed rock and natural sand products) and include VENM from tunnel spoil and excavations, recycled concrete and asphalt, blast and steel furnace slag and low value quarry materials such as crushed sandstone.

Supplementary Cementitious Materials (SCMs) are manufactured powders, which act as 'cement extenders'. Their addition to concrete enhances durability and other concrete performance characteristics. Concrete-grade flyash and ground granulated blast furnace slag (GGBFS) are the most commonly used SCMs.

Virgin Excavated Natural Material (VENM) is a general term describing materials excavated from civil construction projects and which are surplus to the project's requirements. Ground (bored) sandstone from tunnel spoil is the most common type of VENM produced throughout the GSR.

Commonly Used Acronyms

ABS	Australian Bureau of Statistics
ASMS	Australian Steel Mill Services
C&D	Construction and Demolition (waste)
CCAA	Cement Concrete and Aggregates Australia
CRC	Central River City
DGB	Dense Graded Base (road pavement material)
EHC	Eastern Harbour City
ERPs	Estimated Resident Population
FOT	Free on Truck
FY	Financial Year
GGBFS	Ground granulated blast furnace slag
GSR	Greater Sydney Region
RAP	Recycled asphalt pavement
RDC	Regional Distribution Centre
RMS	Roads and Maritime Services
SCMs	Supplementary Cementitious Materials
VENM	Virgin Excavated Natural Material
WPC	Western Parklands City
YE	Year ending

Commonly Used Symbols and Units

%	percentage	m	metre
<	less than	m^3	cubic metre
≤	less than or equal to	mm	millimetre (= 0.001 metres)
>	greater than	Mtpa	Million tonnes per annum
≥	greater than or equal to	t	tonnes
kg	kilogram	tpa	tonnes per annum
km	kilometre		

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Executive Summary

Introduction

The *Greater Sydney Region Plan* identifies that 725,000 new homes are required by 2036 to meet the needs of a growing and changing population. The *NSW State Infrastructure Strategy 2018-2038* and *Future Transport Strategy 2056* also outline significant infrastructure and transport priorities for Greater Sydney and regional NSW.

The construction of housing, non-residential buildings and roads and other engineered infrastructure within the Greater Sydney Region (GSR) relies on a range of construction materials sourced from within and outside the GSR. Construction materials considered in this Study comprise:

- extractive materials (crushed rock products (including manufactured sand) and natural sand products);
- cementitious materials (cement and cement-like materials (fly ash and ground granulated blast furnace slag)); and
- substitute construction materials which are used as substitutes for extractive materials (recycled concrete and asphalt, virgin excavated natural materials (VENM) from civil construction projects, blast and steel furnace slag and low value quarry materials such as crushed sandstone).

This Study presents a base case assessment of the supply and demand of extractive materials for the historical period January 2012 to June 2018, and a forecast assessment for the period from July 2018 to December 2036 to estimate the quantities of extractive materials required throughout the GSR during this period, and establish if there is a supply deficit of any extractive materials. Forecast cumulative demand quantities in the Study are provided for the period January 2018 to December 2036 (a nineteen year period).

In relation to any supply deficit of any extractive materials to December 2036, the Study found that:

- under current approvals, there are <u>sufficient</u> reserves of hard rock to meet the demand for crushed rock products in the GSR to beyond 2036; and
- under current approvals, there are <u>insufficient</u> reserves of natural sand to meet the demand for natural sand products in the GSR to 2036, however there are sufficient potential resources that could be developed adjacent to or within existing quarries to meet the cumulative demand for natural sand products in the GSR.

The Study identifies:

- the number, location, and aggregated production quantities of quarries which currently supply extractive materials to the GSR;
- the transport route, transport mode, travel time, market destination and GSR City destination of extractive materials supplied by these quarries;

- the number, location and aggregated production volumes of concrete and asphalt batching plants which currently supply concrete, concrete products and asphalt to the GSR;
- the transport route, transport mode, travel time, market destination and GSR City destination of products supplied by these concrete and asphalt plants;
- supply costs of extractive materials, including indicative purchase costs at the quarry and the costs of transporting materials to their points of use; and
- potential supply gaps and barriers including the effect of increased transport distances on transport costs, depletion of resource, and existing land uses.

The Study also provides a general assessment of the current and forecast supply and demand of cementitious and substitute construction materials.

Key Assumptions and Limitations

The key assumptions and limitations relied upon for this Study are as follows.

1. **Primary Data Sources**

   Three independent sets of primary data and information have been used to compile the GSR supply and demand Study report and inform its findings.

   – NSW Division of Resources and Geoscience database ('Consmat' database) 2012 to 2017.

   – RWC industry questionnaire and industry survey responses – June to November 2018.

   – Macromonitor demand data series for Construction Materials usage in the GSR, 2006 to 2026, published March 2018.

   The list of quarries that supply extractive materials to the GSR has been established by RWC through references to the Consmat database, from extensive industry consultations, and based on information and knowledge held by RWC as a consequence of the firm's consulting activities in the extractive materials sector over many decades.

2. **Relationship between Extractive Materials and Substitute Construction Materials**

   The contribution of substitute construction materials to meeting demand for total construction materials has been evaluated by deducting the quantities of extractive materials reported by industry survey (for YE 30 June 2018), from the Macromonitor demand series data (for the same period) which reports both extractive materials and their substitutes (but not separately).

   This can be simply expressed (for the 12 months ended June 2018) as:

   – MM demand data (36.2Mt) = Extractive materials (19.5Mt) + Substitute construction materials (16.7Mt).

Thus, according to the relationship, substitute construction materials for extractive materials are estimated to meet 46% of demand for sand and crushed rock products (mainly in the sub-base and roadbase categories).

The Study's use of the deductive approach is considered the most suitable and reliable to establish a 2018 base case given the limitations of the data available to the Study. Future confirmation of its findings is possible only if a reliable future annual flow of data and information can be provided from the extractive and recycling / civil construction sectors to government.

3. Segmentation of Demand and Supply Data into GSR Planning Districts

Neither the Consmat data, industry survey data or Macromonitor data provide granular data on the actual destination of construction materials throughout the GSR. The Macromonitor data available to the Study was purchased for each ABS district. However, the geographic boundary differences are considered negligible when determining a demand profile for the GSR as a whole.

Industry survey information provided the best insight as to where extractive materials were being delivered, and was sufficient to provide an estimate of destination by feeder routes and the GSR's three cities, but not sufficient to justify segmentation into GSR's five Planning Districts.

4. Types of Quarry Products and Percentage of Supply

The types of quarry products sold and their respective percentages of overall supply for the 2018 baseline profile were established by industry survey and to a lesser extent, from the profile established from reviewing the Consmat data.

Whilst the basic technical drivers for consumption of construction materials are fairly well established by engineering design standards, the source(s) of raw material ingredients may change to some extent in the next 15 to 20 years but not the products themselves nor the general proportions of ingredients for use in concrete and asphalt.

For these reasons, the same (2018) quarry product percentages have been assumed to apply to the future demand series to 2036.

5. Sensitivity Analysis of Forecast Demand

The forecast demand and supply profiles for extractive materials are subject to following assumptions.

- For the period 2018 to 2026, Macromonitor forecast series data are adopted without conducting sensitivity analysis on these data.
- Beyond 2026, when the Macromonitor forecasts used by the Study end, forecast demand has been calculated in the Study by reference to estimates of prevailing per capita consumption rates and forecast population series.

Further detail about the assumptions and limitations relied upon are presented in Section 1.4 of the Study.

Key Findings

1. The total annual demand for construction materials in the GSR for the 12 month period ended June 2018 (FY 2018) is approximately 40Mt (39.8 million tonnes), which equates to an annual average per capita demand of 8.1 tonnes.

2. This represents an increase in per capita consumption of approximately 36% from FY 2012 to FY 2018. The increase in per capita demand has been driven by record and coincident levels of demand from all sectors of the building and construction industry (i.e. housing, non-residential buildings, roads and other infrastructure).

3. A key finding of the Study is that whilst the FY 2018 (base-line) level of demand of 40Mtpa represents an historic peak (or near peak) in construction materials demand for the GSR, it also represents a "new norm" in the level of demand. Some future year on year volatility is inevitable, but the total quantity of construction materials presently consumed by the GSR of 40Mtpa is comparable to the Study's forecast longer-term average of 41 Mtpa to 2036.

4. The 39.8 million tonnes of construction materials supplied in FY 2018 comprised:

    - 13.6Mt of crushed rock products (34% of total demand);
    - 5.9Mt of natural sand products (15% of total demand);
    - 3.6Mt of cementitious materials (9% of total demand); and
    - 16.7Mt of substitute construction materials (42% of total demand).

    Figure A displays the breakdown of each construction material and the location of their supply source.

5. There are no quarries producing crushed rock products in the GSR. All crushed rock products are produced from 17 hard rock quarries outside of the GSR, from the four feeder areas[1] adjoining the GSR to the north, west, south west and south. Transport distances from the quarries within the feeder areas into the Sydney CBD typically range from 77km and 190km. Travel times for the delivery of crushed rock products to their points of use typically varied from approximately 1.2 hours to 4 hours.

6. Approximately 66% of the crushed rock products supplied to the GSR in 2018 were transported by road to their points of use and 34% (comprising mainly concrete and asphalt aggregates) were transported by rail to the four regional distribution centres within the GSR. This represents the highest railed proportion of the supply of crushed rock products for any city in Australia. Of the crushed rock products transported by rail to regional distribution centres, approximately 85% were then delivered to their final destination by road.

[1] A feeder area is defined as a group of Local Government Areas – see "Terms and Definitions" for LGAs within each feeder area.

Figure A Construction Materials Used in the GSR for YE June 2018

7. Approximately 63% of the natural sand products were produced in FY 2018 from 15 natural sand quarries in the four feeder areas with an average haulage distance into the Sydney CBD of approximately 150km. The remaining 37% was produced from 12 natural sand quarries in the GSR with an average haulage distance to the Sydney CBD of approximately 66km. Travel times for the delivery of natural sand products to their points of use typically varied from approximately 40 minutes to 4 hours.

8. During an average operating day in FY 2018, approximately 1 980 truckloads of extractive materials (69 000 tonnes of products) were delivered to their points of use throughout the GSR.

9. Total supply costs[2] for extractive materials in FY 2018 were in the indicative range of $45 to $80 per tonne delivered (~$70/t on average), of which transport costs comprised approximately 40% of the total supply cost to consumers.

10. Approximately 80% of the crushed rock and natural sand products supplied to the GSR are high-quality fine and coarse aggregates used in the manufacture of concrete and asphalt.

11. Substitutes for extractive materials such as recycled concrete and sandstone VENM have lower strength and durability performance compared with extractive materials. Approximately 85% of the substitute construction materials are therefore used in road construction and a range of land development and infrastructure projects, principally as roadbase or sub-base products.

12. Approximately 3.6Mt of cementitious materials were used in concrete manufacture in FY 2018 or approximately 8% of construction materials consumed. Cement accounted for 69% by weight of cementitious materials, flyash 25% and ground granulated blast furnace slag 6%.

13. Based on projected building and construction activity data provided by Macromonitor from 2018 to 2026 and the use of per capita consumption estimates from 2027 to 2036, the cumulative forecast demand for construction materials in the GSR from January 2018 to December 2036 (a nineteen-year period) is projected to comprise:
    - 265 million tonnes of crushed rock products (35% of total);
    - 118 million tonnes of natural sand products (15% of total);
    - 63 million tonnes of cementitious materials (8% of total); and
    - 326 million tonnes of substitute construction materials (42% of total).

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14. The total cumulative demand for construction materials in the GSR is therefore estimated at 772Mt (41 Mtpa on average). Over the demand forecast period, this represents an average per capita consumption of 7.1tpa (assuming main series population forecasts for the period 2018 to 2036 are adopted). The forecast per capita consumption of 7.1 tpa is lower than the FY 2018 estimate of 8.1tpa because the 2018 estimate reflects (at a point in time) peak demand in all building and construction sectors including a housing construction boom and major road and infrastructure projects.

15. Whilst the long-term per capita estimate of 7.1 tpa is less than the current peak demand estimate of 8.1tpa in FY 2018, it is nevertheless high by historical demand standards for the GSR. For example, for the 12 months ended FY 2012, the GSR per capita demand for construction materials was estimated to be 6.0 tpa[3].

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[2] For extractive materials, supply costs comprise the cost to the purchaser at the quarry gate and the transport costs between the quarry and the point of use. Indicative cost estimates (exclusive of GST) and economic drivers are further described in the Supply Cost profile (Section 2.12) and demand and supply balance conclusions in Section 3.9 of this report.

[3] Benchmarking with other cities indicates: for 2018 Greater Melbourne a per capita consumption of about 11 tpa and for Greater Brisbane about 10 tpa, for the same construction materials. These cities are more spread out than the GSR's Three Cities (lower population densities) and so per capita consumption is higher. They also rely more heavily on quarries to supply roadbase and sub-base.

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16. The present proportion of demand for construction materials met from substitutes is approximately 42% of total construction material demand (or 46% if cementitious materials are excluded from the calculation). This is very high by large city standards and a surprising finding from the Study. It has important strategic planning and cost implications, if for example the availability of sandstone VENM within the GSR reduces in the future. The products, uses and availability of future quantities of substitutes for extractive materials in the GSR therefore warrants further resolution because there is a shortage of good, reliable data.

17. Assuming the present proportion of demand met by substitutes continues to 2036, the cumulative forecast demand for crushed rock and natural sand products (extractive materials) is 383Mt. Housing is forecast to consume 145Mt (38%) of extractive materials, non-residential buildings 95Mt (25%), road construction and maintenance 127Mt (33%) and other engineered infrastructure 16Mt (4%).

18. The 17 hard rock quarries currently supplying crushed rock products to the GSR have sufficient approved reserves of at least 563 million tonnes, i.e. geologically proven resources with development consent for extraction, and production limits to meet the forecast demand for crushed rock products to 2036 and beyond.

19. Whilst a number of the quarries currently supplying natural sand products to the GSR are forecast to be depleted prior to 2036 (during the 2030s), there are sufficient potential resources within and adjacent to a number of the quarries (subject to development approval) to enable existing quarries to meet the GSR sand natural requirements up to and beyond 2036.

20. If not all potential resources within the GSR are available to replace depleted resources in the future, then natural sand products will be transported over longer distances from outside the GSR (commencing in the 2030s), which would increase transport distances and delivery costs to the GSR.

21. For the forecast period, transport distances and transport routes for the supply of crushed rock products to the GSR are expected to remain comparable to the current distribution pattern. If further increases in traffic congestion occurs, travel times and therefore transport costs will further increase over current levels.

22. Scope to reduce the cost to the consumer of extractive materials by locating quarries closer to markets in the GSR is considered minimal because of the absence of suitable, undeveloped extractive precincts. Purchase costs for extractive materials at the quarry gate are also considered unlikely to significantly reduce from present indicative cost estimates, because of sustained levels of higher future demand, high barriers and entry costs to establish new quarries, and the relative high productivity of existing quarries (where gains from future reductions in costs of production at the quarry and which could translate into price reductions at the quarry gate are considered improbable).

23. Further flexibility in the spread of hours in which extractive materials are delivered to the GSR would help reduce congestion during peak traffic conditions, and moderate increases in direct transport costs, as would the increased usage of high performance vehicles with larger payloads.

Overview of Construction Materials Consumed within the GSR

Extractive Materials

Crushed Rock Products

A total of 17 hard rock quarries in the four feeder areas surrounding the GSR currently supply crushed rock products to the GSR. The average distance of the quarries from the Sydney CBD varies from 118km (Southern Feeder) to 179km (South Western Feeder). There are no quarries producing crushed rock products in the GSR. **Figure B** summarises the quantities and daily loads of crushed rock and natural sand products delivered to sites within the GSR based on industry production levels in FY 2018.

In the 12 months ended FY 2018, approximately 13.6 million tonnes of crushed rock products were delivered to sites in the GSR, i.e. an increase of approximately 48% from the products delivered over the 12 months ended FY 2012.

For FY 2018, approximately 66% of the crushed rock products were delivered from quarries by road to their points of use with the remaining 34% (all as aggregates) transported from quarries by train to Regional Distribution Centres with approximately 85% of these railed products then transported by road to their points of use.

Quarries in the South Western Feeder and Southern Feeder produced the highest and second highest quantities of crushed rock products transported to the GSR in FY 2018, namely 5.0 million tonnes and 4.2 million tonnes respectively.

Natural Sand Products

A total of 27 quarries supplied natural sand products to the GSR in 12 months ended FY 2018. Twelve quarries are located in the GSR, generally between 33km and 70km from the Sydney CBD, and 15 quarries are located outside the GSR at distances of between 77km and 197km from the Sydney CBD.

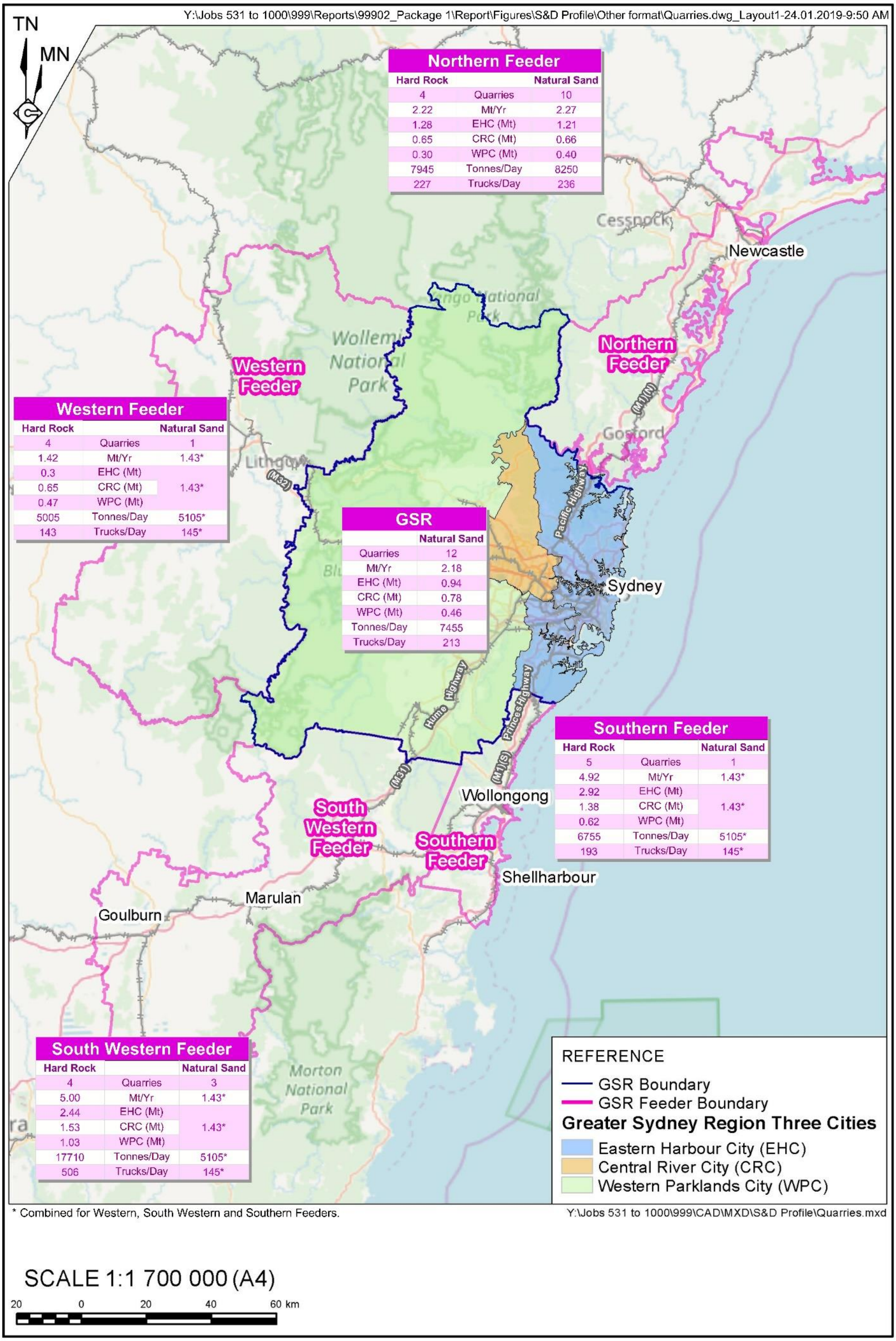
In FY 2018, a total of approximately 5.9 Mt of natural sand products was delivered to sites in the GSR, an increase of approximately 25% from products delivered over the 12 months ended FY 2012. Of the 5.9 Mt, 2.27 million tonnes (38%) was produced by the 10 quarries located in the Stockton/Salt Ash/Williamtown area and Central Coast in the Northern Feeder. Approximately 2.18 million tonnes were produced by the 12 quarries in the GSR and 1.43 million tonnes produced by the five quarries in the Western, South Western and Southern Feeders.

Most natural sand products were used in the production of concrete. The largest proportion of sand products was delivered to the Eastern Harbour City.

Extractive Materials Transportation

Approximately 66% of the crushed rock products supplied to the GSR in 2018 were transported by road to their points of use, and 34% (comprising mainly concrete and asphalt aggregates) were transported by rail to the four regional distribution centres within the GSR.

Figure B Extractive Materials Produced for the GSR in FY 2018



An average of approximately 1 070 truck loads was transported by road daily to concrete and asphalt plants and construction sites in the GSR during FY 2018. These were transported via the four principal transport routes into the GSR, i.e. the Hume Highway (47%), the Pacific Highway M1 (North) (21%), Princes Highway M1 (South) (18%) and Great Western Highway (14%).

Almost all (96%) of the crushed rock products transported to the GSR by rail were sourced from the three largest quarries currently supplying the GSR, i.e. via the Main Southern Railway Line from the Lynwood and Peppertree Quarries (in the South Western Feeder) and via the Illawarra Railway Line from the Dunmore Quarry (in the Southern Feeder). A small quantity was also transported by rail from the Bombo Quarry. A total of approximately 340 truck loads of crushed rock products were re-distributed daily by road on secondary transport routes from the four regional distribution centres in the GSR to their points of use.

Almost all (approximately 97%) natural sand products were delivered from the quarries by road to their points of use. The remaining 3% were transported by rail via the Illawarra Railway Line from the Southern Feeder.

An average of approximately 390 truck loads per day of natural sand products was transported to concrete and asphalt plants and construction sites in the GSR in FY 2018. These were transported via the four principal transport routes into the GSR, i.e. the Pacific Highway M1 (North) (approximately 60%), the Hume Highway (28%), the Great Western Highway (9%) and Princes Highway M1 (South) (3%). Approximately 180 truck loads of natural sand products were delivered on secondary transport routes from quarries in the GSR to their points of use.

Cementitious Materials

Based on Macromonitor data for 2018 and industry survey feedback, a review of the market requirements indicates 3.6 million tonnes of cement and supplementary cementitious materials were consumed in the GSR in FY 2018. Demand for cementitious materials is being met from local production and well as domestic and international importation of the materials. There is limited future scope for increased domestic supply of cementitious materials, a reduction in domestic supply over time is probable, and the trend of increased reliance on shipped imports is expected to continue.

Substitute Construction Materials

Substitute construction materials considered in the Study include the following.

- Recycled concrete from construction and demolition (C&D) waste.
- Recycled asphalt.
- Blast and steel furnace slag.
- Crushed/broken sandstone excavated from civil construction projects, i.e. virgin excavated natural materials (VENM).
- Other low-value quarry materials such as crushed sandstone or hard rock quarry scalps.

It is estimated approximately 16.7 million tonnes of substitute construction materials were consumed in the GSR in FY 2018, principally for construction projects. The amount of substitute construction materials used during FY 2018 (42% of total construction materials, or 46% if cementitious materials are excluded) was the most surprising outcome from the Study[4].

The method by which this estimate has been derived was indirect because of an absence of available data on the products, quantities and actual market uses of substitute materials like recycled concrete and sandstone VENM. General information is available but details are lacking.

The base-line cumulative demand forecasts assume substitutes will maintain their present proportion of supply to the GSR, mainly as roadbase and sub-base materials. However, there are important strategic planning implications if the availability of substitutes reduces in the future, e.g. if less sandstone VENM is available. Replacement roadbase and sub-base materials would need to be sourced from recycled concrete and from hard rock quarries, which would result in significant increases in costs because these materials have higher production costs and substantially higher transport costs from hard rock quarries because they are outside the GSR.

Concrete and Asphalt Products

A total of 78 pre-mixed concrete plants are located principally within industrial-zoned land within the GSR. The plants are located in all three GSR cities, although the plants in the Eastern Harbour City and some Central River City locations have considerably higher capacities and production levels.

It is estimated that approximately 9.3 million cubic metres (Mm^3) of concrete (pre-mixed concrete, pre-cast concrete and mortar) were consumed in the GSR in FY 2018. This represents an increase of approximately 75% since FY 2012.

Of the FY 2018 total, 6.7Mm^3 was pre-mixed concrete. Approximately 3.7Mm^3 or 55% of the total supply of pre-mixed concrete was produced in the Eastern Harbour City, 2.0Mm^3 (30%) was produced in the Central River City and 1.0Mm^3 (15%) was produced in the Western Parklands City. The highest proportion of pre-mixed concrete (44%) was used in the construction of housing.

All pre-mixed concrete is delivered by road in concrete agitators, the bulk of which carry between 6m^3 and 8m^3 of concrete. Destinations for the delivery of pre-mixed concrete are typically less than 5km from the concrete plants in the Central Planning District of the Eastern Harbour City and up to 11km from plants in the Eastern Harbour City and Central River City and between 5km and 25km in the Western Parklands City. The three larger concrete producers sometimes rely on other nearby plants to meet demand shortfalls.

Approximately eleven pre-cast concrete plants are located within the GSR principally within the Central River City and Western Parklands City. These plants collectively produced 2.6Mm^3 of pre-cast concrete products in FY 2018 including concrete panels, pipes, sleepers and masonry blocks.

[4] The proportion of GSR demand met by substitutes is very high by large city standards – it is a function of sandstone geology and high levels of building and construction activity generating C&D waste and surplus earth materials (VENM).

A total of eight asphalt plants are located in industrial areas in the GSR. Three plants are located in each of the Central River City and Western Parklands City and two plants are located in the Eastern Harbour City. Production from all asphalt plants was estimated at 1.3Mt of asphalt during FY 2018 and production of spray seal aggregates at 0.7Mt.

Future Supply and Demand Assessment

Overall, it is expected that demand for construction materials will peak in 2019, followed by a projected dip until around 2023. Demand is then forecast to consistently increase after 2023, principally influenced by population growth and sustained higher levels of building and construction activity.

The Study's forecast demand for extractive materials from quarries (**Figure C**) indicates a cumulative demand of 383Mt for the period January 2018 to December 2036.

Figure C GSR Extractive Materials - Cumulative Demand Forecast by Quarry Product Type for the Period January 2018 to December 2036 (19 years)

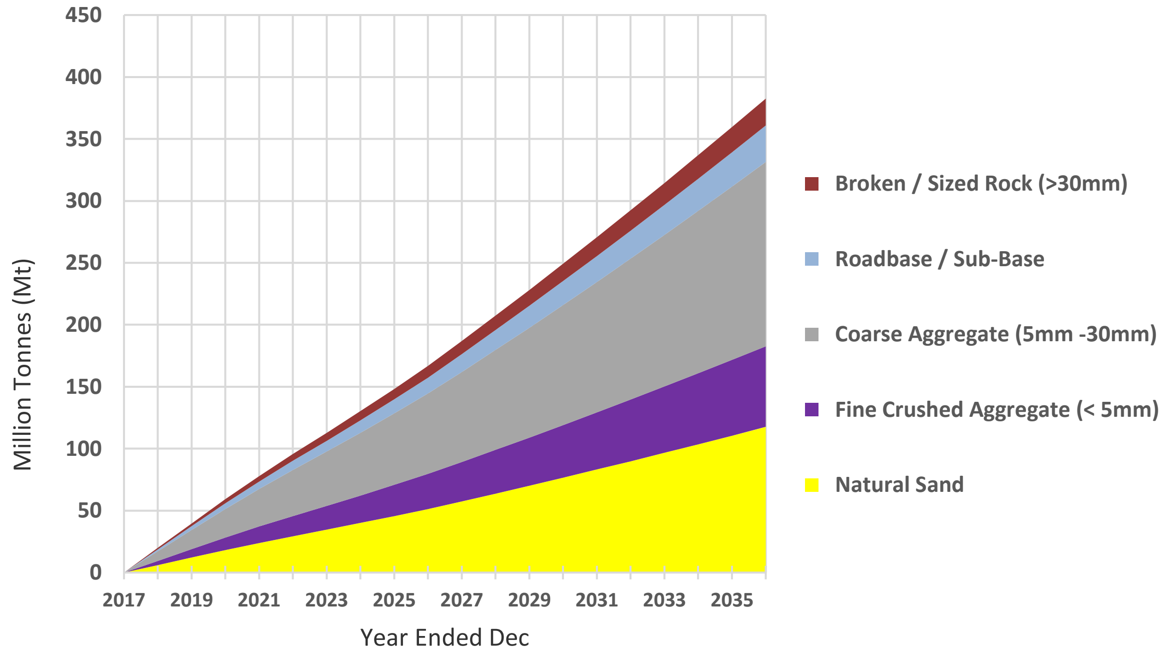


Chart Data Sources

1. Macromonitor Greater SYDNEY Construction Materials Demand forecast, by Quarry Product type 2018 to 2026, data issued Mar 2018
2. From 2027, per capita consumption of 3.5tpa and Main Series population forecasts
3. Demand profile excludes substitute construction materials (estimated at 46% of total demand, mainly as roadbase/sub-base)

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The estimated cumulative demand for extractive materials from quarries was subjected to a sensitivity analysis that indicated the following probable cumulative demand range.

- Crushed rock and natural sand 383Mt to 404Mt (20 to 21Mtpa on average)
- Cementitious materials 63Mt to 67Mt (3.3 to 3.5Mtpa on average)
- Substitute construction materials 326Mt to 344Mt (17 to 18Mtpa on average)

On a per capita basis, these cumulative demand estimates equate to 3.5tpa for extractive materials, 0.6tpa for cementitious materials and 3.0 tpa for substitutes for extractive materials or 7.1tpa in total.

If the proportional supply of substitutes for extractive materials reduces in the future (e.g. less tunnelling), then hard rock quarries would need to make up part of the shortfall for roadbase/sub-base products.

Concrete manufacturing does not rely to any significant extent on the supply of substitute construction materials (because of their lower strength and durability) and therefore quarry production will continue to be closely aligned with concrete manufacturing demand.

Existing transport quantities and feeder routes will continue to prevail to 2036 with a likely greater reliance placed on product transportation from the more distant natural sand sources as a number of the sand reserves within the GSR are depleted. Transport influences all aspects of the supply of extractive materials, from the management of local environmental impacts in the vicinity of quarries to traffic congestion impacts.

The supply of extractive materials from outside the GSR and their commensurate cost of transportation into the GSR by virtue of distance hauled, will therefore prevail into the future (2036 and beyond). Mitigation of existing road transport constraints will be most achievable by changes in transport mode (increased use of rail and ship) and improved road transport efficiencies (for example by extending the spread of hours for despatch of products from quarries to avoid peak congestion periods, and by a wider use of high performance vehicles carrying a larger payload).

In the event that the adoption of emergent hard rock crushing and sizing technologies increases over time, to enable the production of a fully graded manufactured sand from hard rock quarries supplying the GSR, the proportion of natural fine sand used in concrete necessary to achieve the preferred fine aggregate grading is likely to reduce. This contingency would increase reliance on hard rock quarries as suppliers of sand (manufactured sand) and decrease reliance on sources of natural (fine) sand.

Capacity of Existing Quarries to Supply Future Extractive Materials

The 17 hard rock quarries in the four feeder areas providing a range of crushed rock products collectively have sufficient approved reserves and approved production limits to supply the GSR's requirements beyond 2036.

The approved reserves within most of the 27 natural sand quarries in the GSR and four surrounding feeder areas are forecast to be depleted before 2036. Under current approvals there are insufficient reserves of natural sand to meet the demand for natural sand products in the GSR to 2036, however there are sufficient potential resources requiring development adjacent to or within quarries to enable the quarries to supply the GSR's natural sand requirements up to and beyond 2036.

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1. Introduction

1.1 Scope

The NSW Government requires a thorough understanding of the supply and demand of geological construction materials, referred to as "extractive materials" throughout this document, within and surrounding the Greater Sydney Region (GSR). These materials, together with cementitious materials, and substitute construction materials are the key construction materials used in the building of homes and the construction of non-residential buildings, roads and other engineered infrastructure throughout the GSR.

Strategic planning undertaken by the NSW Government has identified a range of priorities and objectives for development throughout the GSR to 2036 and beyond and the Department of Planning and Environment has commissioned a team of consultants led by R.W. Corkery & Co Pty Limited (the Study team – see **Appendix 1**) to undertake primary research, data modelling and analysis to improve the information currently held by the NSW Government, particularly for extractive materials.

This Study presents a base case assessment of the supply of all construction materials for the period 2011 to 2018 and a forecast demand assessment for the period 2018 to 2036 to establish the estimated quantities of extractive materials required throughout the GSR over this period, and whether there may be a supply deficit during this period.

In order to provide a comprehensive analysis of the extractive materials currently being supplied and consumed in the building and construction industry within the GSR, the Study also documents the supply of construction materials not sourced from quarries such as recycled construction and demolition (C&D) waste, particularly recycled concrete, recycled asphalt pavements and sandstone excavated from civil projects (e.g. tunnel spoil and other excavations in the GSR). These materials are collectively referred to as substitute construction materials and are considered as substitutes for extractive materials.

1.2 Objectives

The key objectives of this Study are principally to:

- compile an accurate profile of the current supply and demand, and supply cost profile, of construction materials within the GSR and its planned three cities;
- gain an understanding of the quantities, modes of transport and rates of supply from surrounding areas (beyond the GSR) feeding these materials into the GSR;
- review and assess existing and potential supply-side constraints that impact or are likely to impact upon the availability and cost effective supply of extractive materials to meet future anticipated demand in the GSR;

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- estimate the future demand for extractive materials and cementitious materials needed for housing, non-residential buildings, roads and other engineered infrastructure required within the GSR to 2036; and
- identify strategically important existing and future quarries to enable the Government to protect them from competing land uses.

1.3 NSW Government Planning Documents

The NSW Government has published a range of planning documents that collectively provide the basis for the Government's strategic planning for the GSR for various periods up to 2056. The principal planning documents and their key themes or issues relevant to this Study are set out as follows.

Greater Sydney Region Plan

The *Greater Sydney Region Plan* provides a vision for the growth of Sydney to a metropolis of three cities, namely the:

- Eastern Harbour City (North, Central and South Planning Districts);
- Central River City (Central River Planning District); and
- Western Parkland City (West Planning District).

Figure 1.1 displays the boundary of the GSR and the boundaries of the three cities and its five planning districts.

The GSR Plan vision introduces new approaches to the GSR planning, land use and transport connectivity given the projected population growth, particular in western Sydney to 2056 and where growth is anticipated or planned across the three cities until 2056. The GSR Plan forecasts 725 000 additional dwellings would be constructed in the GSR by 2036.

A key objective of the plan require detailed consideration of the availability and distribution of extractive materials required for housing, other non-residential buildings, roads and infrastructure.

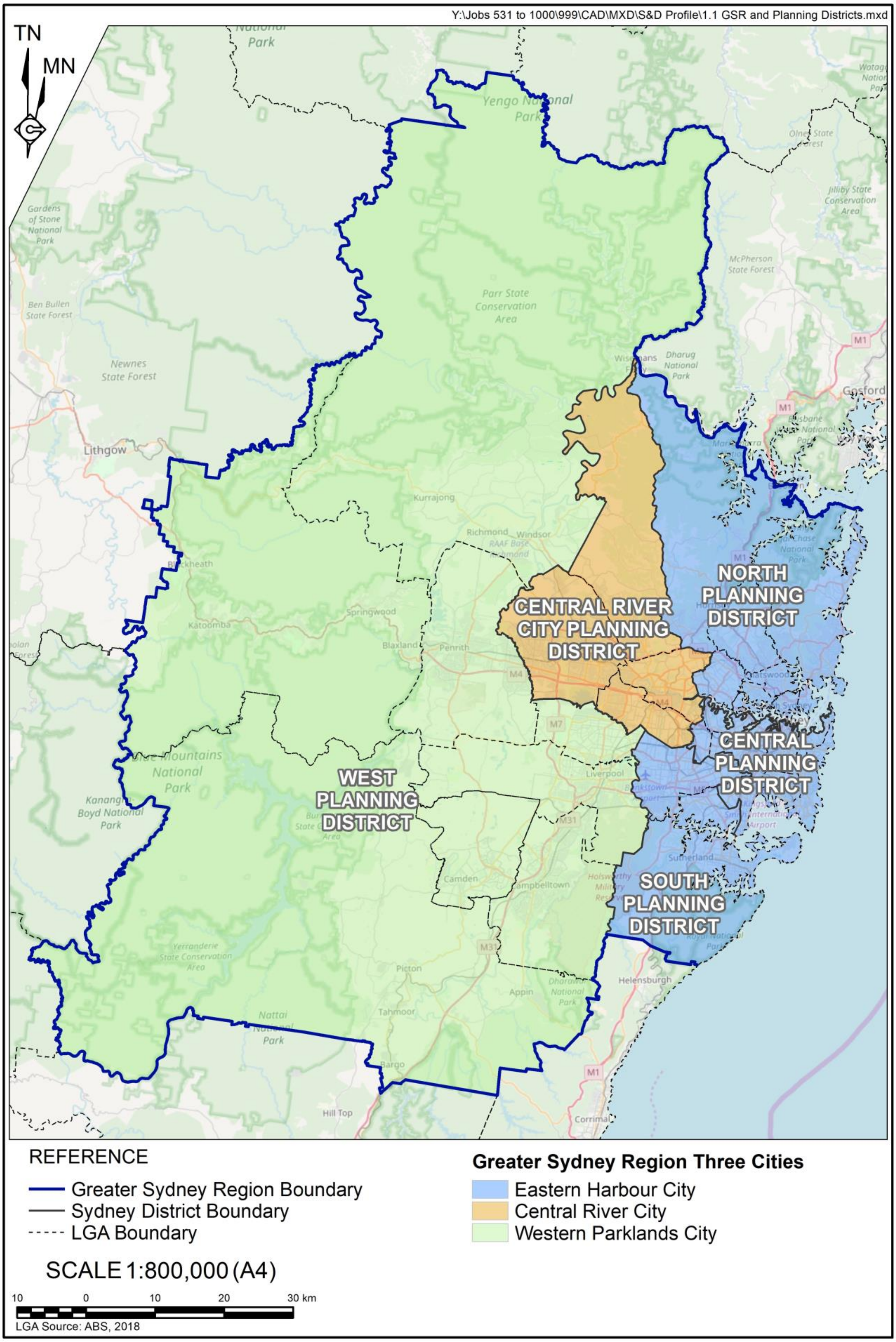
State Infrastructure Strategy 2018 to 2038

The *State Infrastructure Strategy 2018 to 2038* outlines the policies and strategies required to meet the infrastructure needs of a growing population within NSW.

The Strategy recognises the current record levels of investment in housing and infrastructure and the need to address transport and logistical challenges associated with an increasing construction demand.

Maintaining an efficient bulk-handling network within the GSR is identified as a key component of the *State Infrastructure Strategy 2018 to 2038*.

Figure 1.1 Boundaries of Greater Sydney Region and Planning Districts



Roads are recognised in the Strategy to continue to be the dominant carrier of freight and construction materials within the GSR, although the proportion of freight transported by rail is forecast to increase. Glebe Island is also identified as a key hub for the efficient transportation of construction materials delivered by ship for concrete production within the Eastern Harbour City over the next 20 years.

Future Transport Strategy 2056

The key objective of the *Future Transport Strategy 2056* is to provide a 40-year vision for the GSR and the regional transport system that supports the development of the GSR. The document presents the NSW Government's overarching transport strategy supported by a range of related plans. The Plan addresses strategic directions and outcomes for those who use and rely upon transport with an emphasis upon the influence of changing technology on transport systems.

The Strategy identifies dedicated and shared freight corridors as an integral component of the future transport system within regional NSW and the GSR.

NSW Freight and Ports Plan 2018-2023

Construction materials are identified in the Plan as one of the most dominant commodities contributing to freight task in the GSR. The Plan identifies a forecast growth in demand for total construction materials from 2016 to 2036 of 20.4%, from a 2016 base case of approximately 40 million tonnes per annum. The definition of construction materials differs from that used in this Study[5].

The Plan contains strong commitments to increase the use of rail freight, coastal shipping and high productivity vehicles through a wide range of initiatives all of which will assist to contain delivery costs for extractive materials to the GSR.

The Plan records that congestion on the GSR's roads is impacting freight costs and acknowledges the delays upon the efficiency of Sydney's rail network through competition with passenger services.

Intermodal freight terminals or regional distribution centres (RDCs) are identified as a key requirement for increasing the mode share of freight moved by rail in the GSR. The NSW Government recognises the importance of collaborating with industry to ensure suitable locations are identified, protected and zoned appropriately to allow for the efficient operation of intermodal terminals.

1.4 Assumptions and Limitations

The principal assumptions and limitations of data reported in the Study of supply and demand for construction materials in the GSR are summarised below.

[5] The *NSW Freight and Ports Plan 2018-2023 defines construction materials more broadly – it includes timber, plaster, steel, bricks etc in addition to extractive and cementitious materials.*

1. Definition of Construction Materials

Construction materials are defined in the Study as comprising:

- extractive materials (quarry products produced and sold from natural sand and hard rock quarries for use within the GSR);
- substitutes for extractive materials (e.g. products supplied from recycled construction and demolition (C&D) or industrial wastes, sandstone, virgin excavated natural materials, spoil and low value quarry materials such as crushed sandstone); and
- cementitious materials (i.e. cement, flyash, GGBFS).

The definition of Construction materials excludes other types of materials used for buildings such as steel, timber, plaster and glass.

Extractive Materials excludes construction clay (used for brick making for example) and industrial sand / industrial minerals (E.g. natural sand supplied from quarries or mines that is used for foundry mouldings, filler for cement manufacture, glass making etc).

2. RWC Inventory of Sand and Hard Rock Quarries Supplying Extractive Materials to the GSR

The list of quarries that supply extractive materials to the GSR has been established by RWC through references to the Consmat database, from extensive industry consultations, and based on information and knowledge held by RWC as a consequence of the firm's consulting activities in the extractive materials sector over many decades.

The database of natural sand and hard rock quarries established by the Study therefore represents a sub-set of sites recorded within the Consmat database - representing sites that produce either natural sand or crushed hard rock products, and which supply extractive materials to the GSR.

Sites within the Consmat database producing only recycled materials, or lower grade materials from sandstone quarries for example, or which do not supply into the GSR are therefore excluded.

3. Primary Data Sources

Three independent sets of primary data and information have been used to compile the GSR supply and demand Study report and inform its findings.

- NSW Division of Resources and Geoscience database ('Consmat' database) 2012 to 2017.
- RWC industry questionnaire and industry survey responses – June to November 2018.
- Macromonitor demand data series for Construction Materials usage in the GSR, 2006 to 2026, published March 2018.

None of the above data sources, on their own, have sufficient information to establish a supply and demand profile for Construction Materials in the GSR. Collectively, however, the data sources can be used to construct a supply and demand profile for GSR, which is not possible if reliance is placed solely on any one data source.

Primary data source 1 (Consmat data) identifies operating quarries within and external to the GSR but does not nominate the destinations of the quarry products produced at those quarries. It also includes operating quarries that supply some recycled materials. After 2013-2014, when data gaps in industry reporting to the DRG annual survey become relatively common-place, the data are considered by RWC to under-represent quarry output (when demand for construction materials in GSR by reference to economic activity in building and construction increased substantially).

Primary data sources 2 and 3 provide more complete sets of data and information and have therefore been relied upon in the Study, rather than the Consmat data.

4. Relationship between Extractive Materials and Substitute Construction Materials

2018 Base case (or baseline) Demand and Supply Profile

The Macromonitor data includes separate reporting for fine and coarse aggregates, roadbase/sub-base and other quarry products, by ABS planning district. It also separately reports demand for cementitious products (cement, flyash and GGBFS).

However, it is a demand series and does not differentiate between extractive materials supplied from quarries and substitute construction materials supplied from other origins such as C&D waste or sandstone spoil, whereas the industry survey data and information addresses extractive materials supplied from natural sand and hard rock quarries to the GSR.

The contribution of substitute construction materials to meeting demand for total construction materials can therefore be evaluated by deducting the quantities of extractive materials reported by industry survey (for YE 30 June 2018), from the Macromonitor demand series data (for the same period) which reports both extractive materials and their substitutes (but not separately).

The data from the industry survey responses for extractive materials (applicable to YE 30 June 2018) and Macromonitor's extractive materials demand forecast data, are therefore assumed by the Study to conform to the following relationship.

- Macromonitor data = Extractive Materials data (i.e. RWC survey of hard rock and sand quarries) + Substitutes (recyclables, tunnel spoil, sandstone VENM, etc), for the 12 month period ended 30 June 2018.

This can be simply expressed (for the 12 months ended June 2018) as:

– MM demand data = Extractive materials + Substitute construction materials

By inserting the Macromonitor and Industry Survey data, we have:

– 36.2Mt = 19.5Mt + Substitutes.

Therefore Substitute construction materials = 36.2Mt – 19.5Mt = 16.7Mt.

In percentage terms (by weight), the relationship can be expressed as:

– MM demand data (100%) = Extractive Materials (54%) + Substitutes (46%)

Thus, according to the relationship, substitute construction materials for extractive materials are estimated to meet 46% of demand for sand and crushed rock products (mainly in the sub-base and roadbase categories).

If cementitious materials, which are well-documented in the Macromonitor data, are added into the equation (to represent ‘Construction materials’ as defined under this Study), the proportion of demand for construction materials met by extractive material substitutes is 42% by weight.

The relationship described above is an indirect method to establish the contribution of substitute construction materials to meet the demand for all construction materials in the GSR, and clearly has limitations but in the absence of any complete set of demand or supply data for construction materials from government or the recycling / civil construction industries, it constitutes the most reliable approach to establish an overall picture of both demand and supply for construction materials in the GSR.

The adoption of the relationship relies on the assumption that the industry survey responses and Macromonitor demand data series are sufficiently reliable and accurate so as to justify the use of the data to establish a base case or baseline estimate of the contribution to demand met from sources other than natural sand or hard rock quarries.

No particular evidence was found by RWC during the consultations and evaluations for the Study that either the industry survey responses or the Macromonitor demand series data were flawed in some substantial way, that would prevent their use to form a deductive evaluation of demand met by Substitutes.

Notwithstanding this, clearly the lack of a single coherent data set held by government or industry that covers both extractive materials and their substitutes presents a considerable difficulty for anyone wanting to evaluate a future and nuanced demand and supply balance for construction materials in the GSR.

The Study’s use of the deductive approach is therefore considered the most suitable and reliable to establish a 2018 base case given the limitations of the data available to the Study. Future confirmation of its findings is possible only if a reliable future annual flow of data and information can be provided from the extractive and recycling / civil construction sectors to government.

2011 to 2017 Historical Demand and Supply Profile

Finally, it is noted that the relationship (and percentages) described above applies to the 12 months ended June 2018. The derivation of the Study's historical demand and supply series (2011 to 2017) relies on the assumption that this relationship holds generally over the historical period. However, because industry survey responses did not provide year on year statistics of production sold for the period 2011 to 2017, it cannot be known with certainty what the proportion of demand met by substitutes was, for the historical period.

Accordingly, the historical demand and supply profile (2011 to 2017) has been constructed by RWC on the basis it is a hybrid series – it uses Macromonitor data (considered accurate), 2018 industry survey estimates of product percentages sold by quarries, and Consmat data, which prior to 2013-2014 is considered more reliable than post 2013-2014 as under-reporting is less evident in the Consmat statistics. The effect of these inputs and assumptions is that for the historical series the percentage of demand met by substitute construction materials varies between 41% (2011) to 46% (2018).

5. Segmentation of Demand and Supply Data into GSR Planning Districts

Neither the Consmat data, industry survey data or Macromonitor data provide granular data on the actual destination of construction materials throughout the GSR. The Macromonitor data available to the Study was purchased for each ABS district – by deducting ABS Central Coast data from the ABS Greater Sydney data, the geographic coverage by ABS district was found to be very close to the overall geographic planning boundary for the GSR, but they are not perfectly co-incident.

However, the geographic boundary differences (refer to **Appendix 3**), are considered negligible when determining a demand profile for the GSR as a whole because geographic boundary differences where they are not coincident are in rural areas with low population densities.

Industry survey information provided the best insight as to where extractive materials were being delivered, and was sufficient to provide an estimate of destination by feeder routes and the GSR's three cities, but not sufficient to justify segmentation into GSR's five Planning Districts. Indeed, construction material firms consulted in the survey stated that they typically didn't explicitly collate data that expressed their quarry production by point of use or destination.

This limitation was identified by RWC early in the Study's investigations. A solution was to commission Macromonitor to re-segment their data series by GSR planning district, rather than by ABS planning district, but the capital cost for such work was beyond the scope for the Study.

RWC sought to apply an algorithm to re-allocate the Macromonitor data from ABS planning districts to GSR's five planning districts on the basis of population estimates but the exercise proved unreliable because major projects in particular are location-specific and the use of population estimates alone (for LGAs and planning districts) do not necessarily reflect demand at a point in time (which can be 'lumpy' for particular projects in particular geographic locations).

As a consequence, an approximate estimate of breakdown of demand by three cities (for extractive materials and concrete) was produced by the Study having regard to the information provided to the Study from interviews with senior industry representatives from the major and mid-sized construction materials firms. The information provided by industry representatives covered both the existing 2018 breakdown, and an indication on the future demand/supply profile for the three cities.

In order to resolve this limitation, it is suggested that any future analysis that builds upon the GSR Study, should consider purchasing Macromonitor (or similar data) that is segmented by GSR Planning District. In this way, demand forecasts for each of GSR's five planning districts can be more accurately determined. However, the Macromonitor data are not presently produced and sold in such a format, and a capital cost would be required to establish it in such a form.

6. Types of Quarry Products and Percentage of Supply

The types of quarry products sold and their respective percentages of overall supply for the 2018 baseline profile were established by industry survey and to a lesser extent, from the profile established from reviewing the Consmat data.

The Study highlights those product supply areas where changes could or are likely to occur in the future (e.g. where will future roadbase come from if there's less sandstone spoil in the future; How much will manufactured sand replace natural fine sand; will concrete sand be made from sandstone spoil?).

Whilst the basic technical drivers for consumption of construction materials (i.e. aggregates, roadbases and cementitious materials) are fairly well established by engineering design standards, the source(s) of raw material ingredients may change to some extent in the next 15 to 20 years (more recyclables as aggregates etc) but not the products themselves nor the general proportions of ingredients for use in concrete and asphalt.

For these reasons, the same (2018) quarry product percentages have been assumed to apply to the future demand series to 2036.

7. Sensitivity Analysis of Forecast Demand

The forecast demand and supply profiles for extractive materials are subject to following assumptions.

– For the period 2018 to 2026, Macromonitor forecast series data are adopted without conducting sensitivity analysis on these data. This is because these data, which are based on bottom-up estimates and from consumption algorithms, are considered the best available for the next eight years and so there is no particularly justification for third parties to change them, unless they have better data.

- Beyond 2026, when the Macromonitor forecasts used by the Study end, forecast demand has been calculated in the Study by reference to estimates of prevailing per capita consumption rates and forecast population series. Both metrics can change over time and so the forecast series for the period 2027 to 2036 has been subject to interrogation by varying these estimates, within reasonable upper and lower limits.
- Baseline forecasts of future demand assume the proportion of demand met by substitute construction materials is the same as that established for the 2018 base case – i.e. substitutes for extractive materials comprise 46% of total demand (excluding cementitious materials). In the sensitivity analysis, this assumption has been tested by adopting lower (35%) and higher (50%) estimates for substitute construction materials.

2. Base Case Assessment 2011-2018

2.1 Key Messages

1. In Financial Year (FY) 2018, the average per capita demand for all construction materials was approximately 8.1 tonnes - that is, 8.1 tonnes required for every person living in the GSR. This represents a per capita increase of approximately 53% from FY 2012 to FY 2018 and has been driven by record and coincident levels of demand from all sectors of the building and construction industry (i.e. housing, non-residential buildings, roads and other engineered infrastructure).
2. Total annual demand for construction materials in the GSR in FY 2018 was approximately 40Mt (39.8 million tonnes), or 770 000 tonnes per week, of which extractive materials (crushed rock and natural sand) accounted for approximately 50%. This represents an historic peak in construction materials demand.
3. A key finding of the Study is that whilst the FY 2018 (base-line) level of demand of 40Mtpa represents an historic peak (or near peak) in construction materials demand for the GSR, it also represents a "new norm" in the level of demand. Some future year on year volatility is inevitable, but the total quantity of construction materials presently consumed by the GSR of 40Mtpa is comparable to the Study's forecast longer-term average of 41 Mtpa to 2036.
4. The 39.8 million tonnes of construction materials consumed in FY 2018 comprised:
   - 13.6Mt of crushed rock products (34% of total demand);
   - 5.9Mt of natural sand products (15% of total demand);
   - 3.6Mt of cementitious materials (9% of total demand); and
   - 16.7Mt of substitute construction materials (42% of total demand[6]).
5. Approximately 80% of the crushed rock and natural sand products were used in the manufacture of concrete and asphalt, whereas approximately 85% of the substitute construction materials were used in road construction and a range of infrastructure projects. The principal substitute construction materials consumed were crushed concrete and sandstone virgin excavated natural materials (VENM).
6. In FY 2018, 92% of the demand for extractive materials was met from quarries outside the GSR. No hard rock quarries producing crushed rock products are operating within the GSR, while only 37% of natural sand products were supplied from quarries within the GSR.

[6] This is equivalent to 46% of the total construction materials, excluding cementitious products

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7. Approximately 66% of the crushed rock products supplied to the GSR were transported by road to their points of use and 34% were transported by rail to the four regional distribution centres within the GSR. This represents the highest railed proportion of any city in Australia. However, approximately 85% of the extractive materials transported into the GSR by rail were subsequently loaded into trucks for delivery to their final destination.

8. The hard rock and natural sand quarries focus and specialise in producing higher quality aggregates for use in concrete and asphalt, which are not readily substitutable by substitute construction materials. Approximately 80% of the crushed rock and natural sand products supplied to the GSR are used in the manufacture of concrete and asphalt.

9. Total supply costs[7] for extractive materials in FY 2018 were in the indicative range of $45 to $80 per tonne delivered (~$70/t on average), of which transport costs comprised approximately 40% of the total supply cost to consumers.

10. Delivery times for crushed rock and natural sand products vary from approximately 40 minutes to a maximum of 4 hours. The cost of transportation adds considerably to the total cost of materials, with a typical transport delivery cost of $40 per tonne for a 200km transport distance.

11. The demand for construction materials met by sources other than quarries represents approximately 46% of total GSR demand for construction materials (excluding cementitious products). This is very high by major city standards. Uniquely for Sydney, it arises because of the geology of the eastern section of the GSR generating sandstone materials from civil project works including tunnel spoil and the availability of closer and cheaper recycled concrete.

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2.2 Introduction

Section 2 of this Study addresses the supply and demand profile for the construction materials used throughout the GSR focussing on extractive materials from quarries and the raw materials for concrete and asphalt in particular, for the period 2011 to 2018. In addition, substitutes for extractive materials from other sources, i.e. other construction materials, have also been considered.

The extractive materials profiled in the Study consist of crushed rock products comprising fine and coarse aggregates, roadbase/sub-base and broken/sized rock products and natural sand products. The cementitious materials profiled in the Study comprise cement, concrete grade fly ash and ground granulated blast furnace slag (GGBFS).

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[7] For extractive materials, supply costs comprise the cost to the purchaser at the quarry gate and the transport costs between the quarry and the point of use. Indicative cost estimates (exclusive of GST) and economic drivers are further described in the Supply Cost profile (Section 2.12) and demand and supply balance conclusions in Section 3.9 of this report.

2.2.1 Extractive Materials

A summary of the estimated GSR supply profile for extractive materials from 2011 to 2018 is provided in **Figure 2.1**, in millions of tonnes (Mt). The supply profile for the 12 months ending June 2018 is marked on the chart as FY 2018. The data used to construct **Figure 2.1** is included in tabular form in **Appendix 4**.

Figure 2.1 GSR Supply and Demand Profile for Extractive Materials 2011 to 2018

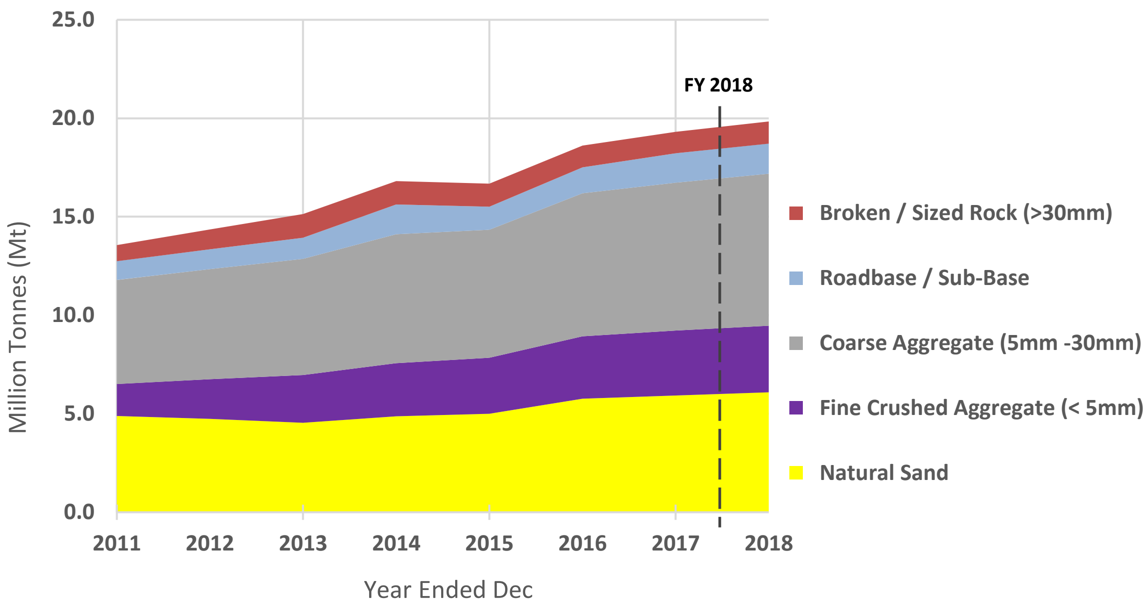

Chart Data Sources

1. Industry Survey of crushed rock and natural sand from quarries - supply profile for FY 2018, RWC Oct 18
2. NSW Govt. Consmat data GSR & Surrounds 2012 to 2017), RWC worked data July 2018
3. Macromoniitor Greater SYDNEY Quarry Products Demand Series YE Dec 2011 to 2026, issued Mar 2018

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Oct 2018

For extractive materials, the Study focusses on hard rock and natural sand quarries that produce fine and coarse aggregates for the manufacture of concrete, asphalt and road sealing (spray seal). The supply and demand profile for extractive materials also includes other processed extractive materials supplied from hard rock quarries such as:

- crushed rock products used in applications other than concrete, asphalt or road sealing (e.g. bedding media, rail ballast, drainage aggregates);
- roadbase and sub-base products used for road construction, road maintenance and hardstand areas; and
- broken and sized products (> 30mm) used, for example, as gabion and revetment rock.

The natural sand products and various crushed rock product types supplied to the GSR in FY 2018 are listed in **Table 2.1**.

Table 2.1
Crushed Rock and Natural Sand Products Supplied to the Greater Sydney Region in FY 2018

Product Type	Quantity	% of Total Quantity
Natural Sand	5.9Mt	30%
Crushed Fine Aggregates (< 5mm)	3.3Mt	17%
Crushed Coarse Aggregates (5mm - 30mm)	7.7Mt	39%
Roadbase / Sub-Base	1.5Mt	8%
Broken/ Sized Rock (>30mm)	1.1Mt	6%
Total	**19.5**Mt	**100%**

The profile in **Table 2.1** for FY 2018 indicates the total crushed rock and natural sand supplies to meet annual demand in the GSR was approximately 19.5Mt. Hard rock quarries accounted for an estimated 70% of the supply of extractive materials to the GSR while natural sand quarries accounted for an estimated 30%.

2.2.2 Substitutes for Hard Rock and Natural Sand Products

It is necessary to differentiate between products supplied from hard rock and natural sand quarries, and materials and products from other sources that substitute for extractive materials in order to appreciate the overall supply profile of construction materials for building and construction throughout the GSR.

The data for **Figure 2.1** do not include:

- material sources that substitute for extractive materials such as recycled concrete, brick and tile from construction and demolition (C&D) waste, crushed steel furnace slag and virgin excavated natural materials (VENM) from civil construction sites such as sandstone tunnel spoil and other excavations in and throughout the GSR that generate surplus rock and soil.
- crushed sandstone supplied from pits or quarries within the GSR that produce select fill, roadbase/sub-base products and aggregates (unsuitable for use in concrete, asphalt or spray seal).
- low-value, unprocessed materials from quarries such as overburden or low-quality processed materials such as ‘scalps’, that are sometimes used as select fill for land development or fill sand, but which have a low economic radius of distribution compared with crushed rock products.

Collectively, the sources of substitute construction materials accounted for approximately 46% of total GSR demand in FY 2018 for all aggregates and roadbase/sub-base products - typically in lower quality applications such as sub-base and drainage aggregates.

Hard rock and natural sand products are therefore estimated to supply approximately 54% of total GSR demand for all construction materials (excluding cementitious materials).

2.2.3 Key Trends in the 2011-2018 Supply Profile

Figure 2.1 shows the increase in the supply of extractive materials to meet demand over the period from 2011 to 2018 as Sydney's building and infrastructure activity has progressively increased – principally through high density residential construction growth and significant infrastructure projects.

Figure 2.1 indicates that supply from hard rock and natural sand quarries to satisfy GSR demand has increased by approximately 44%, i.e. from 13.6Mtpa in 2011 to 19.5Mtpa in FY 2018. This equates to a baseline (FY 2018) GSR per capita consumption of crushed rock and sand of 4.0 tonnes per annum (tpa) – an increase from 3.1tpa in 2011.

From 2012, an increase is evident in the supply of crushed fine aggregate for use as manufactured sand in concrete. This substitution occurred particularly for medium to coarse natural sand, as a number of quarries producing this type of sand closed (e.g. Penrith Lakes). Concurrent with the increased use of manufactured sand has been the increased use of fine dune or coastal sand to achieve the preferred grading for concrete manufacture.

The supply of crushed rock products from hard rock quarries in the GSR feeder areas has increased by approximately 54% in order to meet the increased demand from coincident housing and infrastructure booms. The ensuing supply-side constraints (particularly in development consent conditions for quarries and transportation of crushed rock products) that have arisen because of changes in sourcing of (more distant) raw materials, and the increased level of GSR demand, are of strategic concern to both NSW Government and industry.

The supply-side constraints have the effect of increasing the total cost of construction materials supplied throughout the GSR, which impacts on the affordability of housing, non-residential buildings, roads and infrastructure, as well as traffic congestion. Regular feedback from industry made reference to social pressures relating to potential traffic congestion-related impacts or noise amenity concerns of nearby residents that have led to stronger (and in some cases arbitrary) State and local government restrictions upon truck movements from a number of quarries. This has had the collective impact of restricting hourly truck movements and therefore the efficiency and supply of crushed rock and natural sand products from some quarries.

2.3 Crushed Rock

Hard rock is extracted and processed within quarries to produce a range of crushed rock products for use as aggregates in the production of concrete, asphalt, road surfacing products and rail ballast and crushed roadbase and sub-base pavement materials for roads, broken/sized rock products for gabion and revetment purposes.

The crushed rock supply for the GSR is drawn principally from the four feeder areas surrounding the GSR as all quarries historically producing crushed rock products within the GSR have closed. Small quantities of crushed rock products are transported to the GSR from some more distant regional areas beyond the four feeder areas. These products are invariably of very high quality and destined for use in high value products and/or for use by smaller independent concrete manufacturers who do not have access to their own quarries. A number of the hard rock quarries in feeder areas also supply local and/or regional markets beyond the GSR.

The various crushed rock product types used in FY 2018 are listed in **Table 2.2**.

Table 2.2
Crushed Rock Products Used in the Greater Sydney Region in FY 2018

Product Type	Quantity	% of Total Quantity
Crushed Fine Aggregates (< 5mm)	3.3Mt	25%
Crushed Coarse Aggregates (5mm - 30mm)	7.7Mt	56%
Roadbase / Sub-Base	1.5Mt	11%
Broken/ Sized rock (>30mm)	1.1Mt	8%
Total	**13.6**Mt	**100%**

The profile in **Table 2.2** for the 12 months ending June 2018 indicates the total crushed rock supply to meet annual demand in the GSR was approximately 13.6 Mt.

The production of crushed fine aggregate, which represented an estimated 19% of supply in 2011, has increased to an estimated 25% of the total output of crushed rock products in the FY 2018 estimate. This has been driven by the need to utilise manufactured sand in concrete, as a replacement for natural medium-coarse grained sand.

The quantity of roadbase/sub-base supplied from hard rock quarries to the GSR is significantly reduced because of the availability of crushed sandstone and sandstone VENM – principally for the sub-base component of road construction where sandstone tunnel spoil and excavation surpluses from large civil projects, along with recycled C&D waste, particularly recycled concrete, are available and cheaper.

Because of high surpluses of sandstone tunnel spoil, sub-base materials in the GSR have close to a zero value. The more distant hard rock quarries cannot compete because of the cost of transport and instead stockpile and/or dispose of significant quantities of lower value or zero value waste rock materials produced from their extractive and processing activities.

In other regions of NSW (and for Australian cities generally), where sub-base and roadbase materials are not available from VENM, hard rock quarries as a whole supply a considerably higher proportion of their output as roadbase/sub-base and select fill materials. This also enables the productive use from hard rock quarries of lower value materials that would otherwise be disposed of as waste materials.

2.3.1 Spatial Distribution

Figure 2.2 displays the locations of the 17 hard rock within the four feeder areas supplying crushed rock products to the GSR. Each of these quarries is listed in **Table 2.3** together with the Company's name, rock type and the distance (by road) from Parramatta and Sydney CBD. The average distance of hard rock quarries to the Sydney CBD varies from 118km (Southern Feeder) to 179km (South Western Feeder). No hard rock quarries operate within the GSR.

Figure 2.2 Hard Rock Quarry Locations

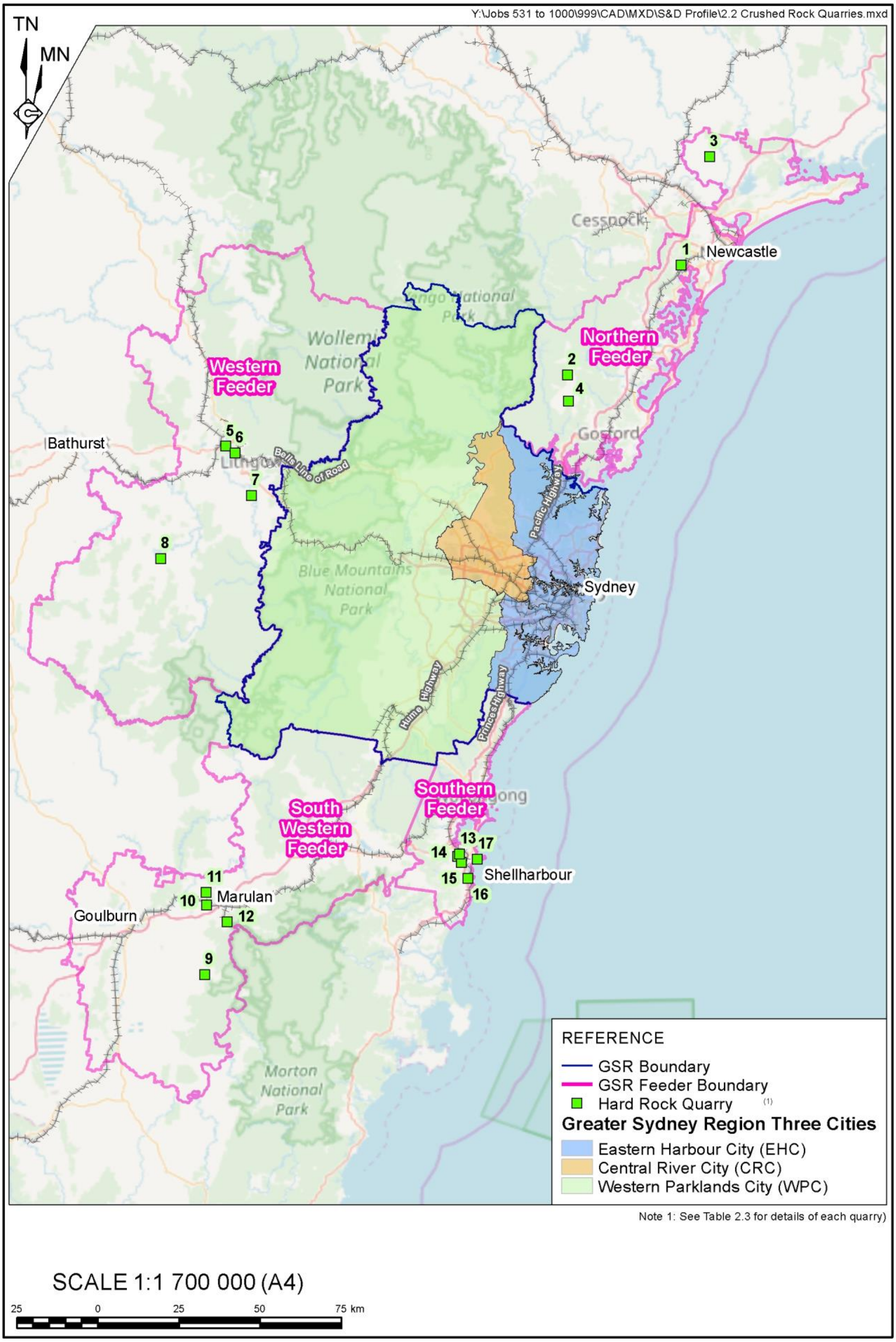

Table 2.3
Approved Hard Rock Quarries in the Greater Sydney Region and Feeder Areas

Ref No.	Company Name	Location (Quarry Name)	Rock Type	Distance (km) from Parramatta	Distance (km) from Sydney CBD
Northern Feeder					
1	Metromix Pty Ltd	Teralba (Teralba Quarry)	Conglomerate	134	139
2	Hanson Construction Materials Pty Ltd	Kulnura (Kulnura Quarry)	Basalt	79	84
3	Hanson Construction Materials Pty Ltd	Brandy Hill (Brandy Hill Quarry)	Rhyodacite	172	177
4	Boral Resources (NSW) Pty Ltd	Peats Ridge (Peats Ridge Quarry)	Basalt	72	77
			Average Distance	**114**	**119**
Western Feeder					
5	Walker Quarries Pty Ltd	Wallerawang (Wallerawang Quarry)	Quartzite	132	153
6	Metromix Pty Ltd	Marrangaroo (Marrangaroo Quarry)	Quartzite	124	144
7	Hy-Tec Industries Pty Limited	Hartley (Austen Quarry)	Rhyolite	118	138
8	Oberon Quarries Pty Ltd	Oberon (Hargraves Quarry)	Basalt	161	181
			Average Distance	**134**	**154**
South Western Feeder					
9	Multiquip Quarries	Bungonia (Ardmore Park Quarry)	Basalt	184	190
10	Holcim (Australia) Pty Ltd	Marulan (Lynwood Quarry)	Ignimbrite	168	174
11	Gunlake Pty Ltd	Marulan North (Gunlake Quarry)	Tuffaceous Rhyolite	166	172
12	Boral Resources (NSW) Pty Ltd	Marulan (Peppertree Quarry)	Granodiorite	172	179
			Average Distance	**172**	**179**
Southern Feeder					
13	Cleary Bros Pty Ltd	Albion Park (Albion Park Quarry)	Latite	97	102
14	Holcim (Australia) Pty Ltd	Albion Park (Albion Park Quarry)	Latite	108	115
15	Boral Resources (NSW) Pty Ltd	Dunmore (Dunmore Quarry)	Latite	114	120
16	Sydney Trains	Bombo (Bombo Quarry)	Latite	123	133
17	Hanson Construction Materials Pty Ltd	Bass Point (Bass Point Quarry)	Latite	116	121
			Average Distance	**112**	**118**

Figure Reference on **Figure 2.2**

2.3.2 Expiry Dates for Approved Quarries Sites

A total of 16 of the 17 hard rock quarries hold development consents until at least 2031 with 14 of the 17 quarries with development consents with expiry dates either beyond 2036 or without any expiry (and with reserves able to supply crushed rock products beyond 2036). The six quarries without expiry dates for their development consents operate under comparatively old development consents issued by their local Council.

The one quarry with a short period left on its development consent has sufficient reserves, if an extension to its development consent is approved, to operate for at least a further 20 years.

Overall, the hard rock quarries supplying the GSR have operational development consents that will enable supply of crushed rock products until 2036 and beyond.

2.3.3 Approved Production Limits

Table 2.4 lists the approved production limits for quarries producing crushed rock products within each of the four feeder areas.

In summary, the combined approved production limits for each feeder area are as follows.

- Northern Feeder – 4.7Mtpa
- Western Feeder – 2.72Mtpa
- South Western Feeder – 10.65Mtpa
- Southern Feeder – >7.5Mtpa

Table 2.4
Approved and Indicative Reserves in Hard Rock Quarries Producing Crushed Rock Products

	No. of Quarries	Combined Approved Production Limits	Production		Combined Approved Reserves	Combined Indicative Resources
			FY 2018 Quantity to GSR	% Products to GSR		
Northern Feeder						
	4	4.70	2.22	47	>32.3[2]	NS[3]
Western Feeder						
	4	2.72	1.42	80	49.0	85
South Western Feeder						
	4	10.65	5.00	95	191.5	500
Southern Feeder						
	5	>7.50[1]	4.92	75	290.1	>75[4]
Totals	**17**	**>25.57**	**13.56**	**78**	**>562.9**	**>660**

1. One quarry does not have a production limit
2. Not all companies provided approved reserves
3. Not supplied by companies
4. Not all companies provided indicative resources

Collectively, the 17 operating quarries supplying crushed rock products to the GSR have approved production limits exceeding approximately 25.6Mtpa.

The combined approved production limits have been assembled based upon data obtained from the DPE website for those quarries with a development consent or project approval issued or managed by DPE and consultations with individual quarry operators.

Furthermore, for many quarries, a proportion of the extractive materials produced are also supplied to local/regional markets outside the GSR. In total, approximately 78% of the hard rock quarry products produced within feeder area quarries were transported for use throughout the GSR in FY 2018. The remaining 22% were consumed by local markets beyond the GSR.

2.3.4 Annual Production

Table 2.4 lists the aggregated total of annual production for crushed rock products delivered to the GSR for the quarries within each of the four feeder areas in FY 2018[8]. In summary, the combined annual production of hard rock products for each feeder area in FY 2018 is estimated as follows.

- Northern Feeder – 2.22Mtpa
- Western Feeder – 1.42Mtpa
- South Western Feeder – 5.00Mtpa
- Southern Feeder – 4.92Mtpa

Collectively, the operating quarries supplied an estimated 13.6Mtpa of crushed rock products to the GSR throughout FY 2018.

2.3.5 Approved Reserves

Table 2.4 lists the approximate aggregated quantity of approved reserves of hard rock within the approved quarries within the four feeder areas. In summary, the combined reserves for each feeder area are as follows.

- Northern Feeder – >32.3Mt
- Western Feeder – 49.0Mt
- South Western Feeder – 191.5Mt
- Southern Feeder – 290.1Mt

Collectively, the operating quarries have approved reserves of at least approximately 563Mt. The aggregated quantity of approved reserves is greater than this amount given not all companies provided details of their approved reserves of hard rock. Those sites, particularly within the Northern Feeder, invariably hold comparatively old development consents and have not been required to publish data about their reserves. It is also understood from consultation with industry that further substantial reserves have been defined within the Northern Feeder that, if approved, would increase the quantity of hard rock reserves able to be transported to the GSR from the north.

2.3.6 Potential Resources within or Adjacent to the Approved Quarries

Table 2.4 lists the approximate aggregated quantity of resources of hard rock capable of producing crushed rock products within or adjacent to the footprint of the approved reserves that could be extracted, if additional approvals are obtained. No detail has been provided by the individual quarry operators indicating the level or rigour of the geological investigation relied upon to define the potential resources within or adjacent to the currently approved quarries.

[8] Insufficient data was available to assemble annual production of crushed rock products for the period 2011-2017.

As in the case of the approved reserves, some companies did not provide any information about the potential resources that could be extracted in the long term.

In summary, the combined potential resources within each feeder area are as follows.

- Northern Feeder – not supplied
- Western Feeder – 85Mt
- South Western Feeder – 500Mt
- Southern Feeder – >75Mt

Collectively, the operating quarries have potential resources of hard rock of at least 660Mt. The likelihood of further development consents to extract the potential resources would reflect a wide range of environmental, social and economic factors. It is industry's preference for the State Government to liaise with the respective companies to ensure planning mechanisms are in place that will protect the potential resources and their respective transport routes from competitive land uses.

2.3.7 Mode of Product Delivery / Delivery Fleet

All crushed rock products from the Northern and Western Feeders are transported to the GSR by road. Both road and rail transportation are used for the delivery of crushed rock products to the GSR from the South Western and Southern Feeders.

Some crushed rock products have previously been transported by sea (until 2011) from Bass Point to Blackwattle Bay near Sydney's CBD.

Road Transportation

Approximately 66% of crushed rock products including most roadbase/sub-base and broken/sized products are transported by road from quarries within the feeder areas to their points of use within the GSR. The products are transported principally in truck and dog trailer configurations with some quarries despatching crushed rock products in high productivity vehicles. The typical average payload (across all truck configurations) assumed for the base case assessment is 35 tonnes.

Rail Transportation

The crushed rock products transported by rail (from the Southern and South Western Feeder areas) consist of aggregates used principally in pre-mixed concrete and asphalt, with lesser quantities of rail ballast. The products that are transported from quarries within the feeder areas by rail (using diesel locomotives) are delivered to a total of four regional distribution centres (RDCs).

Collectively, an average of approximately 40 train loads per week with a capacity of between 2 000t and 2 800t of crushed rock products are transported to the four RDCs. The products transported by rail from quarries account for approximately 34% of total crushed rock products transported into the GSR. Approximately 85% of the crushed rock products unloaded at the four RDCs are reloaded onto trucks for the remainder of their journey to their points of use within the GSR. The remaining 15% of crushed rock products unloaded at the RDCs in the GSR are used on site for concrete and/or asphalt manufacture within an adjoining plant.

Holcim (Australia) Pty Ltd currently proposes to construct and operate a second RDC in the GSR at Banksmeadow where up to 500 000 tonnes of aggregates could be delivered by rail for on-site use and distribution to concrete plants and construction sites in the Eastern Harbour City.

Coastal Shipping

No crushed rock products are currently shipped at present to the GSR, however, a re-commencement of shipping of aggregates by Hanson from Bass Point quarry for unloading at Glebe Island is proposed. Until 2011 when transportation of aggregates by sea (from Bass Point to Blackwattle Bay in Sydney Harbour) ceased, the average ship load was approximately 3 300t, an amount equivalent to approximately 94 truck loads travelling a distance of approximately 120km.

2.3.8 Destinations of Products and Transport Routes

Table 2.5 lists the estimated quantities of crushed rock products transported from the four feeder areas to the Eastern Harbour City, Central River City and the Western Parklands City. Distinction is made between the estimated quantities delivered by road, rail and road/rail during FY 2018. The quantities have been estimated based upon either detailed or an indicative number of loads despatched from the quarries provided by the quarry operator. In some cases, estimates were made without the direct input of the quarry operator. In any event, the number of loads needs to be recognised as indicative as the daily requirements at each point of use naturally varies.

Table 2.5
Destinations of Crushed Rock Products

Mode	GSR Three Cities			Total
	Eastern Harbour City	**Central River City**	**Western Parklands City**	
Northern Feeder				
Road	1.28	0.65	0.30	2.23
Rail	-	-	-	-
Rail/Road	-	-	-	-
Sub-total	**1.28**	**0.65**	**0.30**	**2.23**
Western Feeder				
Road	0.30	0.65	0.47	1.42
Rail	-	-	-	-
Rail/Road	-	-	-	-
Sub-total	**0.30**	**0.65**	**0.47**	**1.42**
South Western Feeder				
Road	0.47	0.30	0.33	1.10
Rail	0.12	0.08	0.10	0.30
Rail/Road	1.85	1.15	0.60	3.60
Sub-total	**2.44**	**1.53**	**1.03**	**5.00**
Southern Feeder				
Road	2.47	1.18	0.55	4.20
Rail	0.15	-	0.02	0.17
Rail/Road	0.30	0.20	0.05	0.55
Sub-total	**2.92**	**1.38**	**0.62**	**4.92**
Totals	**6.94**	**4.21**	**2.42**	**13.57**

The destinations for hard rock products delivered by road are invariably the final points of use, i.e. a concrete batching plant, asphalt plant, concrete products plant or construction site. It is understood that some smaller quarry operators in the feeder areas maintain surge stockpiles of some crushed rock products within the GSR to meet short-term demands of some GSR concrete plants, particularly those with comparatively low stockpile capacities adjacent to their plants. The quantity of products delivered daily to concrete and asphalt plants and construction sites within each of the three cities on a daily basis reflects the extent of construction in each city. Travel times for the delivery of crushed rock products to their points of use typically varied from approximately 1.2 hours to 4 hours.

In FY 2018, the estimated overall distribution of the 13.6Mt of crushed rock quarry products supplied to the GSR was as follows.

- Eastern Harbour City – 51%
- Central River City – 31%
- Western Parklands City – 18%

This profile is similarly reflected in the distribution of concrete production throughout the GSR.

Table 2.6 lists the indicative average number of laden trucks per day travelling on the principal and main secondary roads delivering crushed rock products throughout the GSR.

Table 2.6
Crushed Rock Road Transportation Routes and Daily Truck Loads

Transport Route	Average Daily Truck Loads	Average Tonnes per Day
Northern Feeder		
Principal Transport Routes		
Pacific Highway (M1) (North)	227	7 945
Secondary Transport Routes		
Pacific Highway (M1) (North)	56	1 960
Pennant Hills Road (A28)	148	5 180
Western Feeder		
Principal Transport Routes		
Great Western Highway (A32)	143	5 005
Secondary Transport Routes		
The Northern Road (A9) (northbound)	15	525
The Northern Road (A9) (southbound)	10	350
M4 Motorway	118	4 130
South Western Feeder		
Principal Transport Routes		
Hume Motorway (M31)	506	17 710
Secondary Transport Routes		
The Northern Road (A9) (northbound)	12	420
M5 Motorway	346	12 110
M7 Motorway	160	5 600
Southern Feeder		
Principal Transport Routes		
Princes Highway (M1) (South)	193	6 755
Secondary Transport Routes		
King Georges Road (A3)	30	1 050
Princes Highway (A1)	30	1 050

Figure 2.3 identifies the principal transport routes used by product trucks delivering crushed rock products to concrete and asphalt plants and construction sites throughout the GSR together with the indicative average number of laden trucks and average quantity of crushed rock products transported daily on each route. The average daily number of truck loads was calculated by dividing the FY 2018 production tonnage for each quarry delivered to the GSR by 280 (days)[9] and then the calculated numbers were aggregated.

In total, an average of approximately 1 070 truck loads of crushed rock products were transported to the GSR on a daily basis throughout FY 2018. Approximately 47% of the trucks travelled northwards via the Hume Highway from the South Western Feeder and the Southern Feeder[10] with the Pacific Highway from the Northern Feeder being the next most-travelled route (21%).

Crushed rock products are transported by rail from the two largest hard rock quarries in the South Western Feeder, namely the Peppertree and Lynwood Quarries, near Marulan. The two quarries hold approvals to despatch a combined maximum of 7.0Mtpa of quarry products by rail. During FY 2018, a total of approximately 3.9Mt of crushed rock products were transported by rail from these two quarries to the GSR.

The bulk of the crushed rock products from Peppertree Quarry are transported by rail to Boral's Maldon RDC and then by road throughout the GSR, with some products also railed to the St Peters and Enfield RDCs. Crushed rock products from the Lynwood Quarry are railed to the Rooty Hill RDC where they are similarly unloaded, stockpiled and reloaded onto product trucks for delivery to sites throughout the GSR. Crushed rock products are also transported by road from the Lynwood Quarry to the GSR via the Main Southern Railway Line.

Crushed rock products are transported by rail from the Southern Feeder area from both the Dunmore and Bombo Quarries, although production of crushed rock products (rail ballast) is programmed to cease at the Bombo Quarry during 2019. The products from Dunmore Quarry are delivered by rail to both Enfield and St Peters RDCs for use at the on-site concrete and/or asphalt plants with the remainder transported to other inner city plants.

The delivery of crushed rock products from the South Western Feeder remains comparatively efficient given the route used is part of the Main Southern Railway Line, which caters for rail freight. This is not the case for the Illawarra Railway Line that is predominantly a passenger train line which has a more limited number of rail paths available for freight.

2.3.9 Approved Hours of Transportation

Table 2.7 lists the range of approved hours of transportation for the quarries producing crushed rock products within the four feeder areas.

[9] 280 days is based on 260 weekdays + 28 days equivalent (for Saturday) less 8 public holidays

[10] Approximately 50% of laden trucks from the Southern Feeder travel to the GSR via the Princes Highway with the other 50% travelling via Picton Road to the Hume Highway

Figure 2.3 Crushed Rock Products Transport Routes

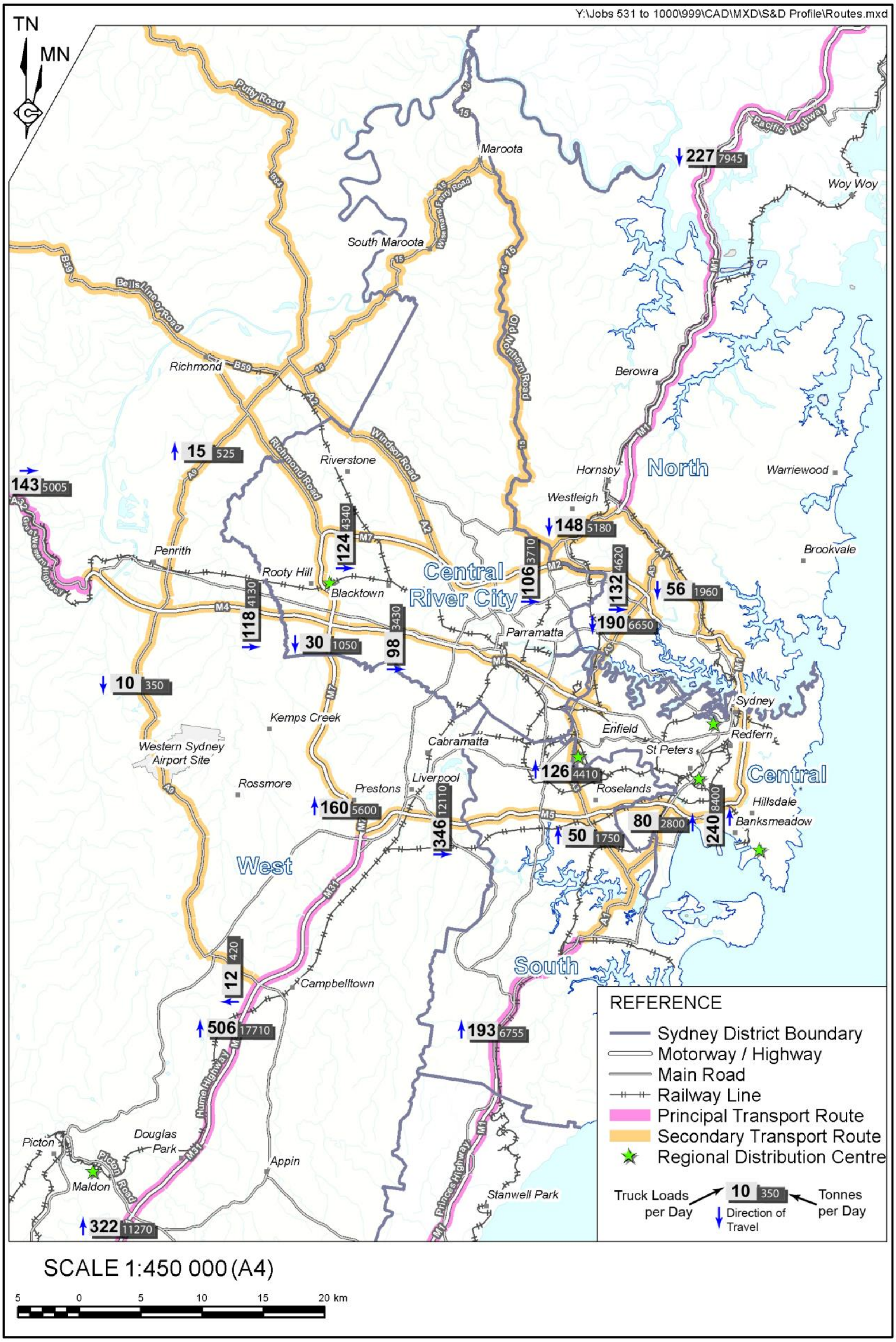

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Table 2.7
Approved Transport Hours for Hard Rock Quarries

Monday to Friday		Saturday		Sunday	
Period	No. of Sites	Period	No. of Sites	Period	No. of Sites
Northern Feeder					
4:00am – 11:59pm	1	12:00am – 6:00pm	1	-	-
7:00am – 6:00pm	1	7:00am – 4:00pm	1	-	-
6:00am – 5:00pm	1	6:00am – 10:00pm	1	-	-
12:00am – 11:59pm*	1	12:00am – 11:59pm*	1	12:00am – 11:59pm*	-
Western Feeder					
4:00am – 10:00pm	1	5:00am – 3:00pm	1	-	-
6:00am – 10:00pm	1	6:00am – 5:00pm	1	-	-
12:00am – 11:59pm*	1	12:00am – 11:59pm*	1	12:00am – 11:59pm*	1
7:00am – 6:30pm	1	7:00am – 2:00pm	1	-	-
South Western Feeder					
12:00am – 11:59pm*	2	12:00am – 11:59pm*	2	12:00am – 11:59pm*	2
7:00am – 6:00pm	1	7:00am – 1:00pm	1	-	-
12:00am – 11:59pm*	1	12:00am – 6:00pm*	1	-	-
Southern Feeder					
12:00am – 11:59pm*	2	12:00am – 11:59pm*	2	12:00am – 11:59pm*	2
12:00am – 11:59pm*	1	12:00am – 11:59pm*	1	8:00am – 6:00pm	1
Not known	2	Not known	2	Not known	2

* 12:00am – 11:59pm equates to continuous or 24 hours/7 days per week operation

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The approved transport hours invariably relate to the periods during which trucks or trains are permitted to enter a quarry, be loaded and travel from a quarry onto the local/regional road network. Considerable variation is present amongst all quarries with the periods often (but not always) related to local community or environmental conditions. A common objective of many operators of hard rock quarries is the preference to commence earlier product despatch to enable trucks to approach the GSR prior to the morning peak period.

Insufficient information was assembled to provide an understanding of extent of product truck movements before, during and after the morning and afternoon peak periods.

2.3.10 Concluding Comments

The 17 hard rock quarries within the four feeder areas that currently supply a range of crushed rock products to the GSR:

- vary in distance to the Sydney CBD from 118km (Southern Feeder) to 179km (South Western Feeder);
- have combined approved production limits capable of meeting demand until and beyond FY 2036;

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- the hard rock products supplied in FY 2018 accounted for approximately 53% of the combined approved production limit of the 17 quarries, approximately 78% of output is delivered to the GSR;
- collectively have substantial approved reserves able to sustain production well beyond FY 2036;
- collectively hold or have access to further hard rock resources (not yet approved) that could extend the operational life of many of the quarries;
- rely principally upon the Hume Highway to supply strategically located destinations principally in the Eastern Harbour City; and
- do not currently rely on shipping for transport of products.

Anecdotal information from a number of quarry operators suggest that the road network could be more effectively used outside of peak periods and that the rail networks availability could be optimised to permit more efficient rail access to the existing and proposed inner city RDCs.

In order to improve transport efficiencies and reduce traffic congestion during peak hours, industry leaders consulted during the Study pointed to supply-side contingencies in major cities around the world, where transport of aggregates by rail or ship, and re-stocking by truck of batching plants outside peak traffic hours, are actively promoted by cities.

These constraints and future trends for the supply of crushed rock products are discussed in more detail in Section 3.6.

2.4 Natural Sand

The term ‘natural sand’ is used in this Study in reference to naturally-occurring deposits of sand of various depositional origins and particle sizing, that are excavated and processed by extractive industry companies to produce washed, sized and graded sands for use in concrete, mortar, asphalt, bedding media and some specialist applications.

Natural sand products are supplied to the GSR from 12 quarries within the GSR and 15 quarries within the four feeder areas surrounding the GSR. A number of the quarries in the feeder areas also supply sand to local and/or regional markets beyond the GSR.

Natural sand of suitable quality can also be used to produce mineral products such as silica sand for foundry or glass use and as a raw material filler in cement manufacture. Demand from these industrial mineral markets for natural sand have not been evaluated for the Study, and they are excluded from the natural sand demand profile.

Sand used for construction purposes is described and specified in engineering specifications for concrete as fine, medium or coarse grain size. Concrete requires an overall graded sand for superior performance and to minimise manufacturing costs (i.e. a combination of fine, medium and coarse sand grain sizes). Manufactured sands from hard rock quarry sources are increasingly used as substitutes for medium-coarse natural sand in concrete because available reserves of medium-coarse natural sand within the GSR are diminishing.

There is much less substitutability at present for natural fine sands. As fine sand reserves in the GSR are now very limited, concrete batching plants within the GSR import the majority of its fine sand requirements from the Northern Feeder area.

Table 2.8 lists the estimated proportion of natural fine sand and natural medium and coarse sand used within the GSR for the 12 months ending June 2018. The total natural sand supply to meet annual demand in the GSR during FY 2018 was approximately 5.9Mt.

Table 2.8
Natural Sand Usage by Product Type in the Greater Sydney Region – FY 2018

Product Type	% of Total Tonnes	Total Tonnes
Natural Fine sand	47	2.8
Natural Medium and Coarse sand	53	3.1
Total	**100**	**5.9**

For FY 2018, natural fine sand was supplied largely from reserves of dune sand or coastal sand, whereas the bulk of the medium grained sand was sourced from quarries extracting friable sandstone from the Hawkesbury Sandstone. The coarse sand produced was sourced from Tertiary sand deposits in the Maroota area and near Bungonia in the South Western Feeder area.

As outlined in Section 2.1, the production of 5.9Mtpa of natural sand products in FY 2018 represents an increase in production of approximately 20% over seven years – up from 4.9Mtpa in 2011. Because substitutes for fine sand are more limited, the quantity and proportion of fine sand within the total natural sand demand profile is of particular interest to the Study.

Data from natural sand quarries is aggregated for the GSR and each feeder area, whenever individual sites can be identified from more granular data. This is to ensure confidentiality of data is not compromised. Given there is only one natural sand quarry in each of the Western and Southern Feeder areas, aggregation of data is undertaken with that assembled for the South Western Feeder area.

2.4.1 Spatial Distribution

Figure 2.4 displays the locations of the 27 quarries supplying sand products to the GSR. Each of these quarries is listed on **Table 2.9** together with the Company’s name, sand source and the distance from Parramatta and Sydney CBD.

Figure 2.4 Natural Sand Quarry Locations

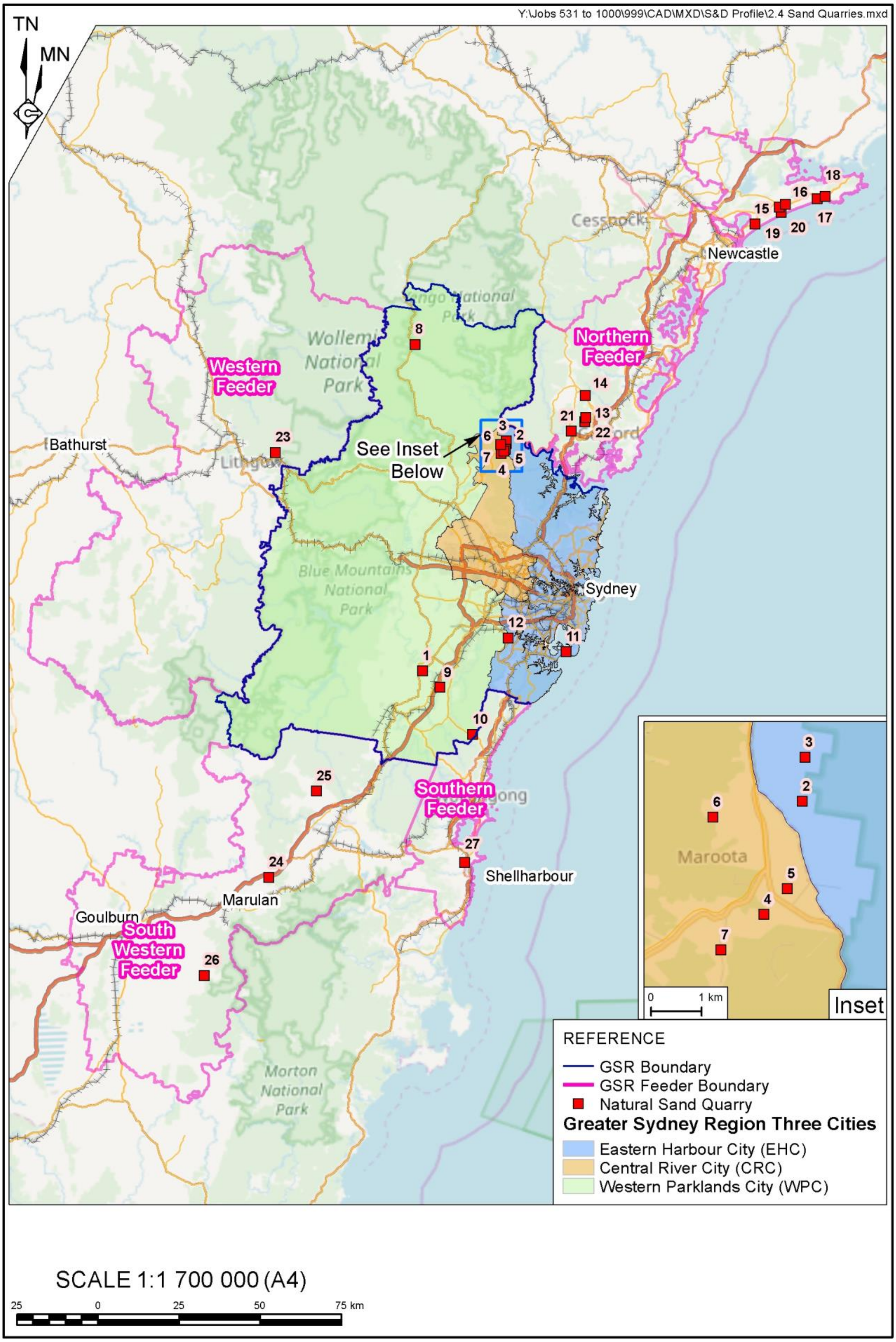

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Table 2.9
Approved Natural Sand Quarries – Greater Sydney Region and Feeder Areas

Ref No.	Company Name	Location (Quarry Name)	Sand Source	Distance (km) from Parramatta	Distance (km) from Sydney CBD
GSR					
1	Collins Construction Materials Pty Limited	Elderslie (Spring Farm Quarry)	Tertiary Sand	53	65
2	PF Formation	Maroota (Old Telegraph Road Quarry (PF Pit 4))	Friable Sandstone	53	66
3	PF Formation	Maroota (Old Northern Road Quarry (Pit 5))	Friable Sandstone	52	65
4	PF Formation	Maroota (Hitchcock Road Quarry)	Friable Sandstone	51	64
5	Hodgson Quarry Products Pty Ltd	Maroota (Roberts Road Quarry)	Friable Sandstone	50	62
6	Dixon Sand (Penrith) Pty Ltd	Maroota (Old Northern Road Quarry)	Friable Sandstone	52	65
7	Dixon Sand (Penrith) Pty Ltd	Maroota (Hearses Road Quarry)	Friable Sandstone	53	65
8	Hy-Tec Industries Pty Limited	Tinda Creek (Tinda Creek Quarry)	Alluvial Sand	100	123
9	Hi Quality Environmental Pty Ltd	Menangle (Menangle Sand Quarry)	Friable Sandstone	54	69
10	Joe Taylor Sands Pty Ltd	Appin (Appin Quarry)	Friable Sandstone	79	73
11	Allsands Pty Ltd	Kurnell (Kurnell Sand Quarry)	Dune Sand	42	33
12	Benedict Industries Pty Ltd	Sandy Point (Sandy Point Quarry)	Friable Sandstone	27	44
			Average Distance	**54**	**66**
Northern Feeder					
13	GR & AK Jones (Grants Road Sands)	Somersby (Grants Road Sand Quarry)	Friable Sandstone	69	75
14	Hodgson Quarry Products Pty Ltd	Somersby (Somersby Quarry (Wards Pit))	Friable Sandstone	76	81
15	Sibelco Australia Limited	Salt Ash (Salt Ash Quarry)	Dune Sand	183	188
16	ATB Morton Pty Ltd - Redisand	Salt Ash (Salt Ash Sand Mine)	Dune Sand	182	187
17	Sibelco Australia Limited	Anna Bay (Anna Bay Quarry)	Construction Sand	192	197
18	SS and LM Johnston Pty Ltd	Anna Bay (Johnstons Quarry)	Construction Sand	194	199
19	Boral Resources (Country) Pty Ltd	Stockton (Stockton Sandpit)	Dune Sand	180	185
20	Mackas Sand & Soil Pty Ltd	Williamtown (Williamtown / Salt-Ash Quarries)	Construction Sand	178	183
21	Hanson Construction Materials Pty Ltd	Calga (Calga Sand Quarry)	Friable Sandstone	74	79
22	Hanson Construction Materials Pty Ltd	Somersby (Central Coast Sand Quarry)	Friable Sandstone	72	77
			Average Distance	**140**	**145**
Western Feeder					
23	Hanson Construction Materials Pty Ltd	Clarence (Clarence Sand Quarry)	Friable Sandstone	113	135
South Western Feeder					
24	Hy-Tec Industries Pty Limited	Penrose (Penrose Quarry)	Friable Sandstone	142	148
25	Benedict Industries Pty Ltd	Mittagong (Mittagong Quarry)	Friable Sandstone	122	128
26	Multiquip Quarries	Bungonia (Ardmore Park Quarry)	Friable Sandstone	184	190
			Average Distance	**149**	**155**
Southern Feeder					
27	Dunmore Sand and Soil Pty Ltd	Dunmore (Dunmore Lakes Quarry)	Coastal Barrier Sands	114	120

Reference number on **Figure 2.4**

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2.4.2 Expiry Dates for Approved Quarries

Table 2.10 lists the range of expiry dates for the approved natural sand quarries supplying sand to the GSR together with the proportion of approved reserves that relate to each group of expiry dates.

Table 2.10
Expiry Dates for Approved Quarries Producing Natural Sand Products

Expiry Dates	Number of Sites	Proportion of Approved Reserves
GSR		
2019 to 2025	2	2%
2026 to 2030	2	5%
2031 to 2036	2	4%
Beyond 2036	6	38%
Subtotal	**12**	**49%**
Northern Feeder		
2019 to 2025	1	1%
2026 to 2030	4	20%
2031 to 2036	0	0%
Beyond 2036	5	15%
Subtotal	**10**	**36%**
Western, South Western and Southern Feeders		
2019 to 2025	1	2%
2026 to 2030	0	3%
2031 to 2036	0	0%
Beyond 2036	4	10%
Subtotal	**5**	**15%**
Total	**27**	**100%**

The following summary applies to the nominated expiry dates for the approved natural sand quarries.

- Four quarries have expiry dates before 2025 although two of the quarries have sufficient reserves to extend the duration of their development consents until at least 2030. The two remaining quarries are likely to cease operating before about 2025.
- Six quarries, which account for 28% of the approved reserves, would either cease operations or seek extensions of their development consents before 2030 for periods of 5 to 20 years.
- Fifteen quarries (both within the GSR and feeder areas) hold development consents or project approvals to operate beyond 2036 and collectively account for approximately 60% of the approved reserves.

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2.4.3 Approved Production Limits

Table 2.11 lists the range of approved production limits for each of the 27 quarries producing natural sand products within the GSR and the four feeder areas. Three natural sand quarries within the GSR do not have production limits placed upon their development consents. Therefore, the combined production limit for the natural sand quarries in the GSR is conservative.

Table 2.11
Annual Production and Reserves at Natural Sand Quarries

	No. of Sites	Approved Production Limits	% Production to GSR	Annual Production		Approved Reserves	Potential Reserves
				2011-2017[1]	2017-2018[2]		
GSR							
	12	>3.49Mt[3]	90%	2.10Mt	2.18Mt	52Mt	56Mt
Northern Feeder							
	10	4.39Mt	72%	2.75Mt	2.27Mt	39Mt	24Mt
Western, South Western and Southern Feeders							
	5	2.55Mt	90%	0.79Mt	1.43Mt	16Mt	20Mt
Total	**27**	>10.46Mt	81%	5.64Mt	5.88Mt	107Mt[4]	>100Mt

[1] Total quarry production calculated as an average of the highest and lowest annual production

[2] Only includes sand products delivered to the GSR

[3] Three quarries have no production limit although FY 2018 production has been included for calculation purposes

[4] This quantity excludes one approved quarry with an approved yield of 30Mt that was approved in 2013 but has an uncertain date of commencement.

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In summary, the combined approved production limits for the feeder areas are as follows.

- GSR – >3.5Mtpa
- Northern Feeder – 4.4Mtpa
- Western, South Western and Southern Feeders – 2.6Mtpa

Collectively, the operating quarries have approved production limits exceeding approximately 10.5Mtpa.

2.4.4 Annual Production

Table 2.11 lists the range of annual production for the quarries producing natural sand products within the GSR and the feeder areas for the period 2012-2017 and in FY 2018. In summary, the combined annual production within the GSR and for each feeder area in FY 2018 is as follows.

- GSR – 2.18Mtpa
- Northern Feeder – 2.27Mtpa
- Western, South Western and Southern Feeders – 1.43Mtpa

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Collectively, the operating quarries supplied an estimated 5.9Mtpa of natural sand products, principally for use in concrete (pre-mixed concrete, pre-cast concrete and mortar) and asphalt in the GSR in FY 2018 which represented approximately 81% of natural sand production from these quarries. The remaining 19% was consumed by local/regional markets surrounding these quarries.

2.4.5 Approved Reserves and Resources

Table 2.11 lists the approximate combined quantity of approved reserves of natural sand within quarries in the GSR and each of the feeder areas. In summary, the combined approved reserves for each feeder area are as follows.

- GSR – 52Mt
- Northern Feeder – 39Mt
- Western, South Western and Southern Feeders – 16Mt

Collectively, the operating quarries have approved reserves of approximately 107Mt, almost 50% of which are held within quarries within the GSR itself.

2.4.6 Potential Extractive Materials Within or Adjacent to the Approved Quarries

Table 2.11 lists the approximate combined quantity of natural sand capable of producing fine aggregates within or adjacent to the footprint of the approved quarries that could be extracted, if additional approvals are obtained.

In summary, the combined potential resources for each feeder area are as follows.

- GSR – 56Mt
- Northern Feeder – 24Mt
- Western, South Western and Southern Feeders – 20Mt

Collectively, the operating quarries have potential resources of natural sand of approximately >100Mt.

It is noted that consultation with industry has identified that the opportunity exists, if supported by the NSW Government, for windblown sand resources in the Williamtown/Salt Ash/Stockton area to be "harvested" with a comparatively low level of environmental impact. At present, this sand is located within the natural encroaching dune system which is progressively smothering native vegetation.

2.4.7 Mode of Product Delivery / Delivery Fleet

Apart from approximately 180 000t (~3%) of fine sand delivered by rail from the Dunmore Lakes Sand Quarry to St Peters and Enfield, all sand products are delivered to their points of use within the GSR by road.

The natural sand products are transported principally in truck and quad dog trailer configurations with some quarries despatching sand products in high productivity vehicles, particularly from those sites north of Newcastle where delivery distances into GSR are in excess of 150km. The Study's consultations with industry indicated the typical average load is approximately 35 tonnes.

2.4.8 Destinations of Products and Road Transport Routes

Table 2.12 lists the estimated quantities of sand products transported from the four feeder areas to each of the GSR Three Cities.

Table 2.12
Destinations of Sand Products within the Greater Sydney Region

No. of Sites	Total Annual Production	GSR Three Cities		
		Eastern Harbour City	Central River City	Western Parklands City
GSR				
12	2.18Mt	1.20Mt	0.66Mt	0.32Mt
Northern Feeder				
10	2.27Mt	1.25Mt	0.68Mt	0.34Mt
Western, South Western and Southern Feeder				
5	1.43Mt	0.79Mt	0.43Mt	0.21Mt
Total	**5.88**Mt	**3.24**Mt	**1.77Mt**	**0.87Mt**

In summary, the indicative quantities of natural sand products delivered to the GSR Three Cities are as follows.

- Eastern Harbour City – 3.2Mt
- Central River City – 1.8Mt
- Western Parklands City – 0.9Mt

Table 2.13 lists the average number of laden trucks per day travelling on the principal and main secondary roads delivering natural sand products throughout the GSR. The quantities have been estimated based upon either detailed or an indicative number of loads despatched from the quarries provided by the quarry operator. In some cases, estimates were made without the direct input of the quarry operator. In any event, the number of loads needs to be recognised as indicative as the daily number of loads at each point of use varies naturally on a daily basis.

Travel times for the delivery of natural sand products to their points of use typically varied from 40 minutes to 4 hours.

Figure 2.5 identifies the various road transport routes used by product trucks delivering sand to the concrete and asphalt plants and construction sites throughout the GSR together with the indicative average number of laden trucks and average quantity of sand products transported daily on each route. The average daily number of truck loads was calculated by dividing the

FY 2018 production tonnage for each quarry delivered to the GSR by 280 (days)[11] and then the calculated numbers were aggregated. The Macromonitor demand data by the 'Point of Use' sectors does not differentiate between demand met by quarries and demand met by substitute construction materials such as, sandstone VENM, crushed sandstone from quarries and recycled materials from C&D waste, principally crushed concrete.

Table 2.13
Sand Products Transportation Routes and Daily Truck Loads

No. of Sites	Transport Route	Average Tonnes per Day	Average Trucks per Day
	GSR		
Transport Routes			
6	Old Northern Road (Tourist Drive 15)	1 785	51
6	Wisemans Ferry Road (Tourist Drive 15)	2 450	70
1	Taren Point Road	NR*	NR*
1	Putty Road (B84)	NR*	NR*
1	Heathcote Road	NR*	NR*
	Northern Feeder		
Principal Transport Route			
10	Pacific Highway (M1) (North)	8 250	236
Secondary Transport Routes			
10	Pacific Highway (A1)	2 240	64
10	Pennant Hills Road (A28)	6 020	172
	Western Feeder		
Principal Transport Route			
1	Great Western Highway (A32)	1 295	37
Secondary Transport Routes			
1	The Northern Road (A9) (northbound)	350	10
	South Western Feeder		
Principal Transport Route			
2	Hume Motorway (M31)	3 850	110
Secondary Transport Routes			
2	The Northern Road (A9) (northbound)	630	18
2	M5 Motorway	2 450	70
2	M7 Motorway	770	22
	Southern Feeder		
Principal Transport Route			
1	Princes Highway (M1) (South)	350	10
Secondary Transport Routes			
2	King Georges Road (A3)	1 085	31
2	Princes Highway (A1) (South)	595	17

* Not Reported as only a single quarry uses the subject road

[11] 280 days is based on 260 weekdays + 28 days equivalent (for Saturday) less 8 public holidays

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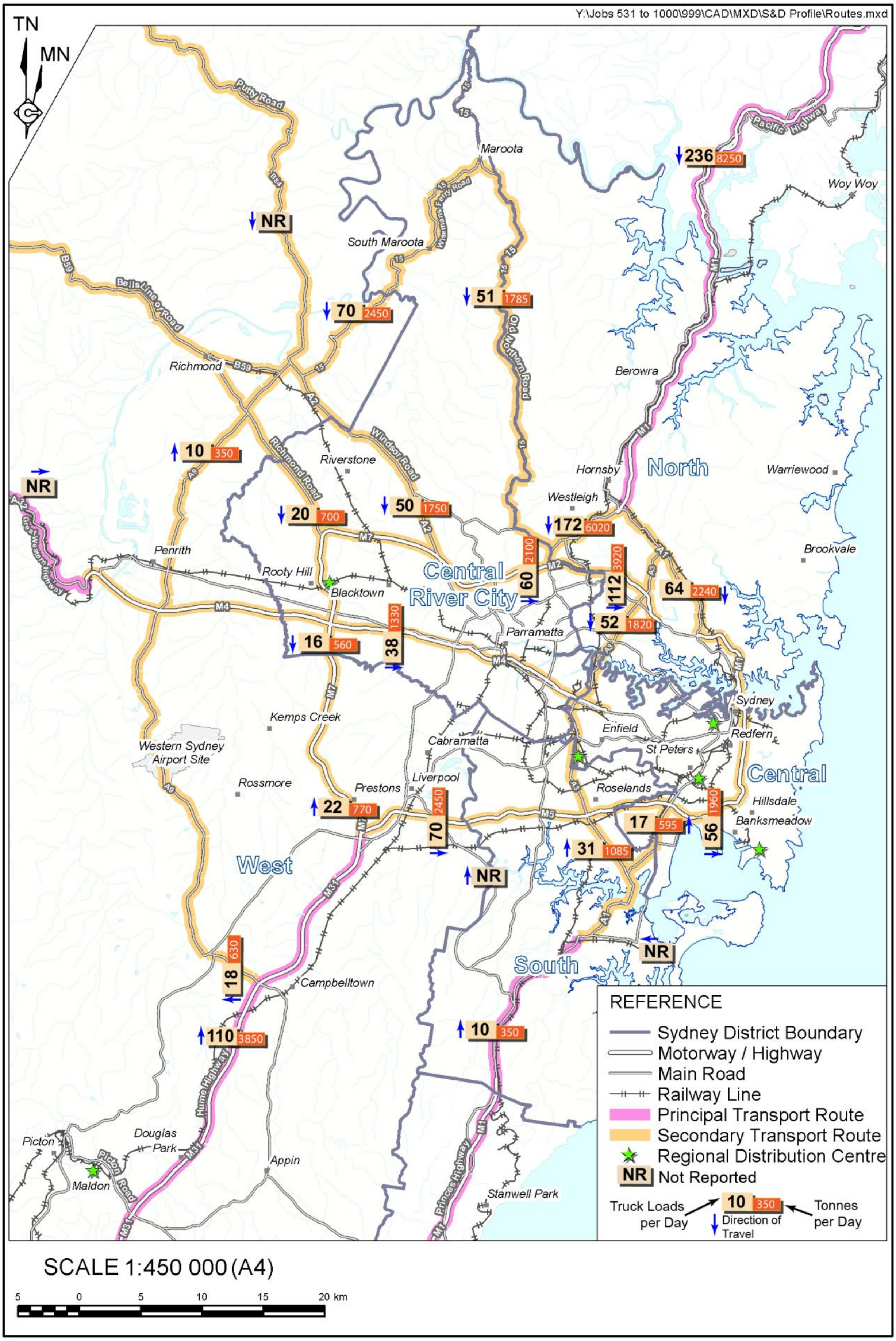
Figure 2.5 Natural Sand Products Transport Routes



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2.4.9 Approved Hours of Transportation

Table 2.14 lists the range of approved hours of transportation for the quarries producing sand products within the GSR and the four feeder areas.

Table 2.14
Approved Hours of Transportation for Natural Sand Quarries

Monday to Friday		Saturday		Sunday	
Period	**No. of Sites**	**Period**	**No. of Sites**	**Period**	**No. of Sites**
GSR					
12:00am – 11:59pm*	3	12:00am – 11:59pm*	3	12:00am – 11:59pm*	3
7:00am – 5:00pm	1	8:00am – 1:00pm	1	-	1
5:00am – 10:00pm	1	6:00am – 3:00pm	1	-	1
7:00am – 5:00pm	1	7:00am – 1:00pm	1	-	1
7:00am – 6:00pm	1	7:00am – 6:00pm	1	-	1
6:00am – 6:00pm	1	7:00am – 1:00pm	1	-	1
6:00am – 6:00pm	3	6:00am – 6:00pm	3	-	3
6:30am – 4:30pm	1	6:30am – 12:00pm	1	-	1
Northern Feeder					
5:00am – 10:00pm	1	5:00am – 4:00pm	1	12:00am – 11:59pm	1
5:00am – 10:00pm	1	5:00am – 4:00pm	1	-	1
6:00am – 4:00pm	1	6:00am – 2:00pm	1	-	1
7:00am – 5:00pm	1	7:00am – 1:00pm	1	-	1
7:00am – 5:00pm	1	8:00am – 1:00pm	1	-	1
6:00am – sunset	1	6:00am to sunset	1	-	1
7:00am – 6:00pm	1	7:00am – 1:00pm	1	-	1
6:15am – 5:00pm	1	6:15am – 12:00pm	1	-	1
Unknown	2	Unknown	2	Unknown	2
Western, South Western and Southern Feeders					
12:00am – 11:59pm*	1	12:00am – 11:59pm*	1	12:00am – 11:59pm*	1
5:00am – 11:59pm	1	6:00am – 6:00pm	1	8:00am – 4:00pm	1
7:00am – 10:00pm	1	7:00am – 10:00pm	1	-	1
6:00am – 9:00pm	1	-	1	-	1
7:00am – 6:00pm	1	7:00am – 1:00pm	1	-	1

* 12:00am – 11:59pm equates to continuous or 24 hours/7 days per week operation

The natural sand quarries within the GSR and feeder areas have variable periods during which products can be transported from the quarries. Product despatch typically commences from 5:00am to 7:00am and concludes between 5:00pm and 6:00pm. Consultation with industry indicates that those operations that start at 7:00am, or even 6:00am, would prefer to start earlier, or continue to despatch products later (until 10:00pm).

A total of four quarries are currently able to despatch sand products 24 hours per day, 7 days per week.

Product despatch on a Saturday typically commences at a similar time to weekdays, however, many quarries cease despatching products by between 1:00pm and 3:00pm. Very few quarries have approval to despatch quarry products of a Sunday.

2.4.10 Concluding Comments

Natural sand is currently supplied into the GSR from 27 quarries with twelve of these quarries located in the GSR itself. These quarries:

- vary in distance from the Sydney CBD with distances of 33km to typically <70km for quarries within the GSR and as far as 199km for more distant locations beyond Newcastle;
- are transporting approximately 5.9Mt of natural sand or 81% of their total production to the GSR, however are not all operating at their understood approved production limits;
- are capable of maintaining the existing level of supply beyond 2036, provided that the current development consents for approximately 12 quarries are extended or new consents received;
- hold approved reserves and unapproved resources capable of maintaining supply to 2036 and beyond, notwithstanding the approval modifications to duration or lateral extension of some operations; and
- are principally relying on road transport with the majority of products delivered to the Eastern Harbour City.

The closure of the Penrith Lakes operations in 2014 resulted in industry responding by increasing the proportion of manufactured sand produced at a number of the hard rock quarries. This in turn required greater use of fine dune sand or coastal sand to achieve the preferred grading for concrete manufacture. Some locations within the GSR, e.g. Maroota have been the focus of considerable production and others are also approaching exhaustion by about 2025. These sources are being complemented by more distant sources of natural sand that are seeking to fill the supply gap from existing GSR quarries. Existing constraints and trends for natural sand supply are discussed in more detail in Section 2.13.

2.5 Cementitious Materials

2.5.1 Overview

The GSR consumed an estimated 3.6Mtpa (FY 2018 base case) of cement and supplementary cementitious materials (SCMs, which comprised concrete-grade fly ash and GGBFS[12]. The cementitious products are used as cement binders in pre-mixed concrete, pre-cast concrete and mortars. Small quantities are also used in cement-treated (stabilised) roadbase.

[12] Macromonitor NSW Sydney construction material consumption and forecast data, March 2018 by cement, fly ash and GGBFS

Table 2.15 provides a summary of the bulk cementitious materials and their sources relied upon for the Study base case (FY 2018) drawn from consultations with industry consultants. This information highlights the reliance on shipping terminals for domestic and international import of cementitious materials.

Table 2.15
Summary of Cementitious Materials and Origin

Cementitious Materials	Primary Sources
Cement	• Boral (Berrima/Maldon) • Cement Australia/Levy JV (Port Kembla) [grinder capacity ~1.0M tonnes per annum] • Adelaide Brighton Limited Cement Plants, South Australia and grinder at Port Kembla [grinder capacity ~0.4M tonnes per annum] • Clinker for Port Kembla plants imported from Asia • Cement Australia Glebe Island – cement products imported from Railton (Tasmania) • Boral terminal Newcastle – cement imported from Sunstate (Qld).
Fly Ash	• Fly ash offtake facilities at Eraring, Mt Piper and Bayswater Power Stations • Cement Australia Glebe Island – fly ash imported from Qld • Boral terminal Newcastle – fly ash imported from power stations in NSW and Qld. • Imported in bulk from Asia, India.
Blast Furnace Slag	• Port Kembla steelworks • Imported in bulk from various international locations

Data derived from Macromonitor 2018 and consultations with industry consultants indicate the quantities of cementitious materials used in the GSR in FY 2018 were as follows.

- Cement: 2.5Mt
- Fly Ash: 0.9Mt
- Blast Furnace Slag: 0.2Mt

The proportion of cementitious materials imported into the GSR Three Cities generally equates with the proportion of concrete produced, namely:

- Eastern Harbour City: 55%
- Central River City: 30%
- Western Parklands City: 15%

2.5.2 Cement

Demand for cement in the GSR is met principally by Boral's Berrima Cement works and the Cement Australia/Levy joint venture grinding plant at Port Kembla. Adelaide Brighton (parent company to Hy-Tec) produces cement from grinding works at Port Kembla and transports cement from their cement works in South Australia to the GSR. Bulk cement is also shipped into Glebe Island from cement works in other states.

Cement is freighted into the GSR by ship (unloaded at Glebe Island), by rail (Berrima/Maldon and Port Kembla) and by road (from interstate). An established and increasing trend is to supplement domestic cement production with cement clinker imported from cement plants in Asia. The cement clinker is shipped to major ports including Port Kembla and then ground in cement grinding plants near the port to produce cements. Fly ash and GGBFS are frequently blended with cement to provide various cement types and grades for use in building and construction.

2.5.3 Fly Ash and Ground Granulated Blast Furnace Slag

Concrete grade fly ash and GGBFS act as 'cement extenders' in concrete. Coal quality affects the quality of fly ash for use in concrete. Most ash produced from power stations is not suitable for use in concrete and is disposed of as tailings in ash dams and is typically referred to as pond ash.

Concrete grade fly ash delivers improved later-age strength, workability and enhances the durability properties of concrete. It is commonly used as a 20% to 30% cement replacement in concrete, as stipulated in technical specifications. It is used as a single product or may be blended with cement to produce a fly ash blended cement.

GGBFS is produced by quenching molten iron slag (a by-product of iron manufacture) from a blast furnace in water, to produce a granular product that is then dried and ground into a fine powder. GGBFS is typically used in concrete requiring a lower heat of hydration, and where resistance to aggressive groundwater and adverse environmental conditions are present. Similarly, to fly ash blends, early age strength development is slower than straight cement concrete. However, strength development from 28 days onwards is equivalent or better. [13]

Local (NSW) sources of concrete grade fly ash for the GSR are from fly ash offtake facilities at coal-fired power stations such as Eraring, Mt Piper and Bayswater.

GGBFS is sourced locally from BlueScope's Port Kembla steelworks by Australian Steel Mill Services (ASMS). A joint venture between Cement Australia and Edward Levy Group manage the distribution of the GGBFS from the steelworks.

2.5.4 Sourcing Trends

Consultation with industry has indicated the following key sourcing trends for cementitious materials and their drivers.

- The industry is experiencing decreasing or static domestic cement production and greater reliance on clinker imports from Asia. This is driven by high levels of cement production in Asia and comparative economies of scale for delivery. Cement is a global commodity and Australia is a relatively small market with the result that Asian plants have surplus capacity, economies of scale and port access. This is coupled with the high cost to upgrade or invest in new domestic cement plants.

[13] http://www.cementaustralia.com.au/wps/wcm/connect/website/bulk/Bulk-Home/our-products/slag/

- Parallel to this, as domestic cement manufacturing plants reach the end of their useful life, the economics of upgrading the plants will be impacted by the economics of importing from Asia.
- Shipped imports of cement clinker and fly ash from overseas requires port facilities, off-loading and bulk handling, which places additional demands on existing ports and bulk handling operations, storage and rail distribution facilities from port to market.
- Over the short-term, fly ash is available from NSW power stations but indications are that they are currently at capacity because of concrete demand, and offtake and fly ash processing and storage capacity constraints.
- The long-term availability of concrete grade fly ash from NSW coal-fired power stations is also dependent upon their continued operation. As coal-fired power stations close, other sources of fly ash for concrete will need to be sourced. Some fly ash is understood to be trucked from Queensland for concrete manufacture in the GSR. Based on international examples, and subject to pond ash quality and recovery economics being proven in the future, some additional usable fly ash may be recoverable from some NSW power station pond ash dams.
- Sourcing of GGBFS relies on the ongoing operation of BlueScope's Port Kembla No. 5 blast furnace. Alternative sources would need to be imported from overseas.
- Both GGBFS and fly ash are already imported in bulk to Australia, and similarly to cement clinker, imports are expected to increase in the future as domestic sources of these SCMs close or diminish.
- The supply of bulk cementitious products is dominated by the vertically integrated construction material firms, is relatively complex and joint ventures common between the major firms. Sourcing and distribution is very capital intensive requiring bulk unloading, storage, re-loading and inter-modal transport and connectivity with concrete plants in the GSR. These requirements significantly restrict the number of suppliers and the locations of bulk handling and distribution centres.

2.5.5 Concluding Comments

Consultations with industry consultants for the Study indicated the sourcing of cement and SCMs for the GSR has changed and will continue to change to a wider reliance on overseas imports, principally from Asia and India. The following factors and trends are relevant.

- Increased demand for concrete.
- Diminishing domestic supply from cement manufacturing plants and industrial waste sources for SCMs.
- The cost disparity between upgrading or developing domestic sources versus imports from locations in Asia and India. Cement and SCMs are global commodities and traded globally. High output, lower cost and coastal cement plants in Asia can reliably supply bulk clinker at economies of scale and lower delivered costs into Australia, compared to the cost of the construction and operation of new cement manufacturing plants in Australia.

- A future need for additional cement grinding facilities and capacity near port lands (e.g. Port Kembla) to grind the imported cement clinker to produce cements and improved rail connectivity to enable non-road distribution to the GSR.
- The yield of concrete grade fly ash is at capacity due to existing demand and relies on the continued operation of coal-fired power plants in NSW.
- Domestic sourcing of GGBFS relies largely on the output from BlueScope's Port Kembla No. 5 blast furnace.

These factors will place additional demands on port infrastructure, bulk handling facilities and rail infrastructure required to receive, store and distribute the cement and SCMs.

2.6 Substitute Construction Materials

2.6.1 Purpose of Assessment

An understanding of the GSR demand for construction materials supplied from other sources i.e. sources other than hard rock and natural sand quarries is necessary for the Study because the economic and demand forecasting data for construction materials available to the Study are based on building and construction activity and do not distinguish between demand met by extractive materials (crushed rock and natural sand products) and demand met by substitute materials from other sources.

In order to establish the FY 2018 base case demand met by extractive materials (i.e. from hard rock and natural sand quarry sources), other sources of construction materials were considered including:

- recycled concrete from construction and demolition (C&D) waste;
- crushed/broken sandstone excavated from civil construction projects (including tunnel projects), i.e. VENM; and
- other low-value quarry materials.

The method of estimation adopted for the Study is based on calculating the difference between the Macromonitor demand data (which does not distinguish between hard rock and natural sand quarries, and substitute sources of supply) and the results of the industry survey of extractive industry (which only identifies supply from hard rock and natural sand quarries).

By this method, substitutes for crushed rock and natural sand products from quarries are estimated to have supplied in FY 2018 approximately 46% of total base case GSR demand for construction materials (excluding cementitious products). For the historical demand profile from 2011 to 2017, substitutes for extractive materials have been assumed to lie in the range of 41% to 45%. These are high-level estimates established by indirect methods and have not been confirmed with primary data from concrete recyclers or civil contractors disposing of crushed sandstone spoil[14].

[14] The Study's scope focusses on extractive materials and concrete raw materials. Industry surveys and questionnaires were not conducted with concrete recyclers and consultations were limited to telephone discussions with some operators. Many concrete recyclers declined to provide information for use in the Study.

The proportion of other construction materials substituting for extractive materials is perhaps the most surprising finding of the Study – in preliminary modelling (July 2018), an estimate of 16% was first used. This has been revised upwards to 46% following receipt by the Study of the final industry survey responses in late October 2018. The majority of these materials are used in roadbase/sub-base and lower value aggregates for use as drainage media, for example.

The proportion of demand met from substitutes for extractive materials in the future is crucial to determining the future supply to be met from hard rock and natural sand quarries. If the estimate of 46% is lower, then the supply of extractive materials will need to proportionally increase to meet forecast demand.

A description of the assumptions and quantities adopted by the Study to account for the proportion of the GSR demand met by substitute construction materials is provided throughout the following subsections.

2.6.2 Recycled Concrete

The purpose of assessing recycled concrete supply in this Study is to establish an estimate of the quantities and product use of recycled concrete sourced from C&D waste materials in the GSR and used as substitutes for some extractive materials.

When suitably separated, crushed, screened (and sometimes washed) at C&D waste recycling facilities, the recycled concrete products are used as substitutes for extractive materials, i.e. in certain product and market applications where the engineering performance properties of the recycled materials are technically acceptable.

Recycled concrete products also include variable but often lesser quantities of brick, tile and some sand/crushed rock as these materials are sometimes mixed with the recycled concrete waste stream from the building and construction sites.

The supply chain flows of C&D waste and its recycling facilities are regulated by the NSW Government through the Environment Protection Authority. It is understood some data is collected by the EPA with respect to concrete recycling facilities and operations, however, it is insufficient to discern accurate estimates of the quantities, qualities and uses of recycled concrete in the GSR.

Because of the quantity of recycled concrete generated within the GSR, there are transport, disposal cost and sustainability advantages in optimising its use as substitutes for extractive materials from quarries. These advantages and any disadvantages are discussed under Benefits and Limitations in Section 2.6.2.3.

2.6.2.1 Spatial Distribution of Concrete Recycling Facilities

Figure 2.6 displays the locations of approximately 25 plants[15] used throughout the GSR for the processing of C&D wastes, principally the recycling of concrete and brick into construction materials such as roadbase/sub-base materials and drainage aggregates.

[15] It is likely other concrete recycling facilities are present throughout the GSR, however, industry registers or a comprehensive database for such facilities are not known to exist. Furthermore, some concrete recycling is undertaken using mobile plants placed on major demolition sites.

Figure 2.6 Sydney Concrete Recycling Plants

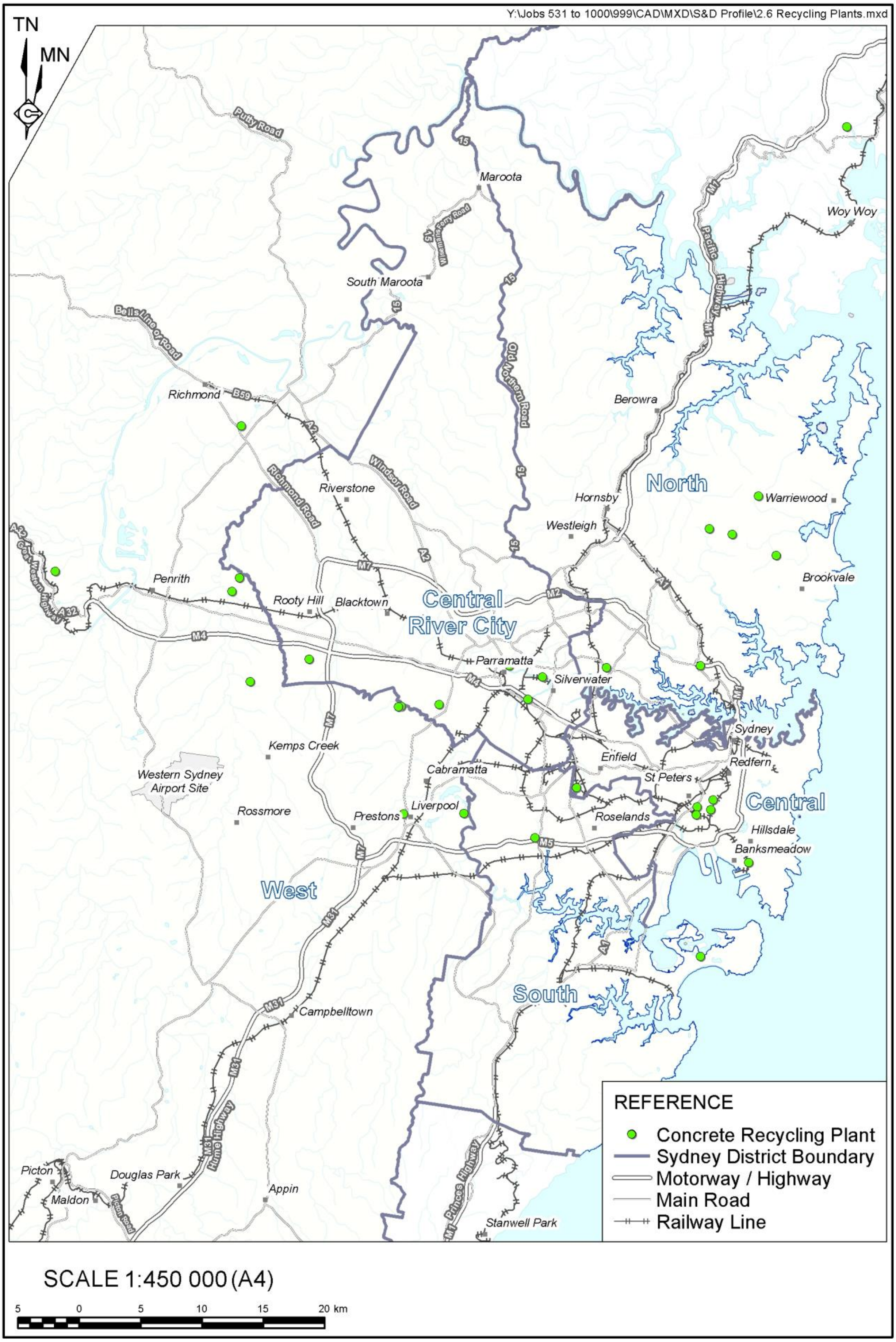

Table 2.16 lists the estimated FY 2018 production of recycled concrete facilities within each of the three GSR Cities.

Table 2.16
Summary of Recycled Concrete Production

No. of Sites	Annual Production
Eastern Harbour City	
15	2.4Mt
Central River City	
5	0.8Mt
Western Parkland City	
8	2.3Mt

Collectively, approximately 5.5Mt of recycled concrete products are estimated to have been generated during FY 2018.

The split of products by tonnage or product type is not available from concrete recyclers or secondary data sources. Concrete recyclers contacted by the RWC Project Team in the course of the Study were prepared to offer information only in general terms and none were prepared to provide specific details on product types and tonnages sold into the GSR market.

2.6.2.2 Recycled Concrete Used as Roadbase/Sub-Base and Aggregates

The proportion of recycled concrete that is crushed and screened to produce products that substitute for crushed rock and natural sand products (excluding fill materials) has not been established with any granularity in the Study.

The principal recycled C&D products of interest in this study are sourced from concrete, brick and tile waste and include the following.

- Roadbases (e.g. graded basecourse and sub-base materials, -20mm blended (brick) bases and sub-bases).
- Select and engineered fill.
- Aggregates (e.g. 10mm and 20mm drainage aggregates, 30-70mm drainage aggregates).
- Sand and packing fines.

Details of the profile of recycled concrete products and annual tonnages of particular products are scarce in the public domain and in the private domain are largely held as confidential information by recyclers.

The recycling base case estimates reported in this Study are therefore relatively high-level as they have been necessarily derived by the RWC Project team from a variety of secondary data and information sources including NSW Government data, and consultations with industry networks and consultants.

For the purposes of modelling sources of substitute construction materials, the Study has adopted a base case (FY 2018) supply estimate of 5.5Mtpa of recycled concrete used principally for roadbase and sub-base applications.

Table 2.17 provides an estimate of the proportions and quantities of recycled concrete products consumed annually in the GSR (base case FY 2018) as substitutes for extractive materials from hard rock and natural sand quarries.

Table 2.17
Estimated Recycled Concrete Products Usage in the Greater Sydney Region – FY 2018

Product Type	Quantity	% of Total Quantity
Roadbase / Sub-Base	3.3Mt	61%
Fine aggregates (< 5mm)	0.2Mt	4%
Coarse aggregates (5mm - 30mm)	1.3Mt	23%
Broken/sized products (> 30mm)	0.7Mt	12%
Total	**5.5Mt**	**100%**

Table 2.17 indicates that approximately 5.5Mtpa of recycled concrete products (with minor quantities of mixed brick and tile) substitute for extractive materials in the product categories indicated. Roadbase, and particularly sub-base materials account for an estimated 61% of supply. Coarse aggregates are predominantly used as drainage aggregates.

2.6.2.3 Benefits and Limitations of Recycled Concrete Products

The benefits or advantages of using recycled concrete as a substitute for extractive materials include the following.

- Reduction of wastes to landfill.
- Decreased transport distance from the concrete recycling centres into the market compared with the distance travelled for the delivery of extractive materials from quarries, thus reducing direct and indirect (externality) transport costs.
- Relatively low cost of production compared with hard rock quarries (no blasting) and relatively low-cost processing by crushing, screening and sometimes washing.
- Maximising re-use of recycled concrete reduces reliance on equivalent geological extractive resources, which are predominantly sourced from the GSR feeder areas and which also have their own local demand needs for construction materials.

Limitations or disadvantages of recycled concrete products include the following.

- Recycled concrete is a composite material and a mixture of composite materials with different concrete types of different strengths containing different types of aggregates. This variability impacts on quality and therefore service applications.
- The concrete recycling industry includes major vertically integrated construction materials companies with strong technical and distribution capabilities and smaller less sophisticated ‘independent’ operators. Product quality can vary accordingly.
- From an engineered materials perspective, the highly heterogenous characteristics of recycled concrete from numerous construction sites makes it difficult to predict technical performance and assurance of technical suitability of recycled aggregates – particularly for higher strength and durability aggregate requirements in concrete and higher performance roadbase specifications.

- For example, a number of technical specifications in building and infrastructure tenders (including those for the NSW Government) exclude or substantially reduce the use of recycled components for use as concrete aggregate or Dense Graded Base/Dense Graded Sub-Base roadbase constituents because of quality variability, and the risk of potential contamination of building material asbestos within the C&D waste sources.
- Developing higher performance aggregates and roadbase products from recycled materials has been a research and development goal over many years and initiatives and progress in developing re-processing methods to maximise quality and re-use continues. However, the principal barrier to wider usage as higher strength and higher durability aggregates are technical in nature and constrained by technical specifications. These specifications tend to be conservative (to ensure the construction materials are fit for purpose and do not, for example, compromise structural integrity of buildings and infrastructure or impair asset maintenance costs).
- The recycling of concrete requires suitable industrial land availability to locate operations, crushing and screening plant (sometimes washing plant) and stockpiling areas and distribution (transport) connections. The opportunity for more sophisticated processing is not always available at all sites.
- The large volumes of spoil (e.g. crushed sandstone generated from CBD tunnel projects) being excavated and which will continue to be generated from major infrastructure projects in the GSR, provide a source of competitively priced VENM that competes with recycled concrete materials in markets such as sub-base for road construction. In the absence or future reduction in the supply of sandstone VENM, the demand met by recycled concrete would be expected to be higher.

2.6.3 Recycled Asphalt

Recycled asphalt products (RAP) are extensively used for re-incorporation into road surfacing pavements. RAP products are generated from the "milling" of existing pavements, when roads are reprofiled and/or resurfaced.

At present, "new" asphaltic concrete (asphalt) mixes consist of approximately 17%-20% RAP (by mass of aggregates in the mix). The industry benchmark objective is that the materials balance is neutral at around 20%. That is, if the new asphalt contains 20% RAP, then there is minimal road millings waste to be dumped to landfill.

In NSW, the Roads and Maritime Services (RMS) has a 15% maximum limit on RAP in their specified asphalt pavement mixes, however trials are being conducted, and consideration is being given to allowing some classes of road pavement to move to a maximum of 30% RAP in the asphalt mixes. This limit is still under assessment and not yet fully incorporated into formal specifications. At present, approval to use 30% RAP requires an intensive in-service assessment and reporting regime.

The asphalt industry is also experimenting and trialling the use of other waste materials into pavement surfacing mixes. Such materials include crushed glass (the Alex Fraser Group in Melbourne is the current industry leader in this area), and also crumbed tyres. Quantitatively, the proportions of these products (relative to natural sand and crushed rock products) are presently insignificant.

2.6.4 Sandstone VENM

Virgin excavated natural material or VENM is excavated from and is commonly surplus to civil construction projects (e.g. broken/crushed sandstone tunnel spoil and sandstone excavated from building and construction sites) [16].

Feedback from wider industry consultation during the Study, suggested that approximately 4Mtpa of tunnel spoil (mainly sandstone) is currently being generated in the GSR, with significant quantities used to partly backfill the former Hornsby Quarry.

Substantial quantities of tunnel spoil will continue to be produced in the future – for example, estimates prepared by the RWC Study team suggest 10km of twin tunnelling per year (160m^3 per lineal m of duel tunnel advance) over 10 years would generate approximately 38 million tonnes (Mt) of spoil (mainly a crushed sandstone equivalent and assuming an in situ density for sandstone of 2.4 tonnes per bank cubic metre).

These materials will require disposal and/or use. Whilst bulk disposal solutions in quarry voids, as fill for land redevelopment, or on vacant land (for bulk stockpiling and later re-use according to demand) remain available, the sandstone VENM surplus can be reasonably managed. However, if (or as) bulk disposal venues reduce in availability in the GSR, increased usage of sandstone VENM as construction materials will be necessary, to avoid costly transport and disposal costs.

Most sandstone VENM that currently substitutes for extractive materials in the GSR is in the roadbase/sub-base category, and particular sub-base materials for road formations and hardstand areas. It is an important cost-effective substitute for such extractive materials that would otherwise have to be supplied from quarries (either friable sandstone quarries or hard rock quarries).

For the purposes of modelling substitute sources of extractive materials, this Study has adopted a base case (FY 2018) estimate for the contribution from crushed sandstone/sandstone VENM (tunnel spoil, and material excavated from other civil projects) of 10.5Mt. This equates to 63% of demand met from substitutes for extractive materials. As for recycled concrete, this estimate is high-level – a best estimate only based on the limited information available to the Study.

Some sandstone VENM can also be processed to produce construction sands and there is a considerable history of the use of friable sandstones in the GSR region for such purposes. However, not all sandstones are suitable and the economics of manufacturing sand depend on a

[16] In the GSR, because of underlying geology, a significant proportion of the re-usable earth materials from civil construction works (including tunnelling) is from the Hawkesbury Sandstone – either a friable sandstone which is relatively soft and removed by excavator, or harder (well cemented) sandstone which requires more vigorous excavation methods. The recovery of these materials is confined mainly to the eastern side of the GSR as the Hawkesbury Sandstone is invariably overlain by shale units in Sydney's western suburbs. The general industry term applied to such materials is VENM – Virgin Excavated Natural Materials. The availability and use of VENM as a substitute for extractive materials depends on geology, excavation method, location, scale and timing of the infrastructure projects that generates the excavated natural materials.

variety of factors including geological factors such as degree of weathering, mineral constituents, clay mineralogy and content, and degree of cementation and sizing of sandstone particles generated by the boring machine.

Because of the anticipated high volumes and continuity of supply of sandstone VENM from GSR tunnelling projects over the coming years, there is some opportunity to further process a proportion of the sandstone VENM to increase the production of sand as an alternative to natural sand. However, harder sandstones are more difficult to dis-aggregate to produce the desired original sand grains required for sizing and grading into higher quality construction sands. Processing economics and technical barriers may therefore constrain their use as a replacement for natural sand in concrete.

The production of higher quality fine aggregates from friable sandstones (and more problematically highly cemented sandstone) typically requires relatively sophisticated processing plants with washing facilities and either filter presses or sedimentation/tailings dams to recover and store clay and silt fines, which are deleterious in concrete.

The processing plants and supporting infrastructure required are comparable to those utilised at sand and friable sandstone quarries and so land use availability and amenity/ traffic constraints, like quarries, restricts the availability of geographically suitable candidate sites in the GSR.

Several industry personnel consulted in the Study saw the future disposal of sandstone VENM from tunnelling projects as a considerable challenge given the quantities likely to be produced and limitations for conveniently available disposal sites.

One suggestion to the Study was that sandstone VENM from tunnels could be railed from the city back to rail-connected quarries and used as backfill in depleted quarry workings, or perhaps processed as sand products, noting however the additional demand that it would place on rail access and connectivity and requirements for sandstone VENM loading and unloading facilities in the GSR.

2.6.4.1 Industrial Wastes

Comparatively small quantities of slag aggregates, furnace bottom ash from coal-fired power stations and glass are recycled from industrial wastes and supplied to the GSR as substitutes for extractive materials, in certain and sometimes specialty applications.

Data on their usage as aggregates in concrete was not obtained with any granularity by the Study, as respondents to the concrete plant survey provided only general feedback and not specific details of their usage. However, the Study’s consultations indicated a low proportional usage to satisfy overall construction material demand, and they do not impact materially on overall supply requirements from hard rock and natural sand quarries.

2.6.4.2 Waste from Concrete Batching

Some fresh (un-set) waste concrete from concrete batching (for example unused concrete returned in concrete agitator trucks from a building site) is washed and screened to recover aggregates at some concrete batching plants. Concrete ‘returns’ less than approximately $0.4m^3$ are typically stored in wash out bays at the concrete plants and the waste must be disposed of. For concrete returns larger than approximately $0.4m^3$ other disposal methods are required.

The quantities of reconstituted sand and aggregates recovered from returned concrete by concrete companies and re-used in concrete are low, but new concrete plants, where space allows, are increasingly incorporating specialist equipment to maximise recovery of aggregates from returned concrete.

Increased washing of concrete returns to separate aggregates also requires larger quantities of process water. The water is highly alkaline and if not able to be re-used must be treated before discharge.

Where fresh waste concrete (for example large un-used loads) cannot be recycled back at the batching plant because of such constraints, it must be disposed of. This is typically at C&D waste recycling facilities.

One estimate from industry is that currently up to 5% of concrete batched from plants servicing high rise development in the inner city is un-used and disposed of as C&D waste. The reason given is that it is cheaper for a builder, under time and cost pressures, to over-order concrete, and pay the disposal costs if not required, rather than under-order and risk not completing the concrete pour. Furthermore, the interruption in the supply of concrete attributable to traffic congestion delays and delays in getting concrete to sites at short notice reportedly influences the builder's decision to over-order concrete.

2.6.5 Other Quarry Materials

A number of quarries within the GSR extract sandstone and shale which is used for a range of construction activities all of which contribute to the overall volume of construction materials used in the Sydney building and construction industry.

2.6.5.1 Crushed Sandstone

A range of crushed sandstone products used in road construction, footpaths, house pads, etc. are produced in quarries located within a number of the outer suburbs of Sydney. Some sandstone quarries have been developed principally to produce principal sub-base products whilst others produce crushed sandstone recovered either as overburden or off-cuts from dimension stone production. Some of these quarries incorporate backfilling programs through the use of sandstone VENM[17] importation.

2.6.5.2 Hard Rock Quarry Scalps

Hard rock quarries in the GSR feeder areas can supply low value construction materials by processing overburden or drawing from lower value product stockpiles of 'scalps' removed early in the manufacturing process for aggregates. However, the quarries are distant from GSR markets and the high delivery costs for low unit value materials reduces their competitiveness into the GSR.

[17] The bulk of VENM imported into these quarries is unsuitable for reprocessing, however, wherever reprocessing is feasible it is undertaken, the materials are typically blended with the quarry products

2.6.6 Summary of Substitute Construction Materials Usage

The Study's key findings and assumptions for the purposes of establishing a base case supply and demand profile for construction materials for GSR are as follows.

- Substitute construction materials (i.e. other than products from hard rock and natural sand quarries) met an estimated 46% of total demand for extractive / recycled construction materials. This estimate has been established based on the adopted 54% of total GSR demand met by extractive materials from hard rock and natural sand quarries (derived from aggregated responses to the industry survey and questionnaire and reference to Macromonitor construction materials demand data for the GSR).
- Of the other or recycled sources, recycled concrete (including some brick and tile) accounts for an estimated 33% of supply, whilst crushed sandstone from quarries, sandstone VENM (excavated from and surplus to civil project needs or from friable sandstone sites) 63%, and RAP and slag aggregates 4% of supply.
- These proportions are approximations only and may vary, depending for example on the availability and degree of substitutability between recycled concrete products and sandstone VENM.
- The estimate of demand met by substitute construction materials applies to the FY 2018 base case and may change in the future. These base case recycling metrics can be varied using sensitivity analysis. A sensitivity range of between 35% and 50% is assessed in Section 3 to model the impact on the size of total extractive reserves necessary to meet future demand.

Table 2.18 provides a summary of the Study's estimated GSR demand for substitute construction materials met in FY 2018 by sources such as crushed sandstone, sandstone VENM from tunnel spoil, recycled concrete and slag and recycled asphalt.

Table 2.18
Estimated Use of Substitute Construction Materials in the Greater Sydney Region – FY 2018

Product Type	Quantity per year	% of Total Quantity
Roadbase / Sub-Base	10.6Mt	63%
Fine aggregates (< 5mm)	0.5Mt	3%
Coarse aggregates (5mm - 30mm)	4.0Mt	24%
Broken/sized products (> 30mm)	1.6Mt	10%
Total	**16.7Mt**	**100%**

Table 2.18 indicates that roadbase/sub-base accounted for 10.6Mt or 63% of substitute sources.

This is a large quantity. Macromonitor data for FY 2018 indicate demand for roadbase/sub-base at 11.9Mt. Yet the industry survey results for hard rock quarries (noting that natural sand quarries do not supply roadbase) indicated total supply from hard rock quarries of 1.5Mt in FY 2018 (from **Table 2.1**). According to the findings from the Study, the difference of 10.4Mt can only be reasonably met from crushed sandstone/VENM and recycled materials from concrete waste.

Table 2.18 records that fine and coarse aggregates produced from substitute sources was approximately 4.5Mtpa in total. A high-level estimate of the approximate usage by product type is:

- 70% drainage aggregates, or in similar civil applications
- 20% concrete (pre-mixed and pre-cast)
- 10% asphalt

The more limited use of fine and coarse recycled concrete aggregates in concrete is because of strength and durability limitations of the recycled concrete aggregate materials.

It is noted that having regard to the FY 2018 demand and supply balance for coarse aggregates (for both extractive materials and substitute materials), there is a misclose in that Macromonitor demand series data suggest more coarse aggregates are consumed, than that supplied (from all sources).

A possible explanation for the difference is that some coarse aggregates for concrete are imported to the GSR from beyond the four feeder areas, though the Study's enquiries and consultations indicated such contributions were very minor. A more probable explanation is because of a NSW regional supply to GSR of pre-cast concrete products, whereby the aggregates in the pre-cast concrete products are sourced from quarries beyond the GSR and its feeder areas.

2.7 Concrete Batching Plants

Concrete is the most widely used construction material in the world. It is a composite material batched in conventional dry-mix or wet-mix plants as pre-mixed concrete for delivery to building and construction sites, or within similar batching plants that produce concrete for the manufacture on site of pre-cast concrete products.

Batched concrete has a finite 'shelf' life – hence concrete batching plants need to be located close to building and construction sites they service to maintain product quality and minimise transport costs.

Figure 2.7 shows the GSR supply and demand profile for concrete raw materials (pre-mixed, pre-cast and mortar) for the period 2011 to 2018. The raw material profile consists of cement, fly ash and GGBFS (collectively referred to as cementitious materials) which provide the cement binder; and fine and coarse aggregates which provide the strong and durable filler materials for concrete.

Figure 2.7 indicates the base case demand in FY 2018 for concrete raw materials was 21.5Mt. This includes fine and coarse aggregates, natural sand and cementitious materials used for pre-mixed concrete production and pre-cast concrete products. The fine and coarse aggregates in **Figure 2.7** includes aggregates supplied from quarries (natural sand and hard rock quarries) and substitute construction materials such as recycled concrete.

Figure 2.7 indicates that supply of concrete raw materials to meet the GSR demand has increased from 12Mtpa in 2011 to 21.5Mtpa by FY 2018 – an increase in supply of approximately 80% over 2011 levels. Much of this increase has been for concrete used in medium-density and high-density residential apartments and coincident demand from roads and infrastructure.

Figure 2.7 GSR Supply and Demand Profile for Concrete Raw Materials 2011 to 2018

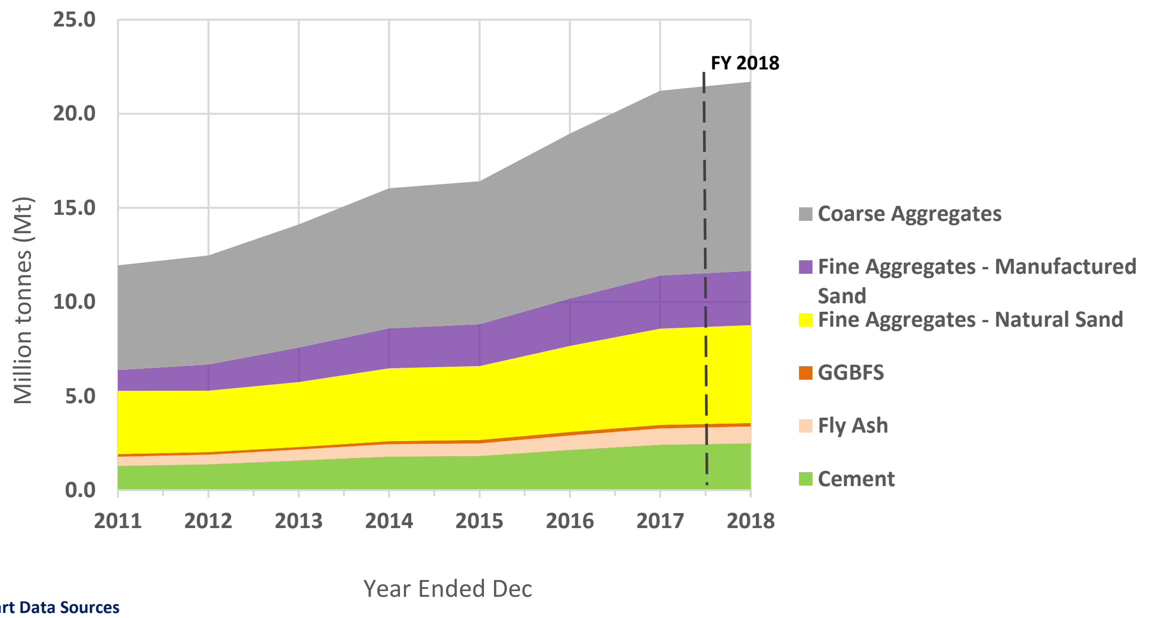

Chart Data Sources

1. Macromoniitor Greater SYDNEY Concrete Aggregates and Cementitious Product Demand Forecast 2011 to 2026 for Pre-mixed concrete, Pre-cast concrete & Mortar, data issued Mar 2018.
2. Macromonitor data does not differentiate natural sand and manufactured sand. The supply profile for fine aggregates is an estimate by RWC based on broader industry consultations.

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This subsection (Section 2.7) provides further profiling of the pre-mixed concrete plants that supply concrete to the GSR. The manufacture of pre-cast concrete products is discussed in Section 2.8.

2.7.1 Spatial Distribution

Figure 2.8 displays the locations of 78 pre-mixed concrete plants throughout the GSR east of the Blue Mountains together with the locations of the manufacturing plants for pre-cast products. The majority of the plants are located in industrial-zoned areas. **Table 2.19** lists the company name and suburbs for each of the plants within the GSR.

Consultation with industry indicated that larger concrete production companies rely on a spatial pattern of concentric circles that allow for supply within relatively short distances, but also overlap with other sources (owned by the same company) in order for supply shortfalls to be rectified. This in turn relies on the strategic availability of suitable industrial-zoned land to meet supply requirements within the expected ‘shelf life’ of pre-mixed concrete.

Figure 2.8 Sydney Concrete and Asphalt Plant Locations

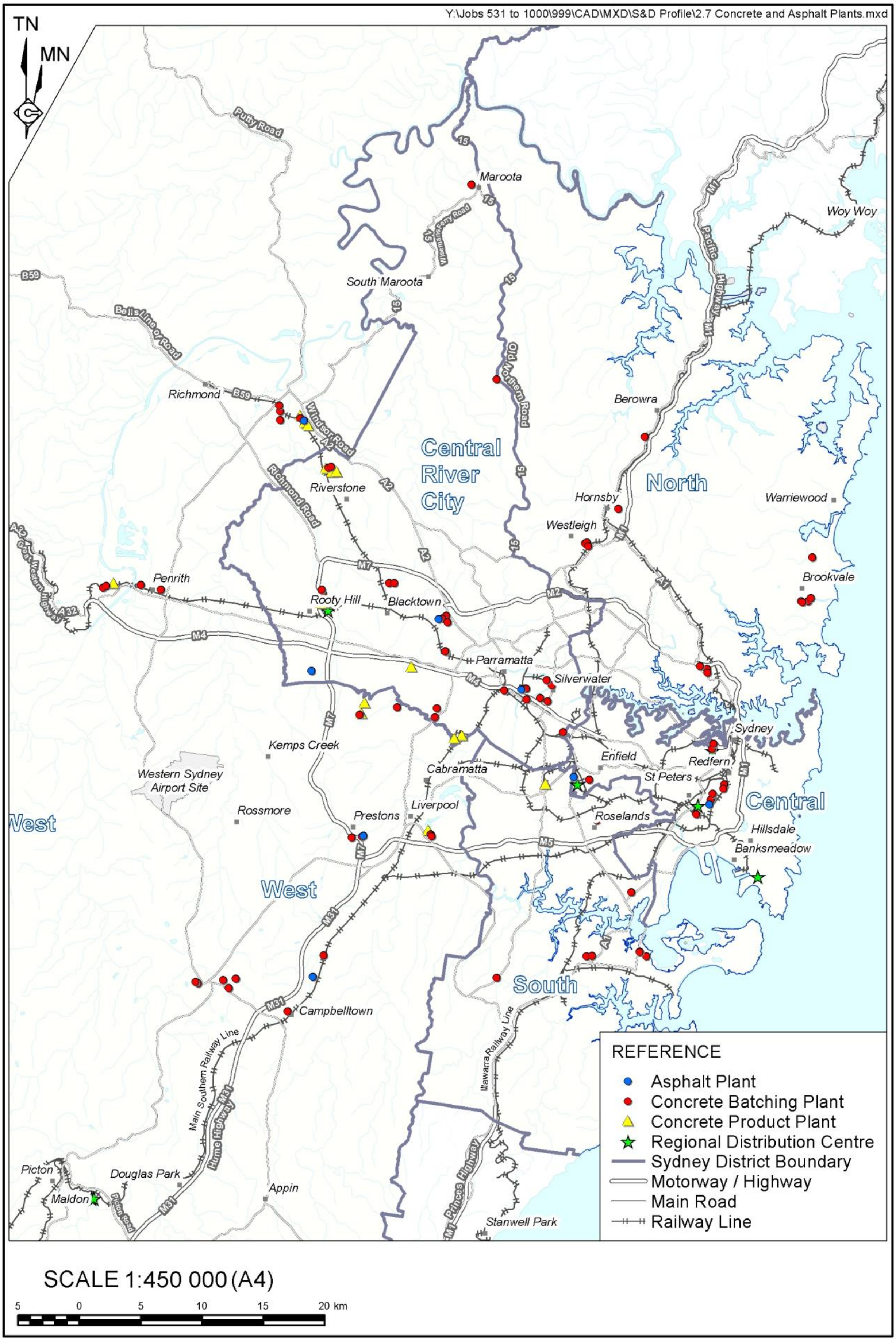


Table 2.19
Pre-mixed Concrete Plants in the Greater Sydney Region Three Cities

Company Name	No. of Plants	Location(s)
Eastern Harbour City		
Able Concrete (Metromix)	2	Alexandria, Hornsby
Boral Resources (NSW) Pty Ltd	7	Banksmeadow, St Peters, Artarmon, Brookvale, Thornleigh, Taren Point, Mount Kuring-gai
Brookvale Minicrete	1	Brookvale
Concrite (Boral)	3	Alexandria, Kirrawee, Lucas Heights
Handycrete Concrete Pty Ltd	1	Kirrawee
Hanson Construction Materials Pty Ltd	5	Glebe, Artarmon, Thornleigh, Taren Point, Strathfield South
Holcim (Australia) Pty Ltd	5	Artarmon, Hurstville, Thornleigh, Alexandria, Brookvale
Hymix (Hanson)	2	Pyrmont, Brookvale
Hy-Tec Industries Pty Limited	1	Alexandria
Metromix Pty Ltd	2	Alexandria, Cromer
Concrete Group Pty Ltd t/a Mini-Crete Concrete	1	Roselands
Sub-Total	**30**	
Central River City		
Advanced Ready Mix	2	Seven Hills, Smithfield
Boral Resources (NSW) Pty Ltd	6	Blacktown, Greenacre, Granville, Smithfield, Kings Park, Glenorie
Concrite (Boral)	1	Auburn
Gunlake Pty Ltd	2	Glendenning, Silverwater
Hanson Construction Materials Pty Ltd	3	Silverwater, Pendle Hill, Riverstone
Holcim (Australia) Pty Ltd	4	Blacktown, Pendle Hill, Greenacre, Lidcombe
Hymix (Hanson)	3	Wetherill Park, Riverstone, Rosehill
Hy-Tec Industries Pty Limited	2	Glendenning, Rosehill
Metromix Pty Ltd	2	Silverwater, Seven Hills
Mini-Crete Pty Ltd	1	Seven Hills
PF Formation Pty Ltd	1	Maroota
Sub-Total	**27**	
Western Parklands City		
Boral Resources (NSW) Pty Ltd	5	Minto, Penrith, Prestons, Windsor, Narellan
Concrite (Boral)	2	Moorebank, Narellan
Constable Bros Concrete	1	South Windsor
Gunlake Pty Ltd	1	Smeaton Grange
Hanson Construction Materials Pty Ltd	2	Prestons, Campbelltown
Holcim (Australia) Pty Ltd	4	Liverpool (Moorebank), Narellan, Emu Plains, Windsor
Hy-Tec Industries Pty Limited	4	Prestons, Mulgrave, Smeaton Grange, Emu Plains
Metromix Pty Ltd	1	Wetherill Park
Western Suburbs Concrete	1	Penrith
Sub-Total	**21**	

2.7.2 Annual Production

Collectively, the pre-mixed concrete plants in the GSR produced approximately 6.7Mm^3 of concrete during FY 2018[18]. Pre-cast concrete products accounted for approximately 2.6Mm^3. The estimated total concrete consumed in the GSR for FY 2018 was therefore approximately 9.3Mm^3, with pre-mixed concrete accounting for 72% and pre-cast concrete 28%. Sufficient data has not been supplied by industry to assemble details of production capacity within planning districts throughout the GSR.

For the purposes of this report, reliance is placed upon a broad breakdown of the production of pre-mixed concrete within the Three Cities, namely:

- Eastern Harbour City – 3.7Mm^3 (55%)
- Central River City – 2.0Mm^3 (30%)
- Western Parklands City – 1.0Mm^3 (15%)

This approximate FY 2018 breakdown of concrete demand by Three Cities is based on industry consultations, which also highlighted that the production capacities of the concrete batching plants in the Eastern Harbour City are substantially greater than those in the Western Parklands City.

2.7.3 Sources of Raw Materials

The ranges of quantities of raw materials typically used in the manufacture of 1m^3 of concrete are as follows.

- Crushed coarse aggregate – 900kg to 1100kg
- Medium to coarse sand[19] – 300kg to 400kg
- Fine sand – 560kg to 600kg
- Cement/SCMs – 325kg to 400kg

The supply profile for the FY 2018 base case for concrete raw materials is summarised in **Table 2.20**.

Table 2.20
Raw Materials used in Concrete Production in the Greater Sydney Region – FY 2018

Raw Material	Quantity	% of Total Quantity
Cement	2.5Mt	12%
Fly Ash	0.9Mt	4%
GGBFS	0.2Mt	1%
Fine Aggregate – Natural sand	5.2Mt	24%
Crushed Fine Aggregate – Manufactured sand	2.8Mt	13%
Crushed Coarse Aggregate	9.9Mt	46%
Total	**21.5**Mt	**100%**

[18] Macromonitor March 2018, Pre-Mixed concrete demand all sectors, 6.7Mm^3, 12 months ending June 2018
[19] The medium to coarse sand fraction includes natural sand and manufactured sand (from hard rock quarries)

Based on the supply profile in **Table 2.20**, cementitious products account for 3.6Mtpa or 17% by weight of concrete raw materials (excluding water and admixtures used in concrete). The combined aggregates account for 17.9Mtpa or 83% by weight.

Table 2.21 lists the sources of crushed rock products (including manufactured sand) and natural sand used in the manufacture of concrete in the GSR in FY 2018. Approximately 50% of the fine and fine to medium grained sand used in concrete manufacture is sourced from quarries within the GSR with most of the fine sand sourced from the Williamtown/Salt Ash area north of Newcastle.

Table 2.21
Locations of Delivered Crushed Rock and Natural Sand Products in the Greater Sydney Region

<table>
<tr><th rowspan="2">Raw Material</th><th rowspan="2">Total Annual Production</th><th colspan="5">Feeder Areas</th></tr>
<tr><th>GSR</th><th>Northern</th><th>Western</th><th>South Western</th><th>Southern</th></tr>
<tr><td colspan="7">Eastern Harbour City</td></tr>
<tr><td>Crushed Rock</td><td>6.93</td><td>-</td><td>1.28</td><td>0.30</td><td>2.44</td><td>2.92</td></tr>
<tr><td>Natural Sand</td><td>2.82</td><td>0.94</td><td>1.21</td><td colspan="3">0.65</td></tr>
<tr><td colspan="7">Central River City</td></tr>
<tr><td>Crushed Rock</td><td>4.21</td><td>-</td><td>0.65</td><td>0.65</td><td>1.53</td><td>1.38</td></tr>
<tr><td>Natural Sand</td><td>1.94</td><td>0.78</td><td>0.67</td><td colspan="3">0.49</td></tr>
<tr><td colspan="7">Western Parklands City</td></tr>
<tr><td>Crushed Rock</td><td>2.41</td><td>-</td><td>0.30</td><td>0.46</td><td>1.03</td><td>0.62</td></tr>
<tr><td>Natural Sand</td><td>1.12</td><td>0.46</td><td>0.40</td><td colspan="3">0.27</td></tr>
</table>

Consultation with industry has indicated that a key constraint on operations is the capacity to store raw materials at most concrete batching plants i.e. stockholding capacity for raw materials. This determines how long or at what capacity production can be maintained before the raw materials need to be replenished. It is understood that some pre-mixed concrete plants only have storage capacity for raw materials to manufacture concrete for 5 to 6 hours. The need to frequently source these materials from distant locations places pressure on operational and logistics planning to ensure that raw material supplies are maintained to meet concrete production and supply requirements. Industry also raised the need for industrial areas in the GSR growth areas to be well planned to ensure 24 hour/7 days per week access to pre-mixed concrete batching plants from the planned road network, i.e. for the delivery of raw materials and the production of concrete to satisfy the hours concrete can be poured at some locations.

2.7.4 Destinations of Pre-Mixed Concrete

From the Study's findings, the destinations or point of use profile for the 6.7Mm^3 of pre-mixed concrete supplied over the 12 months ending June 2018 throughout the GSR was as follows.

- Dwellings – 3.0Mm^3 pa (44%)
- Non-Residential Buildings – 1.9Mm^3 pa (28%)
- Roads – 1.2Mm^3 pa (18%)
- Other Engineered Infrastructure – 0.6Mtpa (9%)

The destinations of pre-mixed concrete vary across the Sydney planning districts. Destinations within the Central Planning District of the Eastern Harbour City are typically less than 5km from the concrete batching plants whereas destinations in the North and South Planning Districts in the Eastern Harbour City and Central River City are typically up to 11km. Destinations between 5km and 25km are common in the Western Parklands City.

2.7.5 Approved Hours of Operations

It is understood the majority of the pre-mixed concrete plants have approval to operate 24 hours per day, seven days per week. The peak concrete product despatch period is typically from 6:00am to noon in order to satisfy morning concrete pours at construction sites. The extended hours of operation are principally in place to provide flexibility for the delivery of raw materials outside this period and ensure production capacity can meet demand. It is understood that industry is seeking to understand the feasibility of late-night concrete pours, which may be satisfied outside of peak demand periods. This is considered an attractive option for areas without noise limitations and permit late night construction operations (such as tunnel construction or in city areas that do not feature residential restrictions).

During consultation with industry, it was established that some of the operators are planning to seek modification of their development consents to allow 24 hours per day, seven days per week access, i.e. for both raw materials delivering and concrete production for approved projects.

2.7.6 Delivery Fleet and Delivery Routes

Pre-mixed concrete is delivered in concrete agitators, the bulk of which carry between 6m^3 and 8m^3 of concrete. A number of the smaller independent plants maintain fleets of small agitators capable of transporting between 1.5m^3 and 2.0m^3 of concrete.

Insufficient information has been provided by industry to enable specific routes to be defined for the delivery of concrete.

2.7.7 Concluding Comments

The information collected from pre-mixed concrete manufacturers was limited by the reluctance of many operators of industry to provide information considered confidential and the source of competitive advantage. However, the Macromonitor data provided detailed information for concrete raw materials demand for GSR and with industry contacts and publicly available documents, the base case profile of pre-mixed concrete manufacture within the GSR is considered reliable. In summary, the concrete batching plants in the GSR:

- relied upon the supply of approximately 21.5Mt of raw materials for FY 2018, with 83% of this supply from fine and coarse aggregates (by weight);
- are spread relatively evenly between the GSR Three Cities, with evidence that larger operators seek to develop supply patterns in overlapping circles that allow for short delivery distance with the capability for other locations to make up supply shortfalls;

- rely on short travel distances to ensure that the quality of concrete is not compromised because of its limited 'shelf life';
- rely on the provision of principally industrial-zoned land at strategic locations;
- rely upon on-site raw materials storage capacity to determine operational planning;
- are principally supplying the Eastern Harbour City, consistent with expectations for development of residential high rise and dwellings in this area, which are the principal destinations for pre-mixed concrete; and
- principally operate 24-hours a day, however, once the peak morning periods of concrete deliveries are satisfied, operations are focused on the delivery of raw materials to maintain supply.

2.8 Concrete Product Plants

In addition to pre-mixed concrete, concrete is cast at pre-cast concrete plants to manufacture a wide range of products used in the building and construction industry such as blocks, panels, tiles, pavers, pipes, headwalls, culverts and rail sleepers – collectively referred to in this Study as concrete pre-cast products.

These products are manufactured in dry-mixed or wet-mixed batching plants (similarly to pre-mixed concrete plants) but cast at the manufacturing premises. The plants manufacturing these products are located both within the GSR and in a number of NSW country centres and then transported to the GSR. Concrete pre-cast products are hardened and cured before despatch and so have a greater economic radius of distribution compared with pre-mixed concrete with its finite shelf life.

Figure 2.8 displays the locations of the known plants within the GSR. The bulk of the plants are located in the Central River City or Western Parklands City.

Macromonitor data used in the Study indicates approximately 2.6Mm^3 of pre-cast concrete products were consumed in the GSR for FY 2018. This equates to approximately 28% of total demand for concrete.

2.8.1 Sources of Raw Materials

Manufacturers of concrete blocks, panels, pipes, rail sleepers and other pre-cast concrete products use a range of extractive materials and substitute construction materials to produce their products, namely:

- Fine aggregates
  - natural sand (fine and coarse)
  - manufactured sand
- Coarse aggregates
  - typically 7mm for concrete blocks
  - 10mm, and 14mm to 20mm for other products

Other raw materials used comprise power station bottom ash (typically <5mm) and cement and fly ash as cementitious binders. The proportion of cement used in these concrete products is invariably higher than pre-mixed concrete due to the need to achieve stronger (e.g. >40Mpa) concrete for the products.

2.8.2 Transport Routes for Raw Materials Delivery

The transport routes described in Sections 2.3 and 2.4 of this report are equally applicable for the concrete product plants throughout the GSR. The truck loads attributed for the delivery of crushed rock and natural sand products in Sections 2.3 and 2.4 incorporate the loads delivered to the concrete product plants.

2.9 Asphalt Plants

Asphalt pavement or asphaltic concrete is produced using a blend of crushed fine and coarse aggregates, natural sand and bituminous binder. Asphalt is principally used in the surfacing of roads, parking lots and other hardstand areas. Asphalt is produced from sophisticated batching plants typically as a hot mix. Used asphalt, recovered from road maintenance works and C&D waste, can be recycled using such plants.

Spray seal aggregates are crushed coarse aggregates used for surfacing of roads, whereby the aggregate is pre-coated with a mineral agent before bitumen is added for road surfacing. The pre-coating of the sealing aggregates is invariably undertaken at quarries or asphalt plants.

2.9.1 Spatial Distribution

Figure 2.8 displays the locations of the eight asphalt plants within the GSR. All plants are located in industrial areas. **Table 2.22** lists the company name and suburbs of each of the asphalt plants within the GSR.

Table 2.22
Asphalt Plants in the Greater Sydney Region Three Cities

Company Name	Location
Eastern Harbour City	
Fulton Hogan	Alexandria
Boral Asphalt	Enfield
Central River City	
Boral Asphalt	Seven Hills
Downer EDI	Rosehill
Fulton Hogan	Eastern Creek
Western Parklands City	
Fulton Hogan	Minto, McGraths Hill
State Asphalts NSW	Prestons

2.9.2 Annual Production

Collectively, the eight asphalt plants produced approximately 1.3Mt of asphalt during FY 2018[20]. Fine and coarse aggregates accounted for approximately 93% of asphalt by weight, with 7% by weight of bituminous binders.

In addition to asphalt aggregates, crushed coarse sealing aggregates (spray-seal aggregates) used for road surfacing in GSR during FY 2018 accounted for an estimated 0.7Mt.

2.9.3 Sources of Raw Materials

The raw materials used in the manufacture of 1 tonne of asphalt are typically as follows.

- Crushed coarse aggregates – 770 kg or 82% of total asphalt aggregates
- Crushed fine aggregates / natural sand – 160 kg or 18% of total asphalt aggregates
- Bitumen hydrocarbons – 70kg

At present, mixes consist of around 17-20% recycled asphalt pavement (RAP) by mass of aggregates in the mix.

Demand for asphalt aggregates, like concrete, is met from crushed rock aggregates supplied from hard rock quarries with lesser quantities of fine sand from natural sand quarries.

The coarse and crushed fine aggregates used in the manufacture of asphalt are supplied from the hard rock quarries within the GSR feeder areas. An important 'substitute' source is from the Port Kembla Steelworks, which supplies approximately 200 000tpa of steel plant slag for use in asphalt in the GSR, principally to reduce vehicle skidding. The natural sand used in the manufacture of asphalt is supplied from natural sand quarries principally within the GSR.

2.9.4 Destinations of Products

Asphalt is transported between 10km and 120km from each plant with destinations limited to approximately two hours from the plant location to maintain asphalt product quality.

2.9.5 Approved Hours of Operations

All asphalt plants have approval to operate 24 hours per day, seven days per week given the need for regular night-time production and application. This is parallel to industry's interest in expanding the hours for concrete pours at construction sites where operations are able to be undertaken at night.

[20] Macromonitor, March 2018, Asphalt demand, 1.33 M tonnes, 12 months ended Jun 20182018 – this includes aggregates from quarries and recycled asphalt (RAP)

2.9.6 Delivery Fleet

Asphalt is delivered in a range of trucks with a maximum capacity of up to 34 tonnes and with an average payload of approximately 24 tonnes.

2.9.7 Concluding Comments

Asphalt production is a smaller but important component of the supply and demand profile for construction materials in the GSR. Total asphalt production during FY 2018 was 1.3Mt, and road sealing aggregates consumed approximately 0.7Mt. Approximately 17% of batched asphalt is produced from recycled asphalt pavement (C&D waste). It is noted that production and delivery of asphalt often occurs during the night time when a large proportion of road works are being undertaken. Whilst similar supply constraints to concrete production and distribution apply, asphalt plants service larger geographic areas and after hours re-stocking of raw materials is the norm.

2.10 Combined Extractive Materials Truck Movements

Section 2.3.8 and 2.4.8 have previously presented the indicative number of product truck loads of crushed rock and natural sand products delivered into and throughout the GSR. Collectively, the delivery of these extractive materials directly from the quarries generates an average of approximately 1 460 truck loads per day or 2 920 movements on the four principal transport routes into the GSR. An estimated 180 loads of sand products are transported from a number of quarries within the GSR to their point of use on secondary transport routes. Approximately 85% of the quarry products despatched by rail from the South Western and Southern Feeder Areas are ultimately delivered by truck from one of the RDCs, i.e. involving a further approximately 340 truck loads per day.

Collectively, the total number of trucks delivering crushed rock and sand products on an average weekday throughout the GSR is estimated to be approximately 1 980 resulting in the delivery of approximately 69 000 tonnes of products each week day. For an above average day, when the total number of trucks could be at least 25% higher, i.e. 2 475 truck loads, the quantity of quarry products delivered in the GSR daily would approach 86 000t.

Table 2.23 lists the combined truck loads for each of the principal transport routes into the GSR and the secondary transport routes within the GSR. The Hume Highway (north of Picton Road) carries the greatest number of trucks (616 or 42%) with the Pacific Highway (north of Sydney) carrying 463 or 32% of trucks. The Princes Highway and Great Western Highway respectively carry 14% and 12% of the total number of daily truck movements.

The main secondary routes within the GSR used for the delivery of quarry products are the M5 Motorway**,** Pennant Hills Road, A3 (North) and the M2 Motorway.

Table 2.23
Combined Truck Loads Delivered into and within the Greater Sydney Region

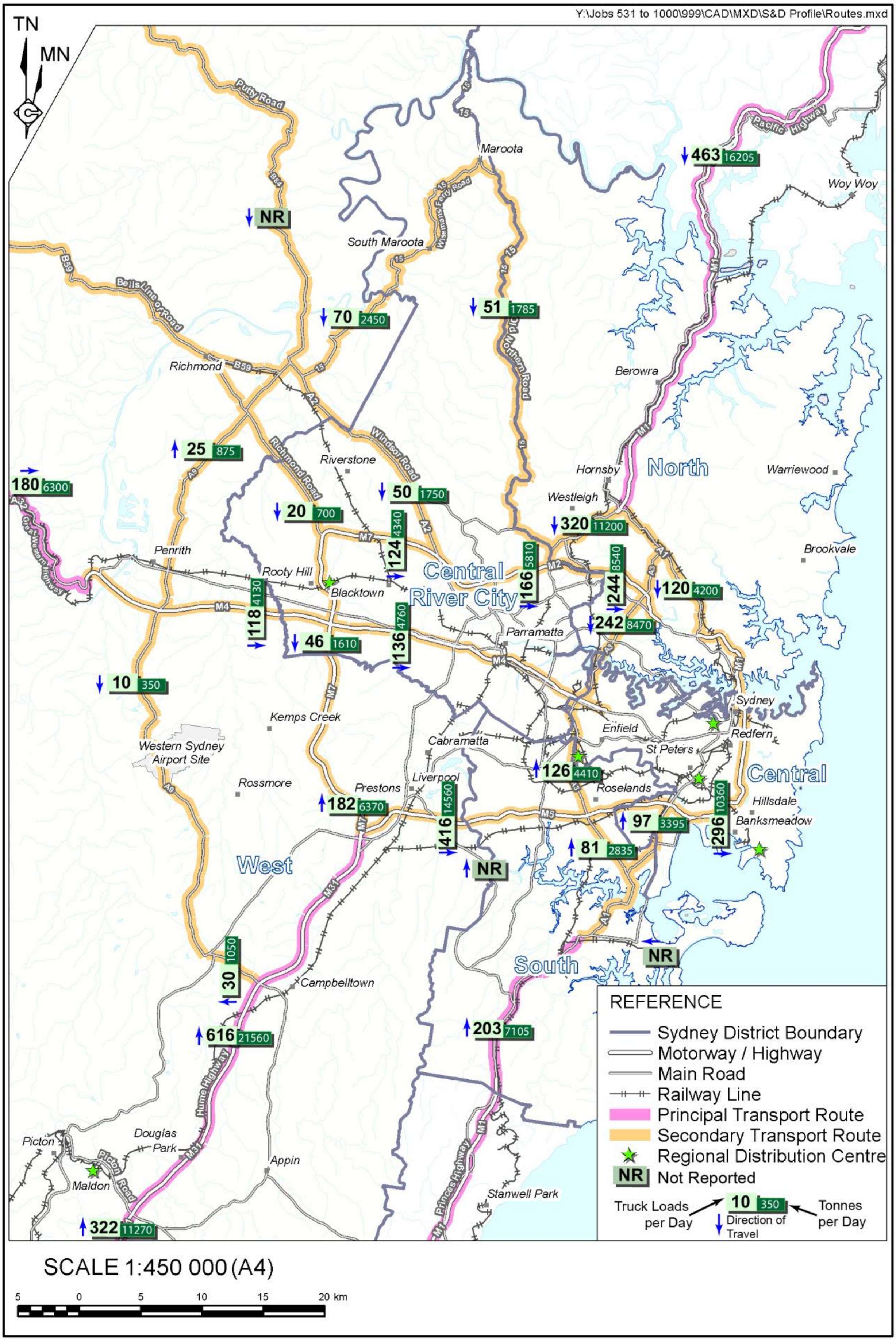
Route	Crushed Rock Products	Natural Sand Products	Total
Principal Transport Routes into the GSR from Quarries in Feeder Areas			
Northern Feeder			
Pacific Highway	227	236	463 (32%)
Western Feeder			
Great Western Highway	143	37	180 (12%)
South Western Feeder			
Hume Highway*	506	110	616 (42%)
Southern Feeder			
Princes Highway	193	10	203 (14%)
Totals	**1 069**	**393#**	**1462 (100%)**
Secondary Transport Routes within the GSR			
M5 Motorway	346	70	416
Pennant Hills Road	148	172	320
A3 (North)	190	52	242
M2 Motorway	106	60	166
A3 (Central)	126	0	126
M7 Motorway	124	0	124
Pacific Highway	56	64	120
A3 (South)	60	26	86
Wisemans Ferry Road	0	70	70
Old Northern Road	0	51	51
Windsor Road	0	50	50
Richmond Road	0	20	20

* The quantity of crushed rock products transported on the Hume Highway (north of Picton Road) includes those products unloaded at the Maldon RDC and transferred by road for distribution throughout the GSR.

The comparatively lower proportion of loads of sand transported into the GSR is accounted for by the higher number of loads generated from quarries within the GSR most of which do not use the principal transport routes from the feeder areas.

Figure 2.9 displays the indicative average daily distribution of all product trucks delivering crushed rock and natural sand products to their point of use within the GSR. No data is reported for three routes given the quarries despatching sand products are the only quarries using these routes.

Figure 2.9 Combined Quarry Product Truck Movements into and within the GSR



2.11 Demand Profile

Demand for extractive materials and concrete is driven by the demand for the goods and services they provide. As the majority of construction materials are used as inputs into building and construction, their demand is driven largely by population growth, economic activity and the concomitant community need for dwellings, non-residential buildings, roads and other engineered infrastructure.

Demand by Point of Use

Macromonitor construction material demand data purchased for the GSR Study (data series dated March 2018) adopts the following 'Point of Use' sectors which have been used to build a demand profile for GSR from 2011 to 2018.

The 'Points of Use' comprise the following building and construction sectors.

1. Houses
2. Medium Density Residential
3. High Density Residential
4. Alterations & Additions
5. Non-residential building
6. Road Construction
7. Road Maintenance
8. Other Engineering Construction

The Macromonitor demand data by the 'Point of Use' sectors does not differentiate between demand met by quarries and demand met by substitute materials (e.g. recycled concrete, sandstone VENM, slag).

As discussed in Section 2.9, these substitute sources of materials are currently estimated to meet approximately 46% of total GSR construction material demand (excluding cementitious materials), with the majority of these materials (crushed sandstone, sandstone VENM and recycled concrete) used in road construction and associated activities.

Demand by Manufacturing

Extractive materials can be used on their own (e.g. as roadbase/sub-base, drainage aggregates, rail ballast, broken/sized rock for gabion and revetment purposes) or as aggregates for use as in the manufacture of composite materials such as concrete and asphalt.

Aggregates for concrete and asphalt are transported from quarries by road and/or rail for distribution to the network of concrete and asphalt plants that rely on them as raw materials. Large vertically integrated construction material firms operate regional distribution centres (RDCs) in the GSR connected by rail and road (and port to rail/ road). These RDCs provide aggregate stockholdings for further distribution by road to concrete batching and asphalt plants in the GSR. The RDCs invariably host concrete and/or asphalt manufacturing plants.

Extractive materials not used in manufacturing (e.g. roadbase, sub-base, drainage aggregates, ballast, revetment rock) are trucked from quarries directly to the building and construction sites.

In order to provide further resolution of demand for extractive materials by manufacturing and from construction sites, a demand profile for extractive materials (sourced from hard rock and natural sand quarries in the GSR and/or the feeder areas) and used in the manufacture of concrete, mortar, asphalt and spray seals for roads has been prepared by the Study. The demand profile is segmented as follows.

1. Concrete Pre-mixed – Fine and Coarse aggregate
2. Concrete Pre-cast – Fine and Coarse aggregate
3. Mortar Sand – Fine aggregate
4. Asphalt and Spray Seal – Fine and Coarse aggregate
5. Roads and Other Engineered Infrastructure – e.g. roadbase, other aggregates (rail ballast), broken/sized rock products supplied direct to the building or construction sites.

2.11.1 Per Capita Consumption

An annual per capita consumption estimate can be derived by dividing the total demand for construction materials by the population. For GSR, the FY 2018 per capita demand profile for construction materials is presented in **Table 2.24**.

Table 2.24
Per Capita Consumption of Construction Materials in the Greater Sydney Region – FY 2018

Material type	Quantity	Per capita consumption*
Extractive Materials (crushed rock and natural sand products)	19.5Mt	4.0tpa
Cementitious Materials (cement, fly ash, GGBFS)	3.6Mt	0.7tpa
Substitute Construction Materials (VENM, recycled concrete)	16.7Mt	3.4tpa
Total	**39.8Mt**	**8.1tpa**

* Based on the Study's estimated resident population (ERP) for the GSR as at Jun 2018 of 4.91 million (For details of population series adopted by the Study, refer population data in **Appendix 4**).

Table 2.24 indicates that total annual demand for construction materials (FY 2018) was 39.8Mt, or 8.1 tonnes per person per year (per capita demand in tonnes per annum or tpa) based on a GSR population estimate of 4.91 million people for FY 2018.

GSR's per capita demand is high by historical standards and reflective of the coincident demand for housing, roads and infrastructure in the GSR.

For the GSR Study, the per capita demand for extractive materials in FY 2018 is estimated at 4.0tpa. This level of demand represents an estimated 29% increase since YE Dec 2011 (when per capita consumption for quarry products was estimated at 3.1tpa).

Future annual demand projections can be calculated by multiplying a forecast per capita consumption estimate by the forecast population. Given that per capita demand can be cyclical, demand forecasting by the per capita method must be subject to sensitivity analysis whereby different (i.e. less likely, but nonetheless possible) per capita consumption and population forecast scenarios, such as high and low series, are evaluated. This work is reported in Section 3 of this Study report.

2.11.2 Extractive Materials – Points of Use

A base case demand profile for extractive materials has been prepared for the GSR by 'point of use' using, as a basis, the Macromonitor construction material demand data for the period 2011 to 2018.

A summary of the demand profile for extractive materials from 2011 to 2018 is displayed in **Figure 2.10**. Demand is expressed in millions of tonnes (Mt). The current demand profile for the 12 months ending June 2018 is marked on the chart at FY 2018 and summarised under **Table 2.25**.

Figure 2.10 GSR Demand Profile for Extractive Materials 2011 to 2018 by Point of Use

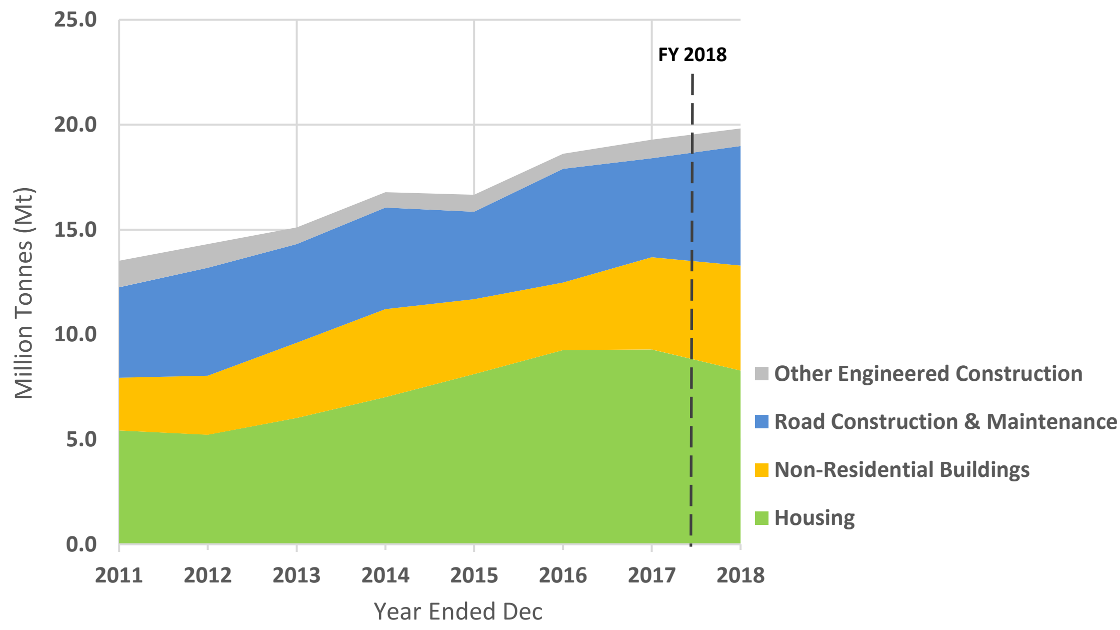


Chart Data Sources

1. Macromoniitor Greater SYDNEY - Demand by Point of Use 2011 to 2026, data issued Mar 2018
2. Study estimate of demand met by substitute construction materials (crushed sandstone/recycling etc) of 46% of total demand

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The total demand for extractive materials in **Figure 2.10** is the same as the total expressed for the supply profile in **Figure 2.1** (i.e. for the 12 months ending June 2018, the supply from hard rock and natural sand quarries was 19.5Mtpa).

From **Figure 2.10,** the base case GSR demand profile for hard rock and natural sand quarry products by Point of Use for the 12 months ending June 2018, is presented in **Table 2.25**.

Table 2.25
Demand for Extractive Materials by Point of Use Sector in the Greater Sydney Region – FY 2018

Product Type	Quantity	% of Total Quantity
Housing	8.8Mt	45%
Non-Residential Buildings	4.7Mt	24%
Road Construction & Maintenance	5.2Mt	27%
Other Engineering Infrastructure	0.8Mt	4%
Total	**19.5Mt**	**100%**

These data indicate demand for housing and non-residential buildings currently consumes 69% of extractive materials supplied to GSR, whilst demand from road construction and other engineered infrastructure accounts for 31%.

Figure 2.10 indicates demand for extractive materials from all housing types reached a peak in 2016-2017 and there has been a slight decrease since. Industry and the Macromonitor data indicates this trend is driven by a reduction in construction of new high rise and medium density dwellings in the inner city – this has reduced concrete demand (and thus the consumption of fine and coarse aggregates) in this sector.

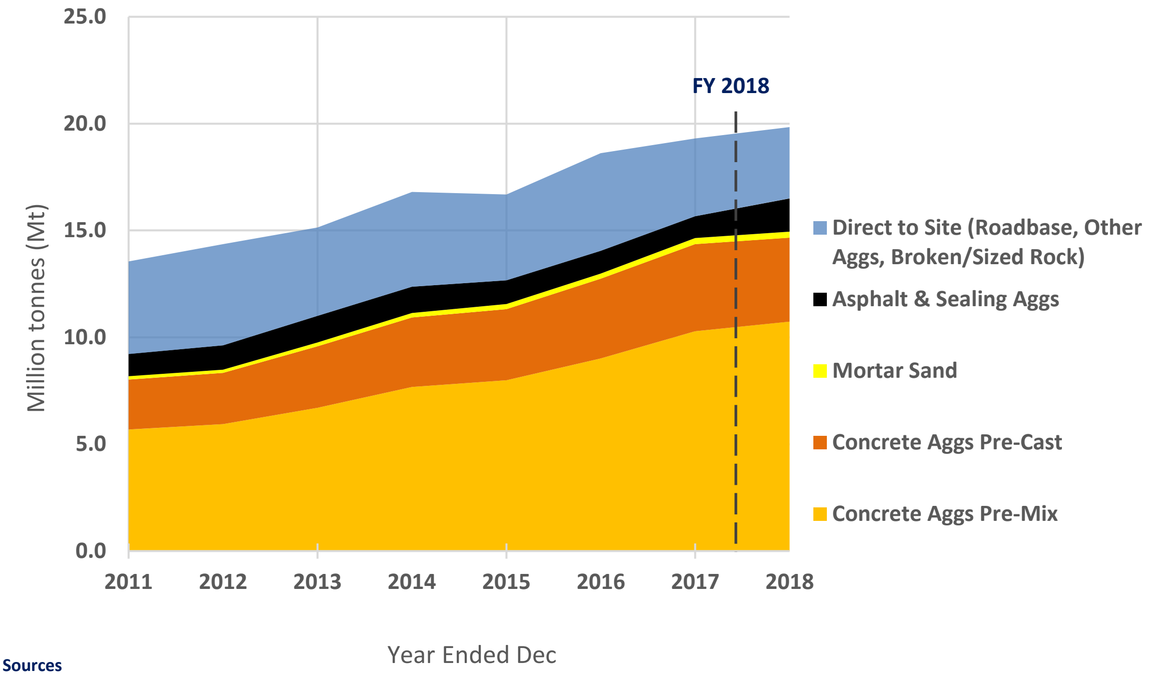
However, overall demand continues to be strong because of demand from non-residential buildings, road construction and major infrastructure projects.

Consultations with industry suggest that the GSR is close to experiencing peak demand but that overall demand is not anticipated to substantially reduce in the foreseeable future because of the pipeline of development projects in roads, other engineered infrastructure and housing.

2.11.3 Extractive Materials – Manufacturing and Direct to Site

Figure 2.11 displays the demand profile for extractive materials by manufacturing usage (i.e. for concrete and asphalt production) and direct supply to building and construction sites for the period 2011 to 2018.

Figure 2.11 GSR Demand Profile for Extractive Materials 2011 to 2018 by Manufacturing and Direct to Site



Sources
1. Macromoniitor Greater SYDNEY Quarry Products - Demand by Manufacturing Sector & Direct to Site , data issued Mar 2018
2. Study estimate of demand met by substitute construction materials (crushed sandstone/recycling etc) of 46% of total demand

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From **Figure 2.11**, the GSR demand profile for hard rock and natural sand quarry products by Manufacturing Sector and Direct to Site, for the 12 months ending June 2018, is presented in **Table 2.26**.

Table 2.26
Demand for Extractive Materials by Manufacturing Sector and Direct to Site – FY 2018

Product Type	Quantity	% of Total Quantity
Concrete Pre-Mixed - Fine and Coarse aggregate	10.5Mt	54%
Concrete Pre-Cast - Fine and Coarse aggregate	3.9Mt	20%
Mortar sand – Fine aggregate	0.3Mt	1%
Asphalt & Spray Seal – Fine and Coarse aggregate	1.3Mt	7%
Road Construction, Maintenance & Other Engineered Infrastructure	3.5Mt	18%
Total	**19.5Mt**	**100%**

Table 2.26 indicates that 82% of total quarry products supplied into the GSR are used in the manufacture of pre-mixed concrete, pre-cast concrete, mortars, asphalt and spray seal.

Extractive materials used directly as construction materials (e.g. drainage aggregate, rail ballast) are included in the above profile under Road Construction, Maintenance and Other Engineered Infrastructure category. Hard rock and natural sand quarry products that are transported by road from the quarry direct to the building and construction site account for an estimated 18% of supply.

The demand for aggregates in concrete, asphalt and for spray sealing for roads is estimated to be split between fine and coarse aggregates according to **Table 2.27**.

Table 2.27
Demand for Extractive Materials by Manufacturing Sector (% by weight)

Product Type	Fine Aggregates	Coarse Aggregates
Concrete Pre-Mixed	44%	56%
Concrete Pre-Cast	44%	56%
Mortar sand	100%	-
Asphalt	18%	82%
Spray Seal	-	100%

2.11.4 Fine Aggregates – Natural Sand and Manufactured Sand

An overall natural sand/manufactured sand supply profile of approximately 64% / 36% for concrete has been estimated for the Study.

Whilst the trend to substitute medium to coarse grained natural sand with manufactured sand from crushed rock quarries in concrete is evident (from the data and **Figure 2.1**), there are technical limits to the degree of substitutability.

Processing technologies are available to produce fine to coarse graded sands from crushed rock (with reduced fines contents) and are increasing in usage in NSW. Wider adoption of these technologies by the vertically integrated concrete producers is likely if natural sand becomes more difficult to source. Further substitutability of natural sand in concrete is therefore anticipated.

However, not all pre-mixed and pre-cast concrete producers own hard rock quarries and it understood from the Study that they are more reliant on natural sand for their concrete products. Likewise, sand for mortar is fine and has special technical characteristics which are difficult to emulate in manufactured sands.

Establishing an estimated limit for natural sand substitution by manufactured sand in concrete and asphalt is important for strategic planning of geological natural sand inventories to satisfy future GSR demand. This is discussed further under Section 3 of this Study report.

2.11.5 Demand Profiles for GSR Three Cities

Based on consultations with industry, the demand profile by extractive materials (**Figure 2.1**) has an estimated segmentation into GSR planning district as follows.

- 55% – Eastern Harbour City – GSR Central, North and South districts
- 30% – Central River City – GSR Central River City district
- 15% – Western Parklands City – GSR West district

This allocation of demand for the GSR Three Cities is considered consistent for both extractive materials and concrete.

2.12 Supply Cost Profile

Construction materials are heavy, bulky and used in large quantities. Their cost of supply consists of the material's selling price ex-quarry or ex-stockpile plus the cost of transport for delivery to their point of use.

Freighting of construction materials may be multi-modal which have differing freight cost profiles. Capital intensive loading and unloading plant and infrastructure are required for distribution of aggregates by rail or sea.

The all-in transport cost from quarry to concrete batching / asphalt plant or construction site represents a significant proportion of the total cost of supply to end users. The most commonly applied industry transport cost benchmark for construction materials is expressed as $ per tonne per kilometre hauled (one way), or $ per tonne/km.

2.12.1 Quarry Gate Prices

The cost of extractive materials when loaded at the quarry is referred to as the gate price, or ex-bin selling price ('Free on Truck' or FOT for road transport). Pricing is influenced by a range of factors including quality, scarcity, production costs, distance from markets, payload, level of demand and degree of competition and substitutability. Industry vertical integration is the norm, with most higher quality aggregates transferred 'internally' between quarries and batching plants.

Pricing at the individual quarry gate can vary considerably depending on these factors. Published sources of aggregate pricing in the GSR are rare. Pricing ex quarry gate also varies according to volumes purchased, with wholesale and retail price signals apparent but not explicit.

In a general sense, prices are set 'barometrically' by quarries having regard to the relative influences of the various factors outlined above. In periods of higher demand and constrained supply, prices for higher performance quarry products will rise, and moderate in price when conditions reverse.

Again, as a general construct, because of the impact of transport costs, the more distant a quarry from GSR markets the lower the gate price, and the closer the quarry to the market, the higher the gate price.

Price discounting at the quarry gate is rare because of the high costs of establishing and maintaining production from quarries, resource scarcity and the risks of the operating environment.

For the GSR Study, indicative quarry gate prices have been estimated from secondary information sources, and not from the supplier firms. This was for probity purposes. It was a key undertaking by the RWC Study team with industry representatives to not engage in pricing discussions with the construction materials industry because of trade practice compliance protocols and commercial sensitivities.

Table 2.28 presents a summary of indicative gate quarry price ranges for crushed rock and sand products along with indicative delivered costs of natural sand and aggregates into the Central Planning District of the Eastern Harbour City. These data have been established from consultations by the RWC Study team with other industry consultants and networks.

Table 2.28
Indicative Gate Prices and Total Delivered Costs by Road to Points of Use within the Greater Sydney Region

Aggregate Type	Delivered into inner GSR $/tonne excl. GST	Indicative Quarry Gate price $/tonne excl. GST	Transport cost comments
Natural Sand	$45 to $55	$25 to $35	Assuming $20 /tonne average transport cost from GSR and GSR feeder areas
Manufactured Sand	$55 to $65	$30 to $40	Assuming $25 /tonne average transport cost from GSR and GSR feeder areas
Coarse Aggregate 10mm	$65 to $75	$40 to $50	Assuming $25 /tonne average transport cost from GSR and GSR feeder areas
Coarse Aggregate 20mm	$70 to $80	$45 to $50	Assuming $25 /tonne average transport cost from GSR and GSR feeder areas
Rail Ballast		$22 to $25	From Southern GSR feeder areas

Table 2.28 offers a guide only to the pricing of natural sand and aggregates delivered to their points of use within the GSR.

2.12.2 Transport Component of Pricing

There are differences in pricing because of transport costs depending on where the quarry is located (i.e. Northern, Western, South Western or Southern GSR Feeder areas) and the mode of transport to distribution centres or other points of use in GSR. For example, Boral Resources (NSW) Pty Ltd (Boral) transport crushed rock products to Maldon by train from their Peppertree Quarry near Marulan, then distribute by truck to various locations throughout Sydney.

They also rail some aggregate to their two rail depots at Enfield and St Peters for use in on-site concrete and/or asphalt plants and some further distribution to other plants. They can transport crushed rock aggregates by road directly from the Dunmore Quarry in the south and Peats Ridge Quarry in the north, to southern and northern GSR districts respectively and can deliver into the Eastern Harbour City’s CBD, if required. The rock types from Boral quarries are different so they tend to adhere to a nominated supply pattern based on geological resource type and geography.

Hanson Construction Materials Pty Ltd (Hanson) operate the Bass Point hard rock quarry in the south and Kulnura hard rock quarry in the north. Hanson has an aggregate distribution depot at Blackwattle Bay which was previously a ship-supplied terminal until 2011.

Holcim (Australia) Pty Ltd (Holcim) operate the Albion Park hard rock quarry in the south and the Lynwood hard rock quarry near Marulan. Crushed rock products are transported by road to the GSR from Albion Park Quarry whereas approximately 25% of the crushed rock products from Lynwood Quarry are transported by road with approximately 75% of the crushed rock products also railed to the Rooty Hill RDC for further distribution in the GSR. A new regional distribution for Holcim is in advanced planning at Banksmeadow in the Port Botany precinct. Hy-Tec Industries Pty Limited operate a hard rock quarry near Lithgow and Gunlake Pty Ltd have a quarry near Marulan.

In considering just these hard rock quarry operations and their distribution centres, significant differences in delivered cost to the points of use (concrete and asphalt plants) exist because of differing transport distances and transport modes.

2.12.3 Road Transport Costs

Road transport costs for extractive materials are influenced by a range of factors including transport distance, the size of the truck payload, average speed, fixed and operating expenses for trucks (e.g. registration, fuel, wages, repairs and maintenance etc), road capacity and condition, degree of traffic congestion, tolls, road maintenance levies or contributions and other road use charges.

Truck time consumed during loading operations (or unloading in the case of concrete agitators) is also factored into the delivery cost to the consumer.

The Study did not survey industry firms directly on the cost of supply of extractive materials, including transport costs per tonne. Instead, transport cost benchmarks were established from other information sources comprising:

- contemporary industry benchmarks, typically expressed by industry representatives and consultants familiar with the GSR, and applied in other published extractive industry studies (e.g. Greater Melbourne and South East Queensland); and
- published NSW Industrial Relations contract determinations for transport of extractive materials and pre-mixed concrete – the most recently available data is from 2014.

For extractive material costing and strategic planning purposes, the principal metric used to express road transport costs for construction materials is in $ per tonne per kilometre – i.e. the cost to haul one tonne of extractive material one kilometre by road.

Consultations undertaken by the Study have established the contemporary industry transport cost benchmarks for road transportation of extractive materials in Australian cities typically lie in the range from $0.15 to $0.20 per tonne per km. Toll charges and delays from traffic congestion can push the transport cost to the higher limit.

For the Study's purposes, an average road transport cost of $0.20 per tonne per km is considered a satisfactory initial cost benchmark to assess the road transport cost component of extractive materials delivered to the GSR.

At a higher level of resolution, transport costs per tonne (or cubic metre (m^3) for pre-mixed concrete) can be expressed as a curve against the laden transport distance in kilometres.

Secondary sources of road transport cost data (referenced below) have been reviewed by the Study to produce two curves – one for extractive materials and one for pre-mixed concrete.

The source data for the transport cost curves was obtained through company websites and historical Contract Determinations published by NSW Industrial Relations for:

- **Extractive Material Transport** which covers aggregates, sub-base, sand and other products sourced from quarries generally transported in 'truck and dog' or high productivity vehicles configuration to various destinations including concrete plants and road construction projects; and
- **Concrete Transport** which covers pre-mixed concrete products sourced from concrete batching plants delivered in concrete agitator trucks to various construction projects.

2.12.3.1 Extractive Material Transport

Extractive materials are predominantly transported by road into and across the GSR. Some quarries are located more than 150km from the target market and the cost of transport is a significant factor in the total cost of quarry products consumed in the GSR.

The data used to estimate a road transport cost relationship with distance hauled, are the most recently published NSW Industrial Relations contract determinations for transport of extractive materials and pre-mixed concrete in NSW.

Contract determinations provide an overview of contract terms and in some cases detail the minimum payments under the contract for a variety of working scenarios. The contract determinations reviewed as part of the study are:

- Transport Industry – Quarried Materials, Carriers Contract Determination (dated 28/03/2014). Provides rates for up to 6 axle truck configurations.
- Transport Industry – Quarried Materials, Carriers Interim Contract Determination (dated 08/02/2008). Provides rates for trucks with larger 42.5 and 48t GCM (Gross Combination Mass).
- Boral Transport Limited Haulier Contract Determination (dated 14/09/2012).

The contract determinations listed above are quite complex with various provisions including rise and fall clauses for various changes in cost contingencies. The analysis of the data by the Study did not extend to detailed evaluation of contract variables to attempt to extrapolate the quoted rates to FY 2018, but it established from a comparison of the published rates over time (e.g. from 2008, 2012 and 2014) that transport cost rates have not changed substantially over this timeframe.

Based on these publicly-available contract determinations reviewed by the Study and the assumption that transport rates from 2014 are not significantly different to rates in 2018, **Figure 2.12** provides an estimate of the cost per tonne relationship with transport distance (laden, one way).

Figure 2.12 Extractive Materials Transport Cost Curve for Road Freight

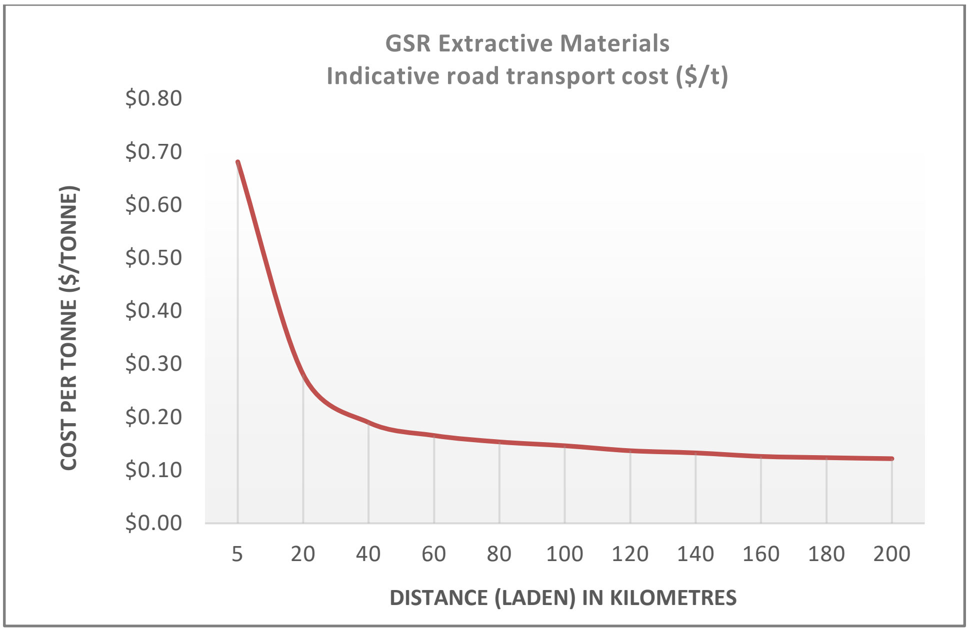


Figure 2.12 depicts the general relationship whereby the indicative cost per tonne is higher for short haul distances because of the proportional cost of truck mobilisation costs (e.g. to present at the quarry for loading). The cost curve flattens over distances greater than approximately 30km as the on-road costs and time spent travelling become the dominant variable for costs, rather than mobilisation costs (sometimes referred to as a 'flag fall' rate).

In **Figure 2.12** the range of values varies from around $0.28/t/km for a 20km haul distance to around $0.13/t/km for a 150km haul distance. It is important to note that these estimates do not include toll charges, nor directly account for delays attributable to increased traffic congestion.

The data that informs the curve in **Figure 2.12** are therefore approximate only. In 2018, they are likely to be higher. The costs curves would also be expected to differ between particular principal routes from the feeder areas.

Having regard to the limitations of these data, the cost curve in **Figure 2.12** is suggested as a guide only, and may under-represent FY 2018 transport costs. If further analysis of the cost of road transport along feeder routes into the GSR is required, then it is suggested the curve be used as a basis for further 'ground truthing'. This would require direct consultations with industry on transport costs from particular quarry sites to particular destinations in the GSR (such enquiries were excluded under the scope for this Study).

Given the limitations of Contract Determination analysis, for the purposes of this Study a contemporary broad (benchmark) cost per tonne for road transport of extractive materials to destinations in the GSR of approximately $0.20/t per kilometre of laden haulage, has been applied. This estimate is based on feedback received from the Study team's consultations with industry consultants, and industry contacts familiar with road transport in the GSR.

The estimate of $0.20/t/km includes a nominal allowance for tolls, and under-speed road conditions from congestion, but is an average, high-level estimate only.

The impact of road transport costs on the total delivered cost to consumers can be illustrated by way of typical example. Under the assumption of road transport cost of $0.20/t/km, a crushed aggregate selling ex the quarry gate at say $40 per tonne and transported 150km by road, has a nominal transport cost of $30 per tonne and thus a total delivered cost of $70 per tonne. In this example, the transport cost component increases the quarry gate price by 75% and represents 40% of the total delivered cost to the consumer.

2.12.4 Pre-Mixed Concrete Transport

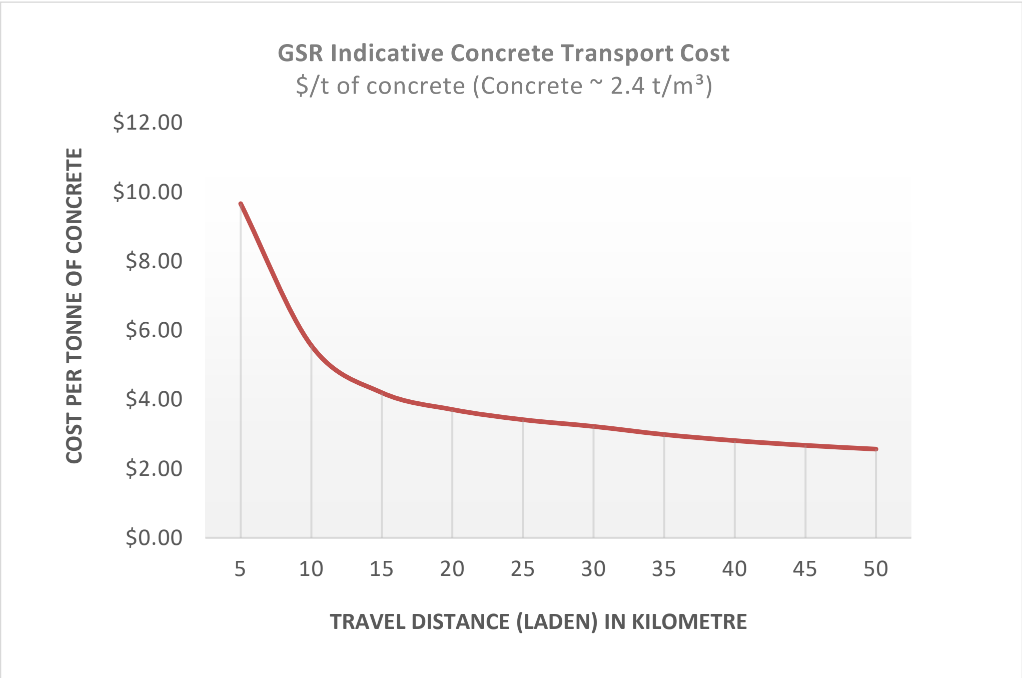
Pre-mixed concrete is transported in agitator trucks of various sizes from 'mini trucks' with a capacity of approximately 1.5m³ to 2m³ to large 10m x 4m models with approximately 9m³ capacity.

Due to limited shelf life of wet concrete, transport time and distance is greatly reduced compared to quarry products. The contract determination documents for concrete, reviewed for the Study are as follows:

- Transport Industry – Concrete Haulage Contract Determination (dated 27/02/2009).
- Hanson Construction Materials Pty Limited Concrete Carriers Contract Determination (dated 28/02/2014)

Figure 2.13 shows a representation of the average cost on the Y axis expressed in dollars per tonne ($/tonne) against the haul distance on the X Axis expressed in kilometres (km).

Figure 2.13 Pre-Mixed Concrete Transport Cost Curve



It is noted that the Contract Determination documents for concrete refer to transport costs by cubic metre of concrete. For consistency in reporting quantities in this Study, a conversion factor for concrete of 2.4 tonnes/m³ has been adopted to express the **Figure 2.13** cost curve for pre-mixed concrete in tonnes.

The indicative pre-mixed concrete cost per tonne in **Figure 2.13** is higher for short haul distances because of the proportional cost of concrete agitator loading time (e.g. to present at the batching plant for loading and slump testing before delivery). The cost curve flattens over distances greater than 10km as the on-road costs and time spent travelling become more influential.

The range of values varies from around $10 /t/km for a 5km haul distance to around $3.70/t/km for a 20km haul distance. Unlike extractive materials, the concrete transport cost includes a longer wait time at the discharge point to account for unloading time.

It is noted that the pre-mixed concrete transport cost curve in **Figure 2.13** has similar characteristics and limitations to the extractive materials road transport cost curve. It should be considered as an initial estimate only, of FY 2018 pre-mixed concrete distribution costs.

If further transport cost details for pre-mixed concrete delivery by concrete agitator truck is required, then further direct consultation with concrete suppliers and/or industry bodies to 'ground truth' the transport cost data would be beneficial.

2.12.5 Rail Freight Costs for Crushed Rock Products

Indicative rail freight costs have been evaluated in the Study based on consultations with wider industry networks. There are no equivalent contract determination documents for rail transportation as there are for road transportation.

Consultations under the Study have established the 'on-rail' cost of the more limited rail freight of crushed rock products is nominally one third of the 'on-road' transport cost. Assuming an 'on-road' transport cost of $0.13 per tonne/km, 'on-rail' costs are around $0.04 per tonne/km[21].

However, rail freight of crushed rock products require rail spur lines, land, producing loading and unloading facilities (at origin and destination), rolling stock and stockholding facilities, which incur large capital costs and additional rail access costs for those producers.

Consultations within industry suggest rail spur lines cost in the order of $10 million per kilometre with about 1.5km needed for a GSR regional distribution centre for crushed rock products. Train loading/unloading and tripper conveyor systems to move the crushed rock products into storage bays can cost in the order of $10 million.

Other cost drivers / contributors to be considered in crushed rock products transported by rail are rolling stock and rail access components such as spur line access, signalling, and the availability of rail paths for rail freight, particularly on the shared metropolitan passenger and freight network. On the shared network, rail freight is generally prohibited from using the network during peak periods.

[21] Total transport costs are higher than just the 'on-road' or 'on-rail' costs because of freight mobilisation costs ('flag fall' costs for trucks and road tolls); and rail/port access and infrastructure costs for crushed rock products freighted by rail/ship.

2.12.6 Cementitious Products and Concrete Pricing

Base case (FY 2018) pricing investigations of cement, concrete grade fly ash, GGBFS and concrete supplied into the GSR were not conducted for the Study. The supply costs of cementitious products, as binders in concrete, are much higher than crushed rock products, which are used as fillers.

Cementitious supply costs are multi-faceted, i.e. linked to domestic capacity, Asian sourcing cost contingencies, shipping costs, transport logistics and other market dynamics. Bulk cement and SCM pricing are not explicitly publicised because of supply chain integration and commercial and competition sensitivities.

Large purchasers of concrete (e.g. major builders and construction firms) represent the most reliable primary source of bulk concrete pricing, but for similar reasons to construction material suppliers they do not typically publicise purchasing details. Anecdotal evidence from wider market consultations is that 30Mpa (indicating average strength) concrete may sell for around $220 per cubic metre (excluding GST) within the GSR market, but this is speculative and not determinative.

Cement manufactured at Berrima is railed into Maldon and then trucked into the GSR. Cement produced at Port Kembla from shipped imports (clinker from Asia and cement from Railton, Tasmania) is railed by 'isotainer' into GSR for use and distribution at RDCs such as Rooty Hill. Cement is also trucked by road from South Australia.

Flyash from NSW coal-fired power stations is transported by road to the GSR in bulk tankers. GGBFS from Blue Scope's Port Kembla steel works is transported into the GSR by either road or rail.

2.13 Supply Constraints for Extractive Materials

Key supply constraints for extractive materials have been identified through consultation with industry including GSR suppliers of extractive materials, cement, pre-mixed concrete, asphalt and pre-cast concrete products.

The identified constraints that impact on the capability and capacity of the industry to supply extractive materials into the GSR were classified in the Study under the following factors.

- **Geological**
  The extent to which geology/resource characteristics influences geological reserves, and the yield and quality of the extractive materials produced including fine and coarse aggregates.

- **Regulatory**
  The extent to which regulatory constraints including the approvals process currently impact on supply including development consent conditions that regulate the duration of the development consents and/or the transport hours, timing and rate of truck movements from quarries.

- **Environmental**

  The extent to which environmental issues currently impact on the extraction and processing of the defined reserves within a quarry and the transportation of the products produced to their point of use.

- **Transport**

  The extent to which transport-related factors currently impact upon delivery of extractive materials through factors such as travel mode, travel distance, payload limits, duration of trip, toll charges and traffic congestion.

Collectively, these factors influence the cost of extractive materials supplied to the GSR at a point in time. The following subsections provide further details of the supply constraints for extractive materials, as identified throughout the preparation of the Study.

2.13.1 Geological Constraints

Table 2.29 lists the key geological constraints identified by industry during consultation.

Table 2.29
Geological Constraints upon Quarry Development and Operators

Material Source	Constraint
Crushed Rock:	• Variations in the thicknesses of weathered overburden. • Management of overburden, particularly if variable in quality and thickness. • Variations in natural hardness of targeted material and source rock quality. • Complexity of the geology and associated quarry planning costs. • Quality variations due to hydrothermal alteration. • Thickness and variability of chilled margins. • Inconsistent geometry of resource chilled margin. • Localised faulting and displacement of high quality rock.
Natural Sand:	• The presence of erratic shale lenses within friable sandstone deposits. • Management of silts and clays that need to be washed from friable sandstone deposits to produce concrete sand products and the associated water requirements. A yield of 80% typically results after sand washing. • Natural variability in the friability of sandstone resources which can constrain supply and necessitate possible blasting/additional processing (crushing). • The quality of manufactured sand products is expected to improve over time to limit the need for natural sands, particularly in concrete and asphalt manufacture.

The geology of the resource areas in which both hard rock and natural sand quarries are located is generally well understood and does constrain the supply of the required quarry products.

Geological constraints invariably impact quarry operations, however, it remains best practice for sufficient geological investigations and testing to be undertaken during the planning stage of a quarry to clearly define the geological constraints as best as possible and to provide the basis for the design of the extraction plan.

2.13.2 Regulatory Constraints

Table 2.30 lists regulatory issues reported to the Study together with the components of the approvals process that currently regulate output and timing of deliveries from quarries as reported by industry and industry consultants. These issues reported widely by industry act to constrain or regulate supply from quarries and could act as significant constraints to future quarry developments.

During the Study's consultations, industry commonly reported that some conditional requirements and restrictions imposed by consent authorities during both the development application process and ongoing operations, contribute to increasing the cost of extractive materials. Most operators identified that practical consent conditions, over longer time periods, would minimise the risks and costs associated with quarry operations and improve the viability of future quarry developments which in turn would assist to contain the costs of the crushed rock and natural sand products.

2.13.3 Environmental Constraints

Table 2.31 identifies the environmental constraints raised during consultation with industry. Whilst industry representatives acknowledged that they need to manage each of the constraints identified, they reported there was often an expectation from Government agencies and the community that the operator should undertake a range of costly mitigation measures, despite the quarry operating in compliance with noise and air quality limits.

2.13.4 Transport Constraints

This subsection provides a description of the key transport supply constraints reported by industry. It is recognised at the outset that there are potentially more possibilities for hard rock resources to be located near railway lines as the types of deposits suitable for the production of crushed rock products are generally more abundant than for sand resource. Furthermore, sand resources are typically not as large as hard rock resources, hence the resource base is not available to sustain the large capital investment for product despatch using rail.

Rail

- The delivery of extractive materials by rail from the South Coast is problematic given the priority given to passenger traffic and limited areas for setting aside whilst passenger trains pass.
- The availability of train paths for freight within the Eastern Harbour City are limited.

Table 2.30
Regulatory Constraints

Material Source	Constraint
Crushed Rock:	• Previous planning buffers to prevent adverse impacts from blasting, e.g. Sydney REP 9(2) have been progressively removed and there appears to be little planning protection for existing or potential hard rock quarries.
Natural Sand:	• The State Government needs to acknowledge and inform the community (through the Health Department) that silicosis is not an environmental issue for natural sand quarries. So much time and cost is wasted each time a sand extraction proposal is placed before a community. It is a non-issue and should not continue to be raised in SEARs, etc. and requested to be addressed in Response to Submissions.
Crushed Rock and Sand:	• The time and expense taken to obtain approvals and modifications is excessive. The practice of the DPE to accept submissions from the community right up until the time a development application is determined is inappropriate. This policy simply adds time to the determination process and extra cost. • Poorly drafted project approvals or development consents often with irrelevant and ambiguous conditions add time and cost through unnecessary auditing and at times engaging lawyers to resolve issues. • Overly restrictive (and sometimes arbitrary) conditions placed on operations and transport e.g. hours of operation. There appears to be too much emphasis placed upon achieving consistent requirements between development consents for quarry operations (so as not to be seen setting precedents) rather than matching a development consent to a particular locality or specific project components. • Inconsistent approach taken by regulators over a wide range of issues. • The identification of issues by agencies late in the development assessment process despite pre-DA meetings, SEARs and adequacy assessments. The assessment process needs to be managed by competent persons in each agency that are familiar with quarrying to avoid inappropriate, irrelevant issues being raised, particularly in the later stages of assessment. • Competency of Council officers in processing development applications (particularly for designated development) and a lack of training/familiarity with the industry. • Increased reporting requirements and ongoing government audits and reviews are consuming considerable amounts of company personnel's time – often for very little added value/improvements. • There is no pro-active planning by State Government to identify key resource areas and putting effective planning in place to protect the resources and the transport routes between the quarries and the main road network. • The duration or term of a development consent should match the proven reserves within a quarry. The need to apply for a new consent (at great expense and time) every 20 or 30 years is inappropriate. If the State Government wants certainty about the long term availability of extractive materials, then a more appropriate procedure should be implemented to achieve this. • The use of "voluntary" planning agreements (VPAs) invariably places additional costs for a new quarry project and can and does delay the issue of project approvals. Some operators expressed a preference that monitoring requirements for road maintenance should be included in the conditions of a development consent and not a VPA. The legal costs to prepare VPAs, advertising, etc. are all additional costs that would not be borne if the conditions covered the relevant matters. • Limited government support is evident on promoting recyclable products to extend the operation life of natural extractive resources. • The cost of resolving often simple issues in court add to the cost of production for all quarry products which are then reflected in product prices. • The need to satisfy both development consent conditions and mining lease conditions for a quarry is excessive, i.e. in conjunction with an environment protection licence, i.e. three masters – officers from all three agencies are keen to inspect, audit and impose instant penalties. Gone are the days when all government officers worked with industry for mutually beneficial outcomes.

Table 2.31
Environmental Constraints

Material Source	Constraint
Crushed Rock and Sand:	• Access to water resources for use in processing and washing sand products. The current embargo on water access licences results in considerable cost to purchase existing licences, particularly when it is documented in some water sharing plans that the groundwater resources are not fully allocated. • Biodiversity offsetting obligations have been identified by industry as a key environmental constraint which may sterilise otherwise viable resources in the future. The process is costly and can threaten the viability of a development prior to its inception. Extractive resources, within and surrounding the GSR, are invariably located in areas fully or partly covered by native vegetation. • Invariably, a number of local communities are present within a reasonable distance from many of the quarries that have been established in recent years within the feeder areas surrounding the GSR. The proximity of these communities and their local infrastructure need to be carefully managed during the operation of quarries. • Aboriginal heritage considerations and restrictions. The requirements for sub-surface investigations at times have been considered excessive when based upon a few isolated artefacts. Much time and cost is expended often for little result. • Groundwater restrictions on some quarry operations are onerous and result in excessive production costs for negligible impacts on the environment. • Visual impacts are often unavoidable in short term but greater acceptance is needed to allow sufficient time for visual barrier construction or growth of tree screens. • Management of noise impacts on nearby receptors, particularly those receptors that have moved into or built their residence within the area in which the quarry operators are audible (but compliant). • Management of air quality, including impacts of dust on surrounding receptors particularly those receptors that have moved into or built their residence within the area in which the quarry operators are compliant with air quality limits. • Costs associated with engaging consultants to assist with or undertake environmental monitoring, particularly when monitoring easily displays compliance and no complaints are received. • Costs associated with monitoring (e.g. for PM_{10}) just to satisfy the EPA's preference for a monitoring station to "fill a gap" in an existing monitoring network.

Road

- Most quarries are typically 50km to 200km from the current points of use for the delivered extractive materials. Hence, considerable transport distances are involved and lengthy periods to deliver the quarry products to the points of use.
- Industry regularly expressed that current payload limits in trucks transporting quarry products need to be increased in line with the objectives of the NSW Freight and Ports Plan 2018-2023.
- The restrictions upon the number of laden truck movements leaving a quarry during a nominated period (that are placed on development consents) is causing substantial queues at quarries. Many of the limits appear to be arbitrary and with no relation to noise or traffic limits.

- The approved hours of operation for product despatch from quarries currently restrict opportunities for trucks to travel to the GSR outside peak periods when road congestion is substantial.
- Industry experiences difficulty in attracting highly trained truck drivers.
- Extractive industries are often required to pay for road maintenance on roads used by many other trucks, using the same roads, who are not directly required to pay for road maintenance.
- Some Councils are not appropriately maintaining roads used by trucks transporting material despite contributions/levies being paid.
- Tolls are payable on some routes used by trucks laden with extractive materials, yet these roads are often congested, and little time benefit is achieved by taking the toll road.
- It remains a frustration to the industry that the State Government and Councils expect that the full costs associated with some road or intersection upgrading need to be met fully by the extractive industry (up front) when in fact, the upgrading works benefit many other motorists or industries.
- General road congestion across most roads within the GSR is contributing to longer travel times with potential to impact factors such as driver fatigue (and family life).
- Providing for appropriately zoned and sized land for future regional distribution centres or surge stockpiling areas near main roads would relieve some congestion
- There is excessive time taken by Councils to approve access roads to quarries for use by high productivity vehicles carrying up to 53t in the case of some Performance Based Standards (PBS) vehicles.

Actions to resolve a number of these transport constraints would assist the extractive industry to deliver the quarry products in a cost-effective and timely manner with least impacts upon both the community and truck drivers.

Improvements to the freight railway network was also identified as a crucial component to contain future delivery costs for quarry products.

2.13.5 Other Constraints

A common issue raised was the management of community expectations and a lack of appreciation of where the basic construction materials originate for their homes, offices, roads, hospitals, schools, factories, etc.

For cementitious materials, the trend towards supplementing local (NSW) sources of cement and SCMs with bulk imports from Asia and India is of material significance, as it impacts on the commercial feasibility of increasing domestic supply and places additional logistics demands on the ports and intermodal freight modes (e.g. port to rail and/or port to road) that service the GSR.

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For concrete and asphalt, the availability and location of land for industry to establish batching plants and inter-modal regional distribution centres that store and distribute crushed rock products within the GSR, along with plant operating hours, are important factors influencing future efficient distribution. Some existing batching plants are also subject to operating constraints because of amenity issues arising from encroaching residential development in their vicinity.

2.13.6 Concluding Comments

Given the preference for quarries to be located as close as practical to the points of use for their products, a number of quarries are located in proximity of residents, schools, native vegetation, important water sources, and various competitive land uses. Although recently developed quarries are developed at greater distances from the GSR, there are invariably local communities that also place constraints upon both extraction and product transportation. The range of constraints are invariably taken into account at the time when a quarry is planned, i.e. through the siting and design of the various components on site and the adoption of a range of mitigation measures and management procedures. Many industry representatives expressed their concerns that there is insufficient regulatory and planning protection to protect quarries and their haul routes from incompatible developments.

A widely articulated concern expressed by industry is that the planning system does not consistently or sufficiently control development of land around quarries nor along the road transport routes, that is incompatible with extractive industry. The consequence is that future locationally-bound extractive resources can be sterilised and rates of production and truck movements reduced, which further increases the cost of supply of extractive materials to the wider community.

Industry and operators generally, reported to the Study a desire and preference to be able to work more effectively with both local and State Government to achieve more practical development consents, and a more cooperative approach to address or mitigate the above constraints to improve efficiency of supply, and thus contain the costs of quarry products to both local and GSR communities.

3. Future Supply and Demand Assessment

3.1 Key Messages

1. The forecast demand assessment for all construction materials for the period from 2019 to 2036 indicates the 'current' peak in demand is anticipated in 2019, followed by a projected dip to 2023. The reduction in demand is expected to be short-lived and forecast to steadily increase from 2024 to 2036.
2. The projected short-term dip in demand is driven by an anticipated downturn in high and medium density housing apartment demand, thus reducing concrete demand. From 2024, demand is anticipated to rebound, principally driven by population growth and the commensurate level of building and construction activity in the GSR.
3. A forecast demand series for all construction materials for the 19-year period from Year Ending (YE) December 2018 to YE December 2036 indicates the following total cumulative demand.
   - Crushed rock products (265 million tonnes).
   - Natural sand products (118 million tonnes).
   - Cementitious materials (63 million tonnes).
   - Substitute construction materials (e.g. VENM / tunnel spoil / crushed sandstone and recycled concrete) (326 million tonnes).
4. The average annual demand for extractive materials is projected to be 20Mtpa over the forecast period which is comparable to the FY 2018 level of demand. Therefore, average future demand is expected to be consistent with the existing levels – setting a 'new norm' for demand from the building and construction sectors in the GSR.
5. In response to growing demand and the closure of sand and gravel quarries in the GSR, industry has increased the use of manufactured sand from hard rock quarries as a replacement for medium and coarse grained natural sand in concrete. With improved technology, which is available internationally but not yet widely used in Australia, this substitution trend may in the future extend to fine sand.
6. It is projected that the demand profile for extractive materials within the GSR will shift gradually westwards. Presently, the Eastern Harbour City consumes about 55% of total extractive and cementitious materials supplied to the GSR. By 2036, this proportion is anticipated to reduce to 50% in response to growth in the Central River and Western Parklands Cities.

7. Quarry production will continue to be closely aligned with supply of aggregates to meet concrete and asphalt demand. Reliance on the substitute construction materials is projected to continue - accounting for an additional 326Mt of products over the 19-year period to 2036. However, there is uncertainty about the long-term supply quantity of sandstone VENM, given it is dependent on the location and timing of major construction projects and the suitability of sub-surface geology. A future reduction in supply of sandstone VENM would require increased supply from recycled concrete and quarries, mainly in the roadbase and sub-base product categories.

8. Consultation with industry and review of development approvals has identified that there are sufficient approved hard rock quarry reserves to supply the GSR with its crushed hard rock requirements beyond FY 2036, whilst accounting for local demand outside the GSR (and higher-demand scenarios explored by sensitivity analysis).

9. Whilst a number of the quarries currently supplying natural sand products to the GSR are forecast to be depleted prior to 2036, there are sufficient potential resources within and adjacent to a number of the quarries (subject to receipt of required development consents) to enable existing quarries to meet the GSR natural sand requirements up unto and beyond 2036.

10. The increasing trend of importation of cementitious materials from overseas is expected to continue, as domestic cement manufacture declines and the availability of concrete grade flyash from coal-fired power stations and ground granulated blast furnace slag (GGBFS) from steel works, plateaus or declines.

11. Suitable port infrastructure will need to be allocated to receive, unload and distribute the additional imported cementitious materials. The trend to increased importation of cement clinker for local grinding will necessitate the further allocation of land for cement grinding and blending facilities near ports.

12. Additional rail connectivity for bulk cementitious materials from port and/or grinding facilities to regional distribution centres will be required to avoid additional imposts on port to road infrastructure.

13. The importation of crushed rock products (and potentially natural sand) by ship into Sydney Harbour from coastal quarries is expected to re-commence in the near future, as an alternative to increases in transport of these products by road from suitable sites.

14. The existing principal and secondary road transport routes used for the delivery of extractive materials will continue to be the major access routes into and within the GSR.

15. Transport operating costs for crushed rock products by rail are about one third the cost of transport by road. However, capital costs to establish connectivity from ports and quarries to intermodal regional distribution centres within the GSR are substantial (> $20 million), and suitable distribution sites within the GSR are scarce.

16. A future increase in port to rail and quarry to rail capacity for bulk cementitious materials and crushed rock products would decrease road traffic congestion. High capital costs, land availability and rail connectivity and access remain as significant constraints to increasing the non-road transport component of construction materials.

17. In order to reduce delays from road traffic congestion (and the cost of extractive materials), industry is investigating opportunities for after hours (night time) supply of construction materials to help re-stock the concrete and asphalt plants with their daily raw material requirements.

3.2 Introduction

Section 3 of this Study uses the base case assessment for the GSR for the period YE December 2011 to YE 2018 (established in Section 2) as a starting point to derive an annual future demand and supply assessment from 2018 to 2036 inclusive.

The future demand profile relies on Macromonitor GSR demand forecasts and the results of the Study's industry survey to establish a short-term estimated demand profile for 2018 to 2026, and thereafter, the per capita method and population estimates are used to estimate future demand over the medium to longer term (from 2027 to 2036 inclusive).

Consistent with the base case assessment to FY 2018, the forecast demand profiles are segmented by:

- Quarry product type;
- Concrete raw materials;
- Manufacturing needs and Direct to Site; and
- Point of Use (comprising the housing, non-residential buildings, roads and other engineered infrastructure sectors).

3.3 Overview of Assessment

3.3.1 Demand-Side Influencing Factors

The principal driver for the purchase of construction materials is the demand for the products and services provided by the materials. For example, the volume of concrete purchased for a residential development influences the production of the materials used to manufacture the concrete. The demand for construction materials is therefore known as a derived demand. Demand is 'derived' by the demand for the goods or services that crushed rock and natural sand products and cement provide.

As construction materials are used as essential inputs for building and construction, their demand is driven by economic activity, population growth and levels of public and private funding for roads and major infrastructure projects.

Demand is met by supply from hard rock and natural sand quarries (extractive materials), cementitious materials and substitute extractive materials as described in Section 2.11.

3.3.2 Forecast Demand Profile 2018 to 2036

Base-case estimates of cumulative demand (in Mt) are calculated for extractive and cementitious materials for the period (YE Dec) 2018 to (YE Dec) 2036 (inclusive).

The forecast demand profile for extractive and cementitious materials from 2018 to 2036, adopts the following inputs.

- Macromonitor construction material forecast demand data for GSR.
- Main Series NSW population series for GSR to 2036.
- Future per capita consumption rates (from 2027 and beyond) equivalent to the average per capita consumption estimate for the period 2011 to 2026.

As described in Section 2.11, the future demand forecasts for extractive materials from 2018 to 2036 are prepared with the assumption that 46% of total GSR demand for aggregates, roadbase/sub-base and broken/sized products is met by substitute construction materials such as crushed sandstone, sandstone VENM and recycled concrete.

For the period 2018 to 2026, the Macromonitor demand estimates for construction materials are used to establish the demand profile. For the medium to longer term (2027 to 2036), per capita consumption multiplied by projected population is used.

A sensitivity analysis has then been conducted to assess the effects of different levels of population growth, per capita consumption and recycling rates, on the future GSR demand for extractive and cementitious materials.

The future demand profile and the results of sensitivity analyses are used in this Study to assess the necessary supply response to meet forecast demand for the period 2018 to 2036.

3.3.3 Supply-Side Influencing Factors

The existing and anticipated supply-side factors or constraints evaluated in Section 2 and which impact on availability and continuity of supply from quarries and concrete/asphalt plants can be used to assess supply-side responses and establish criteria required to meet future demand. Key supply factors and constraints include the following.

- Geographic location of quarries and associated transport costs.
- Resource depletion rates and geological reserve inventories which is also influenced by resource sterilisation from competing land uses.
- Local sensitivities to environmental impacts associated with extending operations or seeking alternative (greenfield) locations as sources of extractive materials.
- Product development trends such as the extent to which manufactured sand will continue to substitute for natural sand in concrete.

- Development consent conditions that regulate output, operating life and operating constraints such as the timing of despatch of construction materials to GSR.
- The trend towards supplementing local (NSW) sources of cementitious materials with bulk imports from Asia and India.
- The availability and location of suitably zoned land for industry to establish concrete / asphalt plants and inter-modal regional distribution centres.

3.3.4 Demand v Supply Balance

At a particular point in time, demand for construction materials is considered to be synonymous with supply (production sold)[22]. The drivers of demand establish the quantities of supply necessary to meet that demand.

This Study concludes by assessing the findings and conclusions regarding the future demand and supply balance for construction materials for the GSR – this is assessed for the baseline conditions, and for higher and lower demand scenarios evaluated from the sensitivity analysis. Any potential shortfalls in supply from the GSR feeder areas and/or implications for the transportation and distribution of extractive materials along the principal transport routes from the feeder areas are flagged.

3.3.5 Assessment Method

Future GSR demand for construction materials for the period 2018 to 2036 has been assessed having regard to the following.

- Base case demand and supply profiles for FY 2018 from Section 2.
- Consideration of demand-side influencing factors such as rate of population growth and level of planned building and construction activity.
- Macromonitor construction material demand profiles for 2018 to 2026 by Point of Use (housing, non-residential buildings, roads, other engineered infrastructure) and by Manufacturing/Direct to Site.
- Macromonitor construction material demand profile from 2018 to 2026 for extractive materials by quarry product type.
- Macromonitor construction material demand profile from 2018 to 2026 for concrete by raw material ingredients. This profile includes a proportion of recycled materials as aggregates, whereas the other demand profiles address only extractive materials produced from hard rock and natural sand quarries.
- From 2027, by multiplying an estimate of per capita consumption of construction materials to 2036 by GSR population forecasts for each year.

[22] This assumption is well-established for forecasting of construction materials usage at a point in time. The traditional pair of demand and supply curves that define the general price-quantity relationship can be visualised as a pair of scissors – their point of intersection or equilibrium point defines the demand and supply balance for a point in time.

Future supply to the GSR of construction materials to meet the demand for the period 2018 to 2036 has been assessed having regard to the following.

- Base case demand and supply profiles for FY 2018 from Section 2.
- Macromonitor construction material demand forecasts from 2018 to 2026.
- Consideration of supply-side influencing factors (or constraints).
- Consideration of substitution of extractive materials from non-hard rock and natural sand quarry sources. The base case assessment adopts an estimate of 46% of demand met by these other sources and the sensitivity analysis explores 35% and 50% scenarios for substitute materials.
- Transport/freight implications of supply response, including freight mode, feeder routes and types and quantities of quarry products and cementitious materials delivered into GSR from the various supply zones.

3.3.6 Per Capita Consumption

The Study has adopted the following GSR profile of per capita consumption rates in tonnes per annum (tpa) for construction materials comprising extractive materials (crushed rock and natural sand) and other extractive materials (e.g. crushed sandstone VENM, recycled concrete) and cementitious materials. **Figure 3.1** shows the adopted per capita demand profile until 2036.

Figure 3.1 Construction Materials – GSR Per Capita Consumption Estimates 2011 to 2036

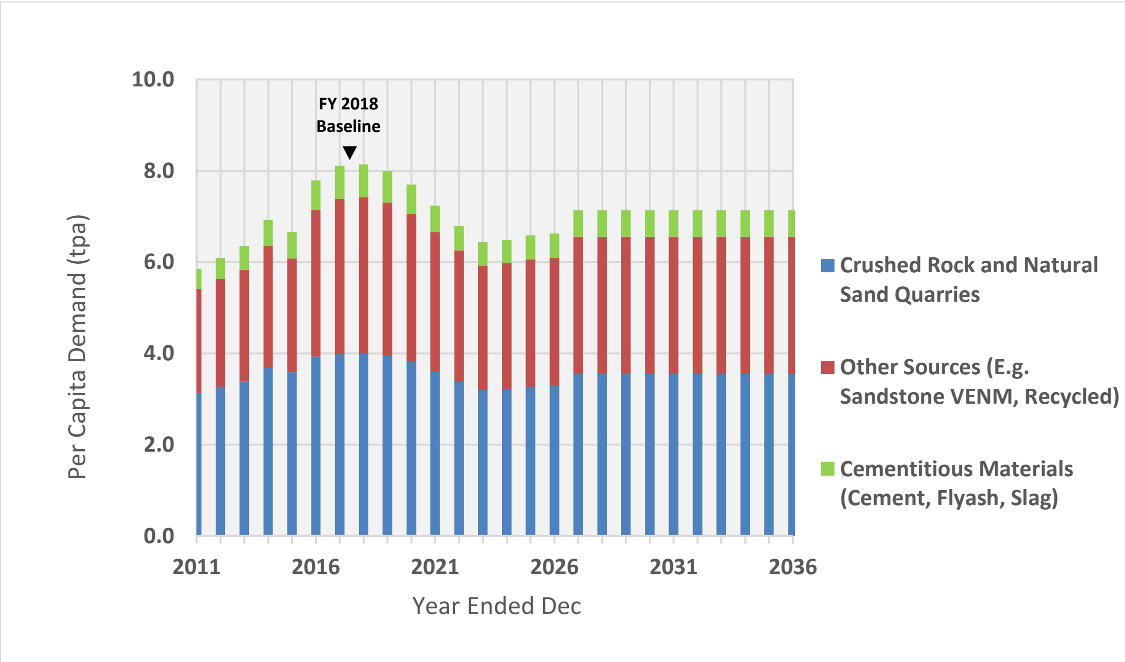


Table 3.1 provides further details of the per capita demand profile for the years indicated over the period 2011 to 2036. **Appendix 4** contains year on year details of the data series.

Table 3.1
Construction Materials – Greater Sydney Region Per Capita Consumption Estimates (tpa)

Construction Material Type	2011	2016	FY 2018	2021	2026	2031	2036
Extractive Materials	3.1	3.9	4.0	3.6	3.3	3.5	3.5
Cementitious Materials	0.5	0.7	0.7	0.6	0.5	0.6	0.6
Substitute Construction Materials	2.3	3.2	3.4	3.0	2.8	3.0	3.0
Total	**5.9**	**7.8**	**8.1**	**7.2**	**6.6**	**7.1**	**7.1**

The FY 2018 baseline for GSR indicates per capita consumption of 8.1tpa for all construction materials (from quarries, substitute sources, and cement and SCMs). Thus, for an estimated (FY 2018) population of approximately 4.91 million people, GSR is presently consuming approximately 39.8Mtpa of construction material products (4.91 million x 8.1tpa).

The FY 2018 per capita consumption rate for construction materials of 8.1tpa represents a 37% increase over the 5.9tpa rate for 2011.

From **Table 3.1**, extractive materials consisting of crushed rock and natural sand from quarries have an FY 2018 per capita consumption rate of 4.0tpa, up from 3.1tpa in 2011.

For extractive materials (and assuming the proportion of demand met from substitute sources remains at FY 2018 levels of 46% of total demand for quarry and substitute products), the forecast per capita consumption for extractive materials is estimated at 3.6tpa by 2021 and 3.3tpa by 2026.

Macromonitor demand forecasting to 2026 (based on assessment of the modelled foreseeable demand pipeline for housing, non-residential buildings, road construction and other engineered infrastructure) indicates per capita consumption rates for all construction materials are anticipated to reduce to 7.2tpa by 2021 and 6.6tpa by 2026.

Beyond 2026, a constant per capita demand estimate for construction materials of 7.1tpa has been adopted by the Study (3.54tpa for extractive materials).

3.3.7 Sensitivity Analysis

Macromonitor demand forecasting is only available to 2026 and as a result, per capita consumption estimates have been used to forecast demand for the medium to longer term (2027 to 2036). A sensitivity analysis has been conducted to assess the effects of different assumptions of population growth, per capita consumption and recycling rates, on the future GSR demand profile for extractive and cementitious materials.

Table 3.2 provides a summary of the inputs used for the baseline assessment and the sensitivity analysis, which considers high and low demand scenarios.

Table 3.2
Greater Sydney Region Extractive Materials Demand – Key inputs for Sensitivity Analysis

Variable	Baseline 2027	Low Case	High Case	Comments
1. Population Forecasts (M)	Main Series	Low Series	High Series	GSR population forecasts
2. Per Capita Consumption (tpa)		-5%	+10%	Higher upside - demand pipeline
– Extractive Materials	3.5	3.4	3.9	Baseline 3.5tpa (Average 2011-2026)
– Cementitious Materials	0.6	0.6	0.6	Refer below
– Substitute Construction Materials	3.0	2.9	3.3	Recycled C&D waste; Sandstone
Construction Materials	7.1	6.9	7.8	Baseline 7.1tpa (Average 2011-2026)
3. Substitute Construction Materials % of Total Aggregate and Roadbase/ Sub-Base	46%	35%	50%	Surplus of Sandstone VENM & C&D Waste, particularly crushed concrete

In **Table 3.2**, Variable 1 (population growth) and Variable 2 (per capita consumption) affect the overall level of demand for all construction materials. A 'low-low' case occurs when both population and per capita consumption are lower than the baseline forecast, and conversely for the 'high-high' demand case.

Variable 3 (demand met from substitute construction materials) affects the level of demand for extractive materials. If the proportion of substitute construction materials is higher, demand from quarries (mainly roadbase/sub-base) is lower.

Per capita consumption of cementitious materials is not separately analysed under the sensitivity analysis for 2027 to 2036. Instead, sensitivity changes in their future demand are driven by the total construction materials per capita estimate.

3.4 Demand Profiles

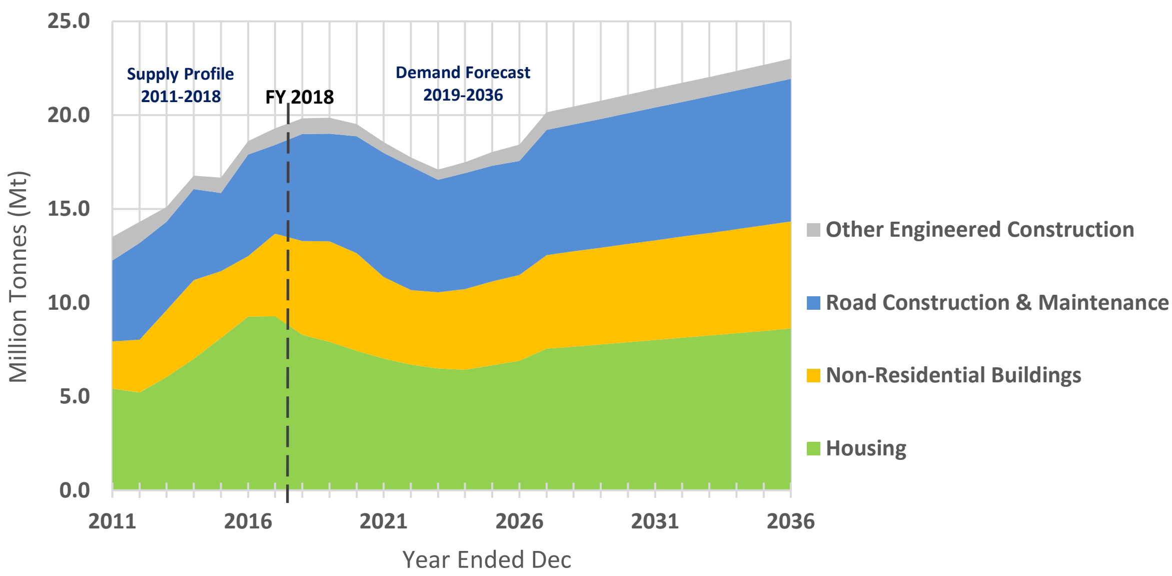
Baseline GSR demand profiles for extractive and cementitious materials for the period 2018 to 2036 (19 years) have been prepared according to:

- point of use by building and construction activity type;
- manufacturing demand (concrete, asphalt, spray seal) and Direct to Site;
- concrete raw materials by aggregates, natural sand and cementitious material type; and
- extractive materials by product type.

3.4.1 GSR Demand for Extractive Materials by Point of Use

Figure 3.2 displays the base case demand profile (2011 to FY 2018) and the forecast demand profile from YE December 2018 to YE December 2036 for extractive materials by Point of Use. The building and construction categories are those described in Section 2.11.

Figure 3.2 GSR Extractive Materials – Base Case and Forecast Demand Profile by Point of Use



Sources
1. Macromonitor Greater SYDNEY Construction Materials Demand forecast, by Point of Use 2011 to 2026, data issued Mar 2018
2. From 2027, GSR Study estimate of per capita consumption and Main Series population forecasts
3. GSR Study estimate of demand met from extractive material substitute sources of 46% of total demand

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The forecast demand profile in **Figure 3.2** indicates a peak in demand for extractive materials of approximately 20Mt in 2019. The projected 'dip' in the forecast demand from 2019 to 2023 arises principally from reduced concrete consumption in medium and high-density housing, based on the Macromonitor demand forecast to 2026. **Figure 3.2** indicates that beyond 2023 the baseline demand increases in response to further growth in demand for road construction, other engineered infrastructure and housing.

Beyond 2026, the total demand curve slopes upwards at a constant gradient using a per capita consumption of 3.54tpa, which is the adopted base for the medium to long term forecast.

Consultation with industry supports the Macromonitor data which indicates the reduction in peak concrete demand from 2016 is already apparent in the GSR but anticipated to be relatively short-lived. **Appendix 3** contains a summary of the Macromonitor data and its derivation.

Table 3.3 provides a summary of the forecast demand profile in **Figure 3.2** for extractive materials by Point of Use, from 2018 to 2036 for the years nominated.

From **Figure 3.2**, the assessment of future demand, year on year, is anticipated to range from a low of 17.1Mtpa (2023) to a high of 23Mtpa (2036). The average demand over the 19 year period from 2018 to 2036 is 20.1Mt. The variation in annual demand from the average is around 15%.

Table 3.3
Greater Sydney Region Extractive Materials
– Forecast Demand Profile by Point of Use (Mt)

Building and Construction Sector	2018	2021	2026	2031	2036
Housing	8.3Mt	7.0Mt	6.9Mt	8.0Mt	8.6Mt
Non-Residential Buildings	5.0Mt	4.4Mt	4.5Mt	5.3Mt	5.7Mt
Roads	5.7Mt	6.6Mt	6.1Mt	7.1Mt	7.6Mt
Other Engineering Infrastructure	0.8Mt	0.6Mt	0.9Mt	1.0Mt	1.1Mt
Total	**19.8**Mt	**18.6**Mt	**18.4**Mt	**21.4**Mt	**23.0**Mt

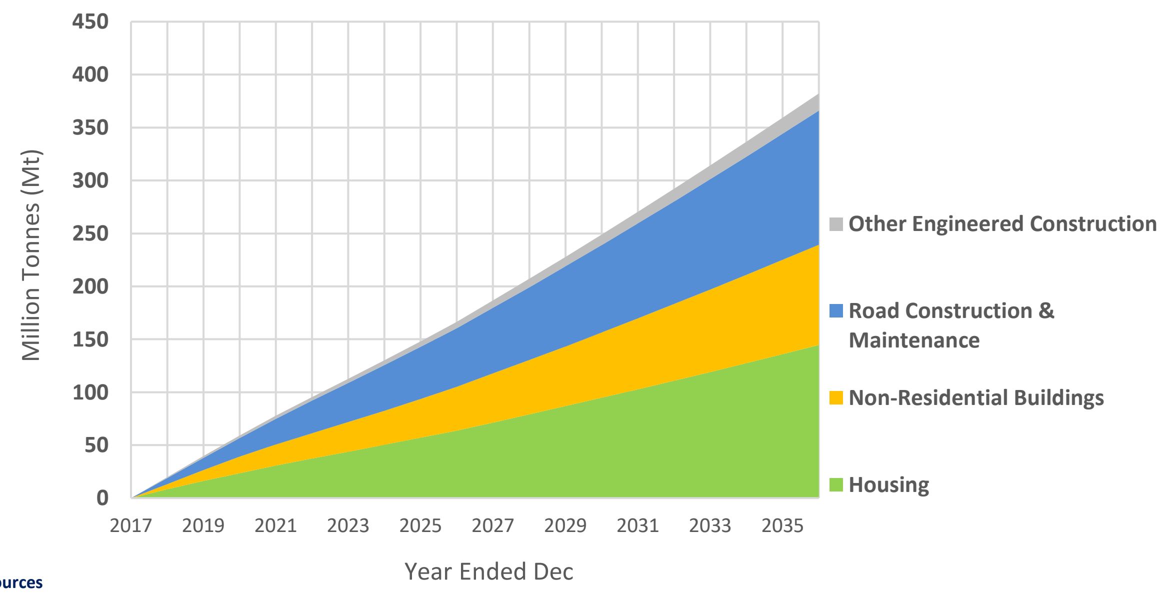
The proportional demand for extractive materials from **Table 3.3** is shown in **Table 3.4**.

Table 3.4
Greater Sydney Region Extractive Materials
– Forecast Demand Profile by Point of Use (% tonnes)

Building and Construction Sector	2018	2021	2026	2031	2036
Housing	42%	38%	37%	37%	37%
Non-Residential Buildings	25%	23%	25%	25%	25%
Roads	29%	36%	33%	33%	33%
Other Engineering Infrastructure	4%	3%	5%	5%	5%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

The estimated baseline cumulative demand by Point of Use for the period 2018 to 3036 (19 years) is shown in **Figure 3.3**.

Figure 3.3 GSR Extractive Materials – Cumulative Forecast Demand Profile by Point of Use 2017 (Zero Base) to 2036 (19 years)



Sources
1. Macromonitor Greater SYDNEY Construction Materials Demand forecast, by Point of Use 2011 to 2026, data issued Mar 2018
2. From 2027, per capita consumption of 3.5tpa and Main Series population forecasts
3. GSR Study estimate of demand met from substitute construction materials of 46% of total demand (deducted from Macromonitor demand forecasts)
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From **Figure 3.3**, the GSR cumulative forecast demand profile for extractive materials by point of use is 383Mt over the 19-year period from 2018 to 2036. According to the forecast demand profile, demand for housing from 2018 to 2036 will consume 145Mt of extractive materials (38%), non-residential buildings 95Mt (25%), road construction and maintenance 127Mt (33%) and other engineered infrastructure 16Mt (4%).

3.4.2 GSR Demand for Extractive Materials by Product Type

Figure 3.4 displays the base case demand profile (2011 to FY 2018) and the forecast demand profile from 2018 to 2036 for extractive materials, by product type. The product types are those referred to in various tables in Section 2.

Figure 3.4 GSR Extractive Materials – Base Case and Forecast Demand Profile by Product Type

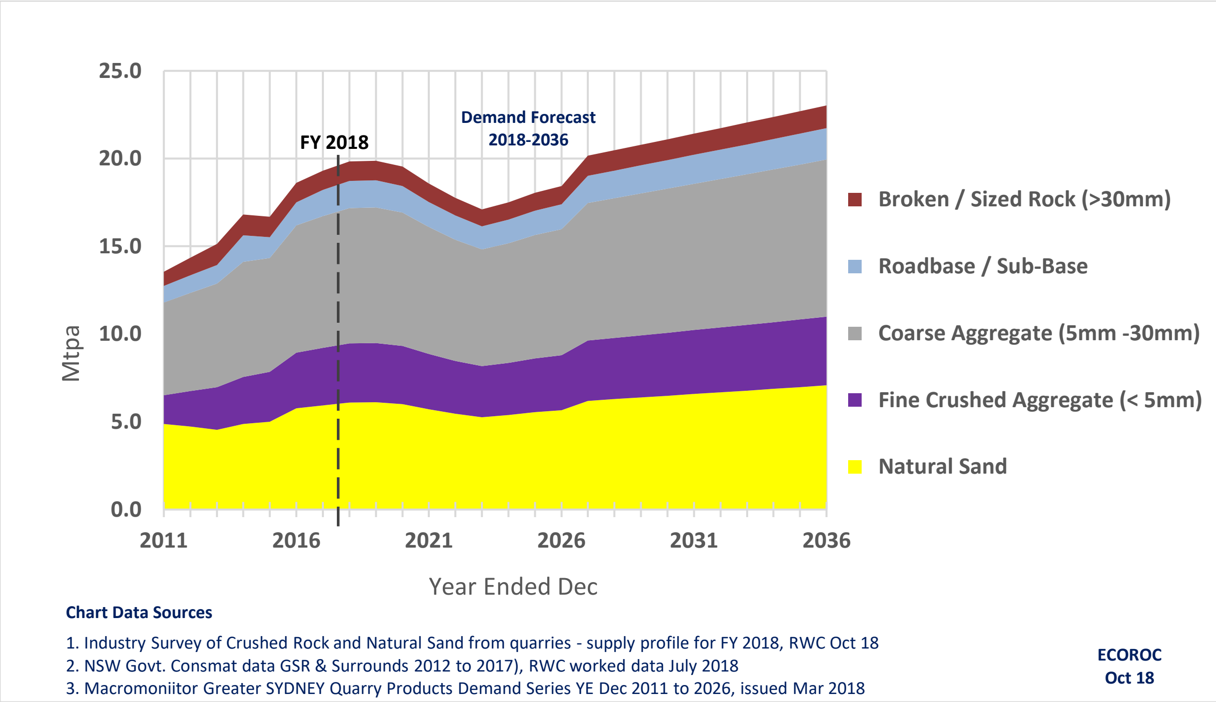

Figure 3.4 has the same total demand profile to the Point of Use demand profile.

Table 3.5 provides a summary of the forecast demand profile for extractive materials by product type, from 2018 to 2036. **Appendix 4** contains details of the year on year data series.

Table 3.5
Greater Sydney Region Extractive Materials – Demand Forecast by Product Type (Mt)

Product Type	2018	2021	2026	2031	2036
Natural Sand (< 5mm)	6.1Mt	5.7Mt	5.7Mt	6.6Mt	7.0Mt
Crushed Fine Aggregates (< 5mm)	3.4Mt	3.2Mt	3.1Mt	3.6Mt	3.9Mt
Crushed Coarse Aggregates (5mm - 30mm)	7.7Mt	7.2Mt	7.2Mt	8.3Mt	9.0Mt
Roadbase / Sub-Base	1.5Mt	1.5Mt	1.4Mt	1.7Mt	1.8Mt
Broken/ Sized Rock (>30mm)	1.1Mt	1.0Mt	1.0Mt	1.2Mt	1.3Mt
Total	**19.8**Mt	**18.6**Mt	**18.4**Mt	**21.4**Mt	**23.0**Mt

Similarly to the forecast demand profile for extractive materials by Point of Use, the assessment of future demand for extractive materials by product type is anticipated to range from a low of 17.1Mtpa (2023) to a high of 23Mtpa (2036).

The proportional demand (in tonnes) for extractive materials from **Table 3.5** is shown in **Table 3.6**.

Table 3.6
Greater Sydney Region Extractive Materials – Demand Forecast by Product Type (% tonnes)

Product Type	2018	2021	2026	2031	2036
Natural Sand (< 5mm)	31%	31%	31%	31%	31%
Crushed Fine Aggregates (< 5mm)	17%	17%	17%	17%	17%
Crushed Coarse Aggregates (5mm - 30mm)	39%	39%	39%	39%	39%
Roadbase / Sub-Base	8%	8%	8%	8%	8%
Broken/ Sized Rock (>30mm)	6%	6%	6%	6%	6%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Under the baseline profile, **Table 3.6** indicates that crushed rock products are forecast to account for 69% of future demand for extractive materials in GSR, and natural sand 31%. Crushed fine and coarse aggregates are forecast to account for 56% of total quarry output over the 2018 to 2036 period (or 81% of total output from hard rock quarries).

The estimated cumulative forecast demand for extractive materials by product type for the period 2018 to 2036 (19 years) is shown in **Figure 3.5**.

Figure 3.5 GSR Extractive Materials - Cumulative Demand Forecast by Product Type – 2018 to 2036

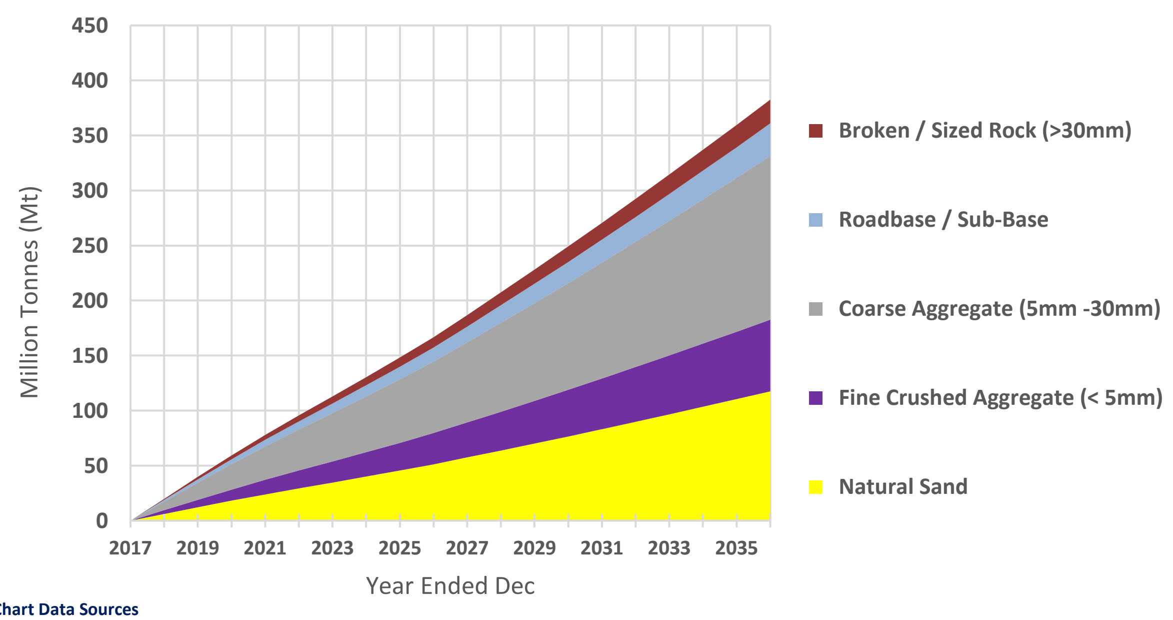

Chart Data Sources

1. Macromonitor Greater SYDNEY Construction Materials Demand forecast, by Quarry Product type 2018 to 2026, data issued Mar 2018
2. From 2027, per capita consumption of 3.5tpa and Main Series population forecasts
3. Demand profile excludes substitute construction materials (estimated at 46% of total demand, mainly as roadbase/sub-base)

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From **Figure 3.5**, the cumulative baseline demand for extractive materials over the 19-year period from 2018 to 2036, is forecast at 383Mt. **Table 3.7** shows the profile by quarry product type and percentages by weight.

Table 3.7
Greater Sydney Region Extractive Materials – Baseline Cumulative Demand Forecast by Product Type – 2018 to 2036

Quarry Product	Quantity	% of Total Quantity
Natural Sand (< 5mm)	118Mt	31%
Crushed Fine Aggregates (< 5mm)	65Mt	17%
Crushed Coarse Aggregates (5mm - 30mm)	149Mt	39%
Roadbase / Sub-Base	29Mt	8%
Broken/ Sized Rock (>30mm)	22Mt	6%
Total	**383Mt**	**100%**

The average per capita demand for extractive materials in the cumulative forecast demand profile of **Figure 3.5** and from **Table 3.7** is 3.53tpa. (Low in 2023 of 3.5tpa, high in 2018 of 4.0tpa).

3.4.3 Reconciliation with Demand met from Substitutes for Extractive Materials

The cumulative demand forecast of 383Mt met by extractive materials in **Table 3.7**, accounts for an estimated 54% of total demand for quarry products and their substitute materials. Substitutes for extractive materials such as recycled C&D waste and sandstone VENM are estimated to account for 46% of total demand (cumulative demand forecast of 326Mt to 2036).

Of this estimated cumulative demand forecast of 326Mt met by substitute construction materials, roadbase/sub-base is estimated to account for approximately 65% of supply.

The reconciliation of the baseline demand profile for all construction materials is summarised in **Table 3.8**.

Table 3.8
Greater Sydney Region Construction Materials – Baseline Demand Forecast All Materials

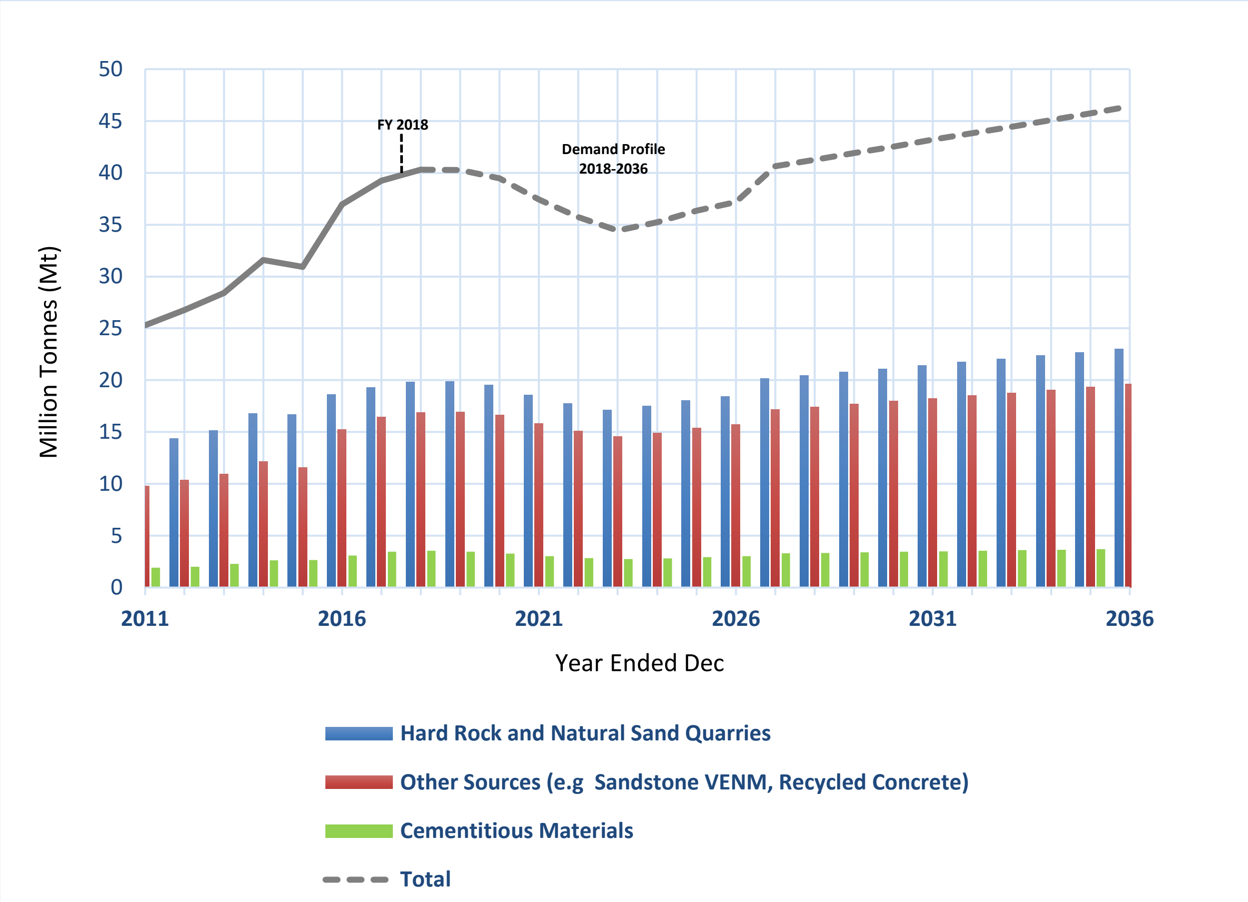
Construction Material	2018	2021	2026	2031	2036
Crushed Rock and Natural Sand	19.8Mt	18.6Mt	18.5Mt	21.4Mt	23.0Mt
Cementitious Materials	3.6Mt	3.0Mt	3.0Mt	3.5Mt	3.8Mt
Substitute Construction Materials	16.9Mt	15.8Mt	15.7Mt	18.3Mt	19.6Mt
Total Construction Materials	40.3Mt	37.4Mt	37.2Mt	43.2Mt	46.4Mt
Estimated Resident Population	5.0M	5.2M	5.6M	6.1M	6.5M
Per Capita Demand	**8.1tpa**	**7.2tpa**	**6.6tpa**	**7.1tpa**	**7.1tpa**

Total construction material demand which includes cementitious materials is forecast to be 40.3Mt for YE December 2018 and increasing to 46.4Mt by 2036.

Figure 3.6 provides a summary of the GSR construction materials baseline demand and supply assessment from 2011 to 2036.

Forecast demand from 2018 to 2036 for the baseline assessment is shown as the dashed upper line on **Figure 3.6**. The supply profiles of the types of construction materials necessary to meet demand are shown as columns, below the total demand profile.

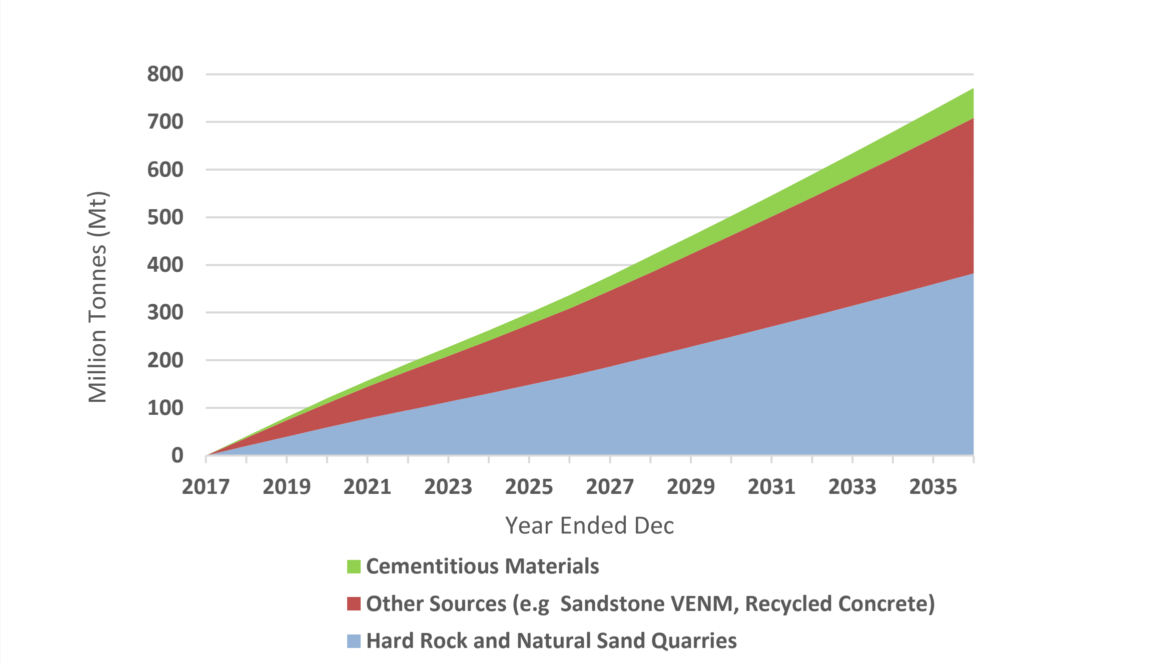
Figure 3.6 GSR Construction Materials – Base Case and Forecast Demand and Supply Profile



The estimated cumulative forecast demand for extractive materials by product type for the period 2018 to 2036 (19 years) is shown in **Figure 3.7**.

Figure 3.7 indicates a cumulative construction material forecast demand profile of 772Mt for the period 2018 to 2036 inclusive, comprising extractive materials (383Mt), substitutes for extractive materials such as VENM / tunnel spoil / crushed sandstone and recycled concrete (326Mt), and cementitious materials (63Mt).

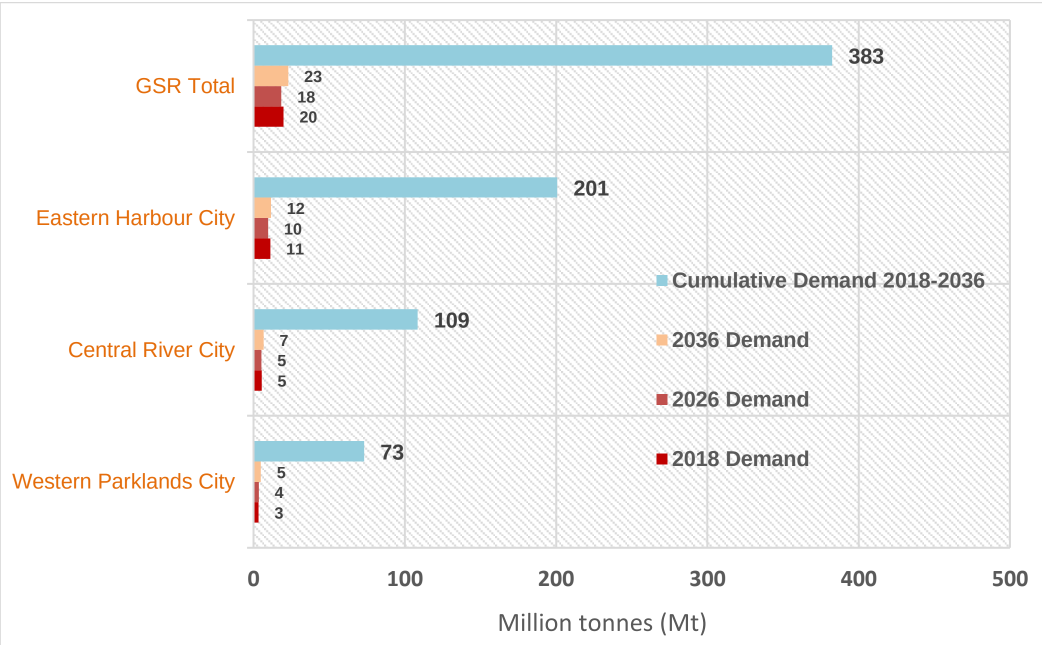
Figure 3.7 GSR Construction Materials – Cumulative Forecast Demand and Supply Profile



3.4.4 Extractive Material Demand for the Three Cities

Figure 3.8 provides, for the three cities, an estimated breakdown of the GSR baseline demand for extractive materials (crushed rock and natural sand from quarries) over the forecast period 2018 to 2036 inclusive.

Figure 3.8 GSR Three Cities Extractive Materials – Cumulative Forecast Demand Profile



Appendix 4 contains the detailed year on year forecast demand data for this estimated breakdown by Three Cities (for Extractive Materials and Cementitious Materials).

Table 3.9 provides the YE December 2018 and cumulative demand data for **Figure 3.8**.

Table 3.9 also indicates the quantities of crushed rock and natural sand based on the proportions of 69% crushed rock and 31% natural sand.

Table 3.9
Greater Sydney Region Three Cities Extractive Materials – Forecast and Cumulative Forecast Demand Profile

Extractive Material	EHC		CRC		WPC		GSR Total	
Year(s)	2018	2018 to 2036	2018	2018 to 2036	2018	2018 to 2036	2018	2018 to 2036
Crushed Rock	7.7Mt	139Mt	3.7Mt	75Mt	2.3Mt	51Mt	13.7Mt	265Mt
Natural Sand	3.4Mt	62Mt	1.7Mt	34Mt	1.0Mt	22Mt	6.1Mt	118Mt
Total	**11.1Mt**	**201Mt**	**5.4Mt**	**109Mt**	**3.3Mt**	**73Mt**	**19.8Mt**	**383Mt**

Figure 3.8 indicates that over the 19-year period from 2018 to 2036 (inclusive), the Eastern Harbour City (EHC) is forecast to consume 201Mt of extractive materials, consisting of 139Mt of crushed rock and 62Mt of natural sand (from **Table 3.9**). This represents approximately 53% of total GSR demand met by quarries, over the forecast period.

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Similarly, the Central River City (CRC) is forecast to consume 109Mt of extractive materials or 28% of GSR demand met by quarries, and the Western Parklands City (WPC) 73Mt or 19% of GSR demand.

The demand profile by GSR Three Cities is an approximation only, because:

- the Macromonitor demand data on which it is based, is segmented by different geographic boundaries (ABS boundaries) within the GSR, compared with the GSR five districts, and there is a loss of resolution when re-allocating granular demand forecasts by differing internal boundaries; and
- over the 2018 to 2036 period, the percentages of total demand will increase in the CRC and WPC compared with the 2018 profile, because of the population growth and concomitant demand for housing, non-residential buildings, roads and infrastructure – whilst the trend is clear, because of data limitations and loss of resolution at the GSR planning district level, a more detailed assessment to derive a more accurate breakdown of demand by three cities has not been developed for this Study.

In the context of the limitations outlined in the dot points above, **Table 3.10** (on which the demand forecasts in **Table 3.9** rely) provides an estimate of the demand profile percentages (by tonnes) for extractive materials for the GSR Three Cities, over the period 2018 to 2036.

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Table 3.10
Greater Sydney Region Three Cities Extractive Materials
– Baseline and Cumulative Demand Profile (% of Total Quantity)

Construction Material	2018	2026	2036	2018-2036
Eastern Harbour City (EHC)	56%	53%	50%	53%
Central River City (CRC)	27%	28%	29%	28%
Western Parkland City (WPC)	17%	19%	21%	19%
Total	**100%**	**100%**	**100%**	**100%**

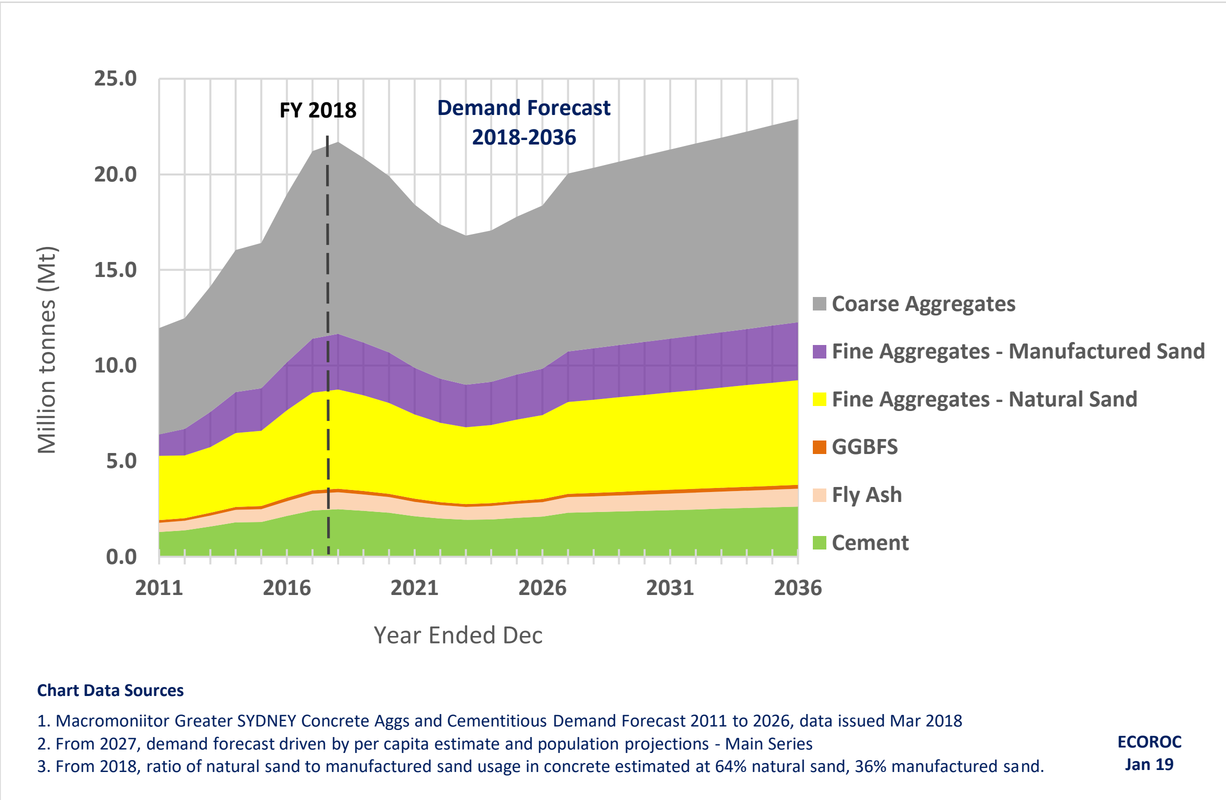
The percentages in **Table 3.10** represent demand met from crushed hard rock and natural sand quarries. GSR demand met from substitute construction materials (and including sandstone quarries) accounts for an estimated 46% of total demand for all aggregates and roadbase/sub-base products mainly as roadbase/sub-base in road construction and hardstand areas but is excluded from the data in **Tables 3.9** and **3.10**.

The key point to note is that a demand profile for all materials (extractive materials and substitutes) for the GSR Three Cities would differ from **Table 3.10** – considerable quantities of roadbase/sub-base will be consumed in the WPC and CRC as the cities grow to the west and connect to the east, but much of this will be supplied from surplus sandstone VENM and recycled C&D waste sources within the GSR. With these materials added, the demand percentages for WPC and CRC would be higher, and EHC proportionally lower.

3.4.5 Raw Materials for Concrete

Figure 3.9 displays the base case demand profile (2011 to FY 2018) and the forecast demand profile from 2018 to 2036 for concrete raw materials used in the manufacture of pre-mixed concrete, pre-cast concrete and mortars. The demand is measured in million tonnes.

Figure 3.9 GSR Concrete – Base Case and Forecast Demand Profile by Raw Material Type



The conversion from raw material tonnes to cubic metres for concrete is approximately 2.4t/m^3 (excluding water and additives).

The concrete raw material profile consists of cement, fly ash and GGBFS (collectively referred to as cementitious materials), and fine and coarse aggregates. Most coarse aggregates are produced from hard rock quarries in the GSR feeder areas, as hard rock and river gravel reserves are now exhausted in the GSR.

For the baseline concrete raw material assessment, the proportions of natural sand and manufactured sand are estimated at 64% and 36% by tonnes of fine aggregates respectively. The data in **Figure 3.9** indicate a (peak) demand of 21.7Mt for concrete raw materials for YE December 2018. The per capita demand estimate for concrete raw materials YE December 2018 is 4.4tpa.

The per capita consumption of concrete raw materials over the forecast demand period in **Figure 3.9** ranges from a high of 4.4tpa in 2018 and 2019 to a low of 3.1tpa in 2023. From 2027 to 2036, a per capita demand of 3.5tpa of concrete raw materials is adopted for the forecast.

As discussed under the Point of Use demand profile, the projected 'dip' in the forecast demand from 2019 to 2023 arises principally from reduced concrete consumption in medium and high-density housing, based on the Macromonitor demand forecast to 2026.

Beyond 2023, demand for concrete increases again in the forecast demand profile. The increase from 2027 is constant and driven by per capita consumption

Table 3.11 provides a summary of the forecast demand profile for concrete raw materials from 2018 to 2036, for the years nominated.

Table 3.11
Greater Sydney Region Concrete – Forecast Demand Profile by Raw Material Type

Concrete Raw Material	2018	2021	2026	2031	2036
Cement	2.5Mt	2.1Mt	2.1Mt	2.4Mt	2.6Mt
Fly Ash	0.9Mt	0.7Mt	0.7Mt	0.9Mt	0.9Mt
GGBFS	0.2Mt	0.2Mt	0.2Mt	0.2Mt	0.2Mt
Fine Aggregates - Natural Sand	5.2Mt	4.4Mt	4.4Mt	5.1Mt	5.5Mt
Fine Aggregates - Manufactured Sand	2.9Mt	2.4Mt	2.4Mt	2.8Mt	3.0Mt
Coarse Aggregates	10.0Mt	8.5Mt	8.5Mt	9.9Mt	10.6Mt
Total	**21.7Mt**	**18.4**Mt	**18.4**Mt	**21.3**Mt	**22.9Mt**

Under the baseline assessment of future demand for concrete raw materials, year on year demand is anticipated to range from a low of approximately 17Mtpa (2023) to a high of approximately 23Mtpa (2036). The average forecast annual demand over the 19-year period from 2018 to 2036 is approximately 20Mtpa[23]. The variation in annual demand from the baseline average, over the 19-year forecast period, ranges from approximately minus 17% (2023) to (plus) 14 % (2036).

[23] This is a similar quantity to extractive material demand, but coincidental.

The proportional demand (in tonnes) for concrete raw materials from **Table 3.11** is shown in **Table 3.12**, rounded to the nearest percentage.

Table 3.12
Greater Sydney Region Concrete
– Baseline Demand Forecast Profile by Raw Material Type (% of Total Quantity)

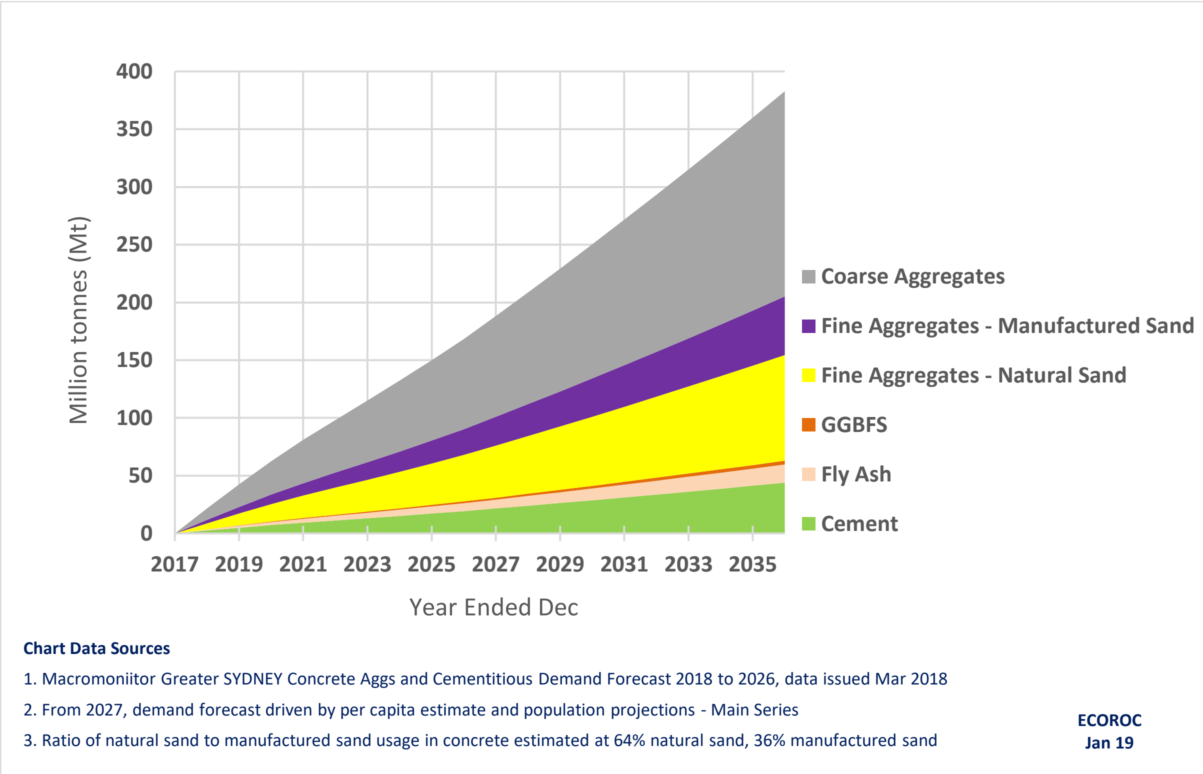
Concrete Raw Material	2018	2021	2026	2031	2036
Cement	12%	12%	12%	12%	12%
Fly Ash	4%	4%	4%	4%	4%
GGBFS	1%	1%	1%	1%	1%
Fine Aggregates - Natural Sand	24%	24%	24%	24%	24%
Fine Aggregates - Manufactured Sand	13%	13%	13%	13%	13%
Coarse Aggregates	46%	46%	46%	46%	46%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

Table 3.12 indicates that cementitious materials account for 17% of concrete raw materials (by weight) and fine and coarse aggregates account for 83%, for the period 2018 to 2036.

Fine aggregates from both crushed hard rock and natural sand quarries account for 37% by weight. Coarse aggregates account for 46% by weight of total raw materials used in concrete (excluding water and additives).

The forecast baseline cumulative demand for concrete raw materials for the period 2018 to 2036 (19 years) is shown in **Figure 3.10**.

Figure 3.10 GSR Concrete - Cumulative Forecast Demand Profile by Raw Material Type (Mt) for 2018 to 2036



From **Figure 3.10**, the cumulative baseline demand for concrete raw materials over the 19-year period from 2018 to 2036, is forecast at 383Mt[24]. **Table 3.13** shows the cumulative demand profile by raw material type and percentages by weight.

Table 3.13
Greater Sydney Region Concrete
– Baseline Cumulative Demand Forecast by Raw Material Type – 2018 to 2036

Concrete Raw Material	Quantity	% of Total Quantity
Cement	44Mt	12%
Fly Ash	16Mt	4%
GGBFS	3Mt	1%
Fine Aggregates - Natural Sand	91Mt	24%
Fine Aggregates - Manufactured Sand	51Mt	13%
Coarse Aggregates	178Mt	46%
Total	**383**Mt	**100%**

From **Table 3.13** and **Figure 3.10**, the average per capita consumption for concrete raw materials for the baseline cumulative demand forecast from 2018 to 2036 is 3.52tpa.

The concrete raw material forecast demand profile includes a small proportion of fine and coarse aggregates derived from substitute construction materials and estimated to be approximately 5% of total aggregates, though this estimate is high-level.

3.4.6 Extractive Materials Demand by Manufacturing Sector/ Direct to Site

Figure 3.11 displays the base case demand profile (2011 to FY 2018) and the forecast demand profile from 2018 to 2036 for extractive materials demand by manufacturing sector and direct to site.

This profile identifies the quantities of extractive materials from quarries that are transported to concrete and asphalt batching plants, and those quarry products that are transported direct to the building or construction site. The categories profiled are those described in Section 2 of this Study.

Table 3.14 provides a summary of the forecast demand profile in **Figure 3.11** for extractive materials (Mt) by manufacturing sector (concrete and asphalt batching) and materials transported directly to building and construction sites from 2018 to 2036.

The proportional demand (in tonnes) from **Table 3.14** is shown in **Table 3.15**.

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[24] Coincidentally, this is the same forecast cumulative total as for Extractive Materials (383Mt). The Concrete Raw Materials total includes 63Mt of cementitious materials.

Figure 3.11 GSR Extractive Materials – Base Case and Forecast Demand Profile by Manufacturing Sector and Direct to Site

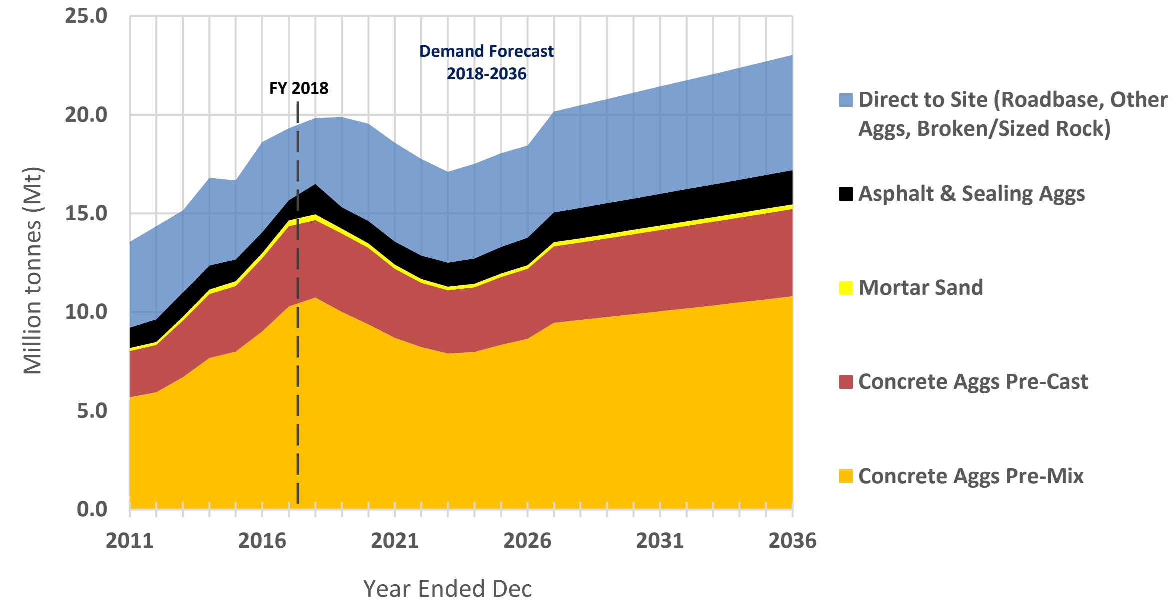

Table 3.14
Greater Sydney Region Extractive Materials
– Forecast Demand Profile by Manufacturing Sector and Direct to Site

Manufacturing Sector / Direct to Site	2018	2021	2026	2031	2036
Concrete Aggregates Pre-Mix	10.7Mt	8.7Mt	8.6Mt	10.0Mt	10.8Mt
Concrete Aggregates Pre-Cast	3.9Mt	3.5Mt	3.5Mt	4.1Mt	4.4Mt
Mortar Sand	0.3Mt	0.2Mt	0.2Mt	0.3Mt	0.3Mt
Asphalt & Spray Seal Aggregates	1.6Mt	1.2Mt	1.4Mt	1.6Mt	1.7Mt
Direct to Site (Roadbase, Other Aggregates, Broken/Sized Rock)	3.3Mt	5.0Mt	4.7Mt	5.4Mt	5.8Mt
Total	**19.8**Mt	**18.6**Mt	**18.4**Mt	**21.4**Mt	**23.0**Mt

Table 3.15
Greater Sydney Region Extractive Materials
– Forecast Demand Profile by Manufacturing Sector and Direct to Site (% of Total Quantity)

Manufacturing Sector / Direct to Site	2018	2021	2026	2031	2036
Concrete Aggregates Pre-Mix	54%	47%	47%	47%	47%
Concrete Aggregates Pre-Cast	20%	19%	19%	19%	19%
Mortar Sand	1%	1%	1%	1%	1%
Asphalt & Spray Seal Aggregates	8%	6%	8%	8%	8%
Direct to Site (Roadbase, Other Aggregates, Broken/Sized Rock)	17%	27%	25%	25%	25%
Total	**100%**	**100%**	**100%**	**100%**	**100%**

The cumulative forecast demand profile for extractive materials by manufacturing sector and direct to site for the period 2018 to 2036 (19 years) is shown in **Figure 3.12**.

Figure 3.12 GSR Extractive Materials – Cumulative Forecast Demand Profile by Manufacturing Sector and Direct to Site

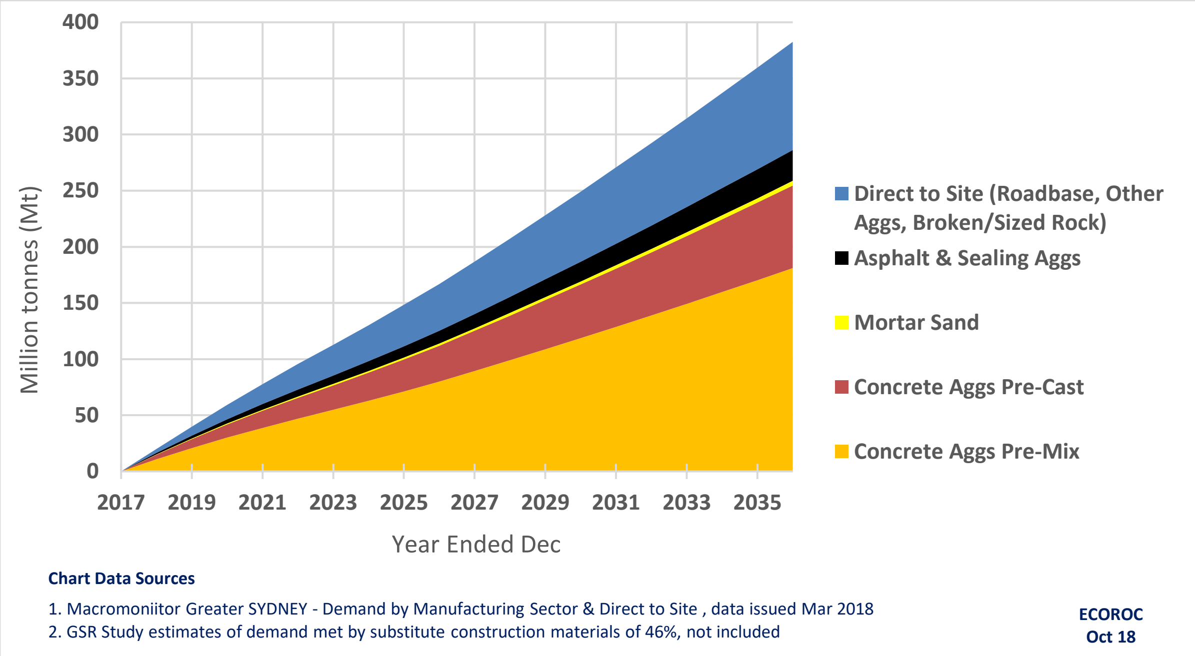

Table 3.16 shows the cumulative forecast demand profile by manufacturing sector and direct to site (Mt and % of total) for **Figure 3.12**.

Table 3.16
Greater Sydney Region Extractive Materials
– Cumulative Forecast Demand Profile by Manufacturing Sector and Direct to Site – 2018 to 2036

Manufacturing Sector / Direct to Site	Quantity	% of Total Quantity
Concrete Aggregates Pre-Mix	181Mt	48%
Concrete Aggregates Pre-Cast	74Mt	19%
Mortar Sand	4Mt	1%
Asphalt & Spray Seal Aggregates	28Mt	7%
Direct to Site (Roadbase, Other Aggregates, Broken/Sized Rock)	96Mt	25%
Total	**383Mt**	**100%**

The forecast demand profile in **Table 3.16** indicates the cumulative demand for pre-mix concrete aggregates, comprising fine and coarse aggregates from crushed hard rock and natural sand quarries, over the 19-year period from 2018 to 2036 (inclusive) is 181Mt or 48%.

Pre-cast concrete products account for 74Mt or 19% of demand for extractive materials. Some pre-cast concrete products are understood to be manufactured in regional NSW and transported to the GSR, in which case not all the aggregates may be sourced from within the GSR and feeder areas.

Table 3.16 also indicates extractive materials transported directly from quarries to building and construction sites, account for approximately 25% of total demand. These materials include rail ballast, drainage aggregates, sand used as bedding or filter media, broken and sized rock products such as gabion and armour rock, and roadbase/ sub-base. Roadbase supplied from hard rock quarries is likely to be higher performance DGB material (unbound or cement-stabilised).

3.5 Supply Profiles

The necessary supply response to meet the anticipated GSR demand for extractive materials (383Mt over 19 years or 20.1Mtpa on average) is reviewed in this section with the supply profile expressed on a tonnes per week basis, for crushed rock and natural sand.

The anticipated supply response will be influenced by the supply-side constraints outlined in Section 2.13 and discussed further under Section 3.6. These constraints create management pressures and logistics challenges for producers of extractive materials and concrete that influence the feasibility of maintaining the necessary levels of supply. The key impacts of these constraints are higher delivered costs for construction materials and traffic congestion costs.

An indication of the breakdown of existing supply, by GSR feeder area and major transport route and mode, is provided in Section 2 of this Study and an analysis of the existing transport network using forecast annual and weekly freight tonnages for extractive materials by road and rail is presented in Section 3.8.

3.5.1 Crushed Rock and Natural Sand

The forecast supply profiles for crushed rock and natural sand products, necessary to meet anticipated future GSR demand, are those shown in **Figures 3.4** and **3.5**.

The profile of annual demand is analysed in Section 2 on a daily basis (assuming 280 working days per year). The demand profile and supply required to meet demand for extractive materials can also be expressed on a tonnes per week basis.

Figure 3.13 charts the historical (2011 to FY 2018) and forecast (FY 2018 to 2036) demand and necessary supply to GSR of crushed rock and natural sand, expressed in tonnes (x 1 000) per week.

Figure 3.13 indicates that the current (FY 2018) tonnage for extractive materials consumed in the GSR is approximately 376 000 tonnes per week. Crushed rock from hard rock quarries in the four GSR feeder areas accounts for 261 000 tonnes per week, and natural sand from within and outside the GSR accounts for 116 000 tonnes per week.

The future supply profile for extractive materials to meet forecast baseline demand indicates peak tonnages per week of 382 000 tonnes in 2019, reducing over the shorter term to 329 000 tonnes per week by 2023, and then increasing to 443 000 tonnes per week by 2036. The overall average freight tonnes per week forecast for the 19-year period is 388 000 tonnes.

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Figure 3.13 GSR Extractive Materials – Baseline and Forecast Supply Profile (tonnes/wk) for 2011 to 2036

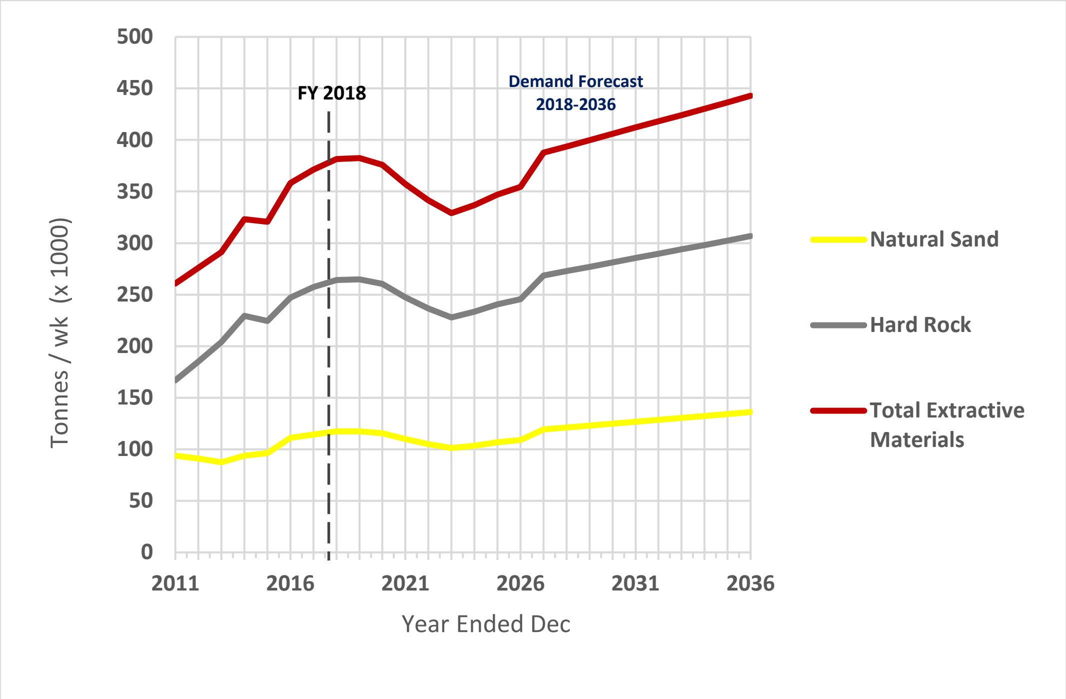

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Figure 3.13 refers to average tonnes/week (over a year), however, for particular weeks and months, demand will fluctuate, depending for example on the timing and overlap of demand from major projects and seasonality factors such as weather conditions.

For supply of crushed rock and natural sand, the two most significant product-related uncertainties that impact on the future supply profiles are:

- the extent to which manufactured sand will continue to replace natural sand in concrete; and
- the proportion of hard rock quarry supply required to satisfy demand for roadbase/sub-base and other rock products – this is influenced by availability of substitutes from sandstone VENM and recycled construction materials.

These two key quarry product-related supply uncertainties are discussed below.

3.5.1.1 Natural Sand v Manufactured Sand Usage in Concrete

The proportion of natural sand required to satisfy future demand will be impacted by the degree of further substitution of manufactured sand (crushed fine aggregate) in concrete, which itself is influenced by:

- the degree of the availability of future natural sand reserves within the GSR and its feeder areas, and
- the adoption by hard rock quarries of processing technologies able to produce manufactured sands that satisfy the full grading and particle shape requirements for fine aggregate in concrete.

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As natural sand reserves in the GSR and feeder areas diminish, the industry will have greater incentive to investigate processing technologies or face higher transportation costs. In terms of global benchmarking, countries such as Japan which faced a shortage of natural sand several decades ago, have in response developed and adopted technologies to produce well-shaped fine, medium and coarse graded manufactured sands from hard rock (e.g. Kayasand V7 crushing and shaping technology[25]).

Consultation with industry indicated that they anticipate an increased adoption of Kayasand or similar crushing and shaping technologies, as natural sand reserves deplete within the GSR and its surrounds.

However, not all natural sands used in concrete and mortar are likely to be completely substituted by fully-graded manufactured sands because of technical and performance characteristics. In addition, there remain other non-concrete applications for natural sand (for example, as filter media, and in industrial applications such as foundry sand and in glass), and smaller pre-mixed concrete producers and pre-cast concrete producers do not necessarily have access to their own crushed rock resources and with capability and capacity to produce highly-engineered manufactured sands.

For these reasons, the proportion of demand for natural sand in construction materials is unlikely to significantly diminish over the period from 2018 to 2036. The baseline estimate for natural sand of 31% by weight of total extractive materials demand, could be driven downwards with increased adoption of sophisticated manufactured sand production and blending technologies. It could also increase, if for example, friable sandstone/sandstone VENM is able to be processed to produce various gradings of washed natural sand. Under this scenario, the sands produced from friable sandstone and sandstone VENM would partially substitute for natural sand from quarries. However, there are constraints that apply to washing and processing of friable sandstone, including removal of clay content. Facilities similar to natural sand quarries are required to process the sand and manage the environmental impacts and land use availability in the GSR for such activities is limited.

Further resolution of the future degree of substitution of natural sand by manufactured sand and/or friable sandstone VENM is beyond the scope of this Study but would benefit from further investigation as a strategic supply-side factor and uncertainty.

3.5.1.2 Roadbase/Sub-Base from Hard Rock Quarries v Substitute Construction Materials

Under the baseline assessment, the contribution of roadbase and sub-base materials from quarries is estimated at 8% of total extractive material supply from quarries. Demand for roadbase/ sub-base in GSR is largely met from substitute construction materials such as sandstone VENM and recycled concrete.

In this respect, the GSR differs from cities such as Greater Melbourne or Greater Brisbane, where roadbase/sub-base demand is largely met from hard rock quarries because of the absence of reliable and continuous supply of suitable alternative sources for such products. In South-East Queensland for example, roadbase/sub-base from hard rock quarries represents approximately 25-30% of total quarry supply.

[25] Kayasand technology and its V7 autogenous crusher with air separation methods, can produce well-shaped and graded manufactured sands for use in concrete, obviating the need for natural sand. The crushing requires a higher energy input compared with natural sands where beneficiation has largely occurred naturally from geological weathering and concentration processes.

The Study has concluded that for the GSR, demand for roadbase/sub-base met by hard rock quarries is estimated to meet approximately 12% of total demand for roadbase/sub-base products. Substitute construction materials therefore supply 88% of total GSR roadbase/sub-base demand.

If further substitution of extractive materials for roadbase/sub-base occurs, then the roadbase proportion from hard rock quarries will be lower than the 8% range. The effect of greater substitution (driven for example by tunnel spoil and C&D waste disposal economics and further changes to technical specifications allowing a greater use of recycled construction materials), would be that hard rock quarries could theoretically allocate a slightly higher proportion of their output as fine and coarse aggregates.

However, this ('yield') is impacted by source rock quality at the quarry, such as degree of weathering and clay content in the primary raw feed for processing by hard rock quarries.

Relatively new hard rock quarries tend to generate higher proportions of overburden waste materials in their early quarry development because of the weathered nature of surface rocks which must be removed to expose fresher (un-weathered) rock beneath. Where markets exist these materials (sometimes blended with crushed, fresh rock) can be used to produce roadbase and sub-base products.

However, where local or regional markets for roadbase/sub-base materials are serviced by sandstone VENM or recycled materials, as in the GSR, then the hard rock quarries in the feeder areas generate a surplus of lower quality materials which are difficult to sell (into the GSR at least), as they cannot compete on price with local GSR sources of substitute roadbase and sub-base materials.

A consequence of the high surplus of sandstone VENM and recycled roadbase/sub-base in the GSR, is that some hard rock quarries in the feeder areas are producing higher proportions of waste rock and clay materials and this is likely to continue into the future, given the ongoing availability within GSR of sandstone VENM and recycled concrete materials.

3.5.1.3 Extractive Reserves Inventory for GSR Supply

Table 3.7 records that the baseline cumulative demand forecast of 383Mt from 2018 to 2036 consists of extractive materials delivered to the GSR market (i.e. finished products sold). Natural sand accounts for 118Mt (24%) and crushed rock 265Mt (76%).

Section 2.2.3 and Section 2.4.4 provide respective estimates of the proportion of quarry output supplied outside the GSR, to meet local building and construction needs for extractive materials as follows.

- Crushed Rock 78% of production supplied to the GSR, 22% outside the GSR
- Natural Sand 81% of production supplied to the GSR, 19% outside the GSR

Adopting these estimates, the size of the inventory of crushed rock reserves in the feeder areas required to meet both GSR and local demand to 2036 is 340Mt and approved natural sand reserves required to meet both GSR and local demand is 146Mt.

Not all reserves are able to be manufactured into crushed rock products within hard rock quarries. A broad estimate of the average, industry-wide percentage of reserve estimates that are technically suitable to manufacture concrete and asphalt aggregates and other saleable hard rock quarry products is 75% to 80% i.e. the yield or recovery of finished crushed rock quarry products is between 75% to 80% of the total approved reserves. The remaining 20% to 25% of reserves are low value materials including weathered rock/overburden, scalps and surplus crusher fines.

Adopting the mid-range for the yield or recovery of finished product, the size of the inventory of crushed rock reserves in the feeder areas required to meet both GSR and local demand to 2036 is 439Mt.

Natural sand deposits typically within the Hawkesbury Sandstone generate approximately 20% to 25% of waste (e.g. from clay fines) whereas the Tertiary sand and dune sand deposits are clean and therefore generate very little waste from processing. By adopting a mid-range (15%), for the yield or recovery of finished product, the size of the inventory of natural sand reserves in the GSR and feeder areas required to meet both GSR and local demand to 2036 is 167Mt.

Section 2.3.5 and Section 2.4.5 discuss the approximate quantity of approved reserves for crushed rock and natural sand, respectively. Based on the Study's research and from consultation with industry, it is estimated that >563Mt of approved crushed rock reserves and 107Mt of approved natural sand reserves are currently available within the GSR (for natural sand only) and the feeder areas currently supplying the GSR. In addition, it is estimated that >660Mt of potential crushed rock resources (Section 2.3.6) and >100Mt of natural sand resources (Section 2.4.6) are available in areas adjacent to or within existing quarries (that is, unapproved resource).

From the discussion above, a demand and supply balance indicates there are sufficient approved hard rock reserves in GSR feeder areas to meet forecast crushed rock demand to 2036 and beyond (>563Mt approved v 439Mt forecast from the cumulative demand profile). It is likely that extensions of existing quarries will increase approved resources over the forecast period and beyond as operators seek to plan their supply sources beyond 2036 and utilise potential resources of more than 660Mt.

The demand and supply balance for sand indicates there are insufficient approved natural sand reserves in the GSR and feeder areas to meet forecast natural sand demand to 2036 (107Mt approved v 167Mt forecast from the cumulative demand profile). However, the potential resources of >100Mt would contribute to satisfying the required demand to 2036, subject to the receipt of the required development consents.

Several natural sand quarries are approved and yet to commence or are seeking approvals that may become available to supply to the GSR. In addition, a substantial source of sand has been identified at Williamtown/Salt Ash (see Section 2.4.6) that may increase available supply.

3.5.2 Concrete

The proportions of concrete raw materials in the forecast supply profile (i.e. the forecast demand profiles from **Figures 3.9** and **3.10**) are well-established for engineering performance reasons and unlikely to change significantly over the 2018-2036 period.

If local (NSW) sources of cement, flyash and GGBFS are closed or become depleted, then the shortfall is anticipated to be taken up by bulk imports – most probably from Asia and India. This scenario (considered probable) places a higher future dependency on ports and related bulk storage/cement grinding facilities to receive, process as required, and distribute bulk cementitious materials into the GSR.

The forecast demand profile for fine and coarse aggregates in **Figure 3.9** consists of aggregates from all sources. These sources include extractive materials (from quarries) and recycled aggregates (from substitute construction materials) such as recycled concrete and smaller quantities of crushed slag, bottom ash and glass. A small proportion of aggregates are recovered at some batching plants from unused (unset) concrete returned from construction sites.

However, collectively fine and coarse aggregates from substitute construction materials are estimated to meet less than approximately 5% of total demand for aggregates in pre-mixed concrete, pre-cast concrete and mortars. This estimate is high-level and has not been established by industry survey, because respondents were reluctant to provide specific information to the Study on production from individual concrete batching plants.

The main reasons for the low penetration rate of recycled aggregates in concrete (as outlined in Section 2) are related to issues concerning their technical performance characteristics and limitations set by technical and engineering standards for the supply of concrete.

3.5.3 Asphalt

The supply profile for asphalt aggregates and spray seal aggregates to meet forecast demand is summarised in **Table 3.17**.

Table 3.17
Greater Sydney Region Asphalt and Spray Seal – Forecast Demand /Supply Forecast Profile

Asphalt and Spray Seal Aggregates	2018	2021	2026	2031	2036
Asphalt Fine Aggregate	0.23Mt	0.23Mt	0.25Mt	0.24Mt	0.26Mt
Asphalt Coarse Aggregate	1.06Mt	1.05Mt	1.15Mt	1.13Mt	1.22Mt
Spray Seal (Coarse Aggregate)	0.72Mt	0.75Mt	0.84Mt	0.83Mt	0.89Mt
Total Quarry and Recycled	**2.01**Mt	**2.03**Mt	**2.24**Mt	**2.20**Mt	**2.37**Mt
Supply of Recycled Asphalt Pavement	0.22Mt	0.23Mt	0.24Mt	0.24Mt	0.26Mt
Total Supply from Quarries	**1.79**Mt	**1.80**Mt	**2.00**Mt	**1.96**Mt	**2.11**Mt

The proportion of recycled asphalt pavement or RAP (from Section 2.6.3 in the base case assessment) is estimated to supply approximately 17% of total asphalt demand. This is close to the industry-sourced estimate of 20% when the recycled supply- demand balance is neutral for asphalt.

Crushed slag from steel-making is also used as a specialist aggregate for asphalt as it provides high skid resistance for road surfaces.

3.6 Future Supply Constraints

An overview of the existing supply constraints encountered by industry were assembled and ranked following consultation with industry. The feedback received from industry is presented in Section 2.13.

This subsection reviews potential supply constraints in light of forecast supply requirements. This section assumes population growth to 2036 continues to result in currently experienced pressures such as traffic congestion. The following supply constraints and their drivers are expected to continue to influence supply of extractive materials to the GSR during the period to 2036.

Geological Supply Constraints

Analysis of available information concerning approved reserves within existing hard rock quarry sources indicates that there are sufficient approved reserves (of 563 million) to satisfy the forecast demand of 265 million of crushed rock products within the GSR well beyond 2036. This capacity would be impacted by demand from regional areas and the continued substitution in the GSR by substitute construction materials such as sandstone VENM and recycled concrete.

The combined approved reserves and potential resources of natural sand (subject to receipt of required development consents) are likely to be able to satisfy forecast demand for the GSR to 2036. However, this too would be influenced by demand from regional areas, which could change from the 2018 estimates considered for the Study. Indicated resources within and adjoining existing quarries are available (based on the information supplied). Future supply of natural sand (beyond 2036) may be impacted through substitution by manufactured sand subject to the necessary adoption of manufactured sand technologies required for this source to satisfy material performance specifications.

Industry has noted the occurrence of sterilisation of extractive resource land by competing land uses. This is particularly evident in the GSR as land released for residential development increasingly covers or abuts potential sources of extractive materials.

Transportation and Resource Locations

It is not clear from consultation with industry whether closer sources of extractive materials are being exhausted at a faster rate than more distant sources due to the convenience of their location. Market forces also influence the rate of extraction at these sites. However, if it is assumed that closer sources are subject to more intense development and depletion of reserves, it can be expected that by 2036, the average distance travelled to supply extractive materials would increase. This would be particularly relevant for sand.

Consultation with industry indicated that transportation costs and logistics will continue to be a key focus of their operations. The industry is focused on the progressive introduction of larger capacity but safer vehicles that maintain or improve operational impacts while improving supply capacities.

The Study's investigations of indicative pricing suggest suppliers from more distant locations will typically set their ex-quarry selling price to compensate for additional transportation costs, while quarries that are closer to their intended point of use can typically receive a higher ex-quarry selling price because of the convenience of their geographic location.

This is particularly important if extractive materials are required at short notice. It may not be feasible to wait 2 to 3 hours for the return journey to source raw materials. However, as closer sources of extractive materials close over time, differential pricing at the quarry because of geographic advantage is likely to be less pronounced and the more distant locations would be relied upon, thus increasing the overall total cost of delivered supply to the GSR.

In summary, transportation costs will continue to be a key determinant of total cost for extractive material supply to 2036. Over the longer term, transportation needs will contribute to higher supply costs due to reliance on more distant supply locations.

The development and use of regional distribution centres (RDCs) will be a key focus of larger industry operators as they seek economies of scale for transportation and distribution within GSR to their concrete operations. The development of RDCs will be subject to development application constraints such as proximity to competing land uses and the availability of appropriately zoned land.

The attractiveness of rail transport for extractive materials will be dependent on the capacity of the rail network to absorb additional freight load given competing pressures for use of this network, and the ability to connect rail access to RDCs.

Some shipping of extractive materials to GSR is likely to recommence and the long-term development of the Glebe Island Terminal precinct will be a considerable benefit to the building and construction industry through the cost-effective delivery of construction materials with reduced road transport-related impacts.

The bulk supply of cementitious materials from Asia and India will continue to influence domestic supply economics. The feasibility of capital-intensive upgrades to ageing cement manufacturing plants within Australia is likely to be impacted by cost-effective and readily available sources outside of Australia. The importation of these materials will place additional pressure on port operations, storage, the need for cement clinker grinding facilities and connectivity of the ports with rail and road.

Regulatory Issues

The operating hours for both extractive material supply and concrete and asphalt plant acceptance of raw material was highlighted to the Study by industry, as a key constraint. Industry operators are investigating options to remove transportation operations from peak traffic periods as delays influence the cost-efficiency of operations. However, apart from asphalt operations that principally occur at night, the delivery of extractive materials and concrete pours at most construction sites is regulated to occur during daylight hours.

Land use planning in the GSR has influenced the availability of suitable and appropriately-zoned land for the development of concrete and asphalt plants. There remains a variety of factors that contribute to the availability of ideal industrial land. These include the size of blocks, access to infrastructure such as transport networks and services such as water and power and the presence of buffers from competing land uses such as residential development. Operators rely on a network of supply locations to maintain the efficiency of their operations and it is not clear, as reported by industry, that this has been adequately considered in land use planning. The size of suitably zoned blocks is as a key constraint for industry, as are the available storage capacity for raw materials and the ability to balance this with the logistical supply of raw materials.

The regulatory and planning constraints described in Section 2.13 demonstrate the range of matters that are currently being managed by industry as they deal with the planning and approvals process in NSW. Industry advises that the current lengthy and expensive planning processes influence the cost of supply for extractive materials as operators need to recover the considerable costs incurred to obtain all required approvals. Industry representatives regularly commented that they would like to see the Study recommend a far more proactive engagement between industry and Government to improve the process and reduce these costs.

Sourcing extractive materials from alternative locations is influenced by the planning process for development of 'greenfield sites' which is often prolonged, complex and expensive for operators due in part to opposition from within local communities in the planning process industry expects that this constraint will remain and is likely to increase in intensity into the future.

Environmental

Industry generally reported to the Study that the costs associated with the environmental management of their operations are an accepted part of business and their corporate obligations. Several senior industry personnel noted that the cost of provision of vegetation offsets for clearing of native vegetation for new quarries, or extensions to existing quarries, can be very costly and time-consuming. The capital and ongoing costs associated with the provision of vegetation offsets increases the up-front and/or operating costs and ultimately need to be recovered by setting product costs to recover these costs. Ultimately, whilst the provision of land for vegetation offsets is a cost borne up front by the quarry, the community ultimately pays because the extractive materials are produced at a higher cost.

As discussed in Section 2.13, a number of industry representatives reported their companies are currently experiencing the imposition of what they consider to be unnecessary and onerous environmental management conditions that in some cases appear to be applied arbitrarily.

3.7 Sensitivity Analysis of GSR Forecast Demand and Supply Profile

3.7.1 Construction Materials Demand 2018 to 2036

The cumulative forecast demand profiles from the sensitivity analysis for years 2018 to 2036 inclusive, are summarised in **Table 3.18**.

It is noted that the Macromonitor forecast demand series data from 2018 to 2026 are not subject to sensitivity analysis because they are based on 'best' estimates of demand from economic modelling by a third party using inputs based on economic forecasting and proprietary algorithms, which already account for sensitivities.

Beyond 2026, when the Macromonitor forecast demand series ends, the demand forecasts are driven by RWC Study estimates of population and per capita consumption and these uncertainties are subject to sensitivity analysis.

The baseline demand series in **Table 3.18** therefore adopt the following key assumptions as inputs:

- The Main Series population forecast projections for GSR.
- Per capita consumption rates from 2027 based on the average per capita consumption over the period 2011 to 2026 (a period which covers both lower and higher demand cycles).
- An assumption that substitute construction materials as substitutes for extractive materials, satisfy 46% of total demand for all aggregates, roadbase/sub-base and broken/sized rock, with 63% of substitute construction materials used as roadbase/sub-base in the GSR.

Table 3.18
Greater Sydney Region Construction Materials Demand Sensitivity Analysis
Cumulative Forecast Demand 2018 to 2036 inclusive

Sensitivity Factor	**Sensitivity Scenario (for 46% of supply from substitutes)**				
Population Growth and Per Capita Demand	**Low-Low**	**Low**	**Baseline**	**High**	**High-High**
Population forecast	Low Series	Main Series	Main Series	Main Series	High Series
Construction Materials Per Capita forecast	6.8tpa	6.8tpa	7.1tpa	7.8tpa	7.8tpa
Construction Materials Demand					
Crushed Rock and Natural Sand	327Mt	372Mt	383Mt	404Mt	448Mt
Cementitious Materials	54Mt	61Mt	63Mt	67Mt	74Mt
Substitute Construction Materials	278Mt	317Mt	326Mt	344Mt	381Mt
Total Construction Materials	**659**Mt	**750Mt**	**772Mt**	**815Mt**	**903Mt**

	Sensitivity Scenario (for 35% of supply from substitutes)				
Demand Met from Substitute Construction Materials	**Low-Low**	**Low**	**Baseline**	**High**	**High-High**
% of Total Demand from Substitute Construction Materials	35%	35%	35%	35%	35%
Crushed Rock and Natural Sand	393Mt	448Mt	461Mt	486Mt	539Mt
Cementitious Materials	54Mt	61Mt	63Mt	67Mt	74Mt
Substitute Construction Materials	212Mt	241Mt	248Mt	262Mt	290Mt
Total Construction Materials	**659Mt**	**750Mt**	**772Mt**	**815Mt**	**903Mt**

	Sensitivity Scenario (for 50% of supply from substitutes)				
Demand Met from Substitute Construction Materials	**Low-Low**	**Low**	**Baseline**	**High**	**High-High**
% of Total Demand from Substitute Construction Materials	50%	50%	50%	50%	50%
Crushed Rock and Natural Sand	302.5Mt	344.5Mt	354.5Mt	374.0Mt	414.5Mt
Cementitious Materials	54.0Mt	61.0Mt	63.0Mt	67.0Mt	74.0Mt
Substitute Construction Materials	302.5Mt	344.5Mt	354.5Mt	374.0Mt	414.5Mt
Total Construction Materials	**659.0Mt**	**750.0Mt**	**772.0Mt**	**815.0Mt**	**903.0Mt**

The High series under **Construction Materials Demand** adopts the following key assumptions as inputs.

- The Main Series population forecast projections for GSR.
- Per capita consumption rates from 2027 based on a 10% increase above the average per capita consumption for the period 2011 to 2026, which covers both lower and higher demand cycles.
- An assumption that substitute construction materials, as substitutes for extractive materials, satisfy 30% of total demand for all aggregates, roadbase/sub-base and broken/sized rock, with 85% of substitute construction materials used as roadbase/sub-base.

The Low series under **Construction Materials Demand** adopts the following key assumptions as inputs.

- The Main Series population forecast projections for GSR.
- Per capita consumption rates from 2027 based on a 5% decrease from the average per capita consumption over the period 2011 to 2026 (a period which covers both lower and higher demand cycles).
- An assumption that substitute construction materials as substitutes for extractive materials, satisfy 46% of total demand for all aggregates, roadbase/sub-base and broken/sized rock, with 63% of substitute construction materials used as roadbase/sub-base).

The Low-Low series under **Construction Materials Demand** adopts the following key assumptions as inputs.

- The Low Series population forecast projections for GSR.
- Per capita consumption rates from 2027 based on a 5% decrease from the average per capita consumption over the period 2011 to 2026 (a period which covers both lower and higher demand cycles).
- An assumption that substitute construction materials as substitutes for extractive materials, satisfy 46% of total demand for all aggregates, roadbase/sub-base and broken/sized rock, with 63% of substitute construction materials used as roadbase/sub-base.

The High High series under **Construction Materials Demand** adopts the following key assumptions as inputs.

- The High Series population forecast projections for GSR.
- Per capita consumption rates from 2027 based on a 10% increase over the average per capita consumption over the period 2011 to 2026 (a period which covers both lower and higher demand cycles).
- An assumption that substitute construction materials, as substitutes for extractive materials, satisfy 46% of total demand for all aggregates, roadbase/sub-base and broken/sized rock, with 63% of these materials used as roadbase/sub-base.

Table 3.18 also summarises the impact of lower and higher percentages of substitute construction materials. The modelled range for the lower and higher series is between 35% (low) and 50% (high).

The most probable sensitivity scenarios for the GSR are considered to lie in the baseline to high range. The Low Low and High High scenarios are more extreme and considered unlikely. The Low range is based on an overall 5% reduction in baseline per capita consumption, which because of the level of anticipated building and construction activity is possible but considered unlikely.

For strategic planning purposes the range between the baseline and high scenarios are considered the most applicable to assess the future quantities of extractive materials to be supplied into GSR to 2036, and to establish the size of reserve inventories necessary to meet that supply. That is:

• Crushed rock and natural sand	383Mt to 404Mt	(20 to 21Mtpa on average)
• Cementitious materials	63Mt to 67Mt	(3.3 to 3.5Mtpa on average)
• Substitute construction materials	326Mt to 344Mt	(17 to 18Mtpa on average)
Total Construction Materials	772Mt to 815Mt	(40 to 43 Mtpa on average)

In the sensitivity scenario in **Table 3.18**, where substitute construction materials of supply account for only 35% of total demand for aggregates, roadbase/sub-base and broken/sized rock products, the supply inventory of extractive reserves necessary to meet forecast demand to 2036 are 461Mt (486Mt for the high case).

If substitute materials were to account for 50% of total demand, then the extractive reserves necessary to meet forecast demand to 2036 are 355Mt (and 374Mt for the high case).

There are technical limits and barriers for crushed sandstone and recycled concrete to significantly substitute further for crushed rock products from quarries. The base case demand profile for extractive materials indicates the hard rock quarries are working to maximise production of fine and coarse aggregates for use in concrete and asphalt plants.

If substitute construction materials increase their supply to GSR (e.g. 50%) there is little displacement of demand met from quarries, because the substitute construction materials produce generally lower quality materials which cannot substitute significantly for aggregates from hard rock and natural sand quarries.

3.8 Future Extractive Materials Distribution

During the period to FY 2036, it is anticipated that there would be few major changes in the transport modes and delivery patterns for crushed rock products to the GSR as it is likely the existing quarries will continue to supply products into the GSR, generally to current points of use (with a shift to the Central River City and Western Parklands City).

Based on approved quarry outputs, there remains further theoretical capacity for both Boral and Holcim to increase the quantity of products despatched from their Peppertree and Lynwood Quarries from FY 2018 levels. The combined quantity of crushed rock products despatched by rail from their Marulan Quarries was 3.9Mt compared with the maximum annual approved level of 7Mt.

From 2030, an increase in sand products being delivered from quarries more distant from the GSR, most likely from the Northern Feeder would be necessary, if additional sand resources adjoining existing GSR sand quarries are not developed.

There will be an opportunity to increase the rate of crushed rock and natural sand products supplied from all feeder areas through the use of high productivity vehicles and trucks compliant with Performance Based Standards. The RMS has a concessional mass scheme targeting the construction sector known as The Safety, Productivity & Environment Construction Transport Scheme (SPECTS) which aims to increase the use of safer, more environmentally friendly and productive heavy vehicle combinations.

3.9 Conclusions on the Future Demand Supply Balance for Extractive Materials

The key future demand v supply balance findings established by the Study for extractive materials are:

- There are sufficient regional hard rock reserves to meet GSR's future needs to 2036 and beyond, even under higher demand scenarios.
- Natural sand and particularly fine sand reserves are more limited. Depletion of approved natural sand reserves is anticipated before 2036 (i.e. 2030 to 2036).
- If manufactured sand technologies are more widely introduced in the future to produce fine sand as part of a fully-graded sand from hard rock quarries, reliance on natural sand would reduce and existing natural sand reserves may extend to meet market requirements around 2036. Potential resources exist around existing sites and, if approved for development, would alleviate the projected shortfall.
- The distribution pattern of quarries and product transport routes is unlikely to significantly change over the period 2018 to 2036. Quarries are locationally-bound, have established haul routes, and most have large reserves or potential resources to 2036, and beyond.
- The 2018-19 level of demand represents a peak, but importantly establishes a new level of anticipated demand for the GSR, which is anticipated to average around 20Mtpa over the next 19-years. In practical terms, the existing flows of extractive materials detailed in Section 2 into and throughout the GSR are unlikely to change significantly over the period to 2036.
- The capacity to reduce or moderate the indicative delivered cost of extractive materials by locating quarries closer to markets in the GSR is minimal, and so the transport cost profile established for the base case is considered to be generally representative as a baseline for future supply.
- Further flexibility in the spread of hours in which extractive materials are delivered to the GSR would help reduce congestion during peak traffic conditions, and reduce direct transport costs, as would the increased usage of high performance vehicles with larger payloads.

- The 2018 indicative prices of quarry materials at the gate (ex-bin pricing), established in the Study from secondary information sources only, are considered unlikely to significantly moderate, given the forecast level of future demand for GSR and the absence of obvious means to significantly reduce production costs (quarries that supply the GSR are fairly efficient, and on-costs are generally increasing from planning requirements such as biodiversity offset lands, buffering provisions and road maintenance levies).
- If the supply of sandstone VENM in the future reduces from present levels of availability, then roadbase and sub-base equivalents will need to be supplied from recycled concrete and hard rock quarries. Supply from hard rock quarries would be at an increased cost to the present, because of the longer transport distances involved.

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Appendices

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Appendix 1

The Study Team

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The Study Team comprised a number of consultants from a range of professional backgrounds and areas of expertise including geologists, mining engineers, civil engineers and transport economists. **Table A1.1** lists the individual team members, their consulting firms and their roles in the Study.

Table A1.1
Study Team Members

Team Member	Role
R.W. Corkery & Co. Pty Limited	
Rob Corkery – Project Manager	Overall project management; liaison with DPE and relevant government agencies, industry consultation; coordination of data assembly, report and figure preparation
Nick Warren – Senior Consultant	Industry consultation; coordination of economic components involving Nine-Squared and report preparation.
Caiden O'Connor – Consultant	Industry consultation; follow up regarding questionnaires for construction materials and concrete and asphalt plants; report preparation
Ecoroc Pty Ltd	
Dugald Gray – Project Manager	Industry network consultation, co-ordination and development of demand and supply base case and forecasting demand model, assessment of supply constraints, sensitivity analysis, management of Macromonitor data and model outputs
Mike Cooper - Supply Cost Engineer & Industry Expert	Review and analysis of demand side data and forecasting using building and construction activity planning documents and demand-side forecasting data (Population data, Macromonitor data); input into industry analysis, hard rock quarrying activities, transport costs.
Nine-Squared Pty Ltd	
Tom Frost – Director	Quality assurance for the economic component for the base case assessment and freight vehicle operating cost.
Anthony Vine – Manager	Assembly of transport economic inputs to the base case assessment ensuring the analysis aligns to the appropriate guidelines, and that the final methodology delivered the appropriate outputs.
Ausrocks Pty Limited	
Carl Morandy – Project Manager	Assembly of publicly available data for industry questionnaires. Compilation of data on transport costs.
Alan Robertson – Industry Expert	Industry Consultation regarding recycled concrete.

Appendix 2

Approach to Study

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A2.1 Introduction

This appendix presents the approach to the Study Team (see Appendix 1) to the collection and analysis of the data relevant to the Study.

A2.2 Industry Consultation

A2.2.1 Extractive Industry

Extensive consultation was undertaken with the extractive industry during the preparation of the base case supply and demand assessment for the Study. The principal method used during industry consultation involved the distribution of questionnaires and subsequent in-depth face-to face or telephone discussions with key quarry personnel in order to establish relevant information relating to production, transport, reserves and operational / supply constraints. Representatives of all hard rock and natural sand quarries with the GSR and feeder areas were provided with a questionnaire relating to their quarry and approached regarding the supply of information for the Study.

Table A2.1 records the number of comprehensive (full) responses or brief responses received from operators of the 17 hard rock quarries. Essentially all small to medium companies provided comprehensive responses whereas the larger companies provided limited information relating only to key matters. Reliance was principally placed upon publicly available data for the eight hard rock quarries operated by the larger companies.

Table A2.1
Summary of Consultation with Extractive Industries

No. of Quarries	No. Approached	No. provided full response	No. provided brief response	No. provided no response
		Hard Rock Quarries		
		Northern Feeder		
4	4	1	3	0
		Western Feeder		
4	4	4	0	0
		Southwestern Feeder		
4	4	2	2	0
		Southern Feeder		
5	5	2	3	0
		Natural Sand Quarries		
		Greater Sydney Region		
12	12	10	0	2
		Northern Feeder		
10	10	5	3	2
		Western Feeder		
1	1	0	1	0
		Southwestern Feeder		
3	3	3	0	0
		Southern Feeder		
1	1	0	1	0

A similar pattern of responses to that for the hard rock quarries was received from the companies operating the 27 natural sand quarries with information not provided on only four quarries, all with comparatively low production levels. The larger companies operate five natural sand quarries within the feeder areas surrounding the GSR.

Management of a number of the larger companies operating quarries in feeder areas, whilst recognising the importance of the Study, expressed concerns regarding the level and detail of information requested for the Study. As such, the Study Team prepared a brief operational profile based on publicly available information and Macromonitor data. This profile was subsequently forwarded to the larger companies for review and comment to confirm accuracy. This approach assisted in the assembly of key information about production levels and distribution of products by rail. Overall, the level of information provided by the operators of the larger quarries was not as comprehensive as that supplied by the operators of the smaller to medium quarries.

Overall, it is estimated that the Companies that did participate in the consultation process would account for in excess of 95% of the total quantity of extractive materials supplied to the GSR.

A2.2.2 Concrete Industry

Consultation with the concrete industry was undertaken in a manner consistent with that adopted for the extractive industry. The operating companies of all 78 concrete plants in the GSR were approached. **Table A2.2** lists the summary of the consultation with the pre-mixed concrete industry. Approximately two-thirds (52 plants) of the concrete plants within the GSR are operated by the three larger vertically integrated companies who similarly expressed concerns about the level and detail of information requested for the Study. Little information was provided by these companies for the Study. Operators of the bulk of the remaining concrete batching plants responded fully to the questionnaire provided, i.e. information was received regarding 22 of the 26 other plants. Overall, reliance was placed upon information drawn from Macromonitor data, key information from the larger companies and the comprehensive information from the smaller companies to assemble the information for the Study.

Table A2.2
Summary of Consultation with Pre-mixed Concrete Industry

No. of Plants	No. Approached	No. provided full response	No. provided brief response	No. provided no response
Eastern Harbour City				
30	30	5	22	3
Central River City				
27	27	7	17	3
Western Parklands City				
21	21	7	13	1

A2.2.3 Asphalt Industry

A total of eight asphalt plants are operated within the GSR by four operators. Only one operator provided data in support of the Study through the completion of a questionnaire relating to production data, transport, storage and constraints. Insufficient information was available from the industry surveys to fully describe the raw materials requirements for the Sydney asphalt industry. However, the Macromonitor demand data provided a detailed breakdown of asphalt demand and its constituent materials and these data have been used in the Study.

A2.2.4 Waste Industry

Consultation with the waste industry involved telephone discussions with the Environment Protection Authority and a total of seven companies operating concrete recycling facilities. The level of participation from the industry was comparatively low as numerous operators were unwilling to participate in discussions regarding the data required for the Study. However, sufficient information was supplied to provide an indicative overview of the construction materials generated by the waste industry for the building and construction industries.

A2.3 Base Case Assessment

A2.3.1 Supply and Demand Profiles

Supply and demand profiles of construction materials used within the GSR have been prepared for the period from 2011 to 2018 (Section 2) and forecast for the period from 2018 to 2036 (Section 3), using both primary and secondary data and information sources.

A principal data source used to construct the base case demand and supply profiles and future profiles through to 2026 was purchased for the Study from Macromonitor[1], who prepares bi-annual construction material demand profiles for the GSR and sub-regions. The Macromonitor data relied upon for the Study covers the period from 2011 to 2026.

The forecast component of the Study's demand assessment for the period from 2018 to 2036 (inclusive) establishes annual and cumulative projected estimates of quantities of construction materials required to satisfy the projected GSR demand over this 19 year period.

Existing and foreseeable supply-side constraints identified from the Study are assessed to evaluate the likelihood and consequences of extractive material supply deficits from the GSR and feeder areas from 2018 to 2036, including implications for cost-effective delivery of the extractive materials and cementitious products during that period.

The supply and demand profiles have been established from the review and analysis of the Macromonitor demand data and supply-side information collected for the Study. The data are summarised in tabular form under **Appendix 4**.

[1] A Sydney-based economic research and forecasting company that specialises in the building and construction, construction materials, mining and utilities sectors

For the 2011 to 2036 period, baseline demand profiles for the GSR are reported in this Study as follows.

- Extractive materials from hard rock and natural sand quarries are segmented by product categories and reported in tonnes per year. The extractive material product categories are:
  - Natural sand;
  - Crushed fine aggregate;
  - Crushed coarse aggregate;
  - Roadbase/sub-base; and
  - Broken and sized rock products.
- Concrete usage including pre-mixed concrete, pre-cast concrete and mortar. The concrete demand profile reported in tonnes per year is established according to the following cementitious materials and aggregate categories.

– Cement – Fly Ash – Ground Granulated Blast Furnace Slag	Cementitious Materials
– Natural sand – Crushed fine aggregate – Crushed coarse aggregate	Aggregates

  Aggregates reported in the concrete demand profile include those sourced from hard rock and natural sand quarries with small quantities of substitute construction materials. The concrete demand profile differs from the other demand profiles (which refer only to extractive materials) because it includes total aggregates, regardless of their origin.
- Extractive materials reported in tonnes per year, used in manufacturing of concrete and asphalt, and those materials such as roadbase and broken/sized rock products that are supplied directly from quarries to building and construction sites. The manufacturing and direct usage categories for extractive materials are:
  - Pre-mixed Concrete
  - Pre-cast Concrete
  - Mortar
  - Asphalt and Spray Seal
  - Direct to Site (Road-base, Other Aggregates, Broken/Sized Rock)
- Cementitious and extractive materials, in tonnes per year, as consumed by point of end use (‘Point of Use’). The Point of Use categories are:
  - Dwellings including:
    - Houses
    - Medium Density Residential

    - High Density Residential
    - Additions and Alterations
  - Non-Residential Buildings
  - Road Construction and Maintenance
  - Other Engineered Infrastructure

The baseline demand profiles prepared for the Study quantify and illustrate an overall 26-year annual series for the GSR from 2011 to 2036. They form the basis for the conduct of sensitivity analysis for strategic planning purposes based on uncertainty generating factors such as actual future population estimates, per capita consumption rates of construction materials including the percentage of demand met from substitute sources of supply.

Three main information sources for deriving the supply and demand profiles from 2011 to 2026 were as follows.

1. Analysis of industry responses to the Extractive and Concrete Batching/ Asphalt Plant Questionnaires, specifically as they related to production for the 12 months ending June 2018 and supply-side constraints.
2. Analysis and collation of data and information obtained from NSW planning reports and documents, and quarry industry contacts and consultants regarding the demand and supply of extractive materials to the GSR.
3. Analysis of data purchased from Macromonitor. These data are specific to historical and modelled supply of construction materials for Greater Sydney for the period 2006 to March 2018 and provide demand forecasts for the period March 2018 to December 2026.

The Macromonitor construction materials demand data series from 2011 to 2026 used in this Study is based on ABS SA3 / SA4 statistical divisions for Greater Sydney (less Central Coast). It comprises demand for construction materials met from hard rock and natural sand quarries, other (substitute) sources of aggregates and roadbase/sub-base, etc. and cementitious materials.

The Macromonitor forecast data from 2018 to 2026 are built up from forecast building and construction demand activity in the GSR for housing, non-residential buildings, road construction and maintenance and other infrastructure projects. The forecasting methods of

Section A2.3.6 provides a further description of the Macromonitor data and **Appendix 3** provides further details of its methodology, inputs and outputs. Estimated construction materials usage data are reported in tonnes per year.

For the GSR Study, beyond 2026 (when the Macromonitor forecast demand series ends), the base case projected demand forecasts have been determined by reference to estimated per capita consumption rates (established from the 2011 to 2026 series) and projected population forecasts for the GSR and its districts.

The forecast model described in Section 3 of this Study is used to undertake a sensitivity analysis for the future demand versus supply balance (i.e. shortfall analysis) by varying key inputs that drive or are anticipated to influence future demand and supply to 2036.

A2.3.2 Extractive Sites - Resources and Supply

The compilation of the required data for a base case (Financial Year (FY) 2018) profile for the assessment was assembled through a structured approach involving the following tasks.

- **Review of Available Data**

  The following documentation was reviewed for the purposes of the Study.

  - Various publicly available documents from the Division of Resources and Geoscience (DRG) website.
  - The DRG construction materials database (Consmat Database) for the period June 2011 to July 2017 which provides, amongst other information, a description of quarry product types and quantities of quarry products sold by quarries within and surrounding the GSR. These confidential data are provided to the NSW Government annually via survey questionnaire of extractive industry operators in NSW. Not all quarry operators respond to the DRG annual survey and those that do, don't necessarily provide comprehensive data.
  - Resource Audits undertaken by the Geological Survey of NSW[2].
  - Production data assembled by the Royalty and Advisory Services[3, 4].
  - Previous reports prepared by the Geological Survey relating to construction material resources.
  - Environment protection licences relevant to extractive industries.

- **Gap Analysis of Assembled Data**

  The information assembled during the review of available data was analysed and any deficiencies and information gaps pertinent to this Study identified. The analysis was undertaken by the RWC project team based on industry knowledge and consultation with industry representatives and colleagues.

  A database of operating quarries that supply extractive materials to the GSR was compiled and location plans prepared for quarries, concrete plants, asphalt plants and regional distribution centres. Supply profiles for crushed rock products and concrete products were developed.

- **Extractive Industry Questionnaire**

  A comprehensive list of data requirements for each quarry was assembled and incorporated into a questionnaire for completion by industry operators. Questions were formulated to assess the proportion and type of extractive materials supplied into the GSR, and the proportion supplied outside the GSR to satisfy local demand.

[2] An entity within the Division of Resources and Geoscience
[3] An entity within the Division of Resources and Geoscience
[4] The supply of production data is not mandatory in NSW although most quarries with recent development consents are required to submit annual production data to the Division of Resources and Geoscience.

The information and data sought from the questionnaire effectively filled gaps identified from the Gap Analysis and brought all information and data up to date in the RWC database, i.e. to 30 June 2018, wherever possible.

The questionnaire was circulated to all companies supplying extractive materials to concrete or asphalt plans or building/construction sites within the GSR. The circulation of the questionnaire was supplemented by either face-to-face meetings or telephone discussions with individual operators of quarries.

- **Industry Consultation**

  Telephone contact was made with many industry representatives in conjunction with the circulated Questionnaire. In addition, representatives of RWC and Ecoroc met with Cement Concrete and Aggregates Australia (CCAA)[5] early in the preparation of the Study to discuss the Study and to establish the most appropriate manner in which to work with their members throughout the Study.

  It is recognised that varying opinions are held throughout the extractive industry about the level and detail of confidential information gathered and relied upon for the Study. As such, the Study Team established early in the Study that the most appropriate manner to present collected information and data was to aggregate it according to geographical areas that are sufficiently large to protect the confidentiality of the data from all individual sites, but of sufficient resolution or granularity to fulfil the requirements of the Study.

  RWC and Ecoroc also consulted with other industry consultants within their networks who are familiar with the supply of construction materials to the GSR. In particular, information relevant to the cost of extractive materials at both their origin and delivery destination were investigated through specialist consultant networks. Supply issues pertinent to cement and SCMs were also investigated through consultant networks.

- **Economic Guidance**

  Nine-Squared provided economic guidance during the Study to ensure the database generated the outputs suitable for subsequent modelling of the economic costs of transport options for construction materials.

A2.3.3 Concrete Pre-Mixed Plants

The compilation of the required data for a base case (FY 2018) profile for the base case assessment was assembled through a structured approach involving the following tasks.

- **Database Review**

  A review of a contemporary database held by RWC for pre-mixed concrete plants and pre-cast concrete manufacturers.

[5] The CCAA is the peak industry body representing a large proportion of the companies producing extractive materials and concrete in the GSR and the feeder areas.

- **Concrete Batching Plant Questionnaire**

  All relevant information required to be assembled for the base case assessment and future planning was included in a questionnaire developed early in the Study. The questionnaire was circulated to each company, rather than individual plants, to obtain the required information. The circulation of the questionnaire was also supplemented by either face-to-face meetings or telephone discussions.

- **Industry Consultation**

  Consultation with the CCAA also covered the interests of the majority of pre-mixed concrete suppliers, although discussions were also held with some of the independent suppliers that are not members of the CCAA.

A2.3.4 Asphalt Plants

A similar approach was taken to assemble information and data for asphalt plants as was adopted for concrete plants. There are only four suppliers of asphalt within the GSR.

A2.3.5 Concrete Product Plants

Information and data for the concrete product plants in the GSR was obtained from Macromonitor demand data and through discussions with industry representatives. The plants produce concrete blocks, panels, tiles, headwalls, culverts and rail sleepers.

A2.3.6 Macromonitor Construction Material Demand Data

The Macromonitor data provide a GSR construction materials demand series that establishes total demand for construction materials, as defined in this Study.

These data are produced from an excel-based model updated bi-annually by Macromonitor and cover the 20-year period from 2006 to 2026 with forecasts from 2018 to 2026 based on anticipated construction material demand.

The Macromonitor annual forecast data from 2018 to 2026 are built up from a variety economic data including ABS data, published NSW Government data and information sources, private research and consultations with industry for the forecasting of building and construction activity in the GSR.

Proprietary algorithms are applied by Macromonitor to estimate specific quantities and types of crushed rock products and cementitious materials required to meet the demand for housing types, non-residential building types, roads, other engineered infrastructure including utilities.

The data are widely purchased under annual subscription by individual construction material suppliers to inform their business planning to respond to future anticipated demand. Industry also provide feedback to Macromonitor. Consultation with industry indicated a high level of confidence in the Macromonitor forecasts. The reliability of these data is also supported by relative consistency with other forecasting for the construction industry such as the NSW *Construction Delivery Assessment: Capability and Capacity* report prepared by BIS Oxford Economics.

The Macromonitor data are closely aligned with the outer boundary of the GSR planning districts. The data were therefore considered reliable and the most suitable to frame the base case supply and demand profile for the Study. However, the data is geographically segmented into Greater Sydney districts based on ABS SA3 and SA4 statistical divisions, which do not align with the five GSR planning districts. In addition, the demand data does not differentiate between extractive materials to be supplied from hard rock and natural sand quarries and 'other' sources - for example, from surplus earth materials such as friable and heavily cemented sandstone commonly excavated from civil construction projects in the GSR (VENM), sandstone quarries in GSR, and material sources such as recycled concrete and asphalt.

For the purposes of this Study, various assumptions arising from consultation with industry have been adopted to align the Macromonitor data with the GSR district boundaries, and to account for the substitute construction materials used in the building and construction industry.

The following principal assumptions have been used to modify the Macromonitor data for this Study.

- Geographic segmentation of the data into the GSR Districts, and in particular the three cities comprising Eastern Harbour City (GSR Districts Central, North and South), Central River City and Western Parklands City.
- Further segmentation of construction sand demand into natural sand and manufactured sand categories.
- For the purposes of base case modelling, an estimate of 56% has been adopted for the proportion of total demand for extractive materials met by hard rock and natural sand quarries. Other sources of materials such as friable and heavily cemented sandstone quarries, sandstone VENM from civil excavation works, recycled materials from C&D and industrial wastes, and small quantities of crushed rock products from quarries beyond the GSR feeder areas, are estimated to account for 46% of the total demand of construction materials, excluding cementitious materials.
- Most of the 'other' materials substitute for hard rock and natural sand quarry products in lower quality and lower engineering performance categories such as roadbase/sub-base for road construction, and drainage aggregates.

Further descriptions of the Macromonitor demand data including its strengths (utility) and its weaknesses (limitations) in relation to the needs of this Study are provided in **Appendix 3** to this Study report, which contains a copy of the key demand charts provided by Macromonitor for the GSR and the assumptions and methods used to estimate the demand.

A2.3.7 Population Forecasts and Per capita Consumption Estimates

Population growth and demand for construction materials are closely correlated. The widely-used method of expressing construction material demand on a per capita consumption basis has been adopted in this Study:

- as a calculation arising from the base case demand profiling, for use in benchmarking; and
- to enable demand forecasting from 2027 to 2036 required for this Study[6].

Table A2.3 provides a summary of the population estimates for the GSR used in the Study. The population series are shown in 5-year intervals by calendar year. Further details of the year on year population estimates (main series) adopted by the Study are provided in **Appendix 4**.

Table A2.3
Estimated Population Data within the Greater Sydney Region – 2011 to 2036 (Million)

	2011	2016	2021	2026	2031	2036
Low Series			5.1	5.5	5.8	6.1
Main Series	**4.3**	**4.7**	**5.2**	**5.6**	**6.1**	**6.5**
High Series			5.2	5.7	6.3	6.8

The future baseline demand profiles for the GSR (described in Section 3) utilise the population forecasts (which are rounded in **Table A2.3**), and from 2027 use the population series multiplied by an estimated per capita consumption rate to calculate forecast demand to 2036.

The population forecasts in **Table A2.3** have been prepared using the following data and method.

- ABS Estimated Resident Population (ERPs) for Greater Sydney [(GCCSA) (1GSYD)] and Central Coast [(SA4) (102)] for YE June 2012 to YE June 2017 (source: http://stat.abs.gov.au last updated 5/2/2018).
- Interpolation of the NSW State and Local Government Area Population Projections (YE Dec 2016 to 2036 in 5-year intervals) by year for Low, Main and High Series population growth rates from 2016 to 2036.
- The ABS statistical divisions for ERPs (SA 4, SA 3, etc.) do not align with the five planning districts under the GSR Plan. However, if the ABS Central Coast SA 3 data is deducted from the ABS Greater Sydney SA 4 data, then an estimate of the population for the Greater Sydney's five districts (the GSR in this Study) can be made.
- There is still a geographic difference between the two sets of Greater Sydney boundaries, but it is in the western and southwestern margins. The differences are described in **Appendix 3**. For the purposes of this Study, the geographic

[6] Macromonitor data purchased in March 2018 ends at December 2026. The per capita consumption x forecast population method is used in this Study for demand profiling beyond 2026. The use of per capita consumption data (tpa) established from an historical time series of construction material demand data and estimated resident population, is an established method for benchmarking 'demand intensity' within a region. For example, the per capita forecast method has been widely used for similar studies in Greater Melbourne and Greater Brisbane.

difference in area is considered negligible for the estimation of demand for construction materials – the ABS boundaries have a slightly larger area, but the areas of difference with the GSR boundary are in rural/non-urban areas with relatively low demand for construction materials.

- A forecast series (low, main and high) for YE December 2018 to 2036 has been prepared using the above assumptions, with population growth rates from NSW Planning population forecasts for 2016 to 2036 applied to the contemporary ABS ERP data for YE June 2017 for Greater Sydney (Less Central Coast). This indicates a population of 4.79 million for FY 2017.
- The Macromonitor construction materials demand data uses the same ABS statistical boundaries to report its forecasts. Both the population estimates and the Macromonitor demand data are therefore geographically aligned in the Study. Historical per capita demand estimates can therefore be reliably made.

Per capita demand rates are a measure of the intensity of building and construction activity within a geographic region. Per capita consumption for cities such as Greater Melbourne are currently around 10tpa to 11tpa of extractive materials and recycled C&D waste, which is high by historical standards. For Greater Brisbane, per capita demand is similar and ranges between approximately 8tpa to 12tpa year on year depending on the economic and building and construction cycle.

These cities have lower overall population density and so overall per capita consumption rates are higher, compared with cities such as Sydney.

For the GSR, the per capita demand rate for FY 2018 for construction materials is estimated by this Study at 8.1 tpa. This is high by historical standards.

Per capita demand rates can be volatile over the shorter term. They tend to rise and fall, year on year, across the economic cycle and are particularly influenced by major infrastructure or development projects that require large quantities of extractive materials over a relatively short period and housing booms.

When used for forecasting extractive material demand, they are best applied for longer term planning, to assess demand versus supply balances for strategic planning purposes as there is a strong correlation between cumulative demand for extractive materials and cumulative population, over time.

Once a baseline per capita estimate is established (having regard to high, low and average per capita consumption estimates from the time series), a sensitivity analysis is then conducted having regard to the building and construction activity outlook for the region of interest. For the GSR, the anticipated building and construction activity level for the foreseeable future is high, and so the sensitivity analysis must reflect this.

The results of the sensitivity analysis of the base case assessment to assess the impacts of variations in future population and per capita demand for construction materials for the forecasting period from 2018 to 2036 is described under Section 3.

A2.3.8 Supply Constraints

The method used to assess the supply constraints of materials focussed principally upon the Study team's experience with supply-side impact analysis for quarries and the results of discussions with the GSR suppliers of extractive materials, cement, concrete and concrete products and asphalt.

For construction materials from quarries, the constraints were classified through reference to the following factors.

- The extent to which geology/resource characteristics influences geological reserves, and the yield and quality of the extractive materials produced including crushed rock products.
- The extent to which statutory regulations and/or planning consents currently impact on supply including development approval conditions that regulate the duration of the development approval and/or the transport hours, timing and rate of truck movements from quarries.
- The extent to which environmental issues currently impact on geological resource security and supply from quarries.
- The extent to which transport-related factors currently impact upon delivery of extractive materials – such as travel mode, travel distance, payload limits, duration of trip, toll charges and traffic congestion.

The transport-related constraints were also established through discussions with transport managers of some major suppliers and independent transport groups that transport substantial quantities of extractive materials to and throughout the GSR.

Collectively, these factors influence the cost of extractive materials that supply the GSR at a point in time.

A similar method of constraints classification for concrete batching plants was adopted for this Study and includes the following.

- The extent to which raw material sourcing impacts on the current and future supply of concrete.
- The extent to which raw material stockholding capacity at batching plants, and at regional distribution centres, impacts on the current and future supply of concrete.
- The extent to which statutory regulations and/or development consents currently impact on supply including development consent conditions that regulate the duration of the development approval and/or the transport hours, timing and rate of truck movements from a quarry to a concrete plant.
- The extent to which transport-related factors currently impact upon delivery of concrete such as travel distance, payload limits, duration of trip and traffic congestion.

A2.3.9 Supply Cost Profile

The compilation of data on the supply cost profile for the base case assessment was undertaken through consultation with industry contacts.

Indicative base case (FY 2018) costs for natural sand and crushed rock products provided through industry consultant networks have been adopted for this Study. Indicative pricing / costing is provided for extractive materials ex-quarry (i.e. Free-on-Truck, or Free-on-Rail at the quarry), and the total delivered cost to the customer – for example in the Eastern Harbour City and Central River City districts.

No ex-quarry gate pricing or transport costs data or total delivered cost data was sought from construction material suppliers because of commercial and trade practices sensitivities around the divulging of pricing and costing information by competitors.

The extractive materials pricing data are indicative only, with distance of quarries from markets (all hard rock quarries are outside the GSR) and the mode of transport having a strong influence on delivered costs of construction materials into GSR, and ex-quarry pricing.

For the purposes of estimating road transport costs, the method used is to adopt a cost per tonne per kilometre basis for an average truck payload. The base case cost metric for road transportation of extractive materials determined from secondary information sources (consultants and published and recommended cartage contract rates) is $0.20 per tonne per kilometre including on road costs and truck mobilisation and loading costs.

Rail costs for crushed rock products into GSR were more difficult to establish because there are a limited number of suppliers who use these transport modes and their arrangements with the freight infrastructure providers are the subject of commercial agreements, which are confidential and not available to the Study. For the Study, on-rail freight costs are estimated to be approximately one-third on-road freight costs.

Rail and shipping of crushed rock products require load-out and off-load facilities at the origin and destination respectively, and the provision of stockholding and off-load facilities at regional distribution centres that link port to rail and rail to road.

These construction material freight and logistics centres with their inter-modal transport connections have specific locational needs and the provision of land for future distribution centres present significant land use challenges. This Study identifies the existing and planned regional distribution centres for crushed rock products and cement servicing the GSR.

A2.4 Transportation Routes and Levels

Throughout the preparation of base case supply and demand profiles, data has also been collected and analysed regarding the existing principal and secondary road transport routes for construction materials, referred as the GSR feeder routes, that connect the quarries in the GSR feeder areas to points of use in the GSR. **Figure A2.1** identifies the extractive material feeder areas adopted for the Study and **Figure A2.2** displays the key road and rail transportation routes used for delivery of quarry products to and throughout the GSR.

Figure A2.1 GSR Planning Districts and Extractive Materials Feeder Areas

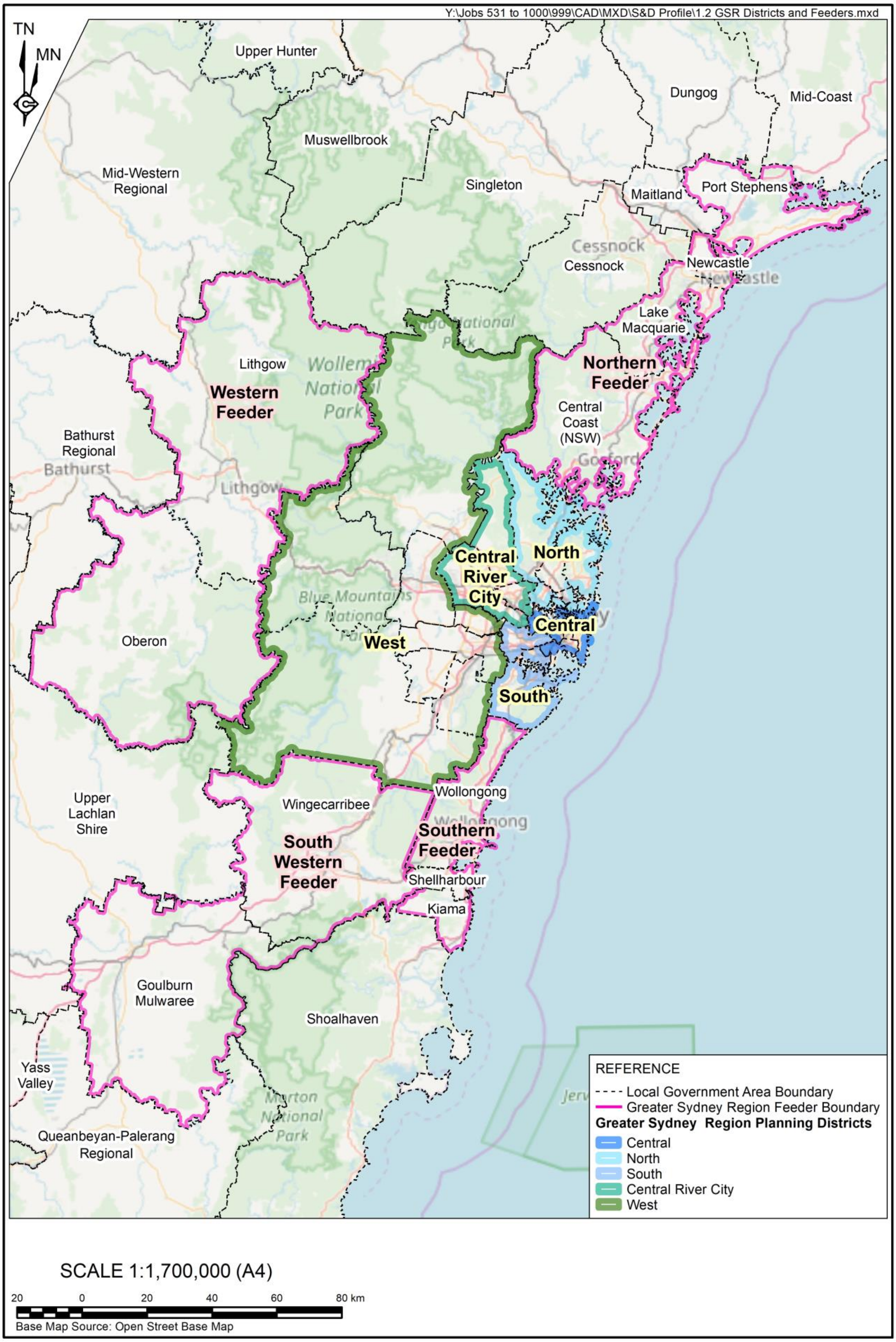
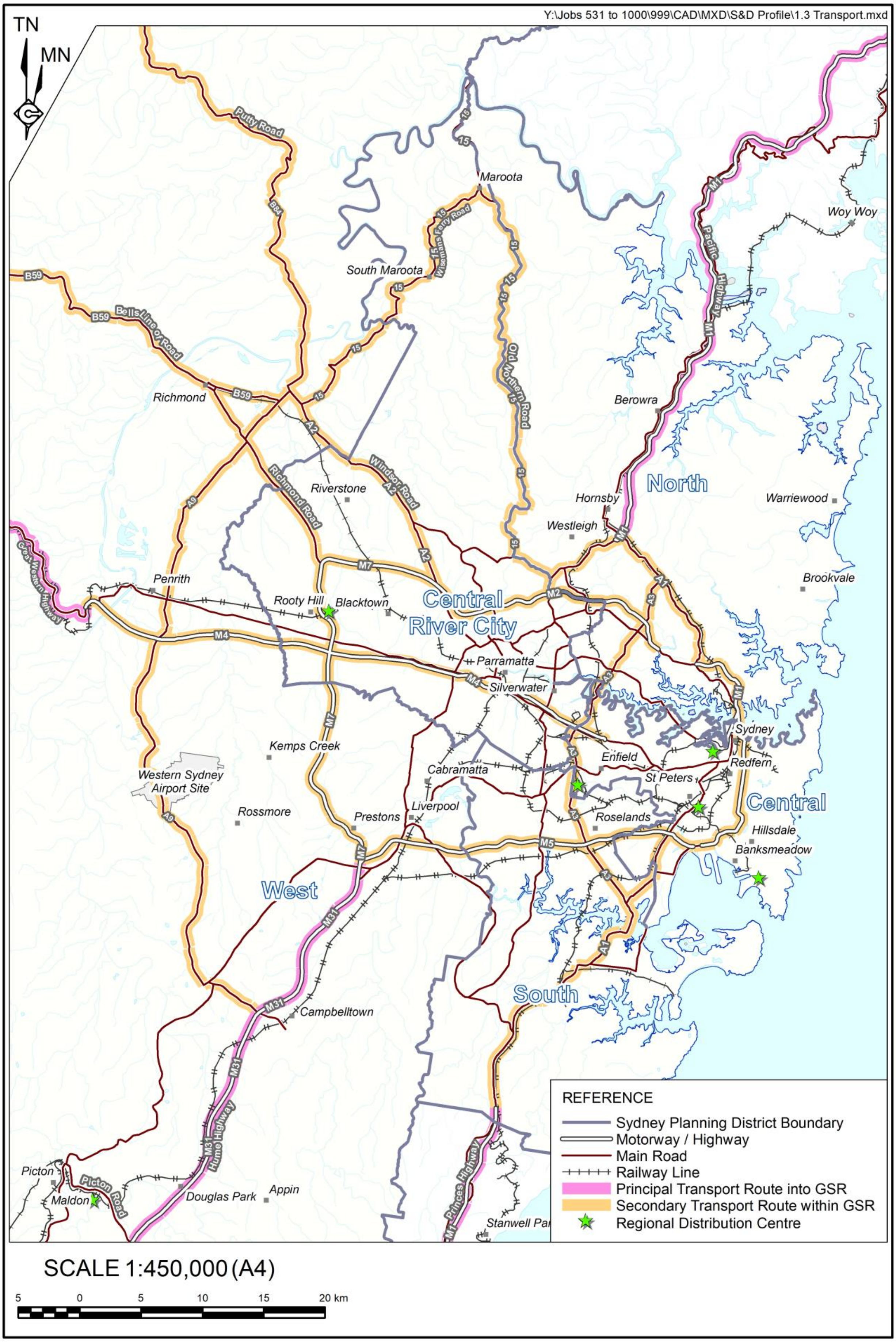


Figure A2.2 Key Transportation Routes into and within the GSR



A2.5 Future Demand and Supply Assessment

The following approach and method of assessing the future demand and supply balance for GSR and its three cities was adopted.

- The future demand profile data from 2018 to 2036 (inclusive) outlined in Section A2.3.9 was used as a base case estimate and cumulative estimates of demand over the 19-year period were calculated for extractive materials (quarry products), by point of use and for concrete raw materials.
- The qualitative supply constraints for quarries and concrete/asphalt plants (outlined in Section A2.3.8) were reported by the industry as part of the questionnaire responses and applied by RWC to the forecast demand modelling to identify potential supply-side shortfalls, with attendant future transport cost implications.
- Development approval timeframes and depletion of recoverable geological reserves for existing quarries were assessed.
- Sensitivity criteria were established and applied to the base line demand forecast from 2027 to 2036 (inclusive) to assess the impact on cumulative demand of increases or decreases from the base line of population forecasts (high and low series), per capita consumption (upper and lower range limits) and the split in demand met by hard rock and natural sand quarries v substitute sources of supply.
- Future trends and drivers for the sourcing of cement, fly ash and GGBFS from outside NSW, were assessed following consultations with industry experts and from published information sources.
- A summary of the assumptions and findings of the Future Demand and Supply balance and sensitivity analysis was prepared.

A2.6 Constraints and Limitations to Study Approach

This report has been prepared with reliance placed upon the information and data sources referred to throughout Section 1 – principally the responses from industry in the survey questionnaires and the Macromonitor demand data series for GSR. The Study Team has endeavoured to gain as much information and data from primary sources, particularly companies that operate quarries, concrete and asphalt plants.

Appendix 3

Macromonitor Construction Material Demand Data to 2026

(Total No. of pages including blank pages = 16)

A3.1 Introduction

The Macromonitor construction materials demand forecast series for Greater Sydney has been used by the Study to provide the overall demand profiles for the GSR through to 2026. This Appendix contains a discussion of the strengths and limitations of the data pertinent to the Study.

The Appendix also provides a summary provided by Macromonitor of their method of derivation of forecast projections using both top down and bottom up methods, and provides copies of the chart outputs in the demand series. The charts shown are for Greater Sydney (less central Coast). Similar charts are available for each of the Greater Sydney district boundaries employed by Macromonitor to geographically segment their total data series.

A3.2 Pertinent Strengths and Limitations of the Demand Data

The strengths and limitations of the Macromonitor demand series as they relate to the Study are summarised as follows.

Strengths

1. Demand profiles established by top down and bottom up forecasting methods for construction material usage – a summary by Macromonitor of their derivation and forecasting methodology is presented in Section 4 of this Appendix.

2. Demand profiles are provided for fine and coarse aggregates, roadbase/sub-base and other quarry products, concrete raw materials (pre-mixed, pre-cast and mortar), and construction materials demand by sector (e.g. various dwelling types, non-residential buildings, road construction, road maintenance and other infrastructure (e.g. bridges, ports, dams, tunnels, utilities, etc.)).

3. High-level of construction materials industry confidence in the Macromonitor data. Most firms purchase an annual subscription and use the data for business and strategic planning purposes.

4. Breakdown of all data by Greater Sydney ABS statistical divisions comprising Central, North, South, North West, West and South West districts. Population data for Greater Sydney reported by ABS aligns with Macromonitor districts providing a sound basis for estimation of per capita demand for Greater Sydney.

5. Demand series updated bi-annually by Macromonitor to account for new projects, and timing/phasing of projects.

Limitations

1. ABS statistical divisions used by Macromonitor do not align with the five GSR planning districts under the GSR plan.

   ABS Greater Sydney region includes Central Coast region. By deducting Central Coast from Greater Sydney, a close approximation to the geographic outer boundaries of the GSR is achieved. The differences in alignment and total geographic area have been assessed by RWC and are not considered significant for the purposes of the Study and GSR as a whole, because the differences in outer boundaries are largely in the western and southwestern margins, which are largely rural in character with low levels of local demand. Because of the differences between ABS districts in Greater Sydney and GSR planning district boundaries, the Study has been unable to determine with any accurate resolution a breakdown of the Macromonitor demand data by the five GSR planning districts.

   However, a high-level estimate of forecast demand for extractive materials and cementitious materials for the GSR's Three Cities has been prepared. The detailed data are included in **Appendix 4**.

   This issue was identified early in the Study and reported to DPE. Macromonitor provided a budget estimate to realign their demand data with the GSR district boundaries. The estimated cost of between $25,000 to $30,000 was considered by DPE to be beyond the Study's budget and the work was not commissioned by the Study. If a re-alignment of Macromonitor data by GSR district was to be commissioned in the future, it would enable detailed evaluation of demand profiles for each GSR district.

2. Demand forecasts rely on published reports and data, and private research conducted by Macromonitor. If data held by government for demand for housing, other buildings, roads and other infrastructure is unpublished, then the Macromonitor forecast series will not include it.

   Macromonitor assert that their bottom up algorithms, by which they produce portions of their demand series, have demonstrated over time that they produce reliable estimates accepted by industry as representative of demand. The rolling updates of the demand series produced bi-annually by Macromonitor capture any new data that is published by government. The main changes occur when the phasing or timing of major projects occurs – i.e. if a major project is brought forward in time (or delayed), then the phasing changes affect the demand profile at a point in time. However, major projects represent only a small proportion of total demand and phasing changes produce only small year on year variations to the Macromonitor data.

3. Macromonitor demand forecasts for quarry products do not distinguish between demand met by hard rock and natural sand quarries, and demand met by other sources such as VENM / tunnel spoil / crushed sandstone and recycled concrete.

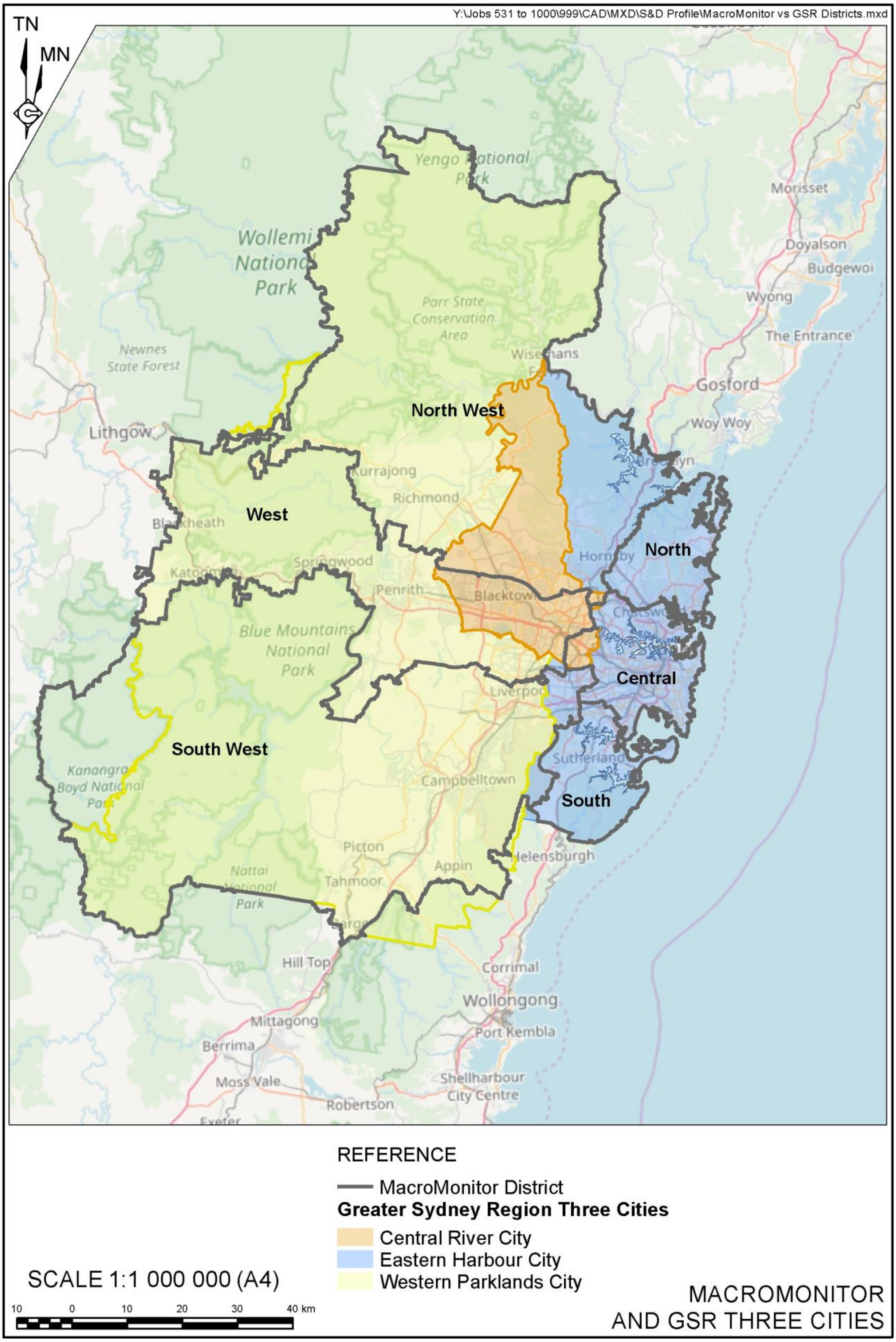
   The difference between the Macromonitor data that captures overall construction material demand irrespective of origin of the materials, and the information provided to the Study by industry of extractive materials supply, has been assessed to estimate the contribution to demand met by non-hard rock and natural sand quarries (46% is the estimate adopted by the Study).

4. Macromonitor demand data uses the term 'Construction Sand' to describe all sand and does not distinguish between origin of sand – i.e. whether natural sand or manufactured sand produced by the crushing and processing of hard rock.

   The Study has therefore segmented the Construction Sand data into natural sand and crushed fine aggregate (a proportion of which is supplied as manufactured sand) to provide better resolution of the fine aggregate demand profile for concrete.

A3.3 Comparison of Macromonitor Districts (ABS) and GSR Three Cities

The figure on the following page illustrates the boundary alignments of the districts used by Macromonitor and the GSR Three Cities.


Y:\Jobs 531 to 1000\999\CAD\MXD\S&D Profile\MacroMonitor vs GSR Districts.mxd
TN
MN
North West
West
North
Central
South West
South
Wollemi National Park
Yengo National Park
Parr State Conservation Area
Newnes State Forest
Lithgow
Blue Mountains National Park
Kanangra Boyd National Park
Nattai National Park
Morisset
Doyalson
Budgewoi
Wyong
The Entrance
Gosford
Woy Woy
Wisemans Ferry
Kurrajong
Richmond
Springwood
Katoomba
Blackheath
Penrith
Blacktown
Hornsby
Liverpool
Sutherland
Campbelltown
Picton
Appin
Tahmoor
Helensburgh
Hill Top
Corrimal
Wollongong
Port Kembla
Mittagong
Berrima
Moss Vale
Robertson
Shellharbour City Centre
Exeter
REFERENCE
MacroMonitor District
Greater Sydney Region Three Cities
Central River City
Eastern Harbour City
Western Parklands City
SCALE 1:1 000 000 (A4)
10 0 10 20 30 40 km
MACROMONITOR
AND GSR THREE CITIES

A3.4 Macromonitor Forecasting Derivation Methodology

The following slides provided by Macromonitor provide a summary of their derivation and forecast methodology for the construction materials demand forecasts for the GSR. Macromonitor produce similar construction materials demand series for all Australian state capital cities.

Our approach

- Data / Measurement (measure activity accurately and meaningfully:
  - Break down sectors into homogenous segments
  - Break down demand into categories which can be understood/modelled
  - Estimation of segments is critical part of forecasting
- Top Down:
  - Commercial sectors – forecast total demand and supply (incl. demand and supply by segment) – forecast investment cycle
  - Govt. sectors – model funding drivers and forecast funding cycle
- Bottom-Up:
  - Project lists with clear assumptions
  - Capital spending plans by category
  - Detailed activity forecasts by region
- Short Term:
  - Model leading indicators (approvals, commencements, loans, grants etc.)

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Techniques

- Manual collection of information, aggregation and segmentation
- Statistical estimation at a low level of segmentation, where there is homogeneity and consistency of drivers, and for leading indicators
- Manual analysis / modelling using detailed information, market knowledge and informed assumptions

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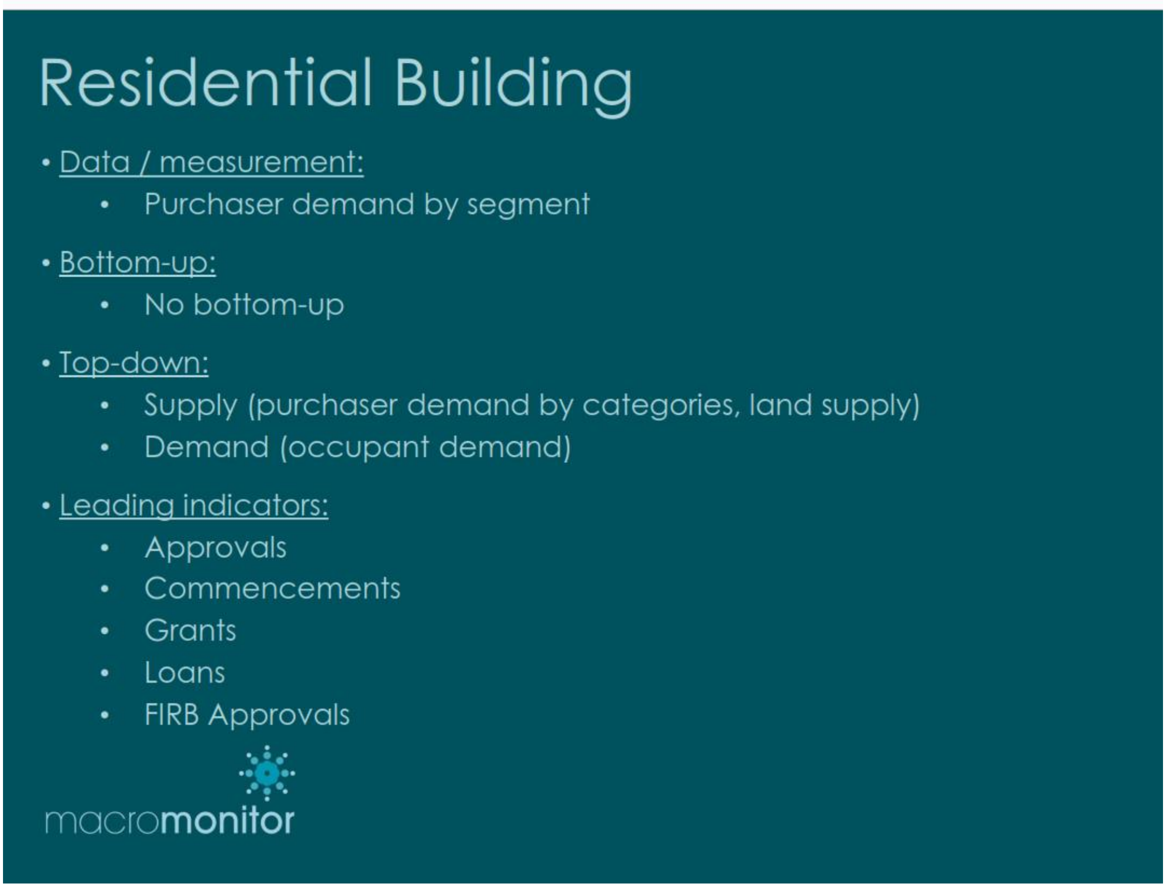
Residential Building
• Data / measurement:
• Purchaser demand by segment
• Bottom-up:
• No bottom-up
• Top-down:
• Supply (purchaser demand by categories, land supply)
• Demand (occupant demand)
• Leading indicators:
• Approvals
• Commencements
• Grants
• Loans
• FIRB Approvals
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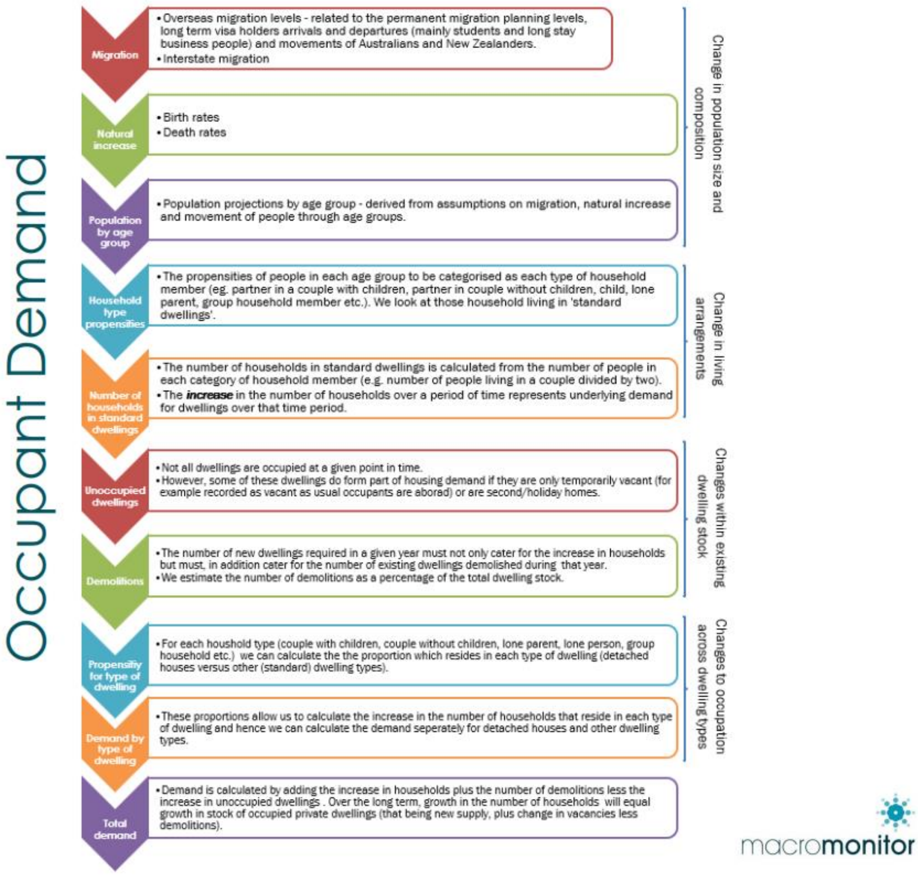
Occupant Demand
Migration
• Overseas migration levels - related to the permanent migration planning levels, long term visa holders arrivals and departures (mainly students and long stay business people) and movements of Australians and New Zealanders.
• Interstate migration
Natural increase
• Birth rates
• Death rates
Population by age group
• Population projections by age group - derived from assumptions on migration, natural increase and movement of people through age groups.
Change in population size and composition
Household type propensities
• The propensities of people in each age group to be categorised as each type of household member (eg. partner in a couple with children, partner in couple without children, child, lone parent, group household member etc.). We look at those household living in 'standard dwellings'.
Number of households in standard dwellings
• The number of households in standard dwellings is calculated from the number of people in each category of household member (e.g. number of people living in a couple divided by two).
• The increase in the number of households over a period of time represents underlying demand for dwellings over that time period.
Change in living arrangements
Unoccupied dwellings
• Not all dwellings are occupied at a given point in time.
• However, some of these dwellings do form part of housing demand if they are only temporarily vacant (for example recorded as vacant as usual occupants are aborad) or are second/holiday homes.
Demolitions
• The number of new dwellings required in a given year must not only cater for the increase in households but must, in addition cater for the number of existing dwellings demolished during that year.
• We estimate the number of demolitions as a percentage of the total dwelling stock.
Changes within existing dwelling stock
Propensity for type of dwelling
• For each houshold type (couple with children, couple without children, lone parent, lone person, group household etc.) we can calculate the the proportion which resides in each type of dwelling (detached houses versus other (standard) dwelling types).
Demand by type of dwelling
• These proportions allow us to calculate the increase in the number of households that reside in each type of dwelling and hence we can calculate the demand seperately for detached houses and other dwelling types.
Changes to occupation across dwelling types
Total demand
• Demand is calculated by adding the increase in households plus the number of demolitions less the increase in unoccupied dwellings . Over the long term, growth in the number of households will equal growth in stock of occupied private dwellings (that being new supply, plus change in vacancies less demolitions).
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Non-Residential Building

- Data / measurement:
  - Supply and demand measured in m^2
- Bottom-up:
  - Detailed project lists (using: Investment Monitor, property council, property market research, media, Govt budgets, local councils, etc.)
  - Monitor approvals by region and identify projects
- Top-down:
  - Commercial sectors: supply and demand – investment cycles
  - Social Building: similar to transport infrastructure
- Leading indicators:
  - Approvals
  - Commencements
  - Vacancy

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Transport Infrastructure

- Data / measurement:
  - Breakdown by type of road
  - Road maintenance data
- Bottom-up:
  - Detailed project lists (using: budget papers, Govt forward planning documents, political policy positions, media coverage, published project documentation, consultation with industry people)
- Top-down:
  - Govt funding cycle modelling (difficult to model now, and poor correlation with infrastructure spending)
  - Manual tracking of funding – including privatisation proceeds, new financing models, changing priorities (road vs. rail etc.) and attitudes to debt
- Leading indicators:
  - Commencements
  - Residential building

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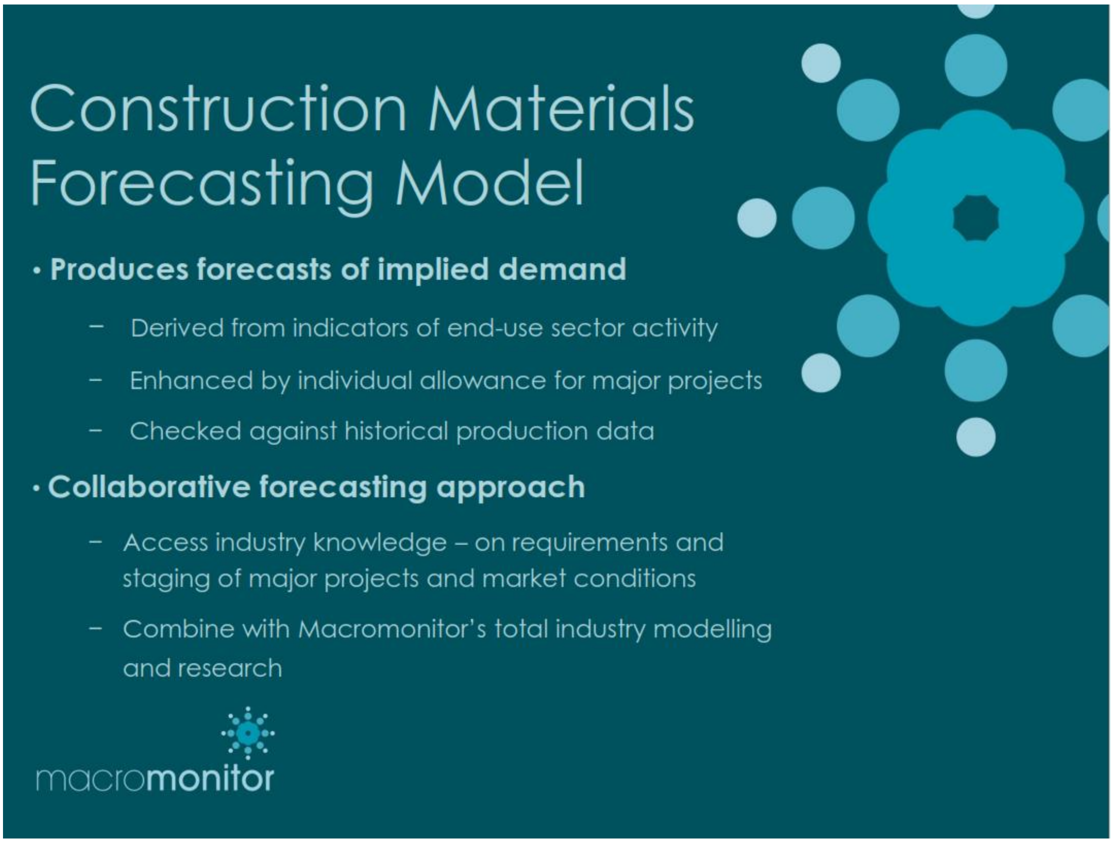
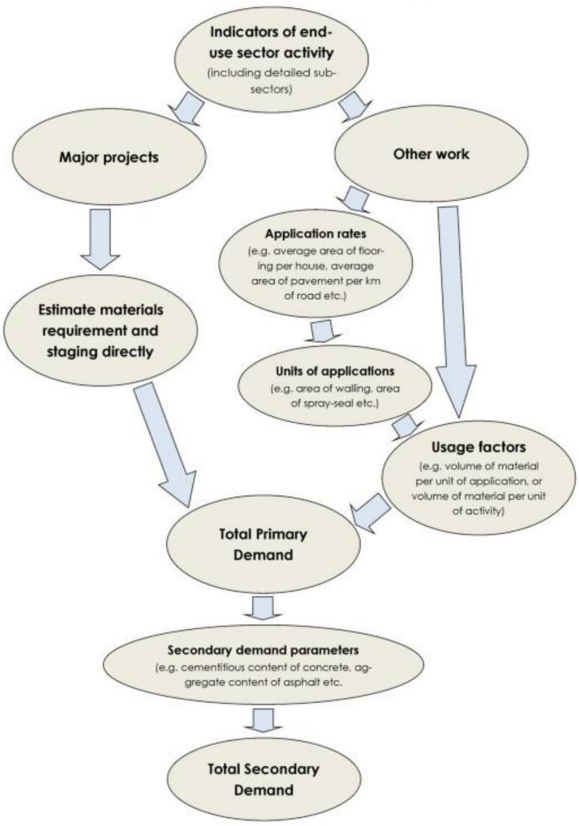


Simplified Methodology



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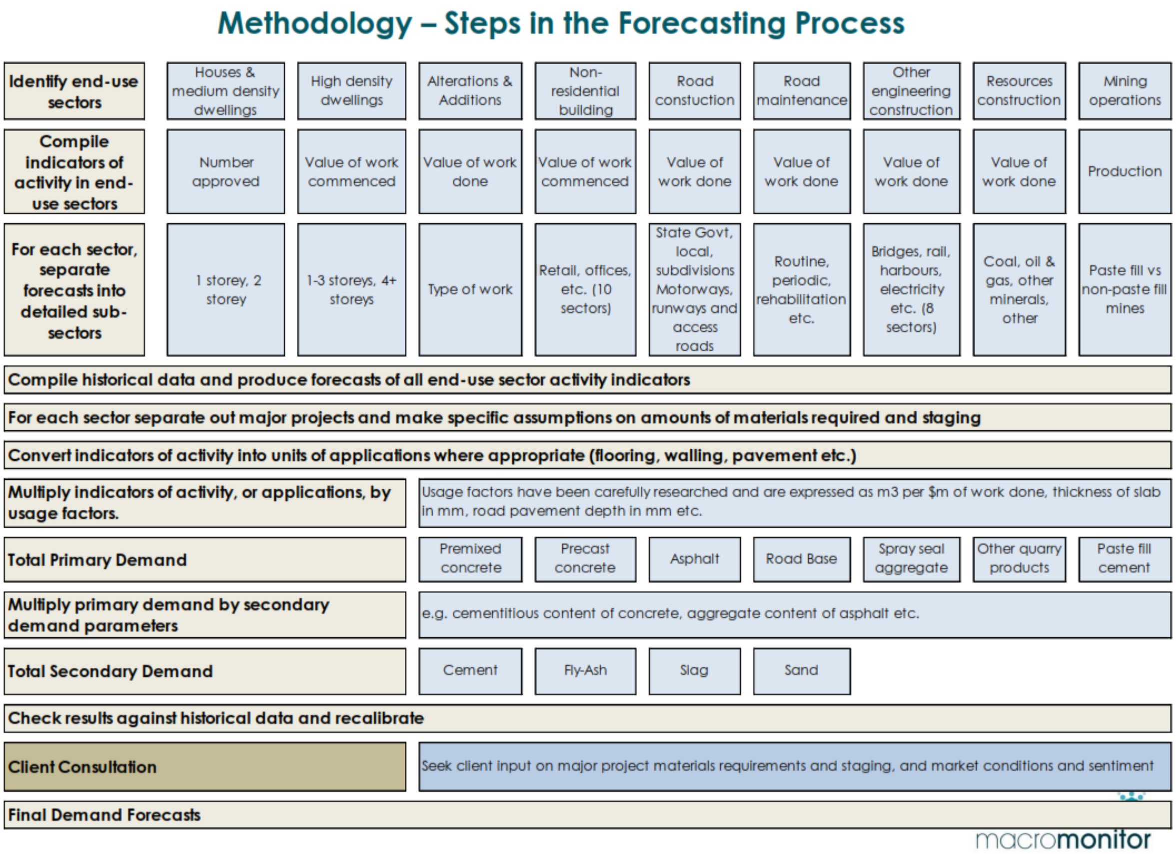

A3.5 Macromonitor demand profile charts for Greater Sydney (less Central Coast)

The Macromonitor construction materials demand forecasts for various construction material types and uses are provided in excel sheets with the data also summarised in chart form.

The following charts are extracted from the excel sheets. They provide the summary of demand (from 2006 to 2026) by the construction material type and sector of use.

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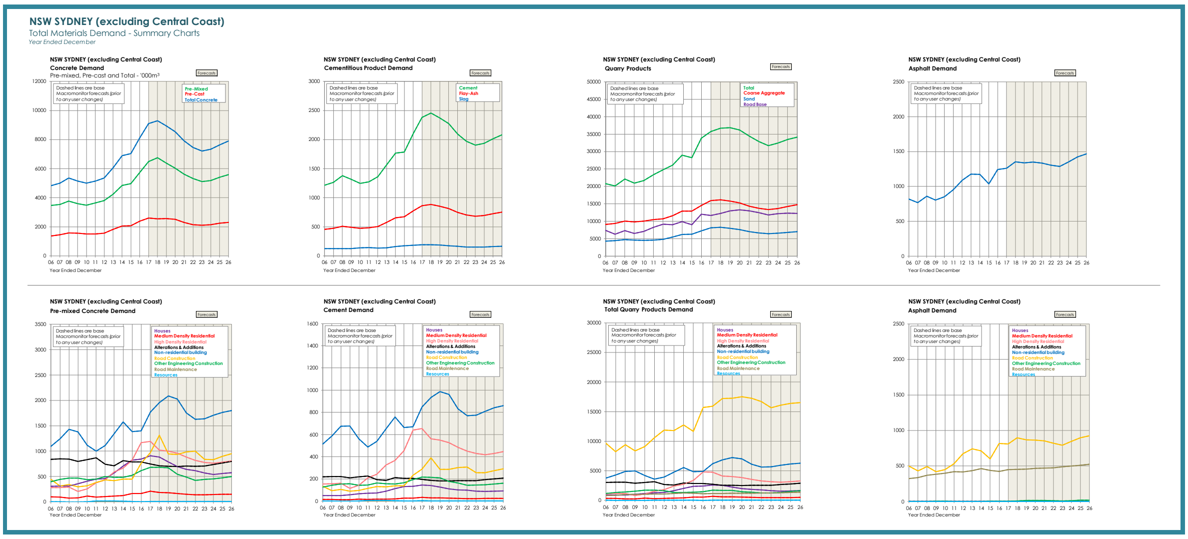
Construction Materials Forecasting Model
NSW SYDNEY (excluding Central Coast)

Model and Base Forecasts Produced by Macromonitor
July 2018

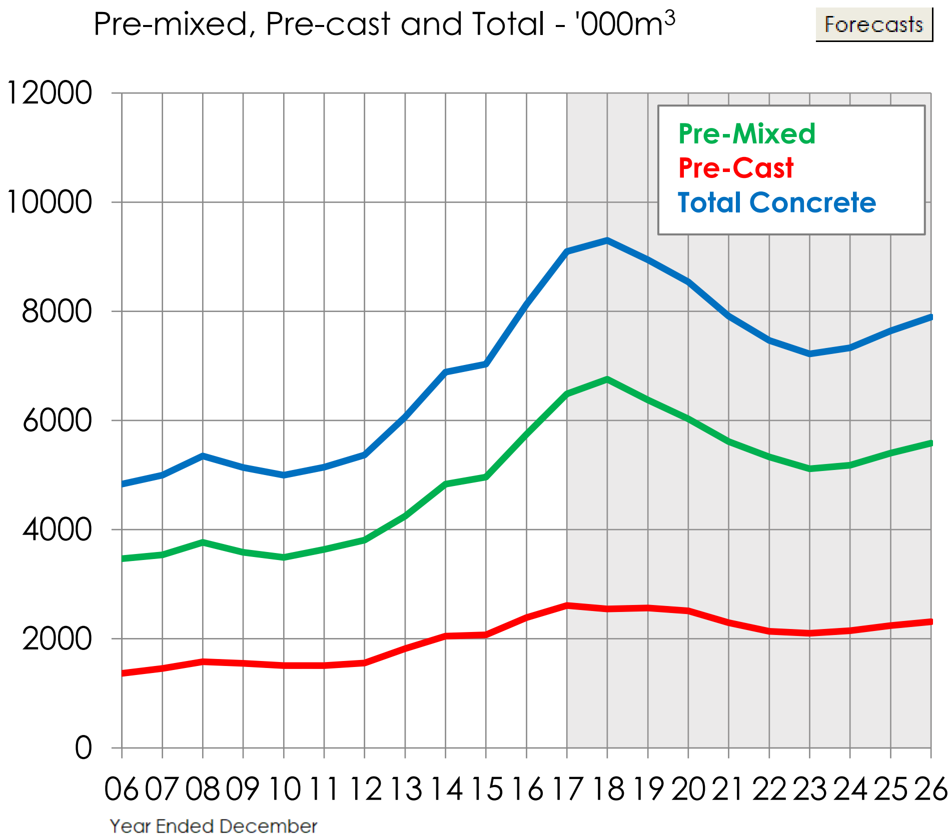
NSW SYDNEY (excluding Central Coast)

Total Materials Demand - Summary Charts
Year Ended December

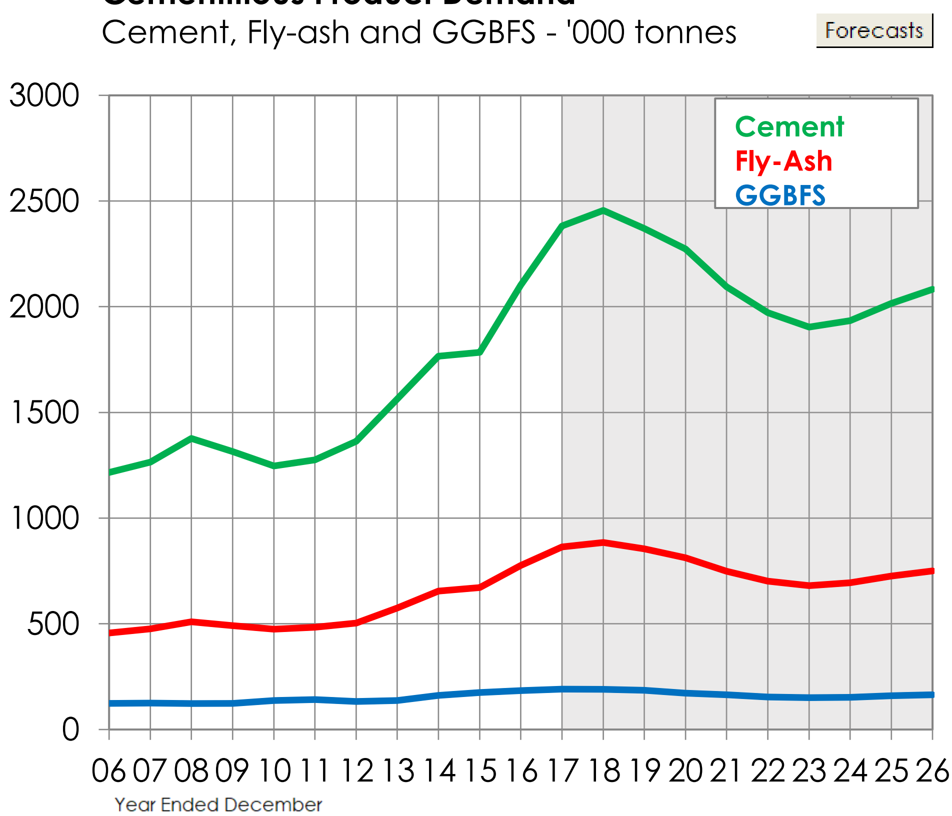


These charts are shown individually on the following pages.

Concrete Demand
Pre-mixed, Pre-cast and Total - '000m^3

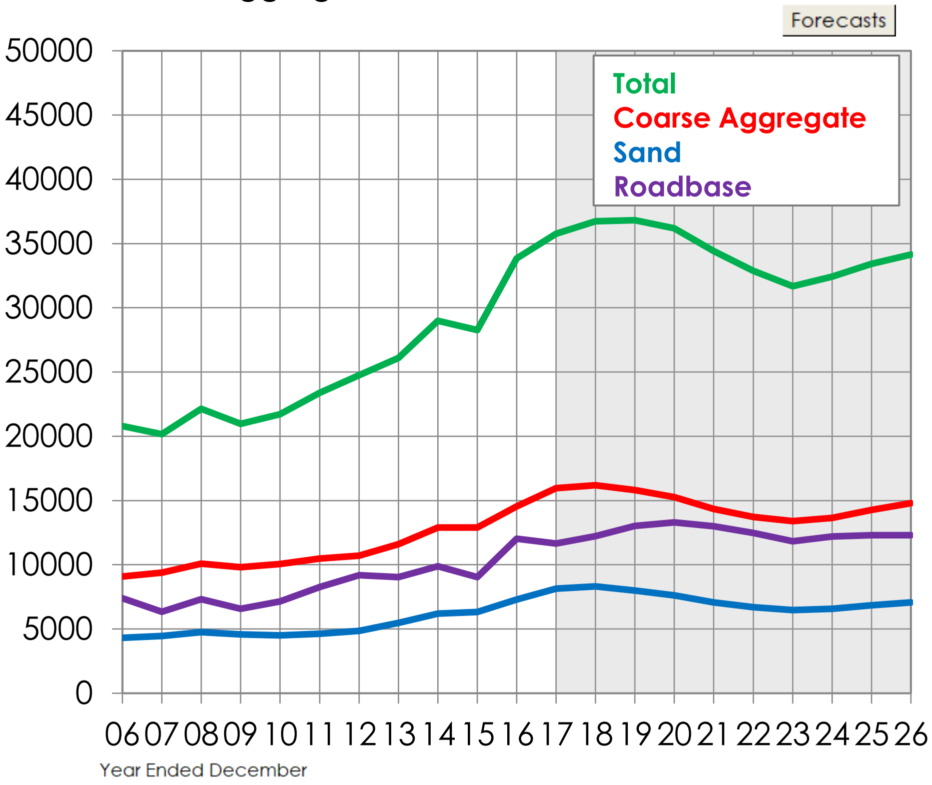


Cementitious Product Demand
Cement, Fly-ash and GGBFS - '000 tonnes



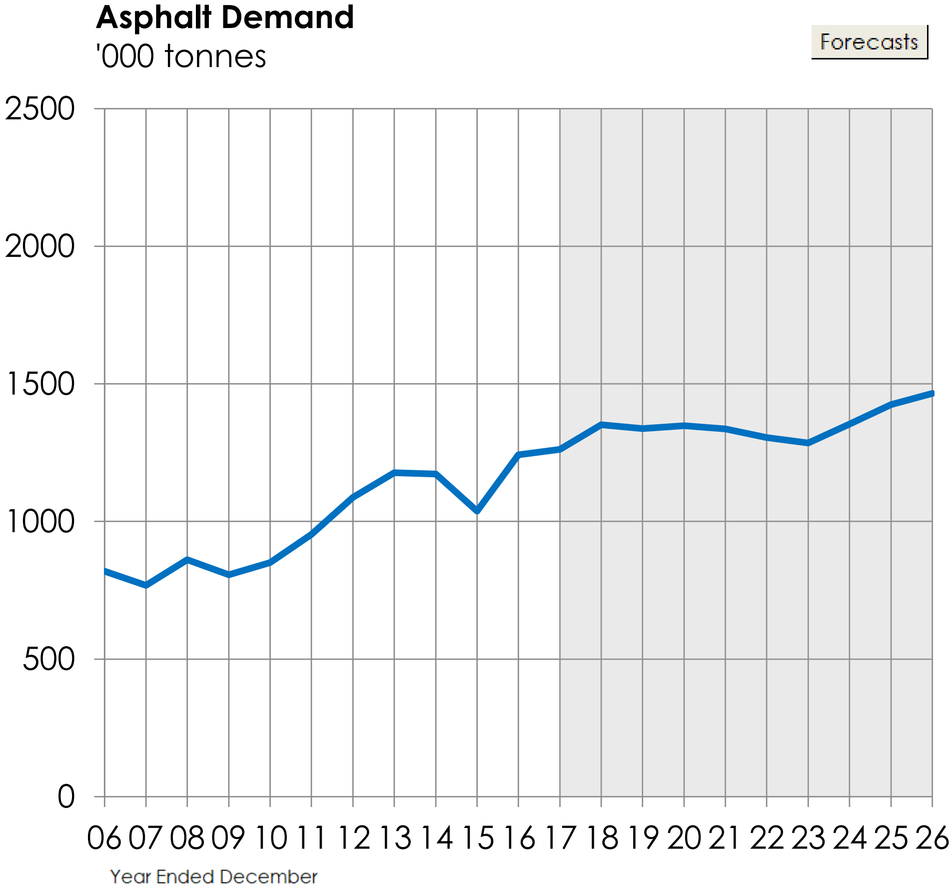
Quarry Products

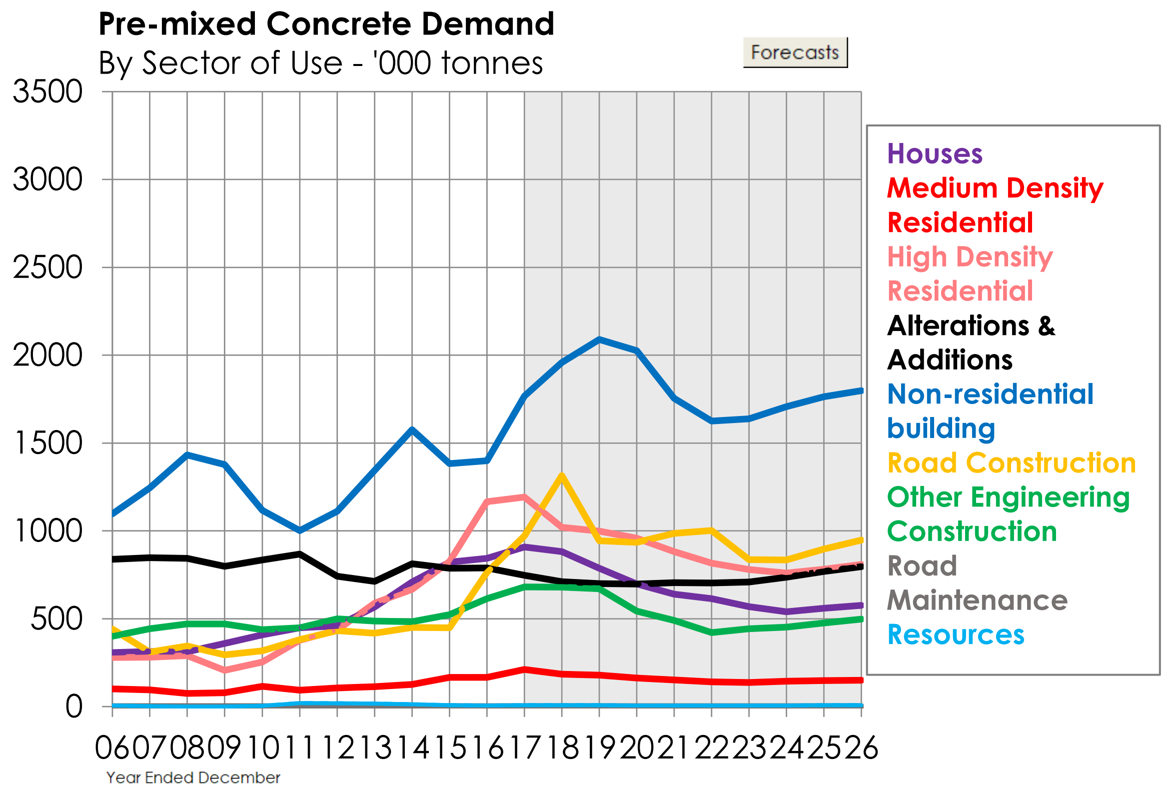
Coarse Aggregate and Construction Sand - '000 tonnes

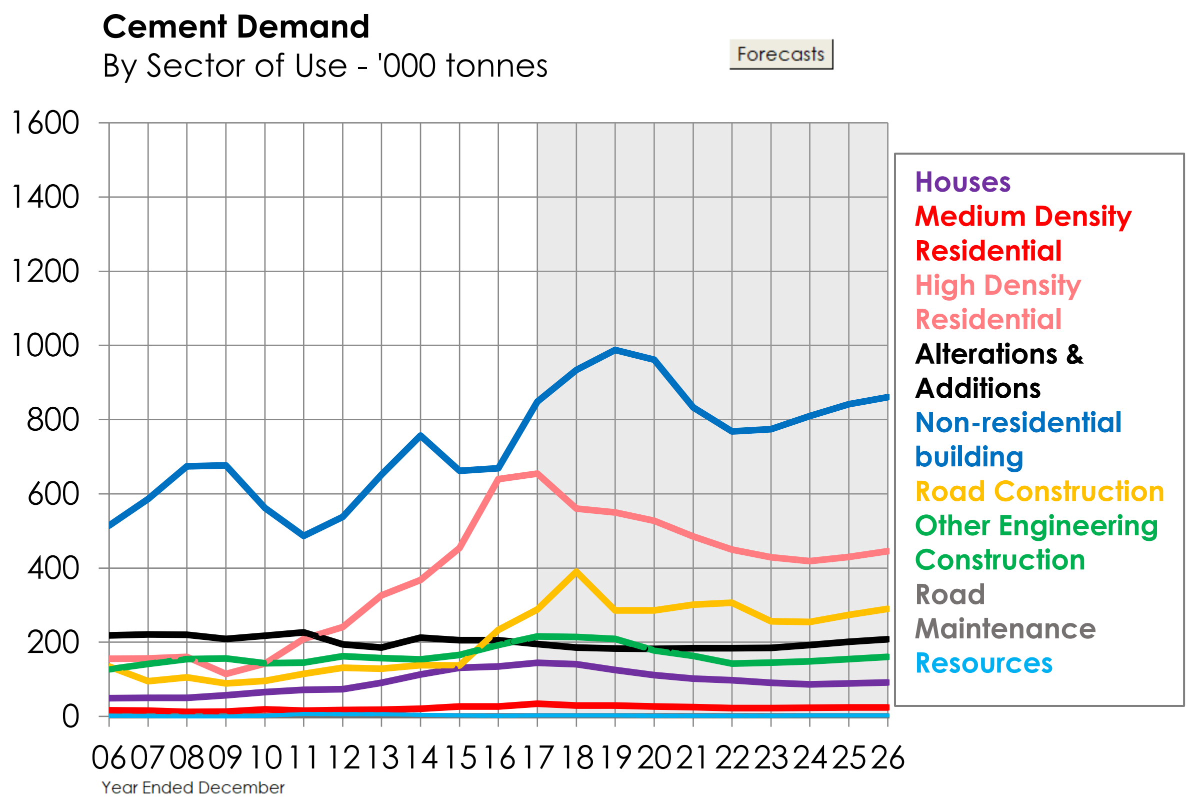


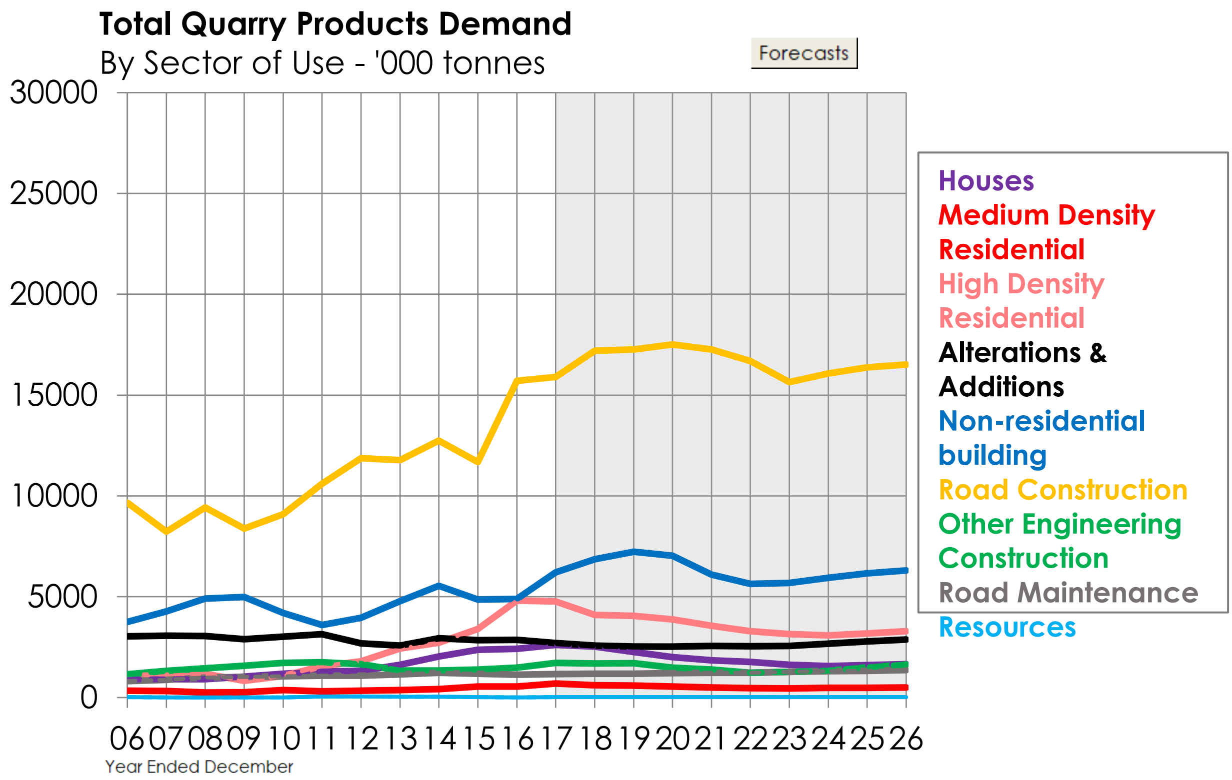
Asphalt Demand

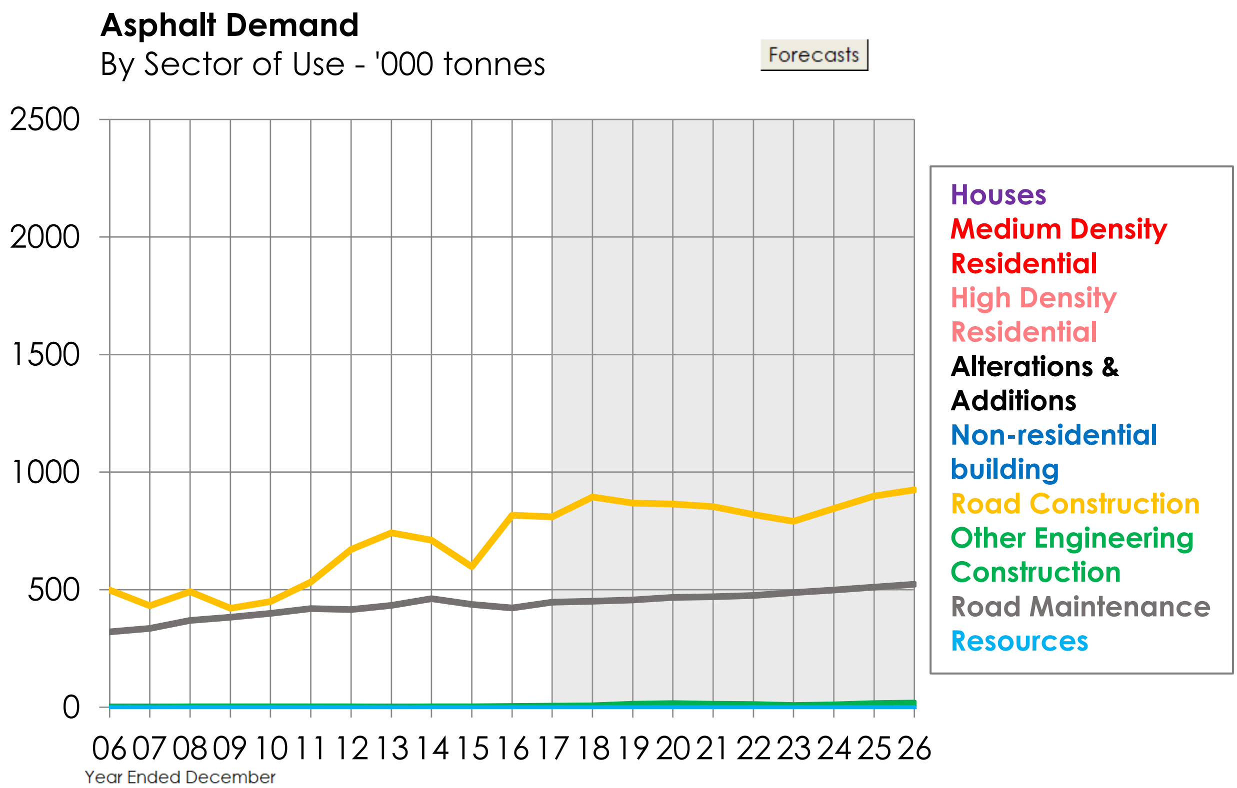
'000 tonnes




Pre-mixed Concrete Demand
By Sector of Use - '000 tonnes
Forecasts
3500
3000
2500
2000
1500
1000
500
0
06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Year Ended December
Houses
Medium Density Residential
High Density Residential
Alterations & Additions
Non-residential building
Road Construction
Other Engineering Construction
Road Maintenance
Resources


Cement Demand
By Sector of Use - '000 tonnes
Forecasts
1600
1400
1200
1000
800
600
400
200
0
06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Year Ended December
Houses
Medium Density Residential
High Density Residential
Alterations & Additions
Non-residential building
Road Construction
Other Engineering Construction
Road Maintenance
Resources


Total Quarry Products Demand
By Sector of Use - '000 tonnes
Forecasts
30000
25000
20000
15000
10000
5000
0
06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Year Ended December
Houses
Medium Density Residential
High Density Residential
Alterations & Additions
Non-residential building
Road Construction
Other Engineering Construction
Road Maintenance
Resources


Asphalt Demand
By Sector of Use - '000 tonnes
Forecasts
2500
2000
1500
1000
500
0
06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
Year Ended December
Houses
Medium Density Residential
High Density Residential
Alterations & Additions
Non-residential building
Road Construction
Other Engineering Construction
Road Maintenance
Resources

Appendix 4

Historical and Forecast Demand Series Data 2011 to 2036

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Table A4-1
Population Estimates and Per Capita Consumption Estimates

	GSR Demand and Supply Profile								FY 2018 base case is the average										Macromonitor Data series ends											
A	**Construction Materials**	**YE Dec**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	**2018-2036**
1	**Extractive (Quarry) Materials (Hard Rock and Natural Sand)**	2018 profile - % by Weight	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Cumulative (2018-2036) Mt
	Natural Sand	31%	4.9	4.7	4.5	4.9	5.0	5.8	5.9	6.1	6.1	6.0	5.7	5.5	5.3	5.4	5.5	5.7	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	118
	Crushed Fine Aggregate (<5mm)	17%	1.6	2.0	2.4	2.7	2.8	3.2	3.3	3.4	3.4	3.3	3.2	3.0	2.9	3.0	3.1	3.1	3.4	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9	65
	Crushed Coarse Aggregate (5mm-30mm)	39%	5.3	5.6	5.9	6.6	6.5	7.3	7.5	7.7	7.7	7.6	7.2	6.9	6.7	6.8	7.0	7.2	7.8	8.0	8.1	8.2	8.3	8.5	8.6	8.7	8.8	9.0	149
	Roadbase / Sub-Base (DGB/DGS)	8%	0.9	1.0	1.1	1.5	1.2	1.3	1.5	1.5	1.5	1.5	1.4	1.4	1.3	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	30
	Broken / Sized Rock (>30mm)	6%	0.8	1.0	1.2	1.2	1.2	1.1	1.1	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	22
	Total	100%	13.56	14.4	15.1	16.8	16.7	18.6	19.3	19.8	19.9	19.5	18.6	17.8	17.1	17.5	18.1	18.4	20.2	20.5	20.8	21.1	21.4	21.7	22.1	22.4	22.7	23.0	383
2	**Substitute Sources**	% by Weight	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Cumulative (2018-2036) Mt
	Fine Aggregate (<5mm)	3%	0.3	0.3	0.3	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	10
	Crushed Coarse Aggregate (5mm-30mm)	24%	2.3	2.5	2.6	2.9	2.8	3.6	3.9	4.0	4.0	4.0	3.8	3.6	3.5	3.6	3.7	3.8	4.1	4.2	4.2	4.3	4.4	4.4	4.5	4.6	4.6	4.7	78
	Roadbase / Sub-Base (DGB/DGS)	63%	6.2	6.6	7.0	7.7	7.4	9.7	10.4	10.7	10.7	10.6	10.0	9.6	9.2	9.5	9.8	10.0	10.9	11.1	11.2	11.4	11.6	11.7	11.9	12.1	12.3	12.4	207
	Broken / Sized Rock (>30mm)	10%	0.9	1.0	1.1	1.2	1.1	1.5	1.6	1.6	1.6	1.6	1.5	1.5	1.4	1.4	1.5	1.5	1.6	1.7	1.7	1.7	1.8	1.8	1.8	1.8	1.9	1.9	31
	Total	100%	9.8	10.4	11.0	12.2	11.6	15.2	16.5	16.9	16.9	16.6	15.8	15.1	14.6	14.9	15.4	15.7	17.2	17.4	17.7	18.0	18.3	18.5	18.8	19.1	19.3	19.6	326
	Substitute Sources % of total demand (excluding cementitious materials)		*42%*	*42%*	*42%*	*42%*	*41%*	*45%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*	*46%*
	Total Quarry and Substitute Sources		23.4	24.8	26.1	29.0	28.3	33.9	35.8	36.7	36.8	36.2	34.4	32.9	31.7	32.4	33.4	34.1	37.3	37.9	38.5	39.1	39.7	40.3	40.8	41.4	42.0	42.6	708
3	**Cementitious Materials**	2018 profile - % by Weight	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Mtpa	Cumulative (2018-2036) Mt
	Cement	70%	1.3	1.4	1.6	1.8	1.8	2.1	2.4	2.5	2.4	2.3	2.1	2.0	1.9	2.0	2.0	2.1	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.6	2.6	2.6	44
	Fly Ash	25%	0.5	0.5	0.6	0.7	0.7	0.8	0.9	0.9	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9	16
	GGBFS	5%	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3
	Total	100%	1.9	2.0	2.3	2.6	2.7	3.1	3.5	3.6	3.4	3.3	3.0	2.9	2.8	2.8	2.9	3.0	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	63
1+2+3	**Total Construction Materials**		25.3	26.8	28.4	31.6	30.9	37.0	39.2	40.3	40.3	39.5	37.4	35.7	34.4	35.2	36.4	37.2	40.6	41.3	41.9	42.5	43.2	43.8	44.5	45.1	45.7	46.4	771
	CHART DATA: ANNUAL DEMAND (BASE CASE)	2018 profile - % by Weight	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative (2018-2036) Mt
	Crushed Rock and Natural Sand Quarries	49%	13.6	14.4	15.1	16.8	16.7	18.6	19.3	19.8	19.9	19.5	18.6	17.8	17.1	17.5	18.1	18.4	20.2	20.5	20.8	21.1	21.4	21.7	22.1	22.4	22.7	23.0	383
	Other Sources (VENM & Recycling)	42%	9.8	10.4	11.0	12.2	11.6	15.2	16.5	16.9	16.9	16.6	15.8	15.1	14.6	14.9	15.4	15.7	17.2	17.4	17.7	18.0	18.3	18.5	18.8	19.1	19.3	19.6	326
	Cementitious Materials	9%	1.9	2.0	2.3	2.6	2.7	3.1	3.5	3.6	3.4	3.3	3.0	2.9	2.8	2.8	2.9	3.0	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	63
	Total	100%	25.3	26.8	28.4	31.6	30.9	37.0	39.2	40.3	40.3	39.5	37.4	35.7	34.4	35.2	36.4	37.2	40.6	41.3	41.9	42.5	43.2	43.8	44.5	45.1	45.7	46.4	771
	CHART DATA: CUMULATIVE DEMAND 2018 to 2036 (BASE CASE)		-	-	-	-	-	-	2017	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
	Crushed Rock and Natural Sand Quarries		-	-	-	-	-	-	0	19.8	39.7	59.3	77.8	95.6	112.7	130.2	148.3	166.7	186.9	207.3	228.1	249.2	270.7	292.4	314.5	336.8	359.5	383	
	Other Sources (E.g. Sandstone VENM, Recycled)		-	-	-	-	-	-	0	16.9	33.8	50.5	66.3	81.4	96.0	110.9	126.3	142.0	159.2	176.6	194.3	212.3	230.6	249.1	267.9	286.9	306.3	326	
	Cementitious Materials		-	-	-	-	-	-	0	3.6	7.0	10.3	13.3	16.2	18.9	21.8	24.7	27.7	31.0	34.3	37.7	41.2	44.7	48.3	51.9	55.5	59.2	63.0	
									0	40.3	80.6	120.0	157.5	193.2	227.7	262.9	299.2	336.4	377.1	418.3	460.2	502.7	545.9	589.7	634.2	679.3	725.0	771	
B	**GSR Population (M)**		**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
	Low Series		-	-	-	-	-	-					5.13					5.49					5.83					6.14	
	Main Series		4.32	4.39	4.48	4.56	4.65	4.74	4.84	4.95	5.04	5.13	5.17	5.26	5.34	5.43	5.52	5.61	5.70	5.78	5.87	5.96	6.06	6.14	6.23	6.32	6.41	6.51	
	High Series		-	-	-	-	-	-					5.22					5.82					6.26					6.84	
C	**Per Capita Consumption (tpa)**	**BASE CASE**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	
	Crushed Rock and Natural Sand Quarries		3.14	3.27	3.38	3.68	3.59	3.93	3.99	4.00	3.94	3.81	3.59	3.38	3.20	3.22	3.27	3.29	3.54	3.54	3.54	3.54	3.54	3.54	3.54	3.54	3.54	3.54	
	Other Sources (E.g. Sandstone VENM, Recycled)		2.27	2.37	2.45	2.67	2.49	3.21	3.40	3.41	3.36	3.24	3.06	2.88	2.73	2.75	2.79	2.80	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	3.01	
	Cementitious Materials (Cement, Flyash, Slag)		0.44	0.46	0.51	0.57	0.57	0.65	0.72	0.72	0.68	0.64	0.59	0.54	0.52	0.52	0.53	0.54	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	0.58	
	Total		5.86	6.09	6.35	6.92	6.65	7.79	8.11	8.13	7.99	7.70	7.24	6.79	6.44	6.49	6.58	6.62	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	7.13	

D	**Concrete: Pre-Mixed, Pre-Cast and Mortar (Mt)**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**
	Cement	1.3	1.4	1.6	1.8	1.8	2.1	2.4	2.5	2.4	2.3	2.1	2.0	1.9	2.0	2.0	2.1	2.3	2.3	2.4	2.4	2.4	2.5	2.5	2.6	2.6	2.6
	Fly Ash	0.5	0.5	0.6	0.7	0.7	0.8	0.9	0.9	0.9	0.8	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	0.9	0.9
	GGBFS	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	Fine Aggregates - Natural Sand	3.4	3.3	3.4	3.9	3.9	4.6	5.1	5.2	5.0	4.8	4.4	4.2	4.0	4.1	4.3	4.4	4.8	4.9	4.9	5.0	5.1	5.2	5.2	5.3	5.4	5.5
	Fine Aggregates - Manufactured Sand	1.1	1.4	1.8	2.1	2.2	2.5	2.8	2.9	2.8	2.6	2.4	2.3	2.2	2.3	2.4	2.4	2.7	2.7	2.7	2.8	2.8	2.9	2.9	2.9	3.0	3.0
	Coarse Aggregates	5.6	5.8	6.6	7.4	7.6	8.8	9.8	10.0	9.7	9.2	8.5	8.1	7.8	7.9	8.3	8.5	9.3	9.4	9.6	9.7	9.9	10.0	10.2	10.3	10.5	10.6
	Total	**12.0**	**12.5**	**14.1**	**16.0**	**16.4**	**19.0**	**21.2**	**21.7**	**20.9**	**19.9**	**18.4**	**17.4**	**16.8**	**17.1**	**17.8**	**18.4**	**20.0**	**20.4**	**20.7**	**21.0**	**21.3**	**21.6**	**21.9**	**22.2**	**22.6**	**22.9**

Notes:

1. These data provide a summary of the GSR Construction Materials historical supply series and forecast demand series referred to in the body of the Study report.
2. These data have been compiled by the Study from a variety of data and information sources referenced in the Study report. Limitations of the data and assumptions made by the RWC project team in preparing the data are detailed in the report.

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Table A4-2
Forecast Demand Series by GSR Three Cities: YE Dec 2018 to YE Dec 2036

EXTRACTIVE MATERIALS (CRUSHED ROCK AND NATURAL SAND) & CEMENTITIOUS MATERIALS

Oct-18

1 GSR Total

1.1 Crushed Rock and Sand (Mt) by Quarry Product	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Cumulative Demand Mt (2018-2036)
Natural Sand	6.1	6.1	6.0	5.7	5.5	5.3	5.4	5.5	5.7	6.2	6.3	6.4	6.5	6.6	6.7	6.8	6.9	7.0	7.1	118
Crushed Fine Aggregate (<5mm)	3.4	3.4	3.3	3.2	3.0	2.9	3.0	3.1	3.1	3.4	3.5	3.5	3.6	3.6	3.7	3.8	3.8	3.9	3.9	65
Crushed Coarse Aggregate (5mm-30mm)	7.7	7.7	7.6	7.2	6.9	6.7	6.8	7.0	7.2	7.8	8.0	8.1	8.2	8.3	8.5	8.6	8.7	8.8	9.0	149
Roadbase / Sub-Base (DGB/DGS)	1.5	1.5	1.5	1.4	1.4	1.3	1.4	1.4	1.4	1.6	1.6	1.6	1.6	1.7	1.7	1.7	1.7	1.8	1.8	30
Broken / Sized Rock (>30mm)	1.1	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.2	1.2	1.2	1.2	1.3	1.3	1.3	22
Total Crushed Rock and Sand	19.8	19.9	19.5	18.6	17.8	17.1	17.5	18.1	18.4	20.2	20.5	20.8	21.1	21.4	21.7	22.1	22.4	22.7	23.0	383

1.2 Crushed Rock and Sand (Mt) by Point of Use	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Cumulative Demand Mt (2018-2036)
Housing	8.3	7.9	7.4	7.0	6.7	6.5	6.4	6.7	6.9	7.5	7.7	7.8	7.9	8.0	8.1	8.3	8.4	8.5	8.6	145
Non-Residential Buildings	5.0	5.4	5.2	4.4	4.0	4.1	4.3	4.5	4.6	5.0	5.1	5.1	5.2	5.3	5.4	5.5	5.5	5.6	5.7	95
Road Construction & Maintenance	5.7	5.7	6.2	6.6	6.6	6.0	6.2	6.2	6.1	6.7	6.8	6.9	7.0	7.1	7.2	7.3	7.4	7.5	7.6	127
Other Engineered Construction	0.8	0.9	0.7	0.6	0.5	0.5	0.6	0.7	0.9	0.9	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.1	16
Total Point of Use	19.8	19.9	19.5	18.6	17.7	17.1	17.5	18.0	18.4	20.1	20.5	20.8	21.1	21.4	21.7	22.0	22.4	22.7	23.0	383

1.3 Cementitious (Mt)	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Cumulative Demand Mt (2018-2036)
Cement	2.49	2.40	2.30	2.12	2.00	1.93	1.96	2.04	2.11	2.30	2.34	2.37	2.41	2.44	2.48	2.52	2.55	2.59	2.63	44.0
Fly Ash	0.88	0.86	0.81	0.75	0.70	0.68	0.69	0.73	0.75	0.82	0.83	0.84	0.86	0.87	0.88	0.90	0.91	0.92	0.93	15.6
Slag	0.19	0.19	0.17	0.16	0.15	0.15	0.15	0.16	0.16	0.18	0.18	0.19	0.19	0.19	0.19	0.20	0.20	0.20	0.21	3.4
Total	3.6	3.4	3.3	3.0	2.9	2.8	2.8	2.9	3.0	3.3	3.3	3.4	3.5	3.5	3.6	3.6	3.7	3.7	3.8	63.0

2 Three Cities Demand Profile (% tonnes) :- High-Level Estimate Only

2.1 FY 2018 Demand Profile	EHC	CRC	WPC	GSR	Comments
1. Industry interviews	55%	30%	15%	100%	Current demand profile (% tonnes) for extractive materials and pre-mixed concrete - based on interviews with major vertically integrated suppliers
2. Macromonitor data	60%	20%	20%	100%	For all materials (extractive + recycled, sandstone, VENM); data re-aligned by RWC/Ecoroc from ABS districts to GSR Three cities, using geographical segmentation
Baseline for Study forecasts	**56%**	**27%**	**17%**	**100%**	Adopted FY 2018 extractive materials and concrete demand profile for GSR by Three Cities

2.2 Future Demand Profiles	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
Eastern Harbour City (EHC)	56.0%	55.7%	55.3%	55.0%	54.5%	54.0%	53.5%	53.0%	52.5%	52.2%	51.9%	51.6%	51.3%	51.0%	50.8%	50.6%	50.4%	50.2%	50.0%
Central River City (CRC)	27.0%	27.2%	27.3%	27.5%	27.7%	27.9%	28.1%	28.3%	28.5%	28.6%	28.7%	28.8%	28.9%	29.0%	29.0%	29.0%	29.0%	29.0%	29.0%
Western Parklands City (WPC)	17.0%	17.2%	17.3%	17.5%	17.8%	18.1%	18.4%	18.7%	19.0%	19.2%	19.4%	19.6%	19.8%	20.0%	20.2%	20.4%	20.6%	20.8%	21.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Notes to Three Cities forecast demand profiles

1. Estimates of demand profiles or % splits for YE Dec 2026 and YE Dec 2036 have been adopted having regard to the GSR Plan, industry feedback and Macromonitor demand forecasts to 2026. The demand split for intervening years is by interpolation.
2. The estimates are for extractive materials (crushed rock and natural sand) and cementitious materials (cement, flyash and GGBFS).
3. They are high-level estimates, and should be considered as a guide only.

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Table A4-2 (Cont'd)
Forecast Demand Series by GSR Three Cities: YE Dec 2018 to YE Dec 2036

3	**Eastern Harbour City (EHC)**																				
3.1	**Crushed Rock and Sand (Mt) by Quarry Product**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand Mt (2018-2036)
	Natural Sand	3.4	3.4	3.3	3.1	3.0	2.8	2.9	2.9	3.0	3.2	3.3	3.3	3.3	3.4	3.4	3.4	3.5	3.5	3.5	62
	Crushed Fine Aggregate (<5mm)	1.9	1.9	1.8	1.7	1.6	1.6	1.6	1.6	1.6	1.8	1.8	1.8	1.8	1.9	1.9	1.9	1.9	1.9	2.0	34
	Crushed Coarse Aggregate (5mm-30mm)	4.3	4.3	4.2	4.0	3.8	3.6	3.6	3.7	3.8	4.1	4.1	4.2	4.2	4.3	4.3	4.3	4.4	4.4	4.5	78
	Roadbase / Sub-Base (DGB/DGS)	0.9	0.9	0.8	0.8	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	0.8	0.9	0.9	0.9	0.9	0.9	16
	Broken / Sized Rock (>30mm)	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.7	11
	Total Crushed Rock and Sand	11.1	11.1	10.8	10.2	9.7	9.2	9.4	9.6	9.7	10.5	10.6	10.7	10.8	10.9	11.0	11.2	11.3	11.4	11.5	201
3.2	**Crushed Rock and Sand (Mt) by Point of Use**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand Mt (2018-2036)
	Housing	4.6	4.4	4.1	3.9	3.7	3.5	3.4	3.5	3.6	3.9	4.0	4.0	4.1	4.1	4.1	4.2	4.2	4.3	4.3	76
	Non-Residential Buildings	2.8	3.0	2.9	2.4	2.2	2.2	2.3	2.4	2.4	2.6	2.6	2.7	2.7	2.7	2.7	2.8	2.8	2.8	2.9	50
	Road Construction & Maintenance	3.2	3.2	3.5	3.6	3.6	3.2	3.3	3.3	3.2	3.5	3.5	3.5	3.6	3.6	3.7	3.7	3.7	3.8	3.8	66
	Other Engineered Construction	0.5	0.5	0.4	0.3	0.3	0.3	0.3	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	8
	Total Point of Use	11.1	11.1	10.8	10.2	9.7	9.2	9.4	9.6	9.7	10.5	10.6	10.7	10.8	10.9	11.0	11.1	11.3	11.4	11.5	201
3.3	**Cementitious (Mt)**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand Mt (2018-2036)
	Cement	1.40	1.34	1.27	1.17	1.09	1.04	1.05	1.08	1.11	1.20	1.21	1.22	1.23	1.25	1.26	1.27	1.29	1.30	1.31	23.1
	Fly Ash	0.50	0.48	0.45	0.41	0.38	0.37	0.37	0.38	0.39	0.43	0.43	0.44	0.44	0.44	0.45	0.45	0.46	0.46	0.47	8.2
	Slag	0.11	0.10	0.10	0.09	0.08	0.08	0.08	0.08	0.09	0.09	0.09	0.10	0.10	0.10	0.10	0.10	0.10	0.10	0.10	1.8
	Total	2.00	1.92	1.82	1.67	1.55	1.49	1.50	1.55	1.59	1.72	1.74	1.75	1.77	1.79	1.81	1.83	1.84	1.86	1.88	33.1
4	**Central River City (CRC)**																				
4.1	**Crushed Rock and Sand (Mt) by Quarry Product**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand (2018-2036)
	Natural Sand	1.6	1.7	1.6	1.6	1.5	1.5	1.5	1.6	1.6	1.8	1.8	1.8	1.9	1.9	1.9	2.0	2.0	2.0	2.1	33.4
	Crushed Fine Aggregate (<5mm)	0.9	0.9	0.9	0.9	0.8	0.8	0.8	0.9	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.1	1.1	18.5
	Crushed Coarse Aggregate (5mm-30mm)	2.1	2.1	2.1	2.0	1.9	1.9	1.9	2.0	2.0	2.2	2.3	2.3	2.4	2.4	2.5	2.5	2.5	2.6	2.6	42.2
	Roadbase / Sub-Base (DGB/DGS)	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	8.4
	Broken / Sized Rock (>30mm)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4	0.4	6.1
	Total Crushed Rock and Sand	5.4	5.4	5.3	5.1	4.9	4.8	4.9	5.1	5.3	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	108
4.2	**Crushed Rock and Sand (Mt) by Point of Use**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand (2018-2036)
	Housing	2.2	2.1	2.0	1.9	1.9	1.8	1.8	1.9	2.0	2.2	2.2	2.2	2.3	2.3	2.4	2.4	2.4	2.5	2.5	41.0
	Non-Residential Buildings	1.3	1.5	1.4	1.2	1.1	1.1	1.2	1.3	1.3	1.4	1.5	1.5	1.5	1.5	1.6	1.6	1.6	1.6	1.7	26.9
	Road Construction & Maintenance	1.5	1.6	1.7	1.8	1.8	1.7	1.7	1.7	1.7	1.9	1.9	2.0	2.0	2.1	2.1	2.1	2.1	2.2	2.2	36.0
	Other Engineered Construction	0.2	0.2	0.2	0.2	0.1	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	4.6
	Total Point of Use	5.4	5.4	5.3	5.1	4.9	4.8	4.9	5.1	5.3	5.8	5.9	6.0	6.1	6.2	6.3	6.4	6.5	6.6	6.7	108

Table A4-2 (Cont'd)
Forecast Demand Series by GSR Three Cities: YE Dec 2018 to YE Dec 2036

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	Cumulative Demand (2018-2036)
4.3	**Cementitious (Mt)**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand (2018-2036)
	Cement	0.67	0.65	0.63	0.58	0.55	0.54	0.55	0.58	0.60	0.66	0.67	0.68	0.70	0.71	0.72	0.73	0.74	0.75	0.76	12.5
	Fly Ash	0.24	0.23	0.22	0.21	0.19	0.19	0.20	0.21	0.21	0.23	0.24	0.24	0.25	0.25	0.26	0.26	0.26	0.27	0.27	4.4
	Slag	0.05	0.05	0.05	0.05	0.04	0.04	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.06	0.06	0.06	1.0
	Total Cementitious	0.96	0.94	0.90	0.83	0.79	0.77	0.79	0.83	0.86	0.94	0.96	0.98	1.00	1.02	1.03	1.05	1.06	1.08	1.09	18
5	**Western Parklands City (WPC)**																				
5.1	**Crushed Rock and Sand (Mt) by Quarry Product**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand (2018-2036)
	Natural Sand	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.3	1.3	1.3	1.3	1.4	1.4	1.5	1.5	22
	Crushed Fine Aggregate (<5mm)	0.6	0.6	0.6	0.6	0.5	0.5	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8	12
	Crushed Coarse Aggregate (5mm-30mm)	1.3	1.3	1.3	1.3	1.2	1.2	1.3	1.3	1.4	1.5	1.5	1.6	1.6	1.7	1.7	1.8	1.8	1.8	1.9	28
	Roadbase / Sub-Base (DGB/DGS)	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.4	0.4	0.4	6
	Broken / Sized Rock (>30mm)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	4
	Total Crushed Rock and Sand	3.4	3.4	3.4	3.3	3.2	3.1	3.2	3.4	3.5	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	73
5.2	**Crushed Rock and Sand (Mt) by Point of Use**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand Mt (2018-2036)
	Housing	1.4	1.4	1.3	1.2	1.2	1.2	1.2	1.2	1.3	1.4	1.5	1.5	1.6	1.6	1.6	1.7	1.7	1.8	1.8	28
	Non-Residential Buildings	0.8	0.9	0.9	0.8	0.7	0.7	0.8	0.8	0.9	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.1	1.2	1.2	18
	Road Construction & Maintenance	1.0	1.0	1.1	1.2	1.2	1.1	1.1	1.2	1.2	1.3	1.3	1.3	1.4	1.4	1.5	1.5	1.5	1.6	1.6	24
	Other Engineered Construction	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	3
	Total Point of Use	3.4	3.4	3.4	3.2	3.2	3.1	3.2	3.4	3.5	3.9	4.0	4.1	4.2	4.3	4.4	4.5	4.6	4.7	4.8	73
5.3	**Cementitious (Mt)**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**	**2034**	**2035**	**2036**	Cumulative Demand Mt (2018-2036)
	Cement	0.42	0.41	0.40	0.37	0.36	0.35	0.36	0.38	0.40	0.44	0.45	0.46	0.48	0.49	0.50	0.51	0.53	0.54	0.55	8.4
	Fly Ash	0.15	0.15	0.14	0.13	0.12	0.12	0.13	0.14	0.14	0.16	0.16	0.17	0.17	0.17	0.18	0.18	0.19	0.19	0.20	3.0
	Slag	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.7
	Total	0.61	0.59	0.57	0.53	0.51	0.50	0.52	0.55	0.57	0.63	0.65	0.67	0.68	0.70	0.72	0.74	0.75	0.77	0.79	12.0

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Notes to Demand Forecasts by Three Cities

1. Demand forecasts for extractive materials comprise crushed hard rock and natural sand, supplied by hard rock and natural sand quarries.
2. All hard rock quarries are located outside the GSR. Sand quarries are located within and outside the GSR.
3. Substitute construction materials available within the GSR that help satisfy demand are not included in the Three Cities forecasts.
4. In the GSR Study, the substitute construction materials are estimated to presently meet approximately 46% of total demand for aggregates and roadbase/ sub-base, across the GSR.
5. Whilst the substitute construction materials are mainly lower specification materials, predominantly used as roadbase/sub-base, it is a very high ratio when benchmarked against other capital cities.
6. The demand forecasts for extractive materials above assumes this ratio will prevail into the future - they are therefore baseline forecasts only, and will change under sensitivity analysis.
7. The proportion of demand met by substitute construction materials may decrease over the longer-term (e.g. in future periods of lower excavation/tunnelling activity in sandstone, when there is less tunnel spoil available to substitute for extractive materials such as sub-base).
8. The origin and source of supply of substitute construction materials varies depending on the location of building and civil construction projects that supply waste materials, and recycling/processing sites that receive C&D waste and produce recycled aggregates and roadbase/sub-base products for sale.
9. If substitute construction materials were to be included in the above Three Cities analysis, the demand profile for the Three Cities would be expected to differ - a city with a high local availability of substitute construction materials consumes less extractive materials - and vice versa.
10. This is important in planning for transport routes and logistics - but aside from recycling facilities and major projects underway like tunnels, supply origins and timing of supply of substitute construction materials are largely project-specific and future supply is difficult to predict for long term planning.
11. Notwithstanding the above uncertainties, the aggregates and other products supplied from hard rock and sand quarries are primarily used in higher quality applications such as concrete, asphalt, road surfacing and rail ballast, and which are not readily substituted by substitute construction materials.
12. The above forecast demand series for extractive materials (crushed rock and sand) by Three Cities is therefore considered a best estimate for extractive materials consumption within the GSR over the next 19-year period (to 2036), based on the information available from the Study.

13. Reliability and accuracy (whilst outside the scope of the GSR Study) could be further improved by:

- future procurement of GSR construction material forecast data (by Macromonitor or similar commercial provider of data) that are aligned by GSR (not ABS) planning districts; and
- further enquiry into the sources, products, quantities and distribution within GSR of substitute construction materials, to test whether the present 46% estimate of demand met by substitute construction materials across GSR applies equally across the Three Cities.

Appendix 5

GSR Supply and Demand Profile Questionnaires

- Hard Rock
- Sand
- Concrete
- Asphalt

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PTY. LIMITED ABN 31 002 033 712
GEOLOGICAL & ENVIRONMENTAL CONSULTANTS

Supply and Demand Profile of Geological Construction Materials for the Greater Sydney Region

Extractive Materials Questionnaire – Hard Rock

Form 1: **Location, Status, Operator, Planning Approval and Geology Data**

Form 2: **Supply Profile**

[Blue box] **Response already entered (from available information)**

[Yellow box] **Question requiring response**

[White box] **Questions that are not highlighted are not relevant to this Quarry**

Form 2 Drop-down Options

Q. 3.5.3		**Q. 3.8.2**	**Q 4.16.1**	**Q. 4.17.1**
North_Hornsby,	West_Windsor,	Mortar Sand	Road	Pacific Highway (A1/M1)-North
North_Northern Beaches,	West_Penrith,	Crusher Dust	Rail	Pacific Highway (A1/M1)-South
North_Ku-ring-gai,	West_Liverpool,	Bedding Media	Sea	Great Western Highway (A32)
Central,	West_Camden,			Hume Motorway (M31)
South_Canterbury/Bankstown,	Central River City_Parramatta,			Bells Line of Road (B59)
South_Sutherland,	Central River City_Blacktown			The Northern Road (A9)

Extractive Materials Source

Form 1: Location, Status, Operator, Planning Approval and Geology Data Entry

Quarry ID (FID)	0
Location / Suburb	
Quarry operator details	
Assessment of quarry activity: Active OR Inactive	
Current Quarry Name	
Planning Approval Status	
Approval/Consent Reference ID DA Number	
Expiry Date	
Lccal Government (LGA)	
GSR District OR Sub-Feeder Area	
Latitude	
Longitude	

GEOLOGY

Source Material	
Lithology Description	
Unit Symbol	
Unit Name	
Geological Map Source	
Notes	

Extractive Materials Source

Form 2: Supply Profile

Quarry ID (FID) 0

Location / Suburb

Quarry operator details

Current Quarry Name

PRODUCTION PROFILE: ESTABLISH FY 2018 SUPPLY-SIDE BASE LINE

3.1.1 What is the maximum approved annual production for the quarry (as nominated in your development consent or development application)? [tpa]

tpa

3.1.2 Is there a transport limit nominated in your development consent [Yes/No]

3.1.3 If yes, what is the limit? [tpa OR truckloads per day]

tpa OR truckloads per day

3.1.4 Days of the week transport is approved?

3.1.5 Any other restrictions?

3.2.1 What tonnage or proportion of your total output are unprocessed or low value extractive materials – e.g. overburden, select fill, etc.? [tpa OR % absolute value or range]

to tpa

to %

3.2.2 What tonnage or proportion of your unprocessed extractive materials is supplied into the GSR? [Mtpa OR % absolute value or range]

Mtpa %

3.3.1 Indicate the annual production range for the quarry (excluding unprocessed extractive materials) over the past 5 yrs (i.e. lower/upper) e.g. 0.8 to 1.8 Mtpa between FY 2012 and FY 2017. [tpa absolute value or range]

to tpa

3.4.1 What was the annual output or range in output for the quarry (excluding unprocessed extractive materials) for FY 2018? [tpa absolute value or range]

[ ] to [ ] tpa

3.5.1 What tonnage or proportion of the quarry's annual production (excluding unprocessed extractive materials) is supplied to sites within the GSR? [tpa or % absolute value or range]

(●) tpa [ ] to [ ]
( ) % [ ] to [ ]

3.5.3 Indicate which GSR sub-districts the extractive materials (excluding unprocessed extractive materials) are delivered into – rate GSR (sub-districts) in descending order of quantities delivered to each district.

1		2		3		4	
5		6		7		8	
9		10		11		12	

3.6.1 Do you produce a fine aggregate for concrete – i.e. crushed and/ or sized aggregate less than 5mm? [Yes/No] [ ]

3.6.2 If yes, what type of concrete fine aggregates does the quarry produce, e.g. fine, fine-medium, medium to coarse or fine to coarse? List estimated proportions for each four grading categories, as relevant. [% absolute value or range]

1. Proportion of fine [ ] to [ ] %
2. Proportion of fine-medium [ ] to [ ] %
3. Proportion of medium to coarse [ ] to [ ] %
4. Proportion of fine to coarse [ ] to [ ] %

3.6.3 What is the proportion of concrete fine aggregates [as a %] of the total processed extractive materials output? [% absolute value or range]

[ ] to [ ] %

3.7.1 Do you produce fine aggregates for asphalt? – i.e. crushed and/or sized aggregate less than 5mm? [Yes/No] [ ]

3.7.3 What is the proportion of asphalt fine aggregates of the total processed extractive materials output? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.8.1 Do you produce fine aggregates for 'other' purposes? – e.g. mortar sand, crusher dust, bedding media? [Yes/No] [ ]

3.8.2 What other fine aggregates do you produce? [ ]

3.8.3 What is the proportion of 'other' fine aggregates of the total processed extractive materials output? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.9.1 Do you produce coarse aggregates (either graded or single sized) for concrete production? (Size range 5mm to 30mm) [Yes/ No]

3.9.3 What is the proportion of coarse aggregates produced for concrete of the total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

3.10.1 Do you produce coarse aggregates for asphalt and/or road surfacing? (Size range 5mm to 30mm) [Yes/No]

3.10.3 What is the proportion of coarse aggregates produced for asphalt and road surfacing of the total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

3.11.1 Do you produce coarse aggregates for 'other' uses? e.g. drainage aggregates, filter media, decorative aggregates etc. (Size range 5mm to 30mm) [Yes/No]

3.11.3 What is the proportion of 'other' coarse aggregates of the total processed extractive materials aggregates supplied? [t OR %, absolute value or range]

to % OR to t

3.12.1 Do you produce aggregates for rail ballast? [Yes/No]

3.12.3 What is the proportion of rail ballast of total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

3.13.1 Do you produce roadbase (DGB) products? [Yes/No]

3.13.3 What is the proportion of DGB products of total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

3.14.1 Do you produce sub base products (DGS or similar specification)? [Yes/No]

3.14.3 What is the proportion of DGS or similar specification products, e.g. scalps or screened materials of total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

3.15.1 Do you produce broken / sized rock products (e.g. armour, gabion, riprap, crusher run, oversize, etc.)? (Size range > 30mm to boulders) [Yes/No]

3.15.3 What is the proportion of sized rock products of total processed extractive materials supplied? [t OR %, absolute value or range]

to % OR to t

DELIVERY RANGE, TRANSPORT MODE, LOAD SIZE, DESTINATION BY GSR SUB-DISTRICT

4.16.1 What mode(s) of transport is/are used to transport the extractive materials to customers/concrete/asphalt plants? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.17.1 Which feeder route [highway/motorway] and secondary road are used to deliver the extractive materials to customers/concrete/asphalt plants?

Main Feeder Route ______ Secondary Main Road ______

4.18.1 What is the typical range [in km] of delivery distances for your aggregates? (e.g. 80km to 130km max) ______ to ______ km

4.18.2 If by rail or sea, indicate the distance [in km] from origin to destination by that mode. ______ to ______ km

4.19.1 What hours are you able to transport extractive materials from your quarry? [Start Time/Finish Time]

On Weekdays	Start Time:		Finish Time:	
On Saturday	Start Time:		Finish Time:	
On Sunday	Start Time:		Finish Time:	

4.20.1 What is the maximum capacity vehicle type transporting extractive materials by road from your quarry? [tonnes]

______ Tonnes Vehicle Type ______

4.21.1 What is the average load size for the extractive materials transported by road from your quarry? [tonnes] ______ t

4.22.1 Are there any conditional limits (daily/hourly) upon truck movements from your quarry? [Yes/No]

4.22.2 What limits are in place?

4.23.1 Do you transport any extractive materials by rail? [Yes/No]

4.23.2 What is the full train load size? [tonnes per load]

4.23.3 What proportion of your processed extractive materials are delivered by rail? [% absolute value or range]

Aggregates ___ to ___ %

Other Products ___ to ___ %

4.24.1 What are the destination(s) within the GSR for railed quarry products (regional distribution centre or centres)?

4.25.1 What is the average weekly trip frequency (i.e. Annual trips divided by 52)? [Number]

4.25.2 What is the maximum weekly trip frequency? [Number]

4.26.1 Do you transport any extractive materials by ship? [Yes/No]

4.26.2 What is the full ship load size? [tonnes per load]

4.26.3 What proportion of your processed extractive materials are delivered by ship? [% absolute value or range]

Aggregates ___ to ___ %

Other Products ___ to ___ %

4.27.1 Which port(s) are the extractive materials delivered to?

4.27.2 What is the approximate sea distance for the ship journey? [km]

4.28.1 What is the average weekly trip frequency (i.e. Annual trips divided by 52)? [Number]

4.28.2 What is the maximum weekly trip frequency? [Number]

IMPORTS, RECYCLING

5.29.1 Do you import cementitious/lime products for on-site blending with extractive materials? [Yes/No]

5.29.2 What tonnages of imported cementitious/lime products are imported? [Tonnes absolute value or range] ___ to ___ Tonnes

5.30.1 Do you import any extractive materials for on-site blending with the quarry's extractive materials? [Yes/No]

5.30.2 What quantities of imported extractive materials are imported for blending purposes, etc.? [Tonnes absolute value or range] ____ to ____ Tonnes

5.31.1 Do you import recycled concrete waste (e.g. recycled aggregates, or concrete washout materials) for on-site blending with extractive materials? [Yes/No]

5.31.2 What is the proportion of imported concrete C and D waste and/or concrete washout materials or products produced on site? [% absolute value or range] ____ to ____ %

SUPPLY CONSTRAINTS

6.32.1 Please rank [from 1 (low) to 6 (high)] the extent to which geological issues currently adversely impact upon supply constraints

6.32.2 Please describe geological issues.

6.33.1 Please rank [from 1 (low) to 6 (high)] the extent to which statutory, regulatory, planning consent issues currently adversely impact upon supply constraints.

6.33.2 Please describe these issues.

6.34.1 Please rank [from 1 (low) to 6 (high)] the extent to which environmental issues currently adversely impact upon supply constraints.

6.34.2 Please describe environmental issues.

6.35.1 Please rank [from 1 (low) to 6 (high)] the extent to which transport issues currently adversely impact upon supply constraints.

6.35.2 Please describe transport issues

6.36.1 Please rank [from 1 (low) to 6 (high)] the extent to which other issues currently adversely impact upon supply constraints.

6.36.2 Please describe other issues.

GEOLOGICAL RESERVES - QUARRY LIFE

7.37.1 Are there published reserves (proven, approved and available to extract) for the quarry? [Yes/No]

7.37.2 If yes to above, indicate the quantity. [tonnes]

7.37.3 Date of published estimate.

7.38.1 If no published reserve estimate exists, do you have sufficient reserves (i.e. proven, approved and available) until 2036 (18 yrs)? [Yes/No/NA]

7.38.2 If no to above, what is the timeframe or year for cessation of the current quarry.

7.38.3 Is cessation year because of [depletion of resources or expiry of DA]?

7.39.1 Are there proven resources that are unapproved/ not able to be extracted in the DA timeframe, for the quarry? [Yes/No]

7.39.2 Indicate the quantity [in Mt or years - absolute value or range] of proven resources beyond the expiry of the DA – e.g. if future DAs to extend quarry life are approved.

◉ tonnes ____ to ____
○ Year ____ to ____

7.39.3 Are the unapproved resources recognised or protected under existing planning documents? [Yes/No]

7.40.1 Are there future unapproved extractive resources /potential reserves within the quarry site or adjoining lands owned by the quarry. [Yes/No]

7.40.2 If Yes, and if willing, indicate the size of potential resources/reserves [in Mt] or their possible life expectancy [in years].

____ to ____ Mt
____ to ____ Years

7.40.3 Provide an estimate of the proportion of unapproved [as a %] that may actually be recoverable. [% absolute value or range]

____ to ____ %

R.W. CORKERY & CO.
PTY. LIMITED ABN 31 002 033 712
GEOLOGICAL & ENVIRONMENTAL CONSULTANTS

Supply and Demand Profile of Geological Construction Materials for the Greater Sydney Region

Extractive Materials Questionnaire – Sand

Form 1: **Location, Status, Operator, Planning Approval and Geology Data**

Form 2: **Supply Profile**

Blue	**Response already entered (from available information)**
Yellow	**Question requiring response**
White	**Questions that are not highlighted are not relevant to this Quarry**

Form 2 Drop-down Options

Q. 3.5.3		**Q. 3.8.2**	**Q 4.16.1**	**Q. 4.17.1**
North_Hornsby, North_Northern Beaches, North_Ku-ring-gai, Central, South_Canterbury/Bankstown, South_Sutherland,	West_Windsor, West_Penrith, West_Liverpool, West_Camden, Central River City_Parramatta, Central River City_Blacktown	Mortar Sand Crusher Dust Bedding Media	Road Rail Sea	Pacific Highway (A1/M1)-North Pacific Highway (A1/M1)-South Great Western Highway (A32) Hume Motorway (M31) Bells Line of Road (B59) The Northern Road (A9)

Extractive Materials Source

Form 1: Location, Status, Operator, Planning Approval and Geology Data Entry

Quarry ID (FID)	0
Location / Suburb	
Quarry operator details	
Assessment of quarry activity: Active OR Inactive	
Current Quarry Name	
Planning Approval Status	
Approval/Consent Reference ID DA Number	
Expiry Date	
Lccal Government (LGA)	
GSR District OR Sub-Feeder Area	
Latitude	
Longitude	

GEOLOGY

Source Material	
Lithology Description	
Unit Symbol	
Unit Name	
Geological Map Source	
Notes	

Extractive Materials Source

Form 2: Supply Profile

Quarry ID (FID) 0

Location / Suburb

Quarry operator details

Current Quarry Name

PRODUCTION PROFILE: ESTABLISH FY 2018 SUPPLY-SIDE BASE LINE

3.1.1 What is the maximum approved annual production for the quarry (as nominated in your development consent or development application)? [tpa]

tpa

3.1.2 Is there a transport limit nominated in your development consent [Yes/No]

3.1.3 If yes, what is the limit? [tpa OR truckloads per day]

tpa OR truckloads per day

3.1.4 Days of the week transport is approved?

3.1.5 Any other restrictions?

3.2.1 What tonnage or proportion of your total output are unprocessed or low value extractive materials – e.g. overburden, select fill, etc.? [tpa OR % absolute value or range]

to tpa

to %

3.2.2 What tonnage or proportion of your unprocessed extractive materials is supplied into the GSR? [Mtpa OR % absolute value or range]

Mtpa %

3.3.1 Indicate the annual production range for the quarry (excluding unprocessed extractive materials) over the past 5 yrs (i.e. lower/upper) e.g. 0.8 to 1.8 Mtpa between FY 2012 and FY 2017. [tpa absolute value or range]

to tpa

3.4.1 What was the annual output or range in output for the quarry (excluding unprocessed extractive materials) for FY 2018? [tpa absolute value or range]

___ to ___ tpa

3.5.1 What tonnage or proportion of the quarry's annual production (excluding unprocessed extractive materials) is supplied to sites within the GSR? [tpa or % absolute value or range]

- (•) tpa ___ to ___
- ( ) % ___ to ___

3.5.3 Indicate which GSR sub-districts the extractive materials (excluding unprocessed extractive materials) are delivered into – rate GSR (sub-districts) in descending order of quantities delivered to each district.

1	2	3	4
5	6	7	8
9	10	11	12

3.6.1 Do you produce a fine aggregate for concrete – i.e. crushed and/ or sized aggregate less than 5mm? [Yes/No]

3.6.2 If yes, what type of concrete fine aggregates does the quarry produce, e.g. fine, fine-medium, medium to coarse or fine to coarse? List estimated proportions for each four grading categories, as relevant. [% absolute value or range]

1. Proportion of fine ___ to ___ %
2. Proportion of fine-medium ___ to ___ %
3. Proportion of medium to coarse ___ to ___ %
4. Proportion of fine to coarse ___ to ___ %

3.6.3 What is the proportion of concrete fine aggregates [as a %] of the total processed extractive materials output? [% absolute value or range]

___ to ___ %

3.7.1 Do you produce fine aggregates for asphalt? – i.e. crushed and/or sized aggregate less than 5mm? [Yes/No]

3.7.3 What is the proportion of asphalt fine aggregates of the total processed extractive materials output? [t OR %, absolute value or range]

___ to ___ % OR ___ to ___ t

3.8.1 Do you produce fine aggregates for 'other' purposes? – e.g. mortar sand, crusher dust, bedding media? [Yes/No]

3.8.2 What other fine aggregates do you produce?

3.8.3 What is the proportion of 'other' fine aggregates of the total processed extractive materials output? [t OR %, absolute value or range]

___ to ___ % OR ___ to ___ t

3.9.1 Do you produce coarse aggregates (either graded or single sized) for concrete production? (Size range 5mm to 30mm) [Yes/ No] [ ]

3.9.3 What is the proportion of coarse aggregates produced for concrete of the total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.10.1 Do you produce coarse aggregates for asphalt and/or road surfacing? (Size range 5mm to 30mm) [Yes/No] [ ]

3.10.3 What is the proportion of coarse aggregates produced for asphalt and road surfacing of the total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.11.1 Do you produce coarse aggregates for 'other' uses? e.g. drainage aggregates, filter media, decorative aggregates etc. (Size range 5mm to 30mm) [Yes/No] [ ]

3.11.3 What is the proportion of 'other' coarse aggregates of the total processed extractive materials aggregates supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.12.1 Do you produce aggregates for rail ballast? [Yes/No] [ ]

3.12.3 What is the proportion of rail ballast of total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.13.1 Do you produce roadbase (DGB) products? [Yes/No] [ ]

3.13.3 What is the proportion of DGB products of total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.14.1 Do you produce sub base products (DGS or similar specification)? [Yes/No] [ ]

3.14.3 What is the proportion of DGS or similar specification products, e.g. scalps or screened materials of total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

3.15.1 Do you produce broken / sized rock products (e.g. armour, gabion, riprap, crusher run, oversize, etc.)? (Size range > 30mm to boulders) [Yes/No] [ ]

3.15.3 What is the proportion of sized rock products of total processed extractive materials supplied? [t OR %, absolute value or range]

[ ] to [ ] % OR [ ] to [ ] t

DELIVERY RANGE, TRANSPORT MODE, LOAD SIZE, DESTINATION BY GSR SUB-DISTRICT

4.16.1 What mode(s) of transport is/are used to transport the extractive materials to customers/concrete/asphalt plants? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.17.1 Which feeder route [highway/motorway] and secondary road are used to deliver the extractive materials to customers/concrete/asphalt plants?

Main Feeder Route ______ Secondary Main Road ______

4.18.1 What is the typical range [in km] of delivery distances for your aggregates? (e.g. 80km to 130km max) ______ to ______ km

4.18.2 If by rail or sea, indicate the distance [in km] from origin to destination by that mode. ______ to ______ km

4.19.1 What hours are you able to transport extractive materials from your quarry? [Start Time/Finish Time]

On Weekdays	Start Time:		Finish Time:	
On Saturday	Start Time:		Finish Time:	
On Sunday	Start Time:		Finish Time:	

4.20.1 What is the maximum capacity vehicle type transporting extractive materials by road from your quarry? [tonnes]

______ Tonnes Vehicle Type ______

4.21.1 What is the average load size for the extractive materials transported by road from your quarry? [tonnes] ______ t

4.22.1 Are there any conditional limits (daily/hourly) upon truck movements from your quarry? [Yes/No]

4.22.2 What limits are in place?

4.23.1 Do you transport any extractive materials by rail? [Yes/No]

4.23.2 What is the full train load size? [tonnes per load]

4.23.3 What proportion of your processed extractive materials are delivered by rail? [% absolute value or range]

Aggregates ____ to ____ %
Other Products ____ to ____ %

4.24.1 What are the destination(s) within the GSR for railed quarry products (regional distribution centre or centres)?

4.25.1 What is the average weekly trip frequency (i.e. Annual trips divided by 52)? [Number]

4.25.2 What is the maximum weekly trip frequency? [Number]

4.26.1 Do you transport any extractive materials by ship? [Yes/No]

4.26.2 What is the full ship load size? [tonnes per load]

4.26.3 What proportion of your processed extractive materials are delivered by ship? [% absolute value or range]

Aggregates ____ to ____ %
Other Products ____ to ____ %

4.27.1 Which port(s) are the extractive materials delivered to?

4.27.2 What is the approximate sea distance for the ship journey? [km]

4.28.1 What is the average weekly trip frequency (i.e. Annual trips divided by 52)? [Number]

4.28.2 What is the maximum weekly trip frequency? [Number]

IMPORTS, RECYCLING

5.29.1 Do you import cementitious/lime products for on-site blending with extractive materials? [Yes/No]

5.29.2 What tonnages of imported cementitious/lime products are imported? [Tonnes absolute value or range] ____ to ____ Tonnes

5.30.1 Do you import any extractive materials for on-site blending with the quarry's extractive materials? [Yes/No]

5.30.2 What quantities of imported extractive materials are imported for blending purposes, etc.? [Tonnes absolute value or range] ____ to ____ Tonnes

5.31.1 Do you import recycled concrete waste (e.g. recycled aggregates, or concrete washout materials) for on-site blending with extractive materials? [Yes/No]

5.31.2 What is the proportion of imported concrete C and D waste and/or concrete washout materials or products produced on site? [% absolute value or range] ____ to ____ %

SUPPLY CONSTRAINTS

6.32.1 Please rank [from 1 (low) to 6 (high)] the extent to which geological issues currently adversely impact upon supply constraints

6.32.2 Please describe geological issues.

6.33.1 Please rank [from 1 (low) to 6 (high)] the extent to which statutory, regulatory, planning consent issues currently adversely impact upon supply constraints.

6.33.2 Please describe these issues.

6.34.1 Please rank [from 1 (low) to 6 (high)] the extent to which environmental issues currently adversely impact upon supply constraints.

6.34.2 Please describe environmental issues.

6.35.1 Please rank [from 1 (low) to 6 (high)] the extent to which transport issues currently adversely impact upon supply constraints.

6.35.2 Please describe transport issues

6.36.1 Please rank [from 1 (low) to 6 (high)] the extent to which other issues currently adversely impact upon supply constraints.

6.36.2 Please describe other issues.

GEOLOGICAL RESERVES - QUARRY LIFE

7.37.1 Are there published reserves (proven, approved and available to extract) for the quarry? [Yes/No]

7.37.2 If yes to above, indicate the quantity. [tonnes]

7.37.3 Date of published estimate.

7.38.1 If no published reserve estimate exists, do you have sufficient reserves (i.e. proven, approved and available) until 2036 (18 yrs)? [Yes/No/NA]

7.38.2 If no to above, what is the timeframe or year for cessation of the current quarry.

7.38.3 Is cessation year because of [depletion of resources or expiry of DA]?

7.39.1 Are there proven resources that are unapproved/ not able to be extracted in the DA timeframe, for the quarry? [Yes/No]

7.39.2 Indicate the quantity [in Mt or years - absolute value or range] of proven resources beyond the expiry of the DA – e.g. if future DAs to extend quarry life are approved.

(●) tonnes ______ to ______

( ) Year ______ to ______

7.39.3 Are the unapproved resources recognised or protected under existing planning documents? [Yes/No]

7.40.1 Are there future unapproved extractive resources /potential reserves within the quarry site or adjoining lands owned by the quarry. [Yes/No]

7.40.2 If Yes, and if willing, indicate the size of potential resources/reserves [in Mt] or their possible life expectancy [in years].

______ to ______ Mt

______ to ______ Years

7.40.3 Provide an estimate of the proportion of unapproved [as a %] that may actually be recoverable. [% absolute value or range]

______ to ______ %

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GEOLOGICAL & ENVIRONMENTAL CONSULTANTS

Supply and Demand Profile Study for the Greater Sydney Region

Concrete Batching Plant Questionnaire

Form 3: **Plant type, Location, Status, Operator and Planning Approval**

Form 4: **Supply Profile**

(blue)	**Response already entered (from available information)**
(yellow)	**Question requiring response**
(white)	**Questions that are not highlighted are not relevant to this Plant**

Form 4 Drop-down Options

Q 4.14.1 & 4.16.1	**Q. 4.14.2 & 4.16.2**
Road Rail Sea	Pacific Highway (A1/M1)-North Pacific Highway (A1/M1)-South Great Western Highway (A32) Hume Motorway (M31) Bells Line of Road (B59) The Northern Road (A9)

Concrete/Asphalt Plant

Form 3: Plant Type, Location, Status, Operator and Planning Approval

Plant ID (FID)	
Plant Type	
Address	
Operator	
Current Operating Status	
Planning Approval Status	
Expiry Date	
Local Government Area (LGA)	
GSR Sub-District	
Latitude	
Longitude	

Approved Operating Hours   Start ____   Finish ____

Concrete Batching Plant Questionnaire   Page 1 of 6

Concrete / Asphalt Plant

Form 4: Supply Profile

Plant ID (FID)	
Plant Type	
Location / Suburb	
Operator	

PRODUCTION OUTPUT

1.1.1 What type of material (concrete or asphalt) is produced at your plant?

2.1.1 If concrete, what type of concrete is produced at your plant? Pre-mixed or Pre-cast?

2.1.2 If Pre-cast, whether panels or building products. [Panels, Masonry, Tiles]

2.2.1 If concrete produced, whether by dry or wet batching plant. [Dry / Wet]

2.3.1 What is the range of annual concrete/asphalt production at your plant? [cubic metre (concrete), Tonnes (asphalt) absolute value or range]

Concrete ____ to ____ cubic metre

Asphalt ____ to ____ Tonnes

2.4.1 What is the maximum output of concrete/asphalt per hour at your plant? [cubic metre (concrete), Tonnes (asphalt) absolute value or range]

Concrete ____ to ____ cubic metre

Asphalt ____ to ____ Tonnes

RAW MATERIALS

3.5.1 Is fine natural sand used as a fine aggregate at the plant? [Yes/No]

3.6.1 Is medium-coarse natural sand used as a fine aggregate at the plant? [Yes/No]

3.7.1 Is manufactured sand used as a fine aggregate at the plant? [Yes/No]

3.7.2 If yes to manufactured sand, what proportion does manufactured sand represent of the total fine aggregates used? [% absolute value or range]

____ to ____ %

3.8.1 Are recycled aggregates (from concrete or asphalt) used at the plant? [Yes/No]

3.8.2 If yes, what proportion are recycled aggregates compared with the total quantity of aggregates used (fine and coarse aggregates)? [% absolute value or range]

to %

3.9.1 Are recycled coarse aggregates from 'other' wastes used as a coarse aggregate at the plant, e.g. Steel slag? [Yes/No]

3.9.2 If yes to above, what proportion are the 'other' coarse compared with the total quantity aggregates used? [% absolute value or range]

to %

3.10.1 Is concrete grade flyash used as a supplementary cementitious material (SCM) at the concrete plant? [Yes/No]

3.10.2 What is the proportion of concrete grade flyash used, compared with the total cementitious products used? [% absolute value or range]

to %

3.10.3 What is the proportion of flyash used in bulk (not as general blend)? [% absolute value or range]

to %

3.11.1 Is ground granulated blast furnace slag (GGBFS or similar) used as an SCM at the concrete plant? [Yes/No]

3.11.2 What is the proportion of GGBFS or similar products used, compared with the total cementitious products used? [% absolute value or range]

to %

3.12.1 Do you use any 'other' SCMs? [Yes/No]

3.12.2 What is the proportion of 'other' SCMs used, compared with the total cementitious products used? [% absolute value or range]

to %

3.12.3 List the 'other' SCMs

RAW MATERIALS TRANSPORT

4.13.1 What mode(s) of transport are used for the delivery of the hydrocarbons for asphalt? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.13.2 If road, which feeder route (highway/motorway) and secondary road are used for the delivery of the hydrocarbons for asphalt?

Main Feeder Route ______ Secondary Main Roads ______

4.14.1 Which transport mode(s) are used for the delivery of cement/supplementary cementitious materials to the plant? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.14.2 If road, which feeder route (highway/motorway) and secondary road are used for the delivery of the cement/supplementary cementitious materials?

Main Feeder Route ______ Secondary Main Roads ______

4.15.1 Do you receive raw materials from a Regional Distribution Centre (RDC) in the GSR? [Yes/No] ______

4.15.2 What is the location of the RDC from where your raw materials are despatched?

______

4.15.3 How many days of stock can the RDC hold? [Days] Cement ______ Days Aggregates ______ Days

4.16.1 Which transport mode(s) are used for the delivery of fine and coarse aggregates to the plant? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.16.2 If road, which feeder route [highway/motorway] and secondary main road are used for the delivery of the fine and coarse aggregates?

Main Feeder Route ______ Secondary Main Road ______

4.17.1 What is the maximum truck capacity and vehicle type able to deliver aggregates to the plant? [Tonnes]

maximum capacity (Tonnes) ______ Vehicle type ______

DELIVERY RANGE, TRANSPORT MODE, LOAD SIZE, DESTINATIONS

5.18.1 What is the typical delivery range (distance in km) for concrete/asphalt from the plant? [km absolute value or range]

[ ] to [ ] km

5.18.2 What is the typical delivery range (in hours) for the delivery of concrete/asphalt from your plant? [hours absolute value or range]

[ ] to [ ] Hours

5.19.1 What is the maximum load size for concrete/asphalt delivery from your plant? [cubic metres / tonnes absolute value or range]

Concrete [ ] cubic metres

Asphalt [ ] Tonnes

5.20.1 What is the average load size for concrete/asphalt delivery from your plant? [cubic metres / tonnes absolute value or range]

Concrete [ ] cubic metres

Asphalt [ ] Tonnes

SUPPLY CONSTRAINTS

6.21.1 Please rank (from 1 (low) to 6 (high)) the extent to which sourcing raw materials is adversely impacting on supply capability. [ ]

6.21.2 Please describe sourcing raw materials issues. [ ]

6.22.1 Please rank (from 1 (low) to 6 (high)) the extent to which on-site raw material stock holding capacity is adversely impacting on supply capability. [ ]

6.22.2 Please describe on-site raw material stock holding capacity issues. [ ]

6.23.1 Please rank (from 1 (low) to 6 (high)) the extent to which statutory, regulatory/planning consent constraints are adversely impacting on supply capability.

6.23.2 Please describe these issues.

6.24.1 Please rank (from 1 (low) to 6 (high)) the extent to which other constraints are adversely impacting on supply capability.

6.25.1 Please describe other issues.

THANK YOU VERY MUCH!

R.W. CORKERY & CO.
PTY. LIMITED ABN 31 002 033 712
GEOLOGICAL & ENVIRONMENTAL CONSULTANTS

Supply and Demand Profile Study for the Greater Sydney Region

Asphalt Plant Questionnaire

Form 3: **Plant type, Location, Status, Operator and Planning Approval**

Form 4: **Supply Profile**

(blue box)	**Response already entered (from available information)**
(yellow box)	**Question requiring response**
(white box)	**Questions that are not highlighted are not relevant to this Plant**

Form 4 Drop-down Options

Q 4.13.1 & 4.16.1 Road Rail Sea	**Q. 4.13.2 & 4.16.2** Pacific Highway (A1/M1)-North Pacific Highway (A1/M1)-South Great Western Highway (A32) Hume Motorway (M31) Bells Line of Road (B59) The Northern Road (A9)

Concrete/Asphalt Plant

Form 3: Plant Type, Location, Status, Operator and Planning Approval

Plant ID (FID)	
Plant Type	
Address	
Operator	
Current Operating Status	
Planning Approval Status	
Expiry Date	
Local Government Area (LGA)	
GSR Sub-District	
Latitude	
Longitude	
Approved Operating Hours	Start ______ Finish ______

Concrete / Asphalt Plant

Form 4: Supply Profile

Plant ID (FID)

Plant Type

Location / Suburb

Operator

PRODUCTION OUTPUT

1.1.1 What type of material (concrete or asphalt) is produced at your plant?

2.1.1 If concrete, what type of concrete is produced at your plant? Pre-mixed or Pre-cast?

2.1.2 If Pre-cast, whether panels or building products. [Panels, Masonry, Tiles]

2.2.1 If concrete produced, whether by dry or wet batching plant. [Dry / Wet]

2.3.1 What is the range of annual concrete/asphalt production at your plant? [cubic metre (concrete), Tonnes (asphalt) absolute value or range]

Concrete ____ to ____ cubic metre

Asphalt ____ to ____ Tonnes

2.4.1 What is the maximum output of concrete/asphalt per hour at your plant? [cubic metre (concrete), Tonnes (asphalt) absolute value or range]

Concrete ____ to ____ cubic metre

Asphalt ____ to ____ Tonnes

RAW MATERIALS

3.5.1 Is fine natural sand used as a fine aggregate at the plant? [Yes/No]

3.6.1 Is medium-coarse natural sand used as a fine aggregate at the plant? [Yes/No]

3.7.1 Is manufactured sand used as a fine aggregate at the plant? [Yes/No]

3.7.2 If yes to manufactured sand, what proportion does manufactured sand represent of the total fine aggregates used? [% absolute value or range]

____ to ____ %

3.8.1 Are recycled aggregates (from concrete or asphalt) used at the plant? [Yes/No]

3.8.2 If yes, what proportion are recycled aggregates compared with the total quantity of aggregates used (fine and coarse aggregates)? [% absolute value or range]

to %

3.9.1 Are recycled coarse aggregates from 'other' wastes used as a coarse aggregate at the plant, e.g. Steel slag? [Yes/No]

3.9.2 If yes to above, what proportion are the 'other' coarse compared with the total quantity aggregates used? [% absolute value or range]

to %

3.10.1 Is concrete grade flyash used as a supplementary cementitious material (SCM) at the concrete plant? [Yes/No]

3.10.2 What is the proportion of concrete grade flyash used, compared with the total cementitious products used? [% absolute value or range]

to %

3.10.3 What is the proportion of flyash used in bulk (not as general blend)? [% absolute value or range]

to %

3.11.1 Is ground granulated blast furnace slag (GGBFS or similar) used as an SCM at the concrete plant? [Yes/No]

3.11.2 What is the proportion of GGBFS or similar products used, compared with the total cementitious products used? [% absolute value or range]

to %

3.12.1 Do you use any 'other' SCMs? [Yes/No]

3.12.2 What is the proportion of 'other' SCMs used, compared with the total cementitious products used? [% absolute value or range]

to %

3.12.3 List the 'other' SCMs

RAW MATERIALS TRANSPORT

4.13.1 What mode(s) of transport are used for the delivery of the hydrocarbons for asphalt? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.13.2 If road, which feeder route (highway/motorway) and secondary road are used for the delivery of the hydrocarbons for asphalt?

Main Feeder Route ______ Secondary Main Roads ______

4.14.1 Which transport mode(s) are used for the delivery of cement/supplementary cementitious materials to the plant? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.14.2 If road, which feeder route (highway/motorway) and secondary road are used for the delivery of the cement/supplementary cementitious materials?

Main Feeder Route ______ Secondary Main Roads ______

4.15.1 Do you receive raw materials from a Regional Distribution Centre (RDC) in the GSR? [Yes/No] ______

4.15.2 What is the location of the RDC from where your raw materials are despatched?

______

4.15.3 How many days of stock can the RDC hold? [Days] Cement ______ Days Aggregates ______ Days

4.16.1 Which transport mode(s) are used for the delivery of fine and coarse aggregates to the plant? [Road/Rail/Sea]

Transport Mode 1 ______ Transport Mode 2 ______

4.16.2 If road, which feeder route [highway/motorway] and secondary main road are used for the delivery of the fine and coarse aggregates?

Main Feeder Route ______ Secondary Main Road ______

4.17.1 What is the maximum truck capacity and vehicle type able to deliver aggregates to the plant? [Tonnes]

maximum capacity (Tonnes) ______ Vehicle type ______

DELIVERY RANGE, TRANSPORT MODE, LOAD SIZE, DESTINATIONS

5.18.1 What is the typical delivery range (distance in km) for concrete/asphalt from the plant? [km absolute value or range]

____ to ____ km

5.18.2 What is the typical delivery range (in hours) for the delivery of concrete/asphalt from your plant? [hours absolute value or range]

____ to ____ Hours

5.19.1 What is the maximum load size for concrete/asphalt delivery from your plant? [cubic metres / tonnes absolute value or range]

Concrete ____ cubic metres

Asphalt ____ Tonnes

5.20.1 What is the average load size for concrete/asphalt delivery from your plant? [cubic metres / tonnes absolute value or range]

Concrete ____ cubic metres

Asphalt ____ Tonnes

SUPPLY CONSTRAINTS

6.21.1 Please rank (from 1 (low) to 6 (high)) the extent to which sourcing raw materials is adversely impacting on supply capability. ____

6.21.2 Please describe sourcing raw materials issues. ____

6.22.1 Please rank (from 1 (low) to 6 (high)) the extent to which on-site raw material stock holding capacity is adversely impacting on supply capability. ____

6.22.2 Please describe on-site raw material stock holding capacity issues. ____

6.23.1 Please rank (from 1 (low) to 6 (high)) the extent to which statutory, regulatory/planning consent constraints are adversely impacting on supply capability.

6.23.2 Please describe these issues.

6.24.1 Please rank (from 1 (low) to 6 (high)) the extent to which other constraints are adversely impacting on supply capability.

6.25.1 Please describe other issues.

THANK YOU VERY MUCH!