Department of Planning

GOVERNMENT OF WESTERN AUSTRALIA

Western Australian Planning Commission

August 2012

Basic Raw Materials

Demand and Supply Study for the Bunbury–Busselton Region

Published by the
Western Australian Planning Commission
Gordon Stephenson House
140 William Street
Perth WA 6000

Locked Bag 2506
Perth WA 6001

Published August 2012

website: www.planning.wa.gov.au
email: corporate@planning.wa.gov.au

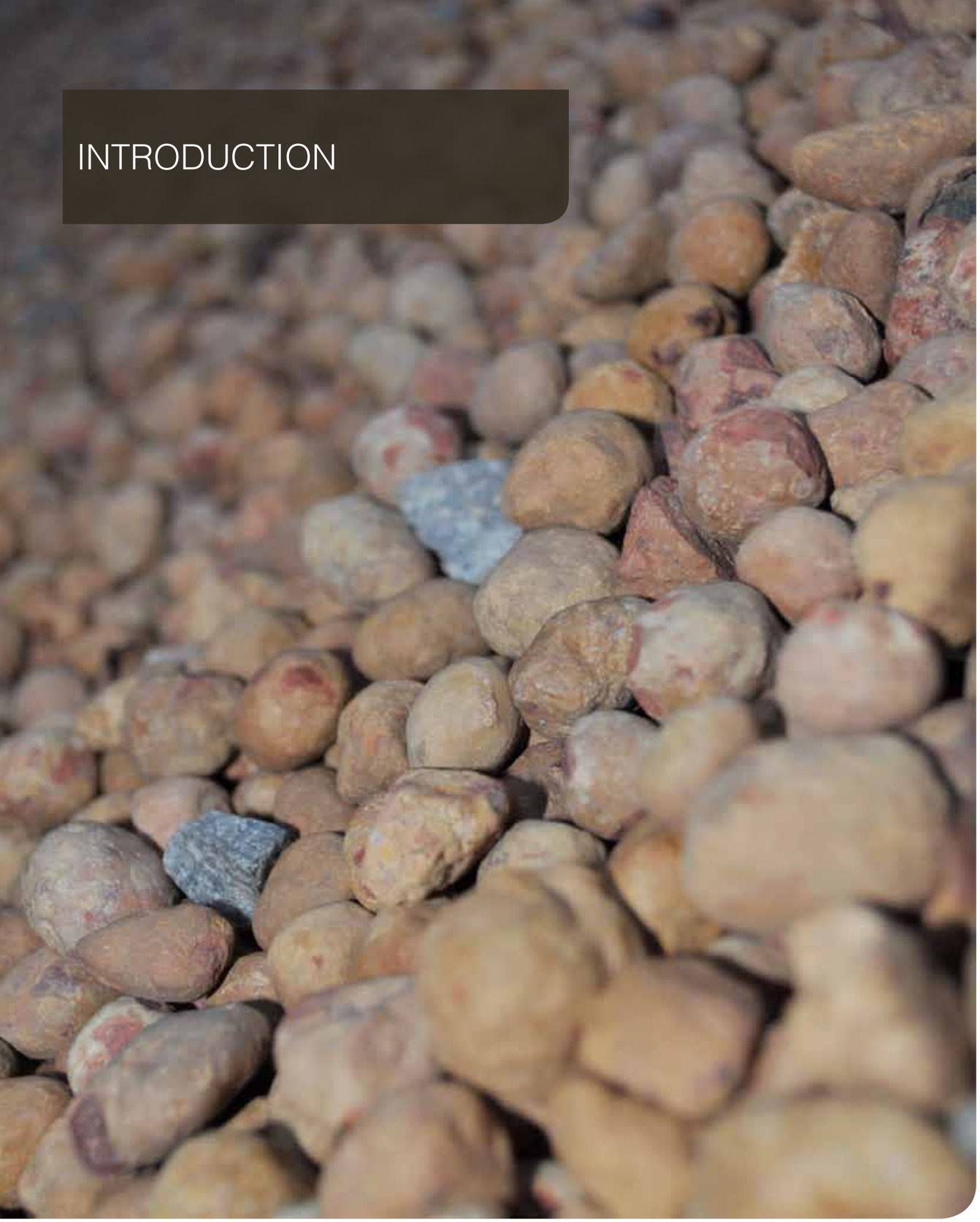
tel: 08 6551 9000
fax: 08 6551 9001
National Relay Service: 13 36 77
infoline: 1800 626 477

The photographs on pages 2, 6 and 15 are courtesy of Colin York

LIST OF MAPS AND TABLES

Basic Raw Materials

Demand and Supply Study for the Bunbury–Busselton Region



INTRODUCTION

INTRODUCTION

Purpose

This document has been prepared to determine the adequacy of current and future supplies of Basic Raw Materials (BRM) to meet the future demand requirements in the Bunbury–Busselton area, including the shires of Harvey, Dardanup, Bunbury, Capel and Busselton.

It fits within the statutory planning framework through the following statutory plans and policies. The study will contribute to the Greater Bunbury Region Scheme and relevant structure plans. It will contribute to the review of *SPP 2.4 — Basic Raw Materials* and *SPP 4.1 — State Industrial Buffer Policy*, and be listed in *SPP1 — State Planning Framework Policy*, when updated. Most importantly it will generate science-based supporting mapping which will be appropriate to both this study and the review of SPP 2.4.

Project area, terms of reference and methodology

This study focuses on the Bunbury–Busselton area, one of the fastest growing residential development areas in Australia. The study area is bounded by the local government areas shown in Map a.

The demand and supply methodology applied to the study is shown at Appendix A.

Definition and use of BRM

An estimated 90% of all extracted BRM is used in residential and commercial development. The supply of BRM differs from conventional mining in a number of ways. Legislatively, BRM extraction does not come under the definition of “Mining Operations” as they are not covered by the *Mining Act 1978*. As such they are subject to planning controls under the *Planning and Development Act 2005*. The mining of minerals under Section 120 of the *Mining Act 1978* provides exemption for activities related to a mine site and does not require development approval under a planning scheme. They are also different to typically high value mining products as BRM are high volume/ low value materials. BRM products are not exported and they are generally consumed by the communities that produce them. A continual local supply of BRM is essential to sustain community development.

For the purpose of this study, BRM are defined as sand, limestone, hard rock gravel and clay. Both gravel and limestone are the subjects of separate studies - the State Gravel Supply Study being undertaken by Main Roads WA and the State Lime Strategy being prepared by the Department of Mines and Petroleum (DMP). It is not the intention of this study to duplicate work of the State’s gravel and limestone strategies however, where appropriate, comments have been made on limestone and gravel.

Map a Study area by local government boundaries

Each type of BRM has several sub-categories dependent on its end use.

Sand categories

Sand categories include:

- land fill; and
- construction pad sand.

Concrete categories

Concrete sands are suitable for use in:

- concrete batching plants; and
- building sands suitable for use in mortar and plaster.

Sand quarry

Silica and mineral sands are higher-value commodities that are not usually classed as BRM.

Limestone categories

Limestone categories include:

- Low-grade limestone used for road base and compacted building blocks; and
- High-grade product used in cement, cut blocks and agricultural lime production.

Hard rock categories

Hard rock is classed by the crushing and screening process for use as aggregate in concrete asphalt and road surfacing materials. Categories are either "A" or "B" grade with "B" often being a by-product of the production of "A" grade material.

Clay categories

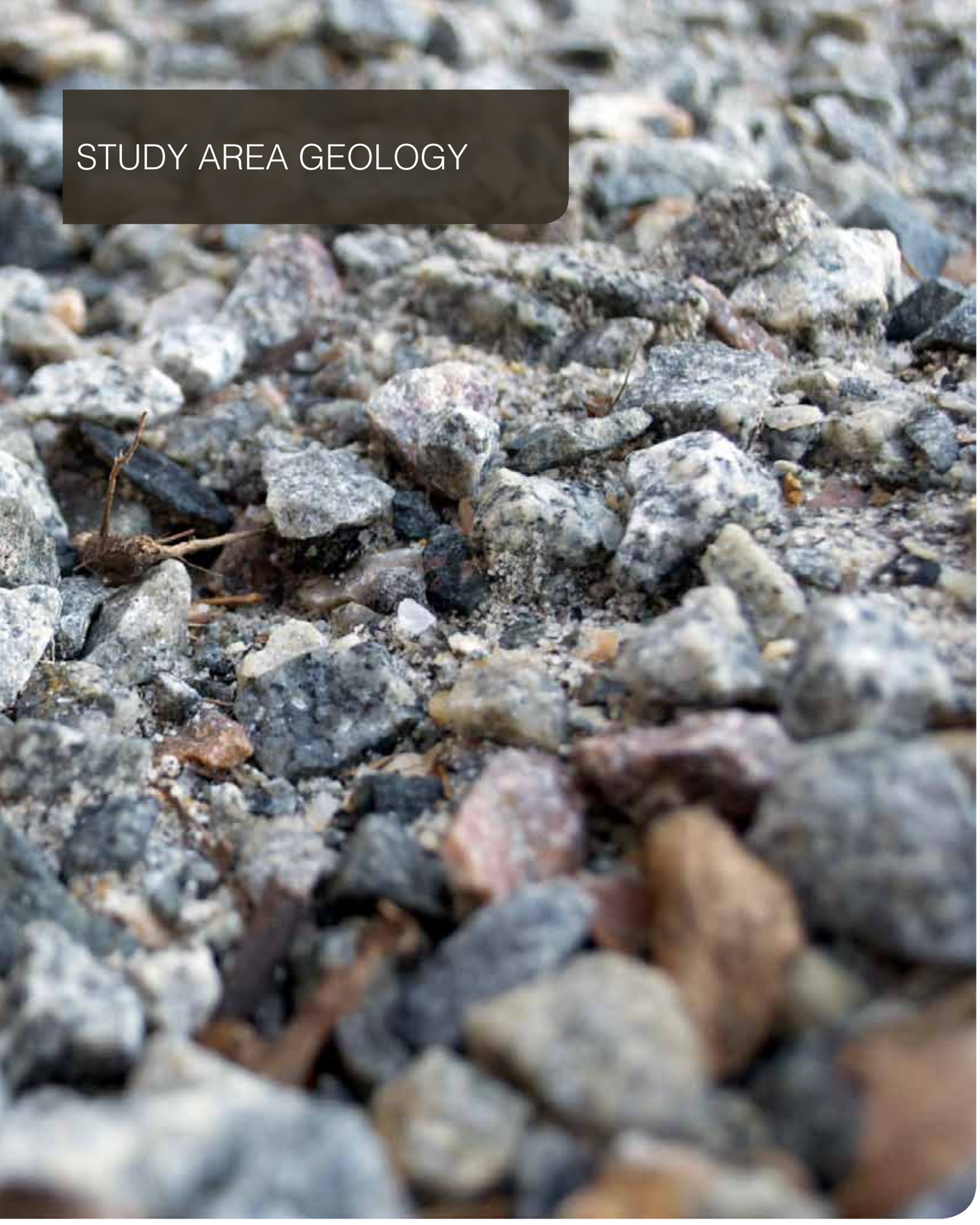
Clay types have different colours, placticity and other characteristics. Clays are often blended dependant on their end use and in many cases a number of clays from different sites go into a finished product.

The BRM approval process

The current approvals process for extracting BRM is not straight forward, and in some cases requires a dual approvals process. In simple terms the DMP is responsible for extractive industry approvals on Crown land, while local government authorities provide approvals on freehold land. Approval could also be required under the provisions of the Greater Bunbury Region Scheme (GBRS) in both instances. The State Planning Policy 2.4 — *Basic Raw Materials* (2000) provides the guiding principles for BRM policy and a mechanism to protect priority resources for future use. This policy is currently under review. Additionally there is the requirement to comply with federal and state environmental legislation and obtain clearing permits as part of the approvals process.

The WAPC's *Basic Raw Materials Applicants Manual* (2009) provides a step-by-step guide for establishing extractive industries in Western Australia.

There is currently no state-wide register of extractive industry sites or production reporting mechanism to assist in management of the BRM industry or resources.



STUDY AREA GEOLOGY

STUDY AREA GEOLOGY

The southern Swan Coastal Plain and its environs can be broadly divided into three areas:

- On the eastern side, igneous and metamorphic rocks of the Yilgarn Craton that are more than 2,500 million years old form the Darling Plateau.
- The Darling Fault separates the Yilgarn Craton from the much younger (425 to 65 million year old) sedimentary rocks of the Perth Basin, which underlies the Swan Coastal Plain and Blackwood Plateau.
- Further to the west, the Leeuwin-Naturaliste region is underlain by igneous and metamorphic rocks belonging to the Leeuwin Complex, which is between 1,100 and 650 million years old.

Most BRM (except for rock) are derived from unconsolidated or partly consolidated materials that overlie rocks of the Yilgarn Craton, Perth Basin and Leeuwin Complex. Many of these surficial deposits were formed during the past two million years of earth history. They comprise unconsolidated sands, gravels, silts and clays, but also include cemented materials such as limestone. They are mostly of marine, estuarine and aeolian (wind-blown) origin and formed during erosional and depositional events related to periods of higher and lower sea levels.

Sand is mainly derived from the Yoganup Formation, Bassendean Sand, and the informally named “Tamala Sand”.

Yellow sands of the Yoganup Formation are found discontinuously along the foot of the Darling Scarp. The yellow colour is caused by an iron oxide coating on the surface of the sand grains. These sands are thought to have formed between 750,000 to 190,000 years ago as beach deposits when the coastline lapped the base of the Darling Scarp.

The Bassendean Sand that is accessible for extraction consists of a series of shoreline deposits and coastal dunes that occur midway between the present day ocean and the Darling Scarp in low hills of the Bassendean Dune system. These dunes were formed during several dune-building events that took place approximately 100,000 years in a warmer, interglacial period that began about 240,000 years ago.

Maidens, Bunbury

Some of these sands have very high silica content and meet the high specifications required for glass manufacture. While cream to off-white at the surface, the Bassendean Sand is typically yellow at depth. Bassendean Sand provides most of the concrete sand and much of the fill sand for the metropolitan area.

The Tamala Sand overlies, and is derived from weathering of the Tamala Limestone. The Tamala Limestone occurs as a series of prominent cemented sandy calcareous dunes that were formed more than 10,000 years ago, but are younger than the Bassendean dunes. This limestone forms prominent ridges parallel to the coast. Between Mandurah and Bunbury, the limestone has been divided into two distinct formations — Tims Thicket Limestone, and the Kooallup Limestone. Several thousand years of weathering has leached the shell fragments and calcareous cement from some of the limestone to form the Tamala Sand. The Tamala Sand is white or grey at the surface, then becomes yellow to orange at depth. It has a higher clay and silt content than the Bassendean Sand, which makes it suitable for building and fill sand.

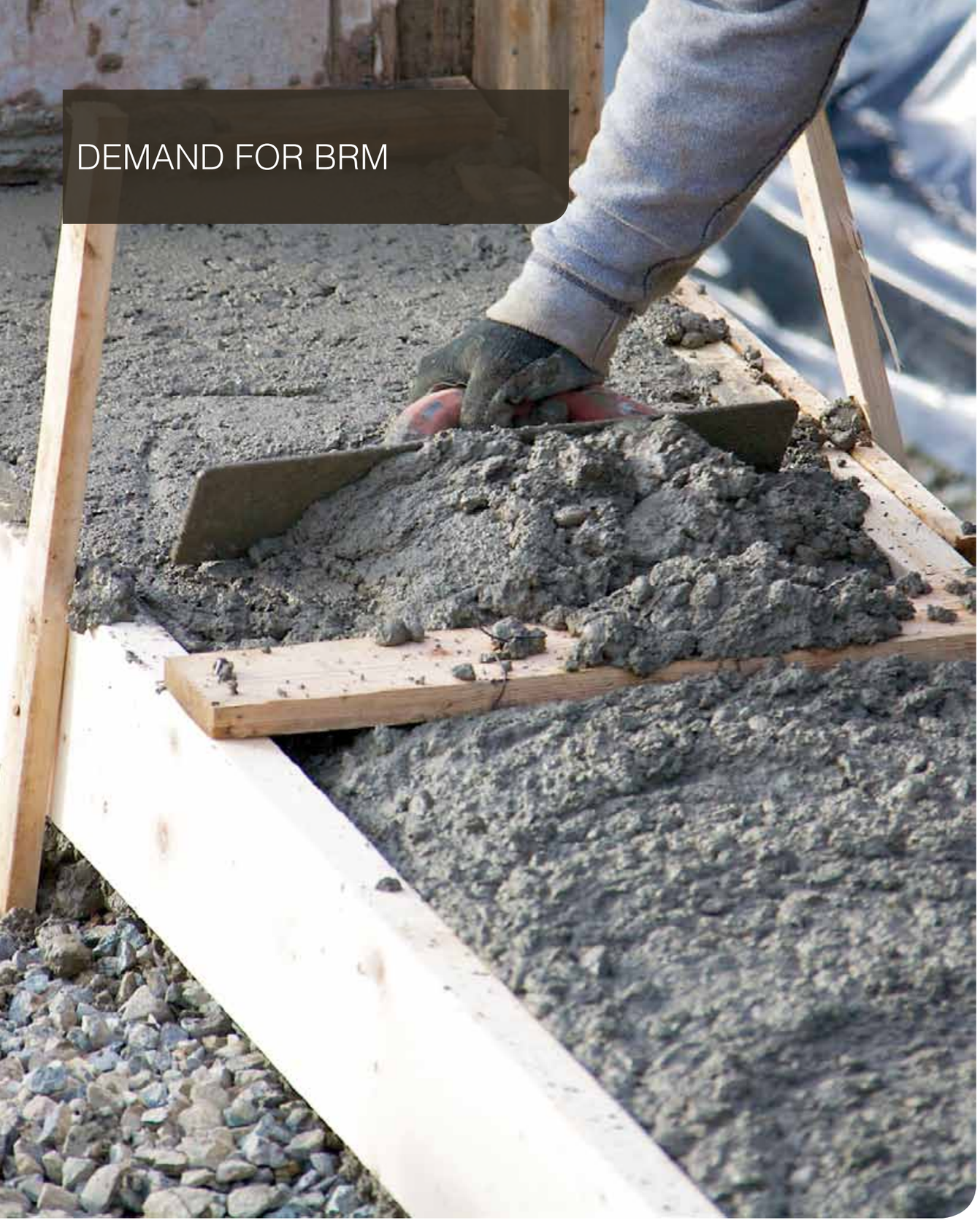
The quality of the Tamala Limestone varies markedly, partly depending on the proportion of calcareous shells in the original limesand dunes. High-grade limestone suitable for cement manufacture, the production of lime products for metallurgical and agricultural purposes occurs in a few isolated pockets. The remaining limestone is suitable for many uses including road base, rock armour in breakwater construction, and as building stone.

Limesand (or shell sand) is the term used for sands rich in calcium carbonate, commonly from fragments of marine shells. The Safety Bay Sand, which forms the present day coastal dunes, is a source of limesand, although as for the Tamala Limestone, the calcium carbonate content varies depending on the proportion of shell and quartz sand content. Currently, the main source of lime for cement and lime product manufacture is dredged limesand. Limesand also has an important role in neutralising soil acidity in broad acre agriculture.

Clay that is suitable for manufacturing bricks, pipes and tiles, and for sealing earth dams, ponds, and landfill sites is extracted from several geological units. Plastic clays are alluvial deposits found on the plains of former river valleys. Floodplains of the Swan River and its tributaries north of Perth provide high quality plastic clays, while south of Perth, the Serpentine River floodplain is a major source of this type of clay. Non-plastic clays include those derived from the weathering of granite and dolerite in the Yilgarn Craton, and shales and schists that occur close to the Darling Scarp. These latter rocks include the Armadale Shale (which is probably around 1390 million years old), and occurs sporadically along the foot of the Darling Scarp between the Darling Fault and the Archean rocks of the Yilgarn Craton.

The main source of gravel is lateritic gravel derived from the natural mechanical breakdown of lateritic duricrust, which is well developed overlying rocks of the Yilgarn Craton on the Darling Plateau. Lateritic duricrust is a hard iron and aluminium-rich layer, which formed from millions of years of weathering of the underlying rocks. Gravel from this source is widely used as a road base and for road surfacing.

Hard rock is a general term covering various rock types that are quarried primarily to supply aggregate in the form of crushed rock. The main rock types used are granite and dolerite from along the Darling Scarp in the Yilgarn Craton. Granite is a coarse-grained igneous rock formed from the slow crystallisation of molten rock deep in the earth. Dolerite is a dark coloured, finer-grained igneous rock that formed by the intrusion of molten rock along fractures in the surrounding rock. Another, much younger source of aggregate is the Bunbury Basalt. The Bunbury Basalt formed about 123 to 130 million years ago from volcanic sources south of the current southern coast. Lava flowed northwards towards Bunbury and then out to sea along valleys eroded into the underlying Perth Basin sedimentary rocks.



DEMAND FOR BRM

DEMAND FOR BRM

Background

The study area has seen a significant increase in the demand for BRM, especially sand, in the past 10 years. Deposits of BRM have always been thought to be abundant and freely available. However, in practice, the occurrence of economically viable deposits is limited, with resources generally restricted by a range of environmental and land-use constraints. The Bunbury–Busselton area has been one of the fastest growing areas in Australia. This growth has resulted in the consumption of easily developed coastal land and sand hills and a subsequent focus on remaining low lying land characterised by high groundwater levels, requiring more BRM inputs. Developments inland of Bunbury and Busselton have occurred where cut-to-fill resources do not exist on-site and have seen a residential lot of 500 m^2 requiring the import of an average of 500 cubic metres of fill to make it developable. This has placed a significant strain on regional sand resources and it has focused developer and supplier attention on the remaining sand supplies. These deposits often have important environmental considerations or attributes which have precluded any previous resource extraction. Extractive license refusals based on environmental reasons have seen a growth in a belief that access to supplies is being restricted and that the market is facing a future supply shortage.

The BRM market has historically been a low-cost market. The exploitation of easily accessible resources and sterilisation of other BRM resources under residential and commercial development has seen competing land uses squeezing out extractive industries. Transport costs have emerged as a significant portion of product price putting additional pressure on the need for close access to land containing reserves of suitable material.

The increasing awareness of the environment, and the biodiversity issues and threats in the South West, has further affected access to viable resource areas and increased the complexity of the approvals process.

It has also been identified that most value-added products requiring regional BRM inputs such as bricks, tiles and cement are produced in the Perth metropolitan area and distributed throughout the State. There is some concrete product production in the South West and an Austral Brickworks facility near Waterloo. However, the majority of BRM demand in the study area is for the raw material and not value-added products.

Current distribution and baseline demand

It is difficult to produce accurate figures for use of BRM in the study area. Although some shires require annual volumetric surveys of materials extracted as a condition of the extractive industry license, in most of the study area product volumes, or material type extracted, is not subject to any reporting mechanism. As commercial operators are protective of production figures for commercial reasons, many of the supply and demand figures in this report are anecdotal. Some broad estimates have been made using available sources and information from state agencies and local governments.

Sand

Sand has historically been sourced from relatively small pits scattered across the South West. This approach has been successful in providing sand for land fill as it has been in plentiful supply and historically located relatively close to development areas. In many cases areas of potential sand extraction have been identified by residential developers as low cost development sites. The sites have been levelled by cut-and-fill, and retained by limestone walls thus sterilising the sand without allowing its value to be fully realised for other sites or projects. The spread of housing has further sterilised a number of early extraction areas initially set up on the edge of townsites and seen the exhaustion of other resources. Some vegetated areas were acquired for sand extraction before the policies of the *Environmental Protection Act 1986*, *Clearing of Native Vegetation*, were introduced. The introduction of additional environmental conditions has restricted the locations available for new sand extraction and increased transport distances resulting in more expensive production and supply costs.

Gravel

Small outcrops of gravel occur across the study area and are sourced by Main Roads WA and local governments for road construction and maintenance. The majority of gravel demand is supplied from the eastern side of the study area and the escarpment. There are no commercial or sufficiently large strategic resources in the region, and gravel resources are subject to research and cataloguing under the State Gravel Strategy. Recently, local governments have purchased construction materials from contractors rather than open a number of borrow pits. In cases where shires do establish their own BRM resources, there has been a move towards establishing larger pits and creating stockpiles for future use and minimising the environmental impact of a multitude of small pits.

Limestone and lime sands

Limestone has predominately been used for retaining walls in residential and commercial developments and road maintenance and construction. It is also used for cement making while lime sands have traditionally been used as a grazing and cropping input with the Department of Agriculture currently recommending the application of 200 kg per hectare in the Wheatbelt. The recent increases in fertilizer costs have seen an increase in the use of lime as an alternative to some fertilizers.

A more recent demand for lime has been for the remineralisation of desalinated water and as a component of fertiliser production.

In the study area, limestone is currently extracted at Myalup and Capel and these sites are included in the Greater Bunbury Region Scheme as resource protection areas. Agricultural lime is also currently distributed from a range of sites in the coastal dunes around Preston Beach. The draft State Lime Strategy recommends a network of regional quarries in the South West approximately 50 km apart to supply lime into the agricultural areas.

Hard rock

There are currently two hard-rock quarries on the southern outskirts of Bunbury and these are identified for resource protection in the Greater Bunbury Region Scheme.

Clay

Brick clay has historically been sourced north of the study area; however, there are strategic resources in the Shire of Capel and near the Waterloo brickworks.

Future demand patterns

Future demand has been estimated through discussions with local governments, the development industry and state government agencies. BRM estimates have been provided for known projects. Additional estimates for residential development have been compiled using forecast population growth data for 2015 and 2030, by house occupancy and lot size using BRM quantity per constructed house estimates provided by the Chamber of Commerce and Industry WA (CCIWA). A factor for associated commercial development has also been included.

Demand for BRM by local government

Local governments in the study area were surveyed on current BRM use based on area previous projects and financial records. Future major projects with BRM implications were identified and estimates adjusted to reflect the projects. The historical figures were adjusted for growth by one per cent per annum to provide estimates to 2030.

Table 1: Residential landfill estimate by local government

Local Government Area	'000 m^3
City of Bunbury	842
Shire of Busselton	9,214
Shire of Harvey	2,086
Shire of Capel	6,423
Shire of Dardanup	1,424
Total	19,989 m^3

Table 1 includes Undeveloped Residential Land, Undeveloped Development Land and Urban Deferred Land.

Source: Greater Bunbury Region Scheme and endorsed Town Planning Schemes

College Grove, Bunbury

Demand for BRM for residential development

The CCIWA has estimated that an average dwelling and supporting infrastructure requires 151 tonnes of hard rock, 255 tonnes of sand, 102 tonnes of clay and 155 tonnes of limestone including product required for road base, site works and building stone. These figures can be used to estimate demand when multiplied by the housing commencements derived from WAPC population forecast data. However, the resultant figures need adjustment to reflect the low lying nature of land in the South West which requires significant quantities of imported fill to meet planning conditions such as finished floor levels. The approach to lot development in Perth is commonly cut-to-fill, with retaining walls. This assumption cannot be transferred to the study area and requires the CCIWA figures to be increased by an additional amount to compensate for the lot-area fill to meet flood and groundwater clearances in the South West. Fill requirements for identified lots have been obtained through discussions with local government staff. See Appendices B – I.

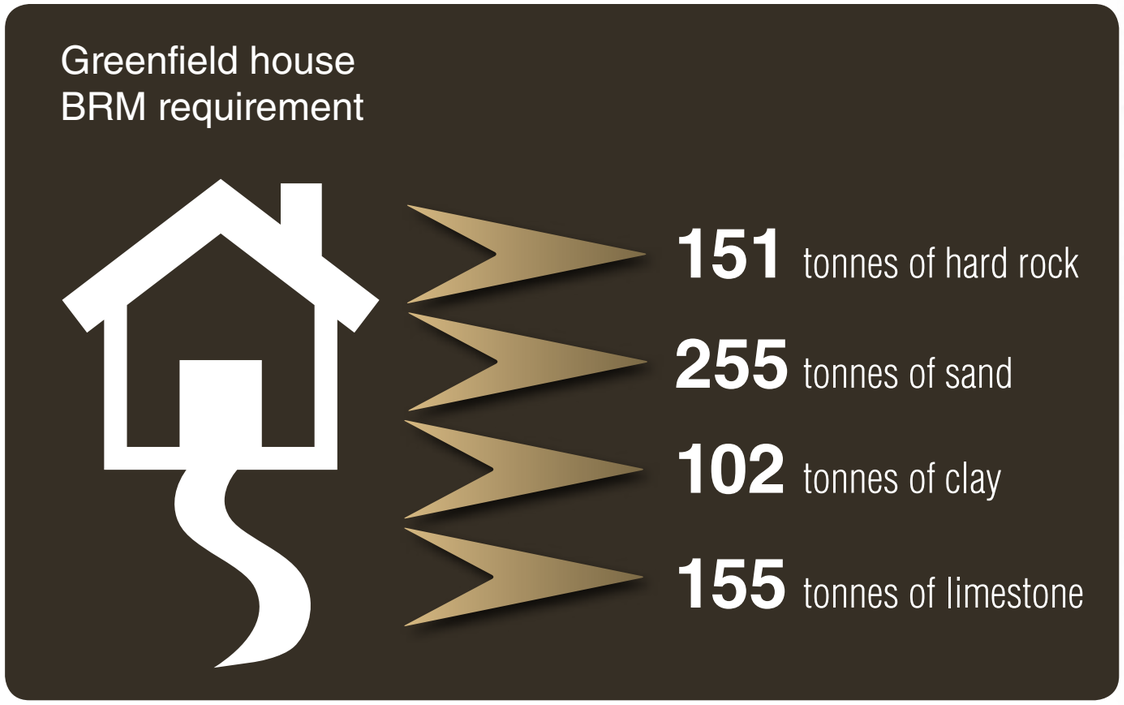


Table 2: Forecast dwelling commencements for the region ('000 m^3)

Local Government Area	2006 Population	2006 Dwellings	2021 Population	2021 Dwellings	Increase Population	Increase Dwellings
Bunbury	29,702	10,684	34,000	12,230	4,298	1,546
Busselton	25,355	9,120	36,500	13,129	11,145	1,009
Capel	10,204	3,670	16,200	5,827	5,996	2,157
Dardanup	10,341	3,719	17,000	6,115	6,659	2,395
Harvey	19,555	7,034	24,000	8,633	4,445	1,599
Total	95,157	34,227	127,700	45,934	32,543	8,706

Based upon an assumed average household occupancy of 2.78 persons/dwelling for Perth and Bunbury

Source: Basic Raw Materials Resource Protection Strategy for the SW of WA. Landvision, 2008. P18

Table 3: Agricultural lime industry sales ('000 m^3)

2008/09 Statewide Sales	1,145						
Convert to 000 m3 using 1.28tper m3	894.5						
Assume SW accounts for 25% of State Sales and assume 1% growth of sales pa							
	2009	2010	2015	2020	2025	2030	Total
Agicultural Lime 000 m^3	895	903	953	998	1,049	1,102	21,891 m^3

Table 4 Demand for BRM estimates for local governments (2009/10 Estimates Apply 1% Growth Annually)

Agencies/Organisations	Source	Current Estimates	Forecast	Forecast	Forecast	Forecast	Total Gravel	Total Sand	Total Limestone
		2009	2015	2020	2025	2030	2009-2030	2009-2030	2009-2030
City of Bunbury	Shire Officers								
Gravel		0.500	0.530	0.557	0.586	0.615	12.250		
Sand		2.000	2.122	2.230	2.344	2.463		49.000	
Limestone		7.000	7.427	7.805	8.203	8.622			171.500
Shire of Busselton	Shire Officers								
Gravel		10.937	11.604	12.196	12.818	13.472	267.968		
Sand		1.750	1.856	1.951	2.051	2.155		42.875	
Limestone		0.625	0.663	0.696	0.732	0.769			15.312
Shire of Harvey	Shire Officers								
Gravel		5.521	5.863	6.162	6.476	6.806	135.264		
Sand		0.500	0.531	0.558	0.586	0.616		12.250	
Limestone		7.031	7.466	7.847	8.248	8.668			172.259
Shire of Capel	Shire Officers								
Gravel		0.500	0.531	0.558	0.586	0.616	12.250		
Sand		1.000	1.062	1.116	1.173	1.232		24.500	
Major Project Bridge Upgrade Sand				60.000				60.000	
Shire of Dardanup	Shire Officers								
Gravel		5.208	5.531	5.813	6.109	6.421	127.604		
Sand		0.625	0.663	0.697	0.733	0.770		15.312	
Limestone		0.555	0.590	0.620	0.651	0.685			13.611
Shire of Donnybrook/ Balingup	Shire Officers ①								
Gravel		10.000	10.620	11.161	11.730	12.329	245.000		
Sand		2.000	2.124	2.232	2.346	2.465		49.000	
① Included as product comes from study area									
Total '000 m^3							800.337	252.937	372.683

Table 5 Forecast residential construction demand by local government (figures shown as '000 m^3)

Local Government Shire	Limestone ①			Sand			Clay ③			Rock		
	2021	2030	Total	2021	2030	Total	2021	2030	Total	2021	2030	Total
Harvey	124			408			163			241		
Dardanup	186			611			244			362		
Collie	2			8			3			5		
Capel	167			550			220			326		
Bunbury	120			394			158			233		
Busselton	310			N/A ②			409			605		
Total Residential Demand	909			1,971			1,197			1,772		
Total Demand	1,410			3,330			1,197			4,491		
+ contingency measure	2,115	2,813	4,928	5,100	6,783	11,883	1,796	2,388	4,184	6,737	8,960	15,697

① It is assumed that limestone for cement manufacture is sourced from the Perth Metropolitan Region

② Not applicable – assumed to be serviced locally

③ It is assumed that clay whether sourced from the study area or elsewhere will be transported to Perth for brick manufacture.

Note 1: Following the CCIWA process it is assumed that 60% of sand consumption, 65% of limestone consumption, 100% of clay consumption and 40% of rock consumption are for residential development.

Note 2: It is assumed that the amount of material included in the allowance per dwelling that is actually used for renovations, can vary between 10% and 20% or even higher. As a result a 50% contingency was factored in to the estimates for the renovation and redevelopment of existing properties.

For the 30-year forecast a factor of 1.5 for Bunbury has been applied by Landvision to the 15-year forecast for the purpose of extrapolation.

2030 figure derived by reducing Landvision figures for 2036 by 33%.

Source: Basic Raw Materials Resource Protection Strategy for the SW of WA. Landvision, 2008. Page 19.

Table 6 State agency demand for BRM and regional major projects (2009/10 Estimates Apply 1% Growth Annually)

Agencies/Organisations	Source	Current Estimates	Forecast	Forecast	Forecast	Forecast	Total Gravel	Total Sand	Total Limestone	Total Rock
		2009	2015	2020	2025	2030	2009-2030	2009-2030	2009-2030	2009-2030
MRWA ①										
New Projects/Improvements	MRWA									
Gravel	Incl 2009-2020			2,400	1,261	1,326	4,987			
Sand				2,500	1,314	1,381		5,195		
Limestone				400	210	221			831	
Bunbury Port ②	Bun Port									
Hard Rock- Breakwater Armour			12	12	0	12				37
Gravel			45				45			
Forest Product Commission	SW Staff									
Estate Road Maintenance										
Gravel		10	11	11	12	12	56			
Sand		0	0	0	0	0		1		
Dept of Environ and Conservation	DEC staff									
Estate Road Maintenance										
Gravel		31	33	35	37	38	174			
Sand		0	0	0	0	0		1		
Limestone		1	1	1	1	1			3	
Watercorp ③	Contractor									
Sand		9	10	10	11	11		50		
Gravel		2	2	2	2	2	9			
Kemerton Industrial Area	SWDC									
Landfill			0	3,500	0	0		3,500		
Construction			0							
Sand						300		300		
Gravel						150	150			
Rock						100		100		
Limestone						100			100	
Agricultural Lime ④	Lime WA	224	237	249	262`	275			1,248	
Coilie Urea Plant ⑤			300	750	750	750			2,550	
Binningup Desal Plant										
Sand			100	40	0	0		100		
Limestone			5	5	0	0	5	5		
Total							5,426	9,251	4,732	37

① MRWA	Forecast 2009-2020 adjusted to 2030 by 1%growth	③ Watercorp	Contractor information
② Bunbury Port	Assume three new berths by 2030 12.7m deep +2 m height at 45 degrees (1.4) by 2 m thick armour hard rock 300m long 5 km new road and hard stand Potential net exporter of sand if full port dredging occurs	④ Ag Lime	Adjusted to SW Region only to 25% of State Ag Line Sales Chris Gazey, Dept of Agriculture WA 2009 Converted to m^3 at 1.28t/m^3
		⑤ Collie Urea Plant	Proponent Information Lime requirement 150,000 m^3 pa

Table 7 Total BRM demand table to 2030 (figures shown as '000 m^3)

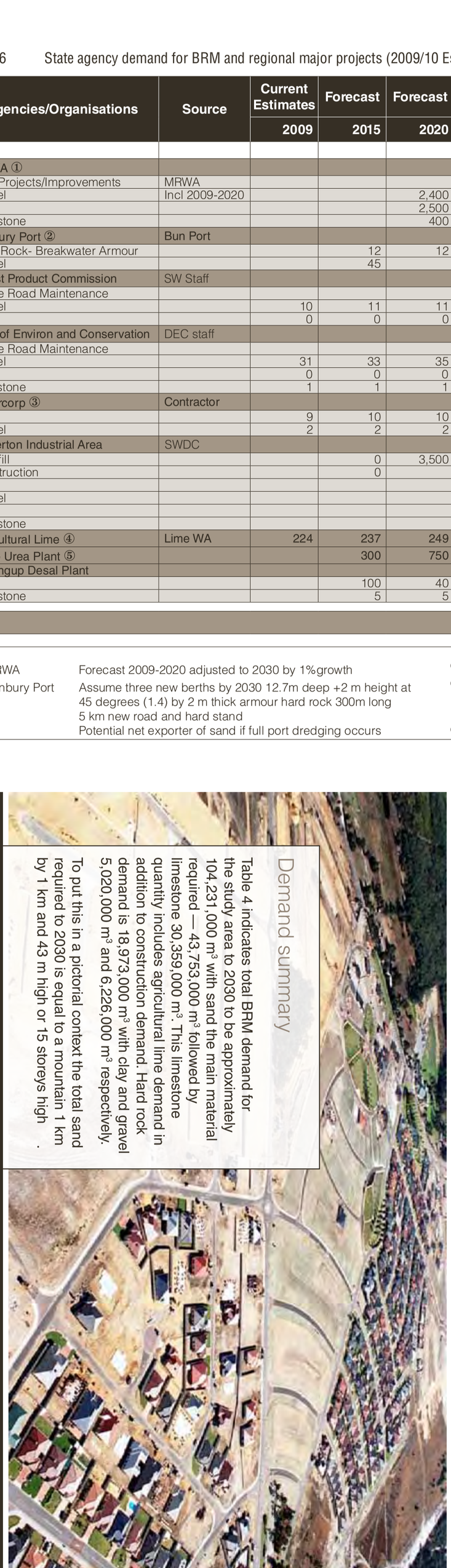
	Sand	Gravel	Clay	Hard Rock	Limestone
Demand for BRM by Agencies and Projects pa ①	9,251	5,426		37	2,182
Demand for BRM by LGAs ②	253	800			373
Residential Landfill Estimate by Local Government Agency ③	19,989				
Forecast Residential Construction Demand by LGA ④	11,883		4,184	15,697	4,928
Estimated Commercial Demand by LGA ⑤	2,377		837	3,139	986
Agricultural Lime Demand ⑥					21,891
Total	43,753	6,226	5,020	18,873	30,359
Total BRM Demand					10,4231

① Table 6
② Table 4
③ Table 1
④ Table 5
⑤ 20% of residential total
⑥ Table 3

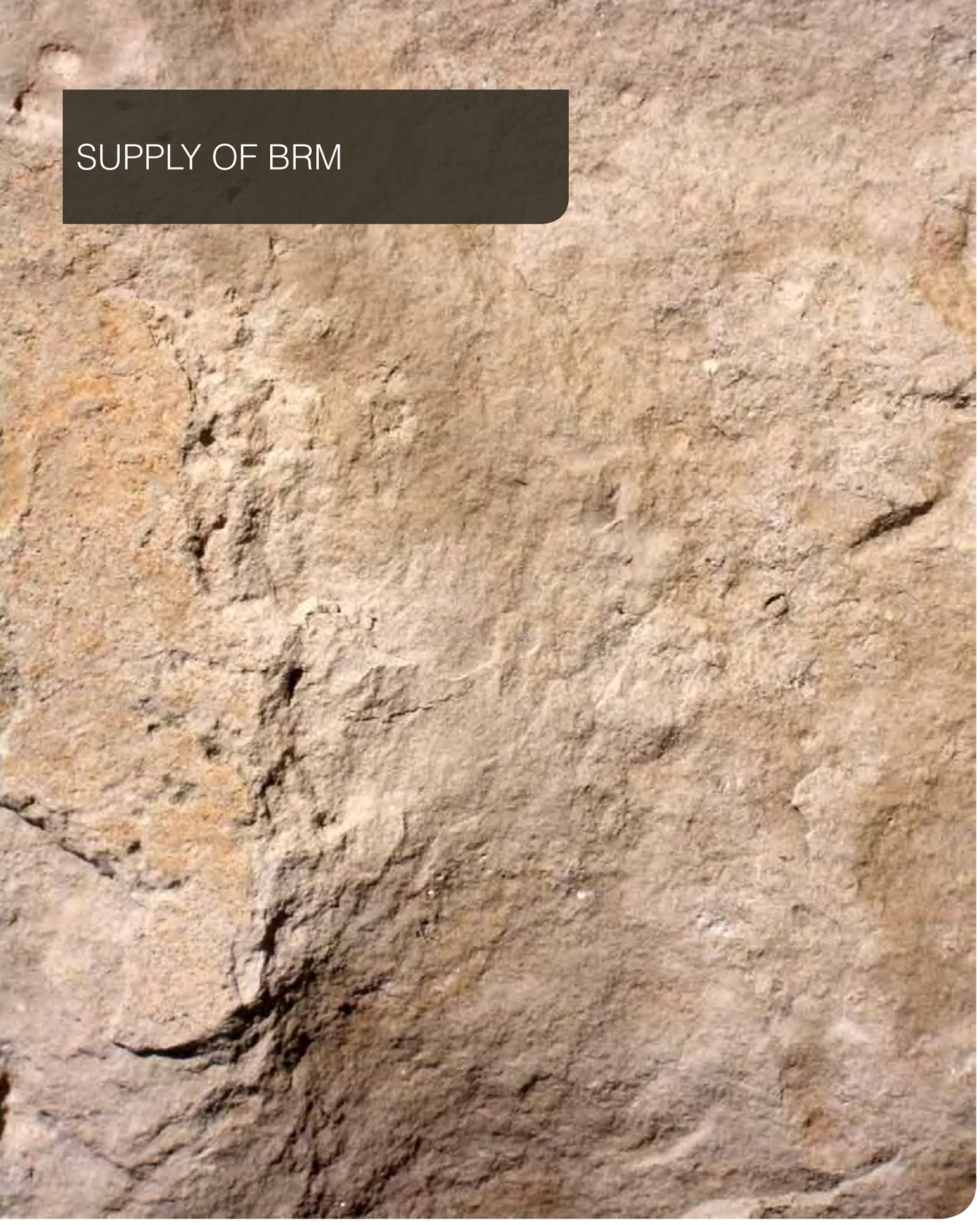
Demand summary

Table 4 indicates total BRM demand for the study area to 2030 to be approximately 104,231,000 m^3 with sand the main material required — 43,753,000 m^3 followed by limestone 30,359,000 m^3. This limestone quantity includes agricultural lime demand in addition to construction demand. Hard rock demand is 18,973,000 m^3 with clay and gravel 5,020,000 m^3 and 6,226,000 m^3 respectively.

To put this in a pictorial context the total sand required to 2030 is equal to a mountain 1 km by 1 km and 43 m high or 15 storeys high .



Land development



SUPPLY OF BRM

SUPPLY OF BRM

Resource identification

This element of the study is based upon resource data provided by the Geological Survey of Western Australia (GSWA), a division of the DMP and held in their geological survey records. Current extractive industry sites have been identified via a registry of extractive industry licences, compiled by consultants Landvision in 2008, and shown on map series 2. It is important to note that there is no consolidated register of the State BRM supply sites or production figures. DMP does hold information on tenements on Crown land, but no register of freehold sites is held other than by the approving local government authorities for their own areas. This makes any empirical supply calculations, planning or resource management of the industry difficult.

Some old BRM sites are exhausted and abandoned, but many may still contain significant material. As BRM resources become scarce and prices increase it may create the situation where previously marginal resources become viable, and may justify reopening old workings. It may also be possible to apply detailed site rehabilitation conditions to new extractive industry licences over old pits on both private and crown land, to allow resource extraction and subsequent site rehabilitation which will give a net environmental benefit. This may allow the Department of Environment and Conservation (DEC) to facilitate rehabilitation of currently degraded sites on Crown land.

Additionally, a geoscience-based mapping approach has been used by GSWA to support the study, looking at actual geological endowment of the larger BRM locations. GSWA complied and updated previous geological mapping in the study area to define surface geological units that have the potential for BRM. Potentially extractable thicknesses of BRM were then calculated as the difference between the elevation of the surface topography and the Department of Water‘s (DoW) two-metre groundwater clearance level. Results were then filtered by applying a range of environmental and planning constraints, and selection criteria to identify the most regionally significant BRM sites. The locations of these regionally significant BRM areas are shown in Map 6. Potential BRM quantities were estimated and reduced by a very conservative recovery factor to account for the fact that theoretical quantities will not be achieved in practice due to extraction constraints such as local quality of material, access, batter requirements and setbacks.

The quantity estimates are not technical resource estimates, but rather are potential global supply figures that are intended to inform government of the order of magnitude of the BRM endowment.

Sites with current extractive industries licences have also been identified on Map 6, but the figures do not include BRM quantities in those generally smaller extraction sites that lie outside the GSWA identified areas. There is currently no inventory of individual BRM extraction site resources on freehold land that would assist in producing more comprehensive supply estimates. Operators tend to be protective of site information for commercial reasons.

Although GSWA results may be conservative they still represent an overall estimate of supply across BRM classes. The results have not been filtered by the application of any environmental constraints.

It needs to be stressed that the results of this analysis do not imply that all regionally significant sites will, or should, be subject to BRM extraction. Any proposal to extract BRM in any of these sites would still need to go through the normal approval process as detailed in the WAPC's *Basic Raw Materials Applicant's Manual*. The mapping, however, is a useful tool to show the locations and magnitude of the regions remaining BRM assets, and will be a valuable contribution to the region's planning tools.

Table 8 shows the supply estimates generated by the methodology outlined above.

Table 8 Supply estimates

BRM Class	Global supply estimate '000 m^3
Sand	492,450
Limestone	35,460
Clay	3,570
Rock	55,000
Gravel	15,080

The results derived also allow an initial comparison to be made on the region's demand and supply for BRM. The results in Table 9 indicate that there are still substantial potential supplies of the BRM types in the study area for all BRM products except limestone, lime sand and clay. It should be noted that these estimates only apply to those areas meeting GSWA significant supply criteria. Many current active extractive industry sites lie outside the significant supply areas identified by GSWA, so the actual potential BRM supply volumes for the region could be more than the GSWA estimates.

The results, however, reinforce the recent application of Section 19 legislation by DMP to the Myalup pines area. This brings access to BRM in this area under government control and should enable timely access in consultation with other government agencies. Further work is required to facilitate an approval mechanism with the DEC, and where necessary the Forest Products Commission, to consider allowing access to areas identified by GSWA including the Myalup Pines, the Kemerton buffer and east of Busselton to ensure future supplies are available close to demand.

These DMP-derived regionally significant BRM areas represent key future BRM supplies for the development of the South West region. Although areas may be constrained by environmental issues, the identified sites should be protected from other incompatible land uses or restrictions using mechanisms such as a revised *SPP 2.4 — Basic Raw Materials*.

Issues impacting on BRM supply

There are a number of factors that affect both the supply of BRM in the region and access to potential BRM sites.

Environmental

Given the widespread development and significant range of farming activities in the South West there is little remnant native vegetation in the study area, and what remains is considered of high conservation value. Often this remaining vegetation is on land not suitable for cropping such as ridges and hills, and it is these features that often contain the viable BRM resources. The South West is recognised as one of the major biodiversity hotspots in the world. There are a number of rare and endangered flora and fauna species which are subject to protection under state and federal legislation. Extractive sites which require the clearing of native vegetation require permits under the *Environmental Protection Act 1986*. If the proposal has the potential to significantly affect a threatened species and/or ecological communities listed under the *Federal Environmental Protection and Biodiversity Act 1999*, then the Australian Department of Sustainability Environment, Population, Water and Communities may declare the proposal a "controlled action" and require further assessment.

The area has a high groundwater table with the groundwater quality in the superficial aquifer varying over the region. Management of the groundwater in extraction operations is important to reduce the risk of pollution for bore users and to minimise the impact on wetlands. The DoW generally requires a two-metre separation distance between extractive mining operations and the water table to prevent groundwater contamination and increased salinity.

The high groundwater levels contribute to a significant chain of wetlands in the region. These have been categorised into three levels of management and protection. Wetlands requiring protection require buffers to reduce the adverse impacts of mining and BRM extraction, and to allow the continuation of the wetland hydrological and environmental processes. These requirements affect general surface run-off and drainage from extractive industries, and discharge of any mining water which must be managed through settling ponds with adequate storage and bunding. This reduces the face heights and volumes that can be removed from the sites.

The Myalup and Binningup areas contain a significant RAMSAR wetland and its buffer, which is also protected under migratory bird agreements and constrains lime extraction.

Both the Swan Coastal Plain and the Scott River Plain are subject to acid sulphate soils. Mapping has been carried out identifying areas of acid sulphate soils. In the wetland areas sediment carries substantial amounts of sulphide minerals which can result in acidic, arsenic and heavy metals contamination if the water table recedes too far and sediment is exposed to the air. This can mean serious consequences for groundwater resources if naturally occurring iron sulphide minerals exposed during resource extraction are allowed to oxidise via a lowered water table and through the groundwater table.

DEC has identified that the application of the DEC GIS Layer — Remnant Vegetation is the most appropriate environmental constraint to apply to results generated under the previous "significant geological supply" data.

South West bushland

Visual amenity

The study area has high tourism values as an activity destination and for its general visual features. Extractive industries have not been encouraged in areas where operations impact on the views from tourist roads. Given the improvements in rehabilitation techniques, there may be an opportunity to allow sequential extraction across sites where there are potential visual impact issues. This could allow the extraction of BRM without the visual footprint of a traditional "quarry". Pre-plantings of screening vegetation and immediate rehabilitation could mitigate the impact of any extraction.

Competing land uses

Throughout the South West there is a range of land uses that compete with BRM extractors for available land. In some areas planning strategies exclude extractive industries from suitable land, especially in wine-producing areas and locations with high tourism values. The rapid expansion of residential and commercial development has sterilised many potential BRM sites.

Acceptance of the importance of BRM to regional growth may allow BRM as a sequential land use whereby BRM is removed then the land used for its future purpose.

Freehold land access

There is anecdotal evidence of reduced production of BRM on freehold land. Easily accessed resources have been removed leaving more marginal resources, which often require additional clearing, and then rehabilitation. Some local planning strategies have prohibited the establishment of extractive industries in possible BRM areas where vineyards, tourist or rural residential activities have been viewed as a preferred land use. Land speculation has also removed possible BRM supply sites from the market as land has been "banked" for future rezoning and then once rezoned to urban/commercial, extractive industries are not a permitted land use.

Crown land

Long-term extractive industry sites can be established on Crown land, under the provisions of *The Mining Act 1981*, but environmental issues significantly reduce the available areas and opportunities. Road maintenance "borrow pits" can also be established by MRWA and local governments for short-term use. There has been some use of shared local government extraction pits on DEC controlled land whereby larger pits are established to gain economies of scale rather than a multitude of small pits being opened. Resources are often stockpiled to further improve economies and reduce environmental damage.

Nearly 85 per cent of the study area's significant sand supplies lie under the Forest Products Commission pine plantations in the Myalup and McLarty areas, with the possibility of some underlying limestone outcrops associated with this sand.

These plantations operate under a State Agreement, however, it may be possible through the use of replacement offsets to open parts of the area to BRM extraction during harvest cycles. The DMP recently enacted Section 19 legislation over this area, which provides for government control over the issuing of mining tenements, and will facilitate future sand extraction.

Mining tenements

The opportunity to produce BRM material as an off take of mining tenement operations was investigated as part of the study. There are a number of heavy metal sand mines in the study area; however, it is not possible for the mines to meet their environmental and rehabilitation requirements and also allow for the removal of BRM. Tenements must meet post mining ground levels as part of their approvals process and this does not allow for the removal of BRM material. Trials of alternatives such as lowering the ground level to leave lakes and wetlands through the removal of BRM have not proved environmentally sustainable. It has been difficult to achieve the nutrient levels required to create stable sustainable natural environments.

Significant areas of the South West have titanium-zircon heavy mineral sands resources. These are covered by DMP's Strategic Mineral Resources Protection Areas, which are intended to protect them from incompatible land uses before mining takes place. As these are higher-value Crown-owned resources, care must be taken that they are not inadvertently mined for BRM before titanium-zircon extraction. These factors combine to constrain the potential extraction of BRM in some potential tenement areas.

Zoning issues

BRM extraction is not a permitted use for all zonings, and permitted uses vary across zonings and local governments. The rezoning process can sterilise potential supplies when land is rezoned into a classification that may exclude extractive industries. Given the time and expense of rezoning, developers are not prepared to make further application for a rezoning to make BRM extraction a permitted use to facilitate extraction and potentially risk losing the higher land use zoning.

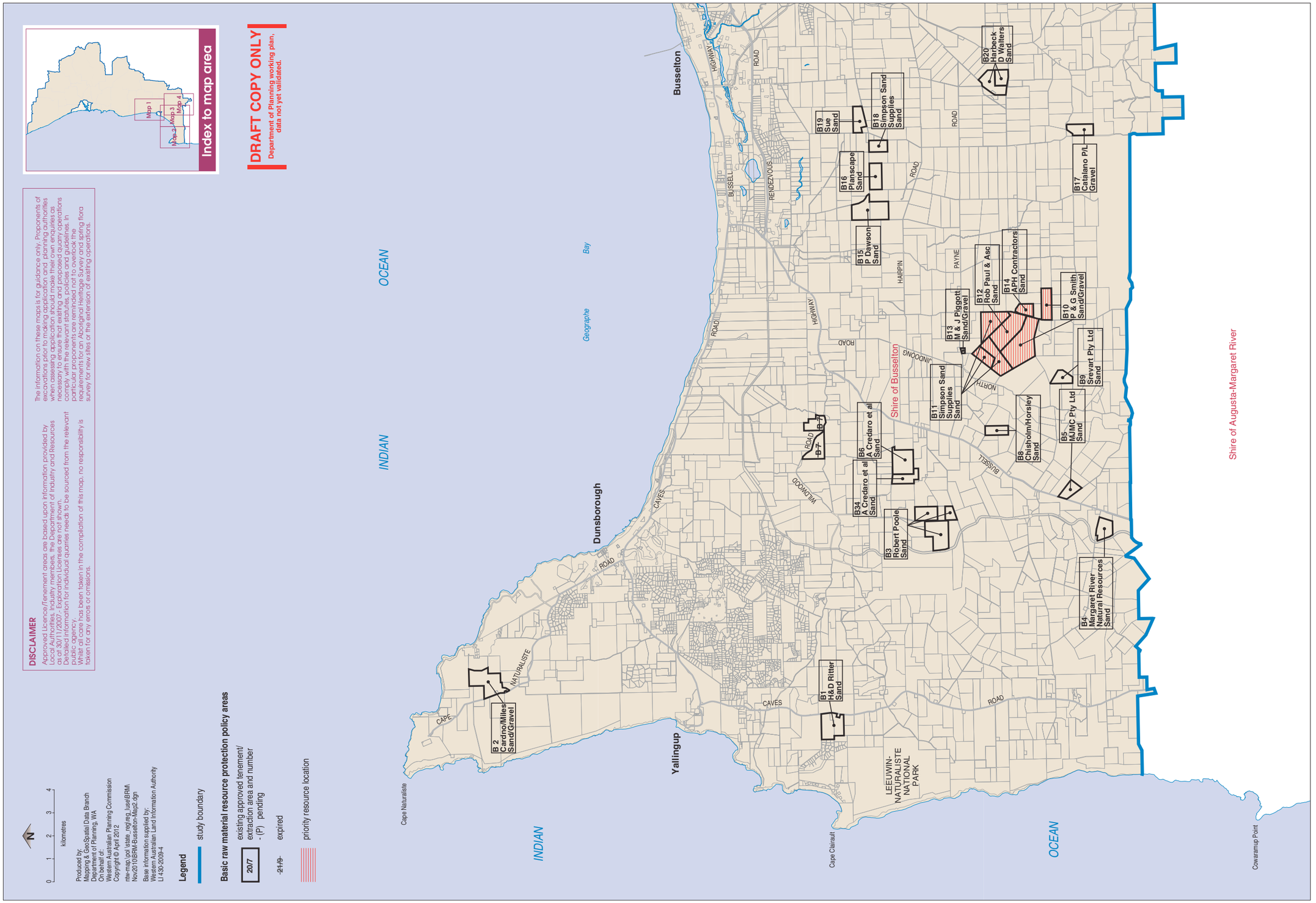
The increased demand for rural-residential lots has seen the re-zoning of rural land and the development of estates in low-lying areas in a number of areas. The construction pads often include areas for large houses incorporating outdoor areas, sheds and aerobic sewerage treatment units that are retained to sit above the water table. Additionally, the lots often require a significant gravel or limestone base course on the driveway and turning areas to meet water table clearance requirements.

The current rezoning policies do not require developers to advise DoP or WAPC on BRM engineering resource requirements to meet conditions for rezoning. There are examples of rezoning applications where, once approved, developers have realised the cost implication of the required fill, the lack of cheap local supplies, and have looked to government to provide a solution.

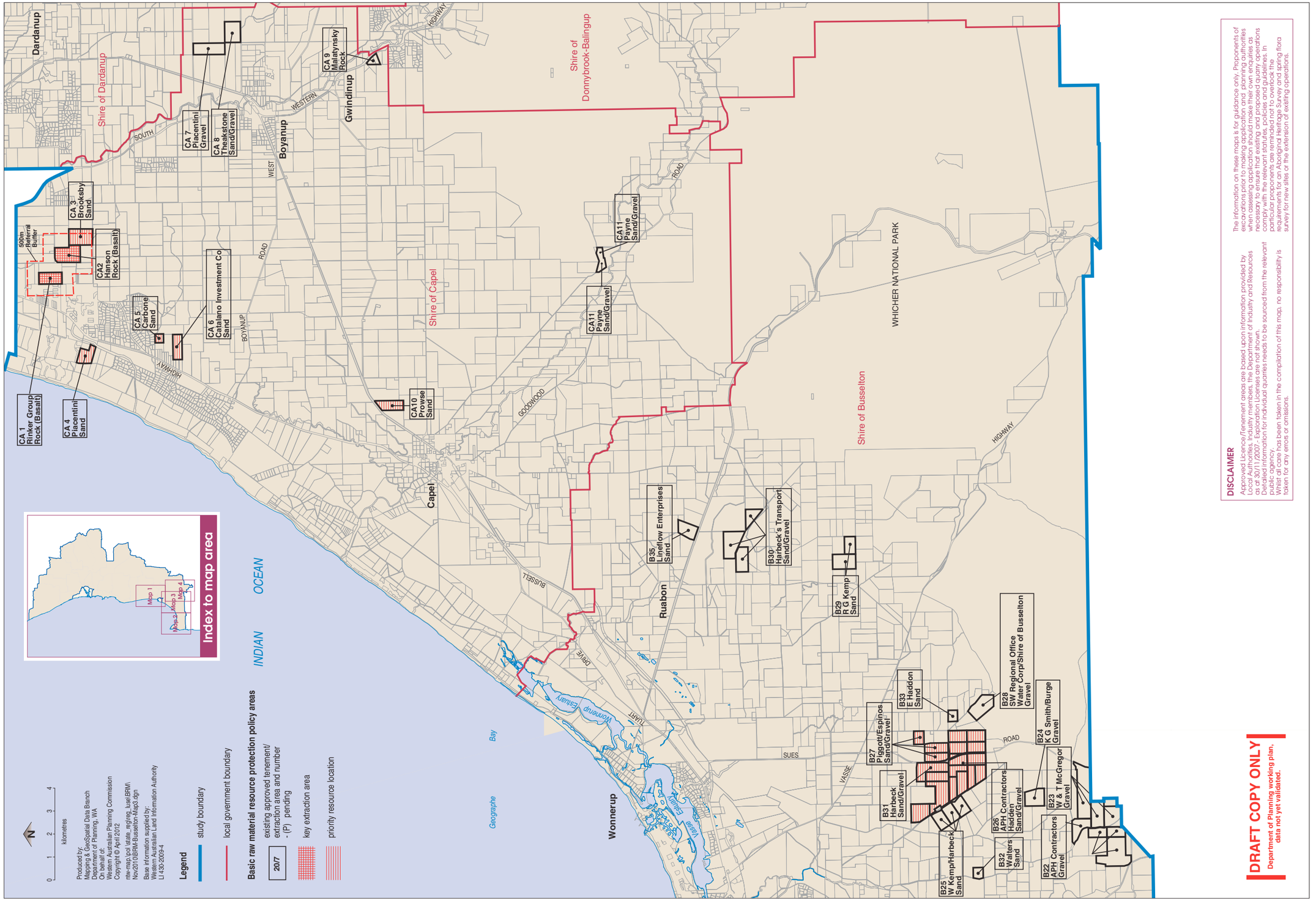
Further work is required to investigate options to review the rezoning process and to include a "first cut" engineering study in areas identified as requiring significant fill and developer advice on the proposed source of fill.

The Kemerton industrial buffer is an interesting zoning example as it contains significant sand resources and land of high conservation value with extensive remnant vegetation. The Shire of Harvey is considering a policy to allow extractive industries to support the development of industries in the Kemerton core by allowing access to resources only on previously cleared areas that have low visual amenity and environmental impacts. However, given the scale of BRM resources in this area, a process for gaining access to these BRM supplies, given there close proximity to Bunbury, should be investigated under strict environmental conditions.

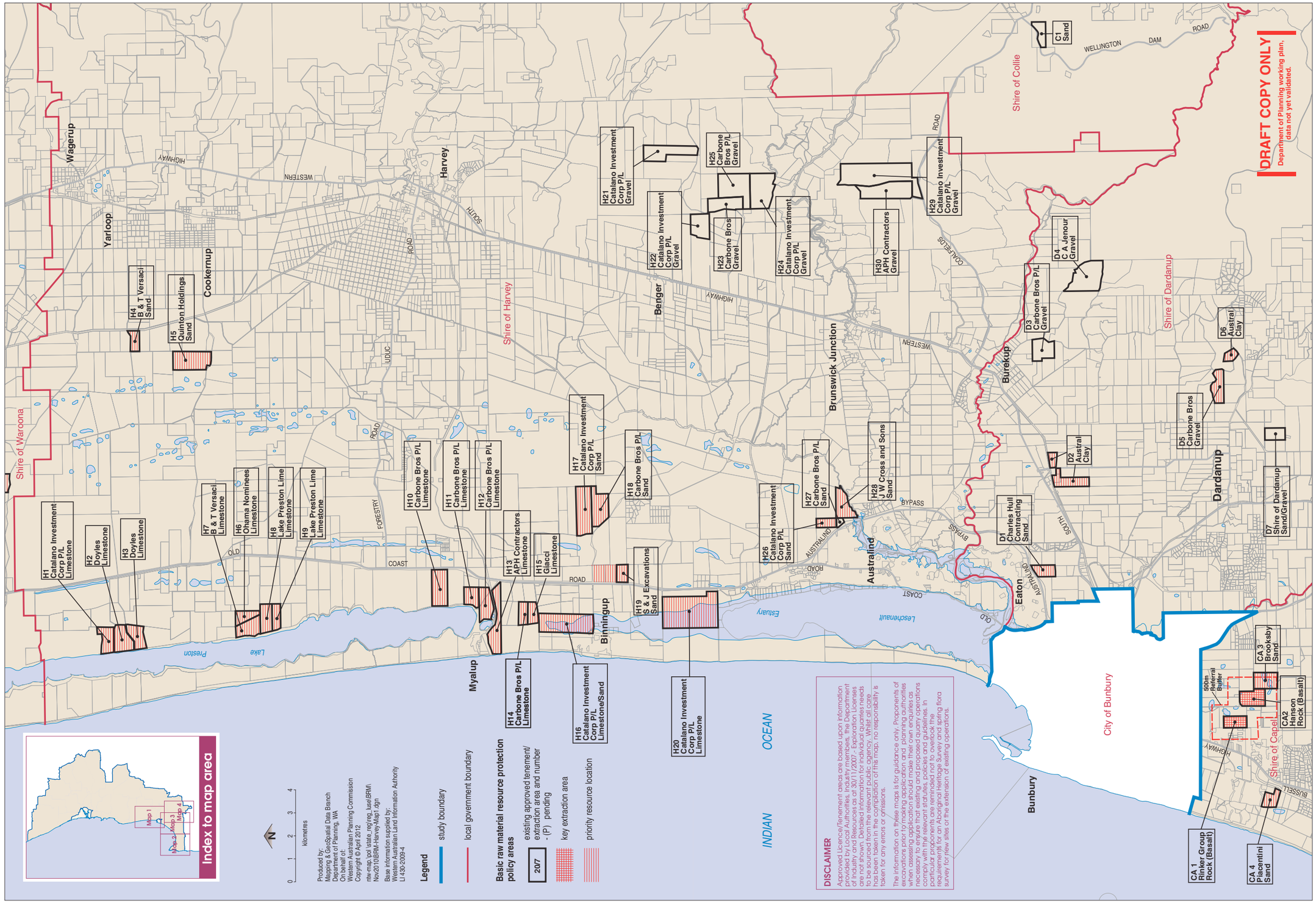
Map 1 2008 extractive industry licence sites in study area (Shire of Busselton)



Map 2 2008 extractive industry licence sites in study area (Shire of Busselton, Shire of Capel)



Map 3 2008 extractive industry licence sites in study area (Shire of Harvey, Shire of Dardanup)



Map 4 2008 extractive industry licence sites in study area (Shire of Capel, Shire of Dardanup)

CA 7 Piacentini Gravel
CA 8 Theakstone Sand/Gravel
CA 9 Malatynsky Rock
DB1 Gosford Quarries Rock (Sandstone)
DB2 Beelerup Rock(Sandstone)
DB4 Donnybrook Civil Gravel
DB5 Hearman Sand
DB6 Greenside Sand
DB7 Catalano Gravel
DB8 Catalano Gravel
DB9 Earthmac Gravel
DB10 Cavallaro Sand
DB11 M70/1273 Je Guest Sand /Gravel
DB12 M70/1276(P) Ruso P/L Dimension Stone
DB13 M70/1217, M70/862 M70/1156 Dejo Nominees Rock(Dimension Stone)
DB14 P70/1511 Goodz & Assoc Rock(Dimension Stone)

Shire of Dardanup
Shire of Capel
Shire of Busselton
Shire of Donnybrook-Balingup
Shire of Augusta-Margaret River
Shire of Bridgetown-Greenbushes

Boyanup
Donnybrook
Newlands
Kirup
Balingup

BOYANUP ROAD WEST
SOUTH WESTERN HIGHWAY
BOYUP BROOK ROAD
DONNYBROOK ROAD
GRIMWADE ROAD
GOODWOOD ROAD
ROAD
SOUTH CAPEL ROAD
UPPER CAPEL ROAD
WESTERN ROAD
HIGHWAY
MALLIANA ROAD
ROAD
ROAD
NANNUP ROAD

N
0 1 2 3 4
kilometres

Produced by:
Mapping & GeoSpatial Data Branch
Department of Planning, WA
On behalf of:
Western Australian Planning Commission
Copyright © April 2012

ntw-map.\pol\state_reg\reg_luse\BRM\Nov2010\BRM-Donnybrook-Map4.dgn

Base information supplied by:
Western Australian Land Information Authority
LI 430-2009-4

Index to map area
Map 1
Map 2
Map 3
Map 4

Legend

study boundary

local government boundary

Basic raw material resource protection policy areas

20/7 existing approved tenement/ extraction area and number - (P) pending

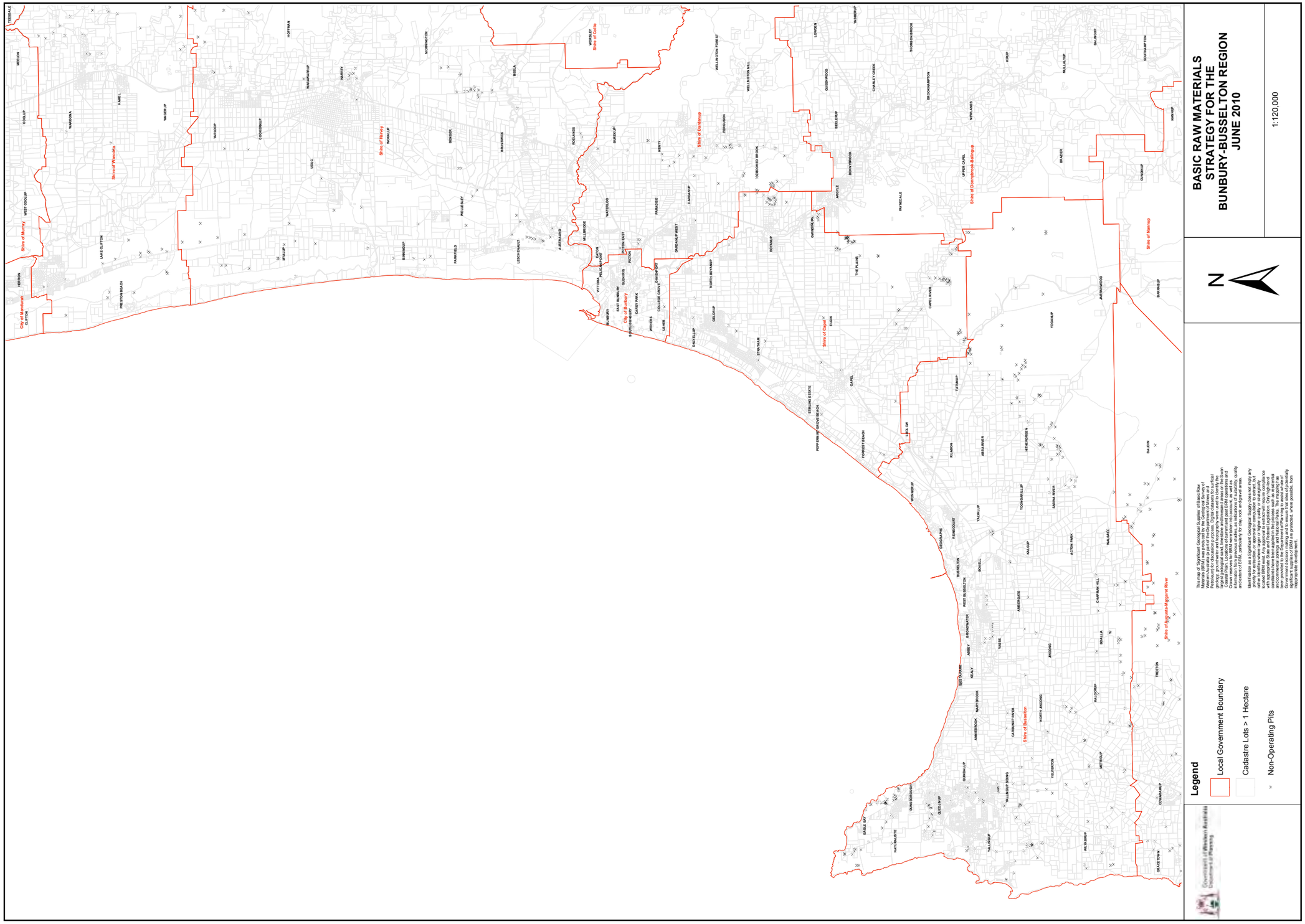
priority resource location

DRAFT COPY ONLY
Department of Planning working plan, data not yet validated.

Approved Licence/Tenement areas are based upon information provided by Local Authorities, Industry members, the Department of Industry and Resources as at 30/11/2007.- Exploration Licenses are not shown.
Detailed information for individual quarries needs to be sourced from the relevant public agency.
Whilst all care has been taken in the compilation of this map, no responsibility is taken for any errors or omissions.

The information on these maps is for guidance only. Proponents ofexcavations prior to making application and planning authorities when assessing application should make their own enquiries as necessary to ensure that existing and proposed quarry operations comply with the relevant statutes, policies and guidelines. In particular proponents are reminded not to overlook the requirements for an Aboriginal Heritage Survey and spring flora survey for new sites or the extension of existing operations.

Map 5 Non operating extraction sites in study area



Map 6 Regionally significant BRM in study area

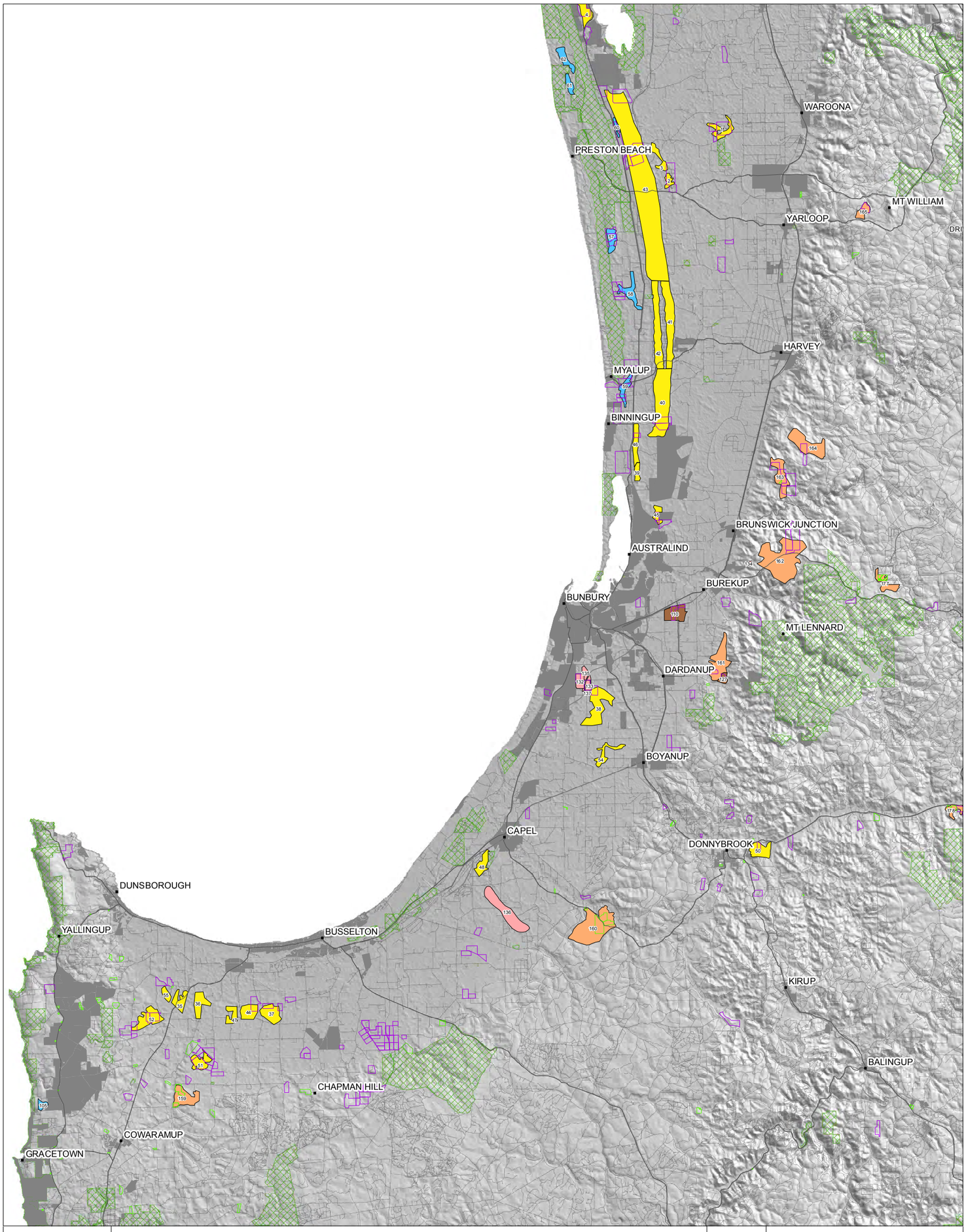
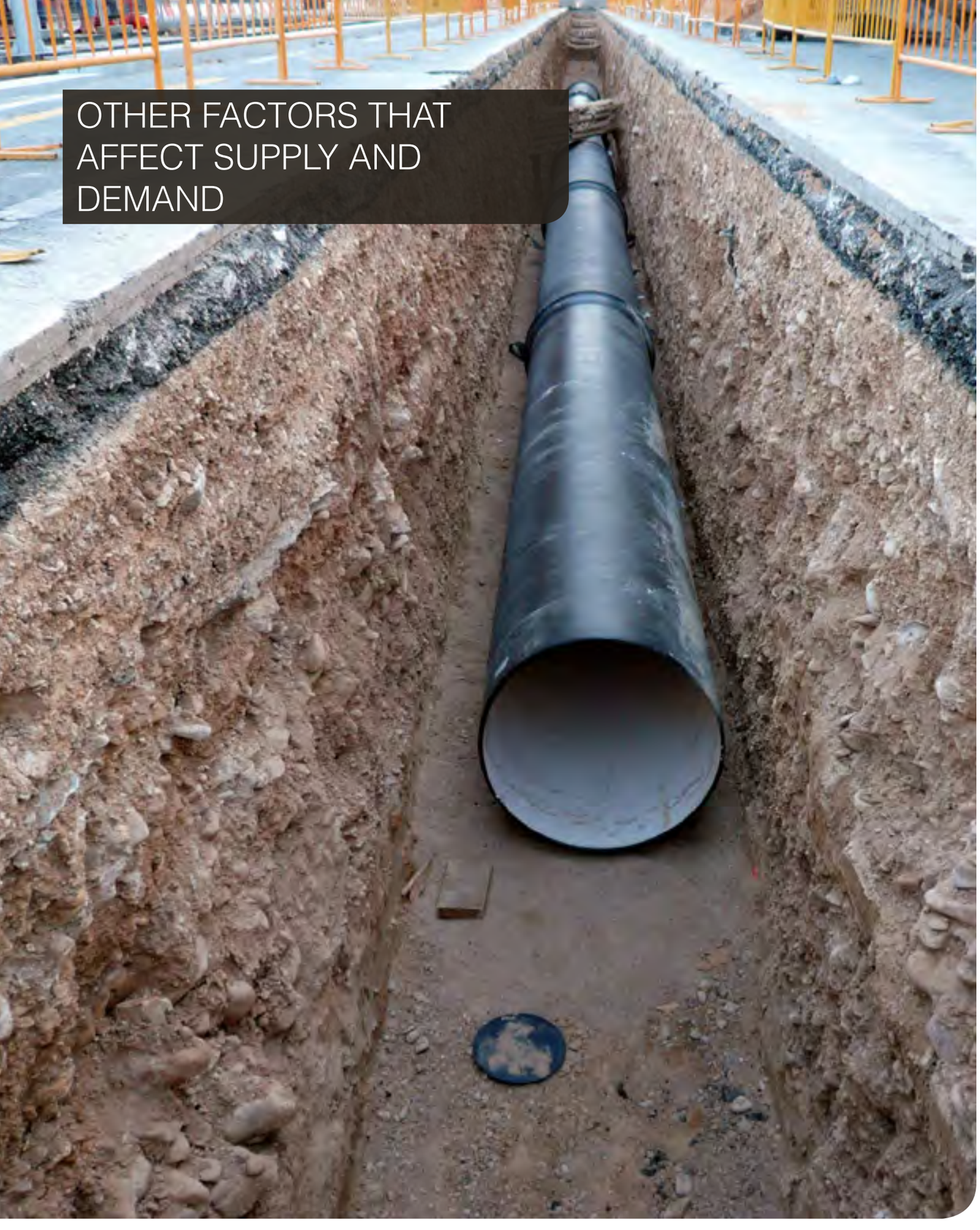


Table 9 Regionally significant BRM in study area

Map Id	Commodity	Local Government Authority	Area Ha	Nominal thickness (m)	Nominal volume ('000 m³)	Recovery factor	Global supply estimate ('000 m³)	Current extraction operations	Native vegetation	Ownership
1	Sand	Waroona	251	7	17,570	0.40	7,030	Yes	Yes	Mainly private
2	Sand	Waroona	100	8	8,000	0.40	3,200	No	No	Private
3	Sand	Waroona	192	7	13,440	0.40	5,380	No	Part	Private
35	Sand	Busselton	236	2	3,540	0.40	1,420	No	No	Private
36	Sand	Busselton	289	2	4,340	0.40	1,730	No	No	Private
37	Sand	Busselton	343	1	3,430	0.40	1,370	Yes	Part	Private
38	Sand	Capel	707	6	42,420	0.40	16,970	Yes	Yes	Private
39	Sand	Harvey	104	12	12,480	0.40	4,990	No	Part	Crown
40	Sand	Harvey	1,231	13	160,030	0.40	64,010	Yes	Part	Mainly private
41	Sand	Harvey	814	14	113,960	0.40	45,580	No	Part	Mainly Crown
42	Sand	Harvey	726	13	94,380	0.40	37,750	No	No	Crown
43	Sand	Waroona/Harvey	4,568	15	685,200	0.40	274,080	Yes	Part	Crown
44	Sand	Busselton	271	1	2,710	0.40	1,080	Yes	No	Private
45	Sand	Harvey	127	6	7,620	0.40	3,050	Yes	Yes	Private and DEC
46	Sand	Harvey	242	8	19,360	0.40	7,740	Yes	Yes	Mainly private
47	Sand	Busselton	179	1	1,790	0.40	720	No	Part	Private
48	Sand	Capel	219	6	13,140	0.40	5,260	Yes	Yes	Private and Crown
50	Sand	Donnybrook-Balingup	323	2	6,460	0.30	1,940	Yes	Yes	Crown and private
51	Sand	Busselton	265	2	3,980	0.40	1,590	Yes	Part	Private
52	Sand	Busselton	435	3	13,050	0.40	5,220	Yes	Part	Private
54	Sand	Capel	216	2	4,320	0.40	1,730	No	Part	Private
55	Sand	Busselton	102	2	1,530	0.40	610	No	Part	Private
							492,450			
57	Limestone	Harvey	212	10	21,200	0.40	8,480	Yes	Part	Private
58	Limestone	Harvey	303	6	18,180	0.40	7,270	Yes	Part	Private
59	Limestone	Harvey	189	3	5,670	0.40	2,270	Yes	Part	Private
60	Limestone	Waroona	66	6	3,960	0.40	1,580	Yes	Yes	Private and Crown
61	Limestone	Waroona	126	11	13,860	0.40	5,540	No	Part	Private
62	Limestone	Mandurah	206	11	22,660	0.40	9,060	No	Yes	Private
105	Limestone	Busselton	79	4	3,160	0.40	1,260	No	Part	Private
							35,460			
110	Clay	Dardanup	360	2	7,200	0.40	2,880	Yes	No	Private
127	Clay	Dardanup	86	2	1,720	0.40	690	Yes	Part	Private
							3,570			
132	Rock_aggregate	Capel	146	20	29,200	0.40	11,680	Yes	Part	Private
133	Rock_aggregate	Capel	64	20	12,800	0.40	5,120	Yes	Part	Private
134	Rock_aggregate	Harvey	24	20	4,800	0.40	1,920	Yes	Yes	Crown
135	Rock_aggregate	Capel	70	20	14,000	0.40	5,600	No	Part	Private
136	Rock_aggregate	Busselton	685	20	137,000	0.20	27,400	No	Part	Private
137	Rock_aggregate	Capel	15	20	3,000	0.40	1,200	No	Yes	Private
138	Rock_aggregate	Capel	5	20	1,000	0.40	400	No	No	Private
139	Rock_aggregate	Capel	21	20	4,200	0.40	1,680	No	No	Private
							55,000			
159	Gravel	Busselton	433	1	4,330	0.30	1,300	Yes	Yes	Crown and private
160	Gravel	Capel	1,247	1	12,470	0.30	3,740	No	Yes	Crown and private
161	Gravel	Dardanup	601	1	6,010	0.30	1,800	Yes	Part	Private
162	Gravel	Harvey	1,528	1	15,280	0.30	4,580	Yes	Part	Private
163	Gravel	Harvey	437	1	4,370	0.30	1,310	Yes	Part	Private and Crown
164	Gravel	Harvey	624	1	6,240	0.30	1,870	Yes	Part	Private
165	Gravel	Waroona/Harvey	160	1	1,600	0.30	480	Yes	Part	Private
							15,080			



OTHER FACTORS THAT AFFECT SUPPLY AND DEMAND

OTHER FACTORS THAT AFFECT SUPPLY AND DEMAND

Rehabilitation

There is a range of rehabilitation guidelines applied to extractive industries to ensure post extraction areas have long-term land use options. Depending on the final end-use of the site, topsoil backfill levels can vary between 100 mm and 1,000 mm. The cost of rehabilitation and the associated site management of overburden and topsoil increases the cost of extractive industry operations and focuses attention on sites with large potential face heights. Large face heights allow the minimum quantity of topsoil to be removed for maximum yield and reduce rehabilitation requirements.

There have been significant improvements in the success of site rehabilitation with the increased focus on the environment. Several larger operators have developed recognised environmental practices and techniques. The collection of seed banks and careful treatment of topsoil during initial clearing have proved more successful and reflect a greater awareness of the need for post extraction site rehabilitation.

The South West has extensive areas of freehold and Crown land with high conservation value. Improvements in rehabilitation practice may offer the opportunity to access some of these areas under strict license conditions, pending relevant environmental approvals. The improvements in rehabilitation techniques may result in increased BRM yield and supply.

Regulatory control

The system of regulation that has evolved across agencies relating to extractive industries has occurred in an environment where resources were considered abundant, and focuses on the control of operations rather than the protection of resources. In many South West examples, large economic resources have been sterilised through land development without allowing for prior extraction of the BRM for other uses. There are no standard approval processes across local government for freehold land, and the State through DMP approves BRM tenements on Crown land. There needs to be a whole-of-government regional approach to reviewing land-use priorities to protect both key environmental assets and areas and future BRM supplies. BRM for high value end uses needs to be available to meet the demonstrated demand. This will result in the protection of land currently used for extractive industries and land identified with significant BRM supplies to meet future demand. The overall planning strategy for the region will be considered based on sequential land use with either rehabilitation or regional development as an end use.

Further work is required to identify potential improvements to the current BRM approvals process to provide a regional focus on BRM needs and establish common standards for access, operations and rehabilitation. Using the methodology being established in the State Strategic Assessment process, it may be possible to identify strategic regional BRM sites for each class of material and identify offsets to allow their successful extraction and site rehabilitation.

Alternative materials and techniques

Owing to a range of factors, Australian states have adopted different norms in building practices and especially residential building construction. The Western Australian residential norm is a concrete raft slab on a compacted sand pad with double brick construction. The relative abundance of sand and brick making clay encouraged this form of construction especially on the coastal plain. In other areas of Western Australia and many other states the landform, availability of timber and relative lack of fill sand has encouraged construction of a stump and timber/steel frame form clad in a variety of materials including brick veneer, weather board and colourbond steel.

The low-lying land in the study area requires local governments to specify a finished floor level for houses to ensure 100 year flood heights are met. The common practice of raft slab construction has resulted in the need for considerable quantities of sand fill to meet these levels. With developers preparing a number of lots across a subdivision, they have adopted a practice of filling from boundary to boundary and retaining with limestone blocks. In the areas where sand is plentiful this is a viable and simple approach, but as developments occur in non-sandy areas, or areas with high water tables, developers have been importing sand to continue this construction technique. The transport consequence of this fill places additional strain on the local road networks and increases the cost of developing lots.

Adoption of alternative building techniques including stump construction will reduce the need for sand fill in areas with low groundwater levels. However, there is a public perception that any variation from the common concrete raft slab construction is an inferior product and this will require significant education and change in perception. This is hindered by a building pricing policy where construction site works costs are minimised through the lot construction process so builders can offer the most competitive housing product.

Despite stump construction contributing to reduced fill on some sites there can still be considerable BRM demand for infrastructure needs such as roads. There has been some investigation by developers into offering "S" rather than "A" class lots as they may require less fill, but the nett impact on overall BRM demand has not been significant. Australia generally has not had much success with recycling building materials to date. The economies of scale and long transport distances have not encouraged the development of an industry that can crush waste building products allowing their reuse as fill. The higher level of concrete construction in Europe has created an alternative fill material in high density areas, but it is unlikely to be applicable in Western Australia. There has been some attempt to increase the use of recyclable BRM materials as fill on sites, but small economies of scale, environmental legislation and the cost of transport have limited wide use.

There are few alternatives to the use of sand. Laterite sands and gravels can be used as fill in some scenarios, but resource location requires significant transport. Ocean sand has been investigated as a replacement for terrestrial sand for low value uses such as fill. There are some examples of mixing ocean or beach shell-based sand with quartz type sands, but the poor compaction properties of lime based local ocean sand reduces its end uses as it does not have the required compaction qualities of quartz based sands. Crushed and screened rock can replace sand in concrete batching, but the rock processing adds to overall costs. There are also no practical alternatives for glass sands even through recycling.

Impact of climate change influences and sea level changes

In the study area there is significant concern about the effects of climate change and the possible effects of a rise in sea level. The current predictions for sea level rise on the South West coast by *The Climate Change Risks to Australia's Coast Report* (2009) is 0.1 m by 2030 and 1.1 m by 2100. This will have impacts on 100-year flood levels raising the minimum development levels and thus further increasing demand for fill.

The Shire of Busselton is conducting a study into the possible impact for the shire and the DoP is working with Geoscience Australia to look at sea level rise, storm surge and erosion in the Greater Bunbury area. Long-term sea level rises may need to be addressed to protect assets and infrastructure and the construction of an integrated protection network would require significant BRM resources.

Another demand which is likely to increase in the future is limestone and hard rock for sea wall and breakwater armour. The consequences of climate change and sea level increase could see construction of sea walls for beach protection in the low lying areas of Busselton and Bunbury in addition to an increasing consumer demand for rock and limestone walls for canal and water side living.

Busselton Jetty

CONCLUSION

Findings

This study has investigated both supply and demand issues associated with BRM on the Bunbury–Busselton coastal plain.

The study area contains significant sand and other BRM supplies that are constrained by environmental factors. Existing sites are progressively being exhausted or sterilised under townsite development frontiers impacting on the supply of BRM. New extraction sites are meeting environmental and amenity objections and face a complex approvals process. Improvements in rehabilitation are addressing stronger environmental conditions on extractive industry licences and offer a solution to the current impasse, but this will require a paradigm shift for both legislators and operators.

There is continued future demand for BRM as the study area continues to be one of the fastest growing development areas in Western Australia and as the BRM products are generally consumed by the communities that produce them their continued supply is essential to sustain community development. Despite there being material in the study area sand and limestone are becoming critical and supplies need to be made available close to demand areas to reduce cost and associated road transport issues.

There is little industry supply information and it is only recent government science-based mapping that has allowed a better understanding of the actual BRM supply locations and potential volumes. Demand for BRM will continue to grow as townsites look to expand onto low-lying land while the impact of a high water table will continue to be a significant issue in the South West. It may even worsen through factors associated with climate change, especially around Busselton and Bunbury. Incorporating BRM requirements into the land-use planning process and the introduction of site registers and annual extraction reports will lead to a better understanding of the operation of the industry, regional demand, and ensure a proper value is assigned to BRM inputs. Improvements in site rehabilitation techniques should allow BRM extraction to be part of a sequential land- use process.

The results of the study indicate that there are still substantial potential supplies of the BRM types to meet future demand in the region for all BRM products except limestone, including lime sand, and clay. Many current active extractive industry sites lie outside the significant supply areas identified by GSWA, so the actual potential BRM supply volumes for the region could be more than the GSWA estimates. The identified significant supply areas should be protected from other incompatible land uses or restrictions using planning mechanisms including a revised *SPP 2.4 — Basic Raw Materials* and the extraction approvals process streamlined to ensure a regional perspective is applied.

A number of regionally significant BRM supplies have been identified across all the classes in the study area. The utilisation of these will require a whole-of-government approach to ensure a suitable balance is achieved between meeting the regional growth demand, protecting the environment and ensuring social amenity in the South West. In the short term these finite resources need protection from encroachment from inappropriate land uses so they are available to be used in the future.

APPENDICES

Appendix A Methodology

The basic report methodology is to estimate current annual demand for BRM across a range of uses and apply an annual growth figure to provide total demand estimates for the major BRM types out to 2030. A growth estimate of one per cent per annum has been applied to 2008/09 figures and a contingency figure has been included where appropriate.

Potential supply estimates have been derived by the DMP via their geological survey information. BRM types have been identified across the study area, and those which meet a range of parameters listed in Table 9 have been identified as 'significant geological supply' areas with, potential quantities estimated. The significant geological supply areas have been mapped and are shown on Map 6. Some of these areas are currently constrained by environmental issues; however, they have been included to allow a more accurate picture of BRM supplies in the region to be identified.

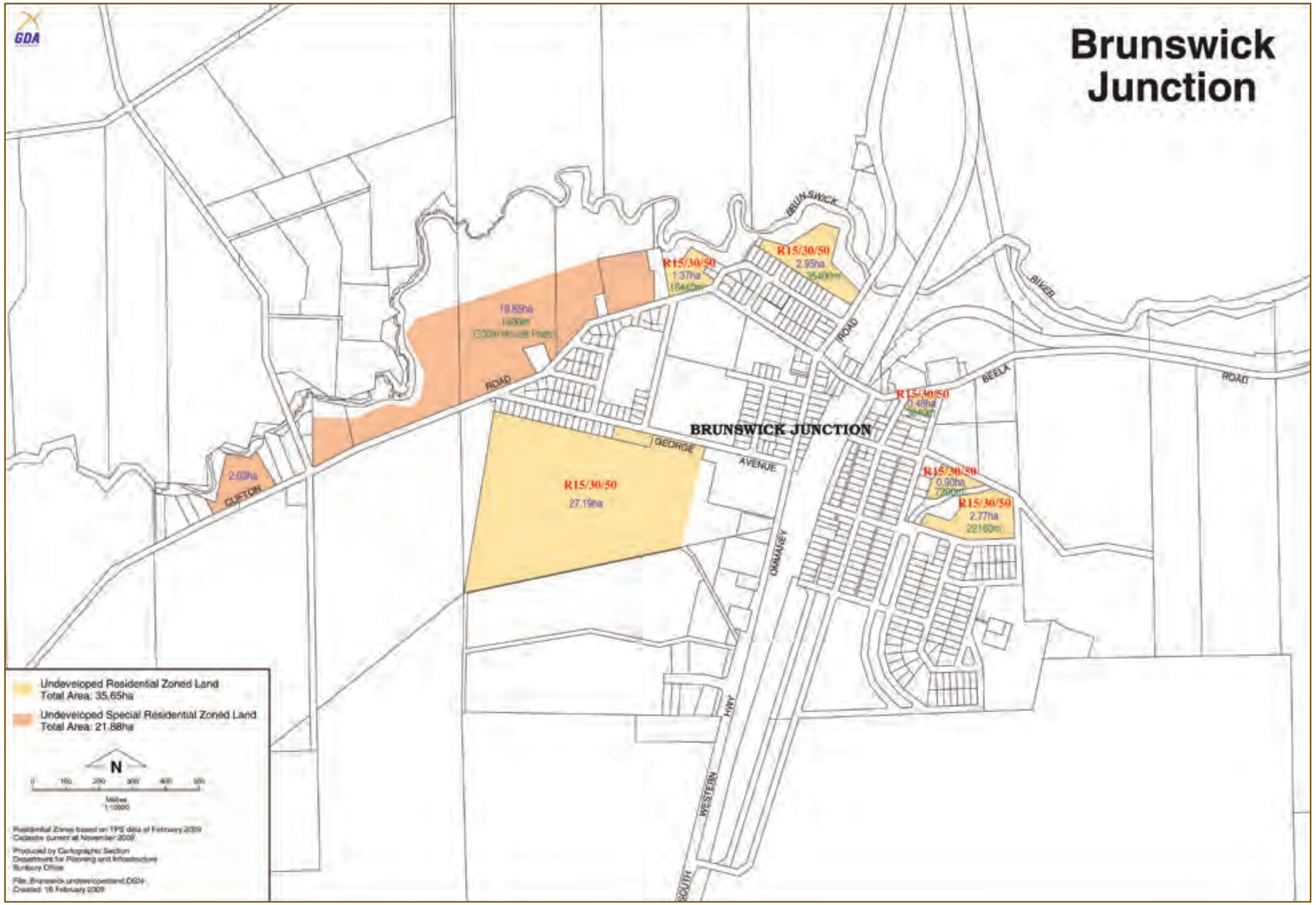
To maintain consistency all quantities are expressed in '000 m^3 and where data is sourced in tonnes, conversion rates are stated.

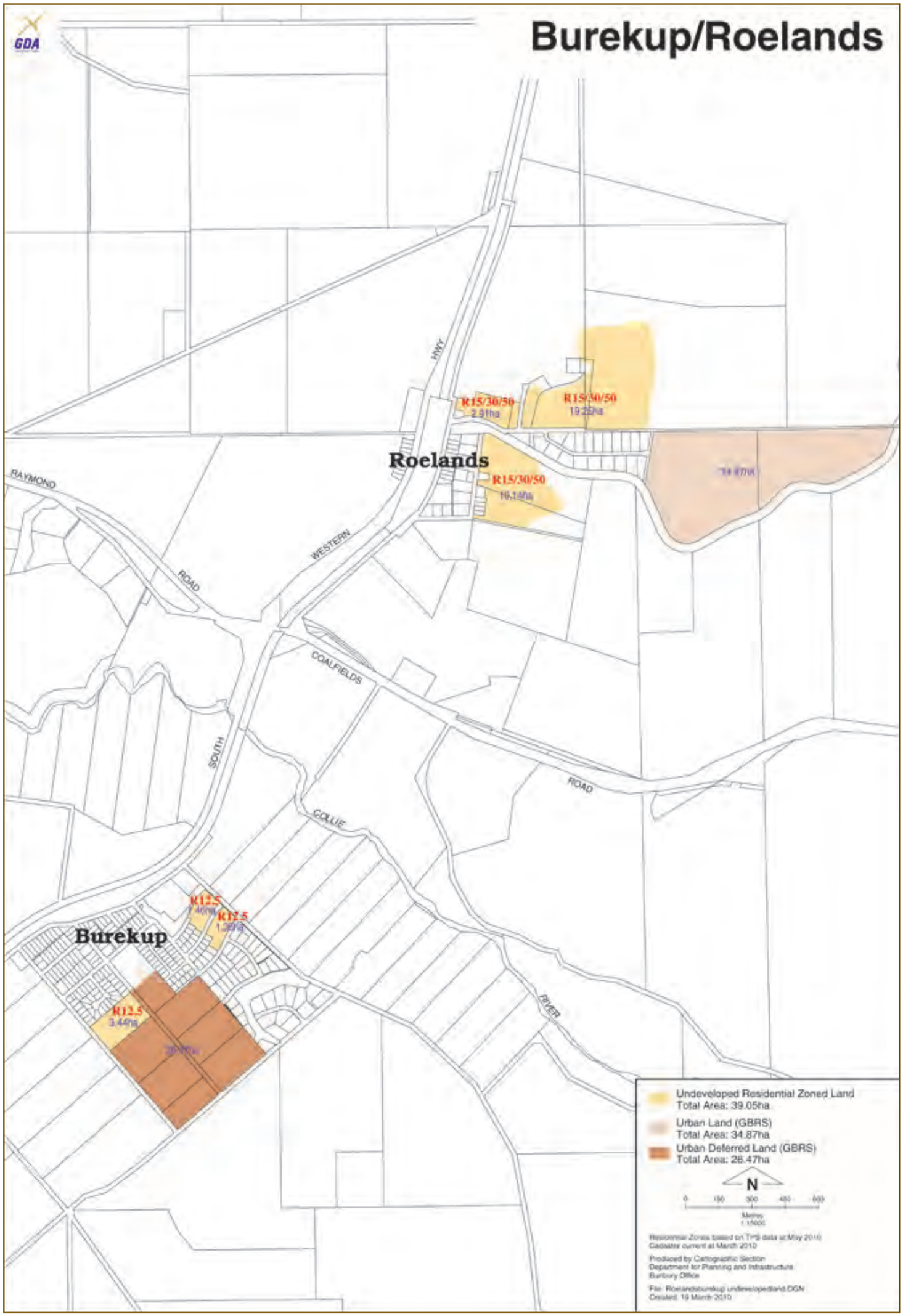
As there is no legislative requirement to report any extractive industry volumes, it is difficult to obtain accurate supply figures. Similarly, demand figures are also difficult to obtain and much of the information in this study has been obtained directly from state agency and local government users on their actual usage. Previously recognised demand estimate methods for house construction quantities have been used where applicable.

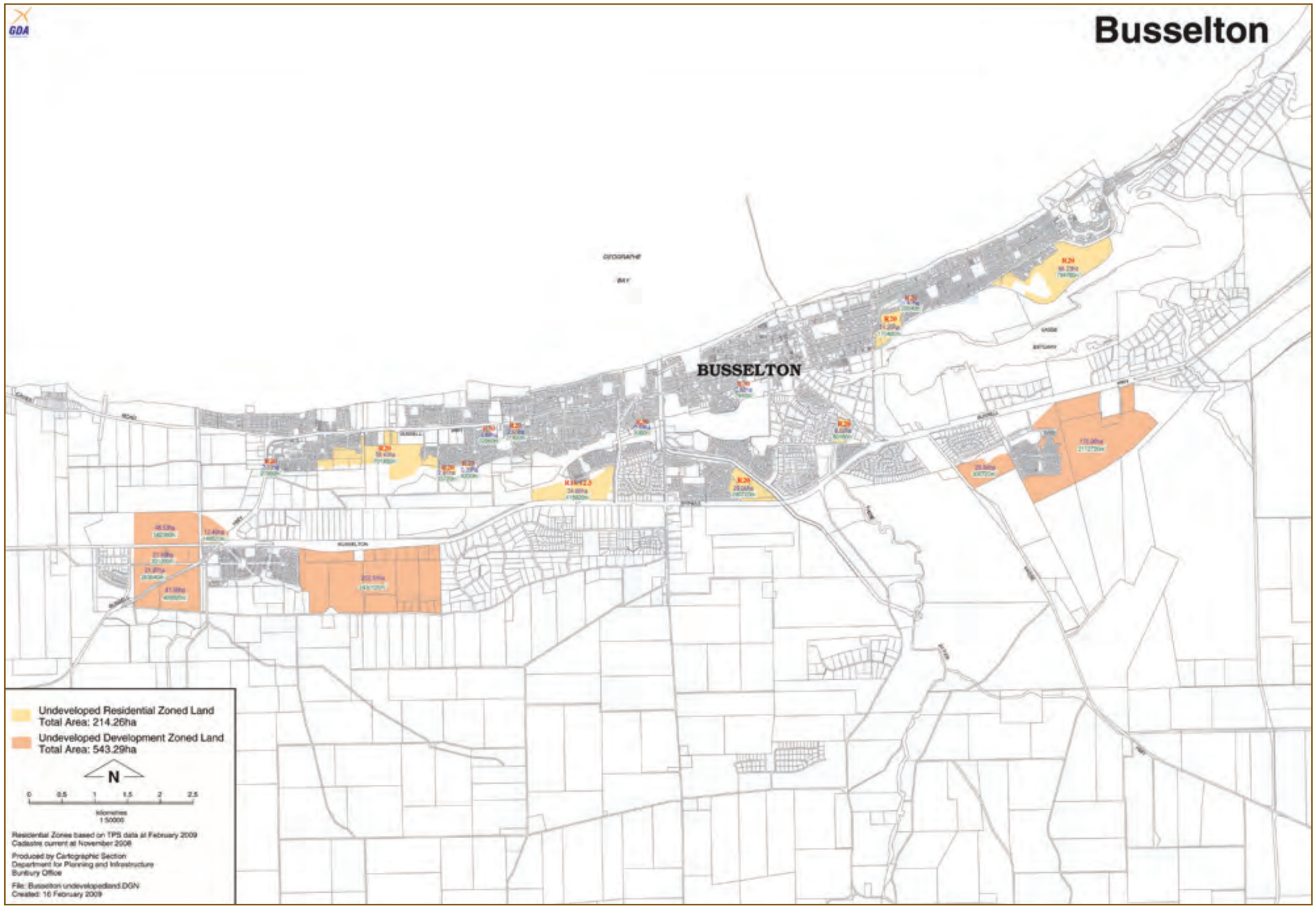
Due to a lack of hard statistics, a range of demand data has been estimated for this study. The areas of demand covered include:

- Estimates of BRM required to meet housing commencements for Western Australian Planning Commission (WAPC) endorsed population growth in the region using Chamber of Commerce and Industry WA (CCIWA) figures for BRM requirements for dwelling construction.
- Sourcing base-fill requirements to bring land identified and endorsed by the WAPC to a level suitable for actual construction. Much of the land identified for future growth in the region is low lying with high groundwater levels and requires significant fill to bring it to a level for construction.
- Surveying local government engineering and planning staff to obtain current usage levels for BRM and identify future projects that may require increased demand.
- Surveying a range of agencies with BRM demand needs including Main Roads WA, Forest Products Commission, DEC, Watercorp to obtain current use levels and assess future needs where agency forecasts do not exist. These have been adjusted with a one per cent growth to provide estimates to 2030.
- Assess BRM requirements for major forecast developments or projects such as possible Bunbury Port development, Kemerton industrial area, Ballingup desalination plant. It has been difficult to estimate timings for these projects so a 20 per cent of residential demand figure has been included as a contingency factor to cover potential accompanying commercial and major developments.
- Assessing industry supply and demand where it is not covered in other estimates, such as agricultural lime.

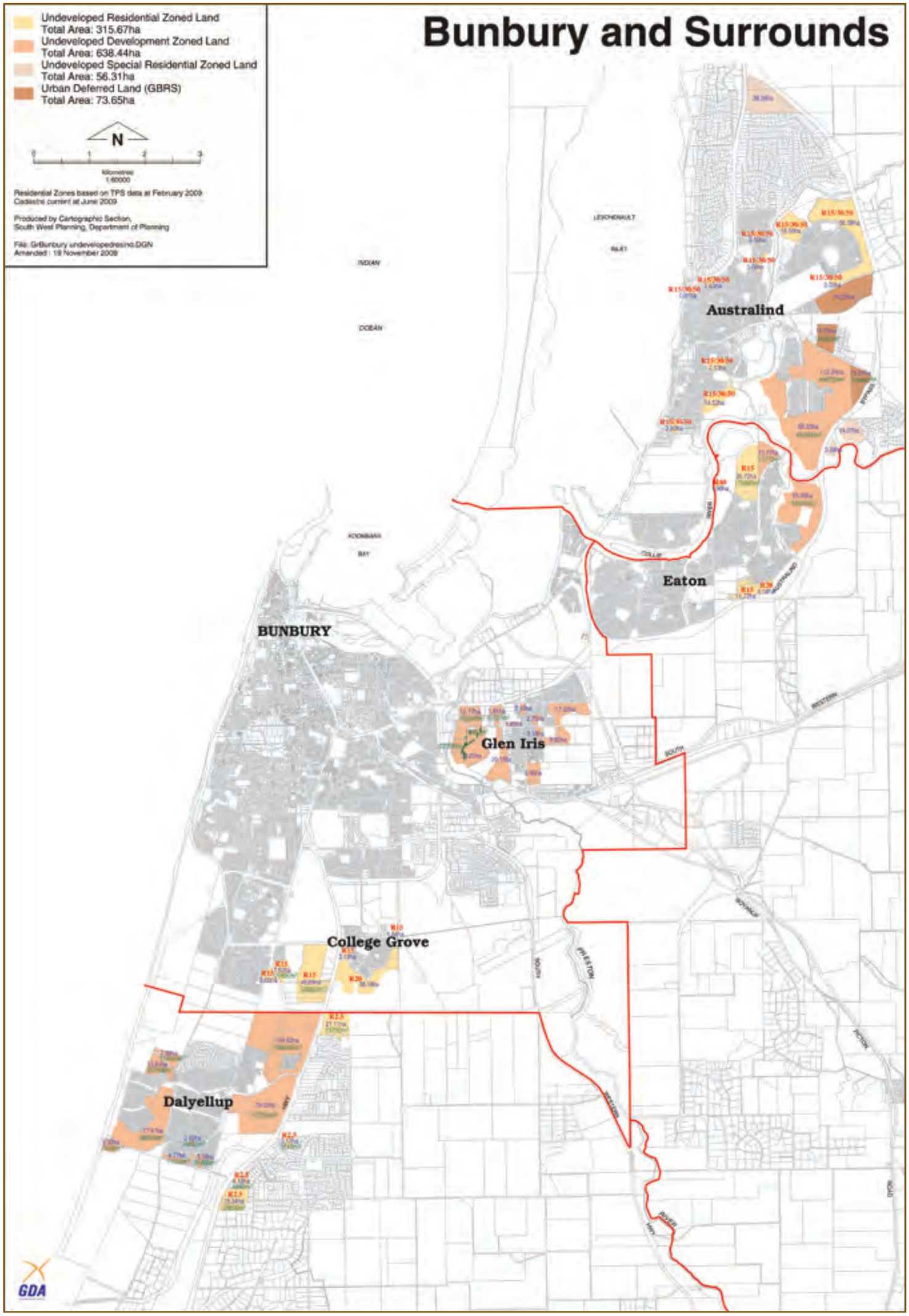
Supply data has been difficult to obtain from extractive industries as there is no requirement to report extractive volumes and for reasons of commercial interest companies are reticent to provide data. The DMP has produced broad estimates of potential supplies in the area. Not all of the resources identified maybe available for environmental reasons; however, the figures indicate the potential BRM availability based on geological survey data of the DMP.

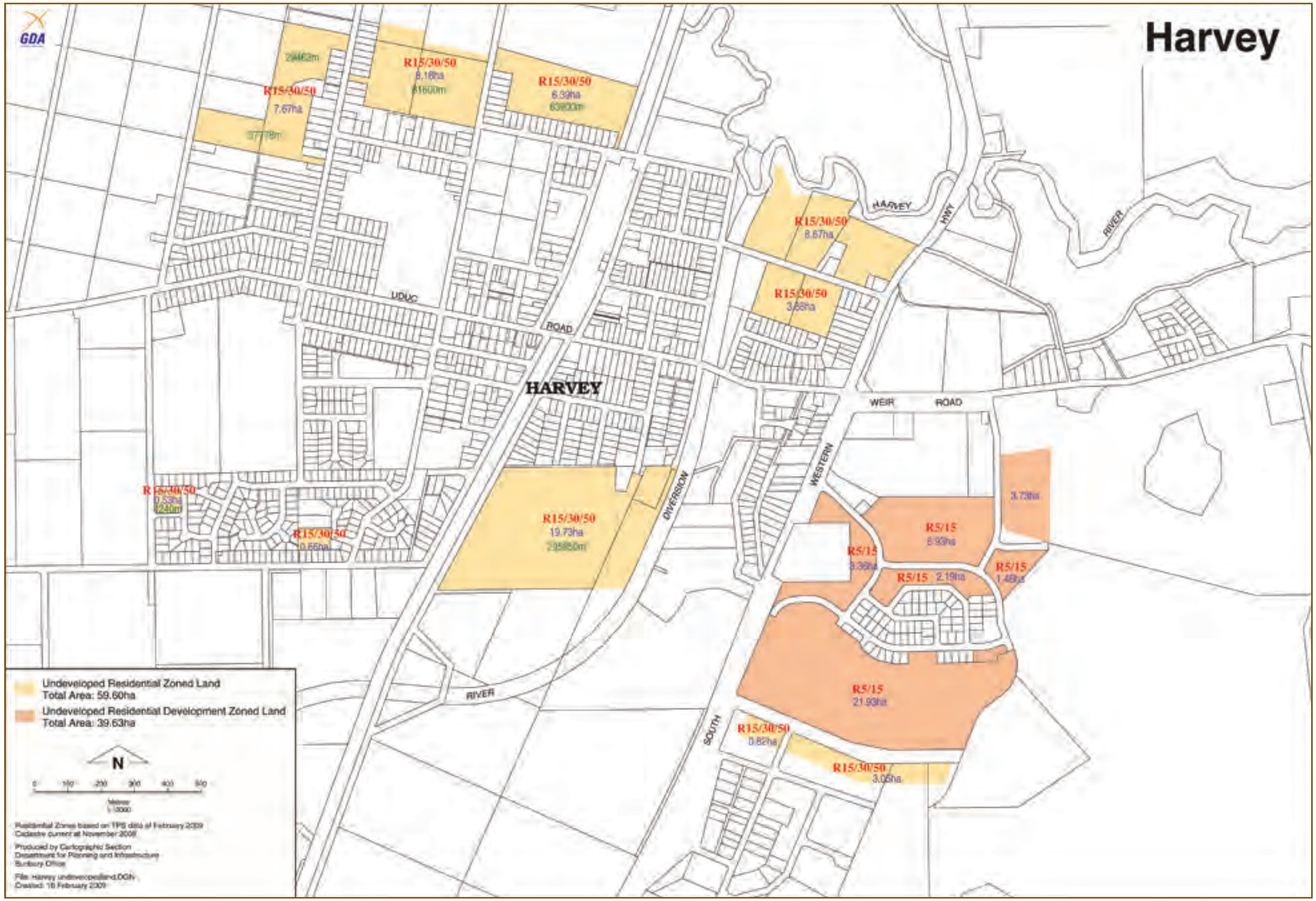

GDA
Brunswick Junction
BRUNSWICK JUNCTION
R15/30/50
1.37ha
R15/30/50
2.95ha
18.85ha
R15/30/50
0.48ha
R15/30/50
27.19ha
R15/30/50
0.90ha
R15/30/50
2.77ha
2216m
2.03ha
BRUNSWICK
ROAD
BEELA
ROAD
RIVER
GEORGE
AVENUE
CLIFTON
OKANAGEY
WESTERN
HWY
SOUTH
Undeveloped Residential Zoned Land
Total Area: 35.65ha
Undeveloped Special Residential Zoned Land
Total Area: 21.88ha
N
0 100 200 300 400 500
Metres
1:10000
Residential Zones based on TPS data at February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Brunswick undevelopedland.DGN
Created: 16 February 2009

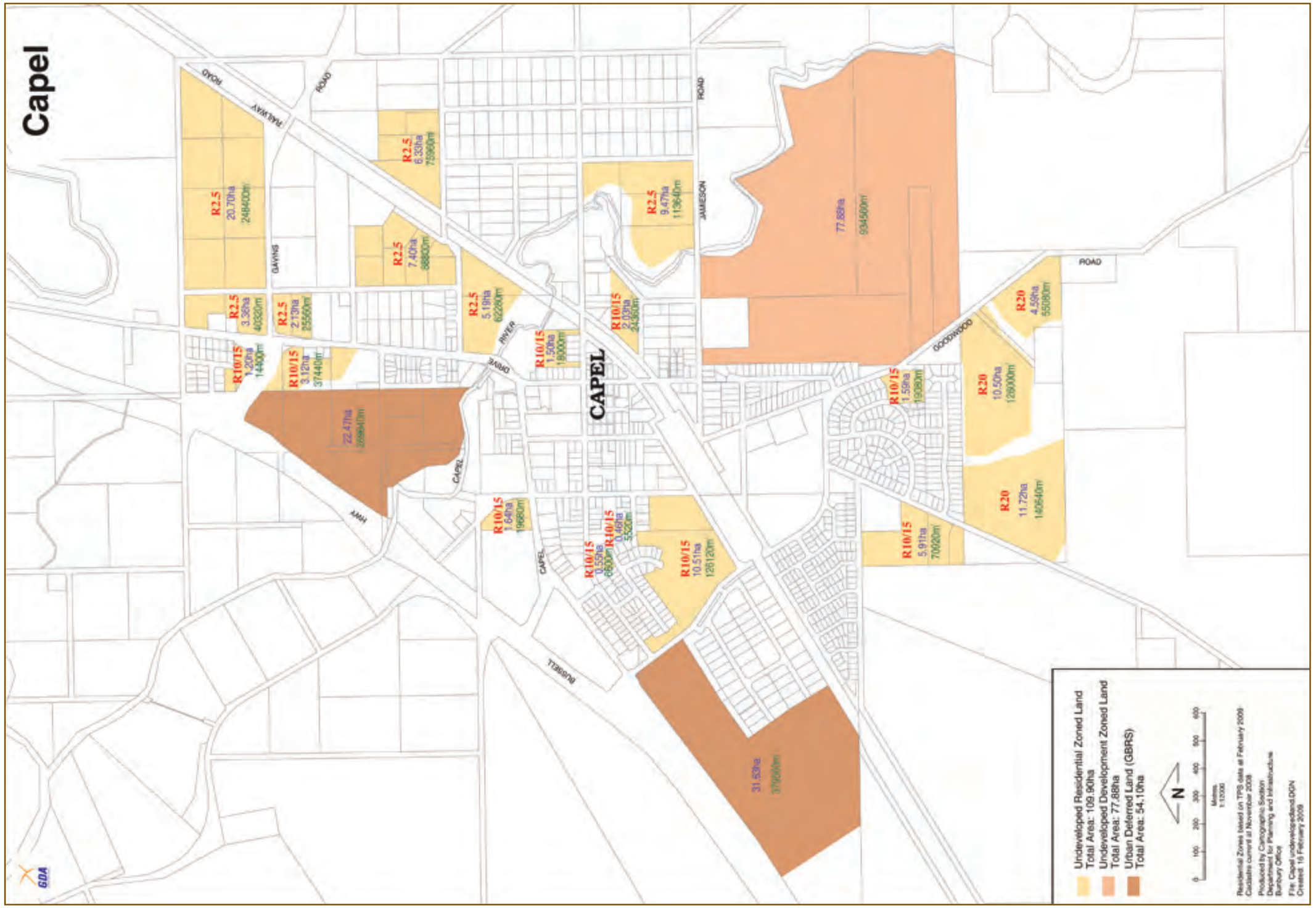

Burekup/Roelands
GDA
HWY
R15/30/50
2.91ha
R15/30/50
19.25ha
Roelands
R15/30/50
16.14ha
RAYMOND
ROAD
WESTERN
COALFIELDS
SOUTH
ROAD
COLLIE
R12.5
7.46ha
R12.5
1.39ha
Burekup
R12.5
3.44ha
RIVER
Undeveloped Residential Zoned Land
Total Area: 39.05ha
Urban Land (GBRS)
Total Area: 34.87ha
Urban Deferred Land (GBRS)
Total Area: 26.47ha
N
0
150
300
450
600
Metres
1:15000
Residential Zones based on TPS data at May 2010
Cadastre current at March 2010
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Roelandsburekup undevelopedland.DGN
Created: 19 March 2010

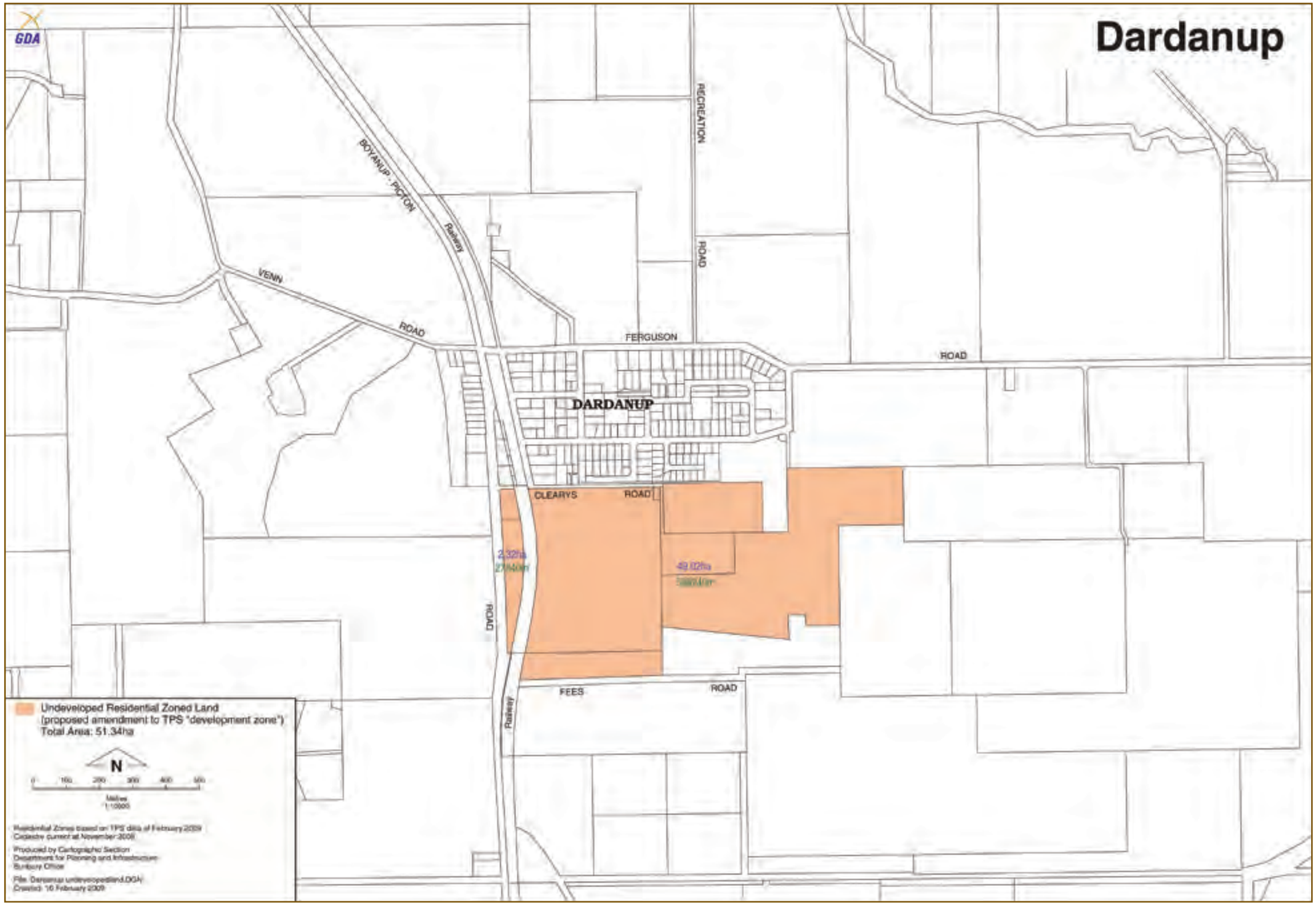

Busselton
BUSSELTON
Undeveloped Residential Zoned Land
Total Area: 214.26ha
Undeveloped Development Zoned Land
Total Area: 543.29ha
N
0 0.5 1 1.5 2 2.5
kilometres
1:50000
Residential Zones based on TPS data at February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Busselton undevelopedland.DGN
Created: 16 February 2009

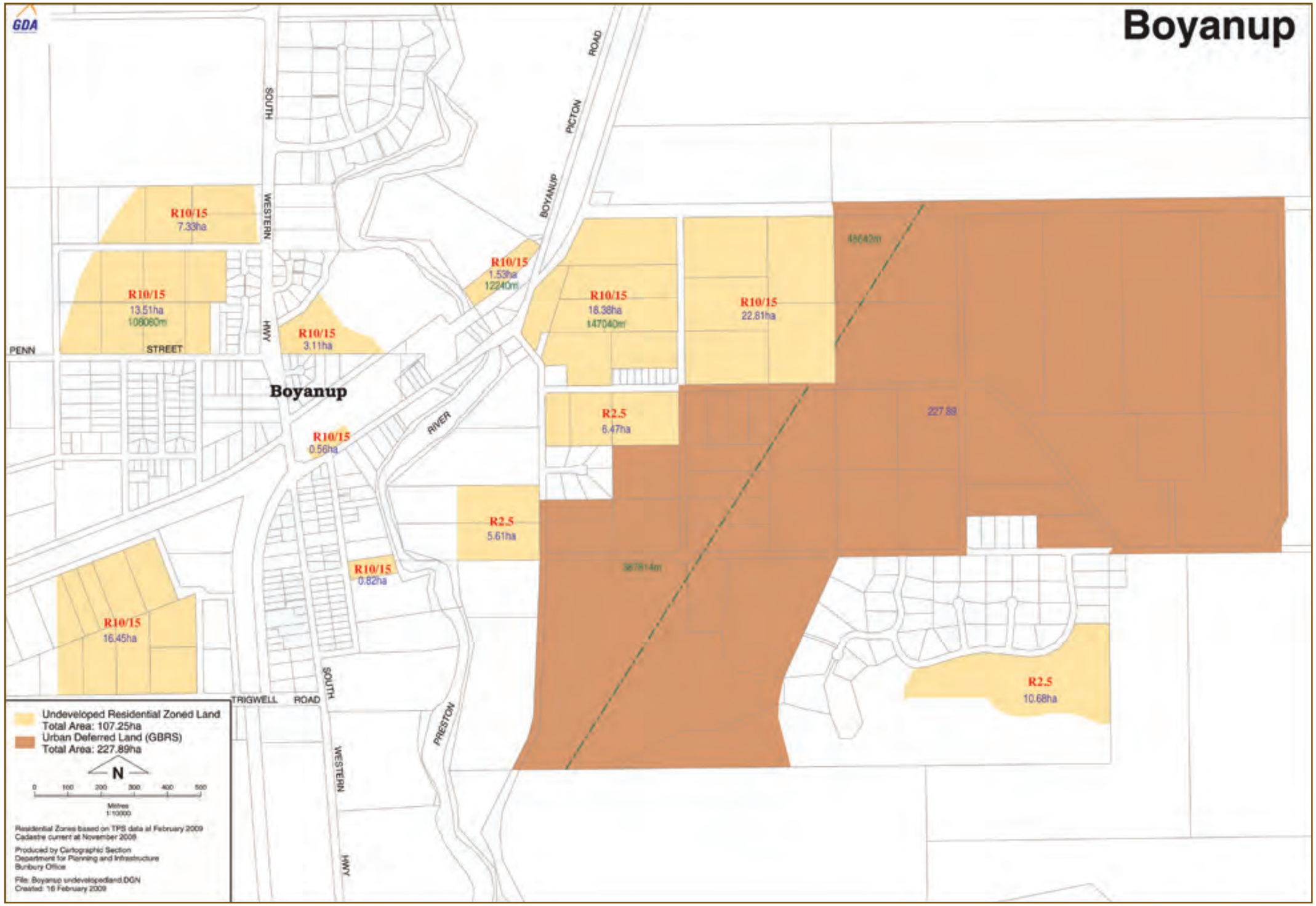
Bunbury and Surrounds




GDA
Harvey
R15/30/50
8.16ha
R15/30/50
6.39ha
63903m
R15/30/50
7.67ha
R15/30/50
8.67ha
R15/30/50
3.68ha
HARVEY HWY
RIVER
UDUC
ROAD
HARVEY
WEIR ROAD
WESTERN
R15/30/50
0.53ha
R15/30/50
10.66ha
R15/30/50
19.73ha
205850m
DIVERSION
3.73ha
R5/15
6.93ha
R5/15
3.36ha
R5/15 2.19ha
R5/15
1.48ha
R5/15
21.93ha
RIVER
SOUTH
R15/30/50
0.82ha
R15/30/50
3.05ha
Undeveloped Residential Zoned Land
Total Area: 59.60ha
Undeveloped Residential Development Zoned Land
Total Area: 39.63ha
N
Residential Zones based on TPS data of February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Harvey undevelopedland.DGN
Created: 16 February 2009


Capel
CAPEL
PALMAY ROAD
ROAD
JAMIESON
ROAD
GOODWOOD
RIVER
DRIVE
CAPEL
R2.5 20.70ha 24840m²
R2.5 6.33ha 75960m²
R2.5 7.40ha 88800m²
R2.5 9.47ha 113640m²
R2.5 3.36ha 40320m²
R2.5 2.13ha 25560m²
R2.5 5.19ha 62280m²
R10/15 1.20ha 14400m²
R10/15 3.12ha 37440m²
R10/15 1.50ha 18000m²
R10/15 2.03ha 24360m²
77.88ha 934500m²
R20 4.59ha 55080m²
R20 10.50ha 126000m²
R10/15 1.59ha 19080m²
R20 11.72ha 140640m²
22.47ha 269640m²
R10/15 1.64ha 19680m²
R10/15 0.55ha 6600m²
R10/15 0.46ha 5520m²
R10/15 10.51ha 126120m²
R10/15 5.91ha 70920m²
31.53ha 378360m²
Undeveloped Residential Zoned Land
Total Area: 109.90ha
Undeveloped Development Zoned Land
Total Area: 77.88ha
Urban Deferred Land (GBRS)
Total Area: 54.10ha
N
0 100 200 300 400 500 600
Metres
1:12000
Residential Zones based on TPS data at February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Capel undeveloped.DGN
Created: 16 February 2009
GDA


GDA
Dardanup
BOYANUP - PICTON
Railway
RECREATION
ROAD
VENN
ROAD
FERGUSON
ROAD
DARDANUP
CLEARYS
ROAD
2.32ha
49.02ha
ROAD
Railway
FEES
ROAD
Undeveloped Residential Zoned Land
(proposed amendment to TPS "development zone")
Total Area: 51.34ha
N
0
100
200
300
400
500
Metres
1:10000
Residential Zones based on TPS data of February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Dardanup undevelopedland.DGN
Created: 10 February 2009


Boyanup
GDA
SOUTH WESTERN HWY
PICTON ROAD
BOYANUP
PENN STREET
RIVER
TRIGWELL ROAD
SOUTH WESTERN HWY
PRESTON
R10/15
7.33ha
R10/15
13.51ha
108080m
R10/15
3.11ha
R10/15
1.53ha
12240m
R10/15
18.38ha
147040m
R10/15
22.81ha
48642m
227.89
R2.5
6.47ha
R10/15
0.56ha
R2.5
5.61ha
R10/15
0.82ha
367814m
R10/15
16.45ha
R2.5
10.68ha
Undeveloped Residential Zoned Land
Total Area: 107.25ha
Urban Deferred Land (GBRS)
Total Area: 227.89ha
N
0 100 200 300 400 500
Metres
1:10000
Residential Zones based on TPS data at February 2009
Cadastre current at November 2008
Produced by Cartographic Section
Department for Planning and Infrastructure
Bunbury Office
File: Boyanup undevelopedland.DGN
Created: 16 February 2009