ECONOMIC CONTRIBUTION OF THE EXTRACTIVE INDUSTRIES IN VICTORIA

REPORT BY
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FOR

CEMENT CONCRETE & AGGREGATES AUSTRALIA

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ACCESS ECONOMICS

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EXECUTIVE SUMMARY

BACKGROUND

Cement Concrete and Aggregates Australia (CCAA) commissioned Access Economics (AE) to prepare a report describing the economic contribution of the extractive industries in Victoria. The objective is to provide policymakers and the Victorian public with facts and analysis to help inform the development of sound policies toward the industry.

CCAA determined the scope of the study and coordinated the provision of industry information. AE directly approached four main industry players (Barro Group, Boral, Hanson, and Readymix) for information about their quarrying operations. Much of the detailed analysis is based on data provided by these firms. The interpretations and findings in the study are those of AE, but these are in turn conditional on the underlying information from industry sources.

Hard rock and sand/gravel are the particular concern of CCAA and are therefore the focus of this report. CCAA membership includes the cement industry and, by extension, the extraction of limestone, but it does not cover clay, which is heavily transformed (into bricks, pavers etc.) before being used in construction. Nor does it cover minor specialist products such as scoria and tuff. CCAA represents the bulk of the Victorian extractive industries' activities.

The hard rock and sand/gravel which CCAA covers are either directly input to building, construction and infrastructure projects, or else are only simply transformed into pre-mix concrete or asphalt. Because stone has a low weight-to-value ratio, transport costs are a significant component of the final delivered cost to the consumer. Consequently the economics of hard rock and sand/gravel are determined by those of (A) quarrying and (B) road transport.

Issues and policies associated with quarry siting relative to market location, quarry operation and road transport, are crucial to the economics of the industry.

Of the 854 operating and non operating quarry sites in Victoria, 206 are located in the Metropolitan Supply Region.

ECONOMIC CONTRIBUTION

In 2003-04 Victorian quarries[1]:

- Produced 38.8 million tonnes of stone;
- Had total sales of almost $450 million; and
- Employed 2,218 full time equivalent (FTE) staff.

In 2003-04 Victorian quarries contributed:

- Just under half (42%) of the total value of mining production in Victoria, and

[1] All quarries which produce hard rock, clay, limestone, sand, scoria, soil or tuff.

- Over half (51%) of total employment in Victorian mining.

Specifically, in 2003-04 Victorian hard rock and sand/gravel quarries produced 33.7 million tonnes of hard rock and sand/gravel, and overall (directly and indirectly):

- **Contributed around $450 million to Gross State Product**; and
- **Accounted for around 3,800 FTE jobs**.

Role in Victorian Construction

Hard rock and sand are widely used in construction and are a significant part of the costs of certain types of investment projects. AE analysis of typical project data provided by the industry suggests that hard rock and sand contributes to:

- approximately 33% of the cost of pre-mix concrete delivered to metropolitan construction sites, and
- approximately 14% of the cost of asphalt delivered to metropolitan construction sites.

Furthermore hard rock and sand contributes between 5% and 15% of the total cost of a wide range of metropolitan civil engineering and infrastructure projects, including:

- trunk sewer,
- urban arterial road,
- urban freeway, and
- residential subdivision.

Any increases in the delivered cost of hard rock, sand, pre-mix concrete and asphalt will flow through strongly to the costs of such projects.

Pre-mix concrete is an essential part of most building projects. Hospitals, offices and shopping malls depend on concrete floors and structures. Low rise buildings sit on concrete slabs. The Victorian Government's Five Star thermal rating system for housing has delivered a major endorsement of concrete slab on ground construction, with the inherent thermal mass of concrete earning significant credits under the rating system.

In 2005 1.3 million tonnes of asphalt and 4 million cubic metres of pre-mix concrete were delivered to Melbourne construction sites. The asphalt and pre-mix concrete contained a total of 5.2 million tonnes of hard rock aggregate and 3.6 million tonnes of sand.

Efficient production and distribution of these quarry products is crucial if the Victorian construction industry is to contribute effectively to the state's economic and social development.

Low construction costs ensure high levels of investment in infrastructure projects, consequently maintaining higher living standards now, and enabling faster growth in living standards in the future.

The Current Cost of Hard Rock and Sand/Gravel Delivered to Metropolitan Melbourne

For every kilometre a quarry is located from the investment project using the stone (usually in metropolitan areas) the higher the cost of the delivered product.

Transport costs contribute significantly to the delivered cost of quarry products, and that there are substantial social costs associated with road transport that are not reflected in the prices charged by transport operators.

Industry advice is that aggregate delivered in metropolitan Melbourne currently moves 30-35 km from quarry to point of use, while sand currently moves around 60kms from quarry to point of use.

- This distance adds 27%-51% to the ex-bin price of the product (or $4.50 to $9.00 per tonne of product).

Transport costs contribute significantly to the delivered cost of quarry products, and that there are substantial social costs associated with road transport that are not reflected in the prices charged by transport operators. These **externalities** of road transport typically include additional road accidents, environmental costs (noise, air and water pollution, and greenhouse gas emissions), and additional road maintenance costs.

- Externalities not reflected in operator costs would raise the cost of transport to 31%-61% of the ex-bin price of the product (or $5.33 to $10.66 per tonne of product).

Implications of Restricting Supplies from Existing Well-Located Quarries

Quarry location is a key influence on delivered cost and on the total cost paid for by society.

If supply from existing quarries ceased, and were replaced (say) by that from quarries 50km further from the city[2], then transport operator costs would rise by $7.50 per tonne and total private and social costs of transport by $8.89.

- **Thus increasing the price of the delivered product by between 28% and 39%**, depending on the type of product.

The subsequent increase in construction costs would reduce investment in infrastructure projects and/or require increases in State taxes to fund it, resulting in additional distortions and inefficiencies in the Victorian economy and slower growth in living standards in the future.

When the social costs (externalities) associated with road transport are included[3]

- **the total social cost of the delivered product would increase by between 32% and 45%**, depending on the type of product.

[2] The 50 km distance is hypothetical. However, it is within the range found in specific case studies reviewed by AE.

[3] Does not include the deadweight loss (the additional distortions and inefficiencies in the economy) from increasing taxes to pay for the higher construction costs.

If the 8.8 million tonnes of hard rock and sand embodied in the premix concrete and asphalt annually delivered to metropolitan Melbourne had to cover this additional distance, the additional transport operator cost would be $66m annually. The total cost, including externalities, would be $78m annually.

Cessation of supply from existing quarries could also mean substantial upfront capital costs if closure of existing quarries meant that new quarries had to be opened on greenfields sites.

These costs need to be given full weight in assessing applications to protect or expand operations of existing quarries, or approve new quarries close to metropolitan areas.

Protecting supply of high quality rock from existing quarries would appear important in achieving strategic goals, such as those set out in *Melbourne 2030*.

Access Economics

May 2006

1. BACKGROUND

Cement Concrete and Aggregates Australia (CCAA) commissioned Access Economics (AE) to prepare a report describing the economic contribution of the extractive industries in Victoria. The objective is to provide policymakers and the Victorian public with facts and analysis to help inform the development of sound policies toward the industry.

The report uses official data and unpublished statistics from major firms in the industry to establish the overall importance of the extractive industries to the Victorian economy and its construction sector. It is also an important contribution to understanding the economic, environmental, and social effects that need to be assessed when making an extraction application. In particular it explores the economic consequences of possible curtailment of the operation and/or extension of existing quarries, which are close to major metropolitan markets for quarry products.

CCAA determined the scope of the study in consultation with AE and coordinated the provision of information not available from the Department of Primary Industries (DPI) and other official sources. AE directly approached four main players in the extractive industries in Victoria (Barro Group, Boral, Hanson, and Readymix) for information about their quarrying operations. Much of the detailed analysis is based on the data provided by these firms. However, in order to maintain confidentiality the results reported in this study are from data pooled across the four firms, often extrapolated to the industry as a whole, based on benchmark information published by the DPI.

AE is grateful for the cooperation of the industry in providing information for this study and for allowing access to existing economic analyses of the implications of proposed quarry extensions. The interpretations and findings in the study are those of AE, but these are in turn conditional on the underlying information from industry sources.

1.1 WHAT ARE "EXTRACTIVE INDUSTRIES"?

Extractive industries (commonly referred to as quarries) are an important part of the mining industry. They produce crushed stone (aggregate), sand and other quarry outputs that are used mainly in building and infrastructure construction. Outputs are either used directly, as road base, or as constituents in pre-mix concrete, pavers, asphalt etc, which are themselves used in the construction industry.

The Extractive Industries Development Act 1995 (EIDA) defines **"extractive industry"** as the extraction or removal of stone from land if the primary purpose is the sale or commercial use of the stone in construction, building, road or manufacturing work. **"Stone"** includes building stone; basalt, granite, limestone and other rock used for building, manufacturing, road making or construction purposes; quartz; gravel; clay; sand, earth, and soil.

Extractive industries so defined appear to correspond well with ABS Industry Group 141:"Construction Material Mining". However, for regulatory purposes, the Victorian Act also includes "the treatment of stone or the manufacture of bricks, tiles, pottery, or cement products on or adjacent to land from which the stone is extracted".

Stone divides broadly into **hard rock**, whose extraction generally requires the use of explosives, and **soft rock**, which can generally be extracted without explosives. Hard rock is durable and strong and is used in building and road construction.

The quality of hard rock is depends mainly on its Polished Stone Value (PSV) and strength. The hard rock classes of sealing aggregates are as follows.

- Class A Stone: required for sealing and higher quality asphalt aggregates in road surfacing applications. It requires a high PSV in order to provide sufficient traction for roads.
- Class B Stone: used for general asphalt aggregates, concrete aggregates, and high quality base or upper layers in road construction.
- Class C Stone and below: lower grades of rock used for low strength general concrete aggregate production, but more appropriately used in crushed rocks as they are not as strong as other classes.

The main types of **hard rock** extracted in Victoria are:

- **Basalt** (from lava flows). "Old" basalt (15 to 65 million years old) is typically hard, dense and glassy, well suited for road construction. "New" basalt (less than five million years old) is generally grey or blue-grey in colour. It is more reactive than old basalt, and therefore more subject to chemical alteration and break-down when exposed to moisture.
- **Granite** (formed from magma solidifying deep under the surface).
- **Hornfels** (formed by metamorphosis of sedimentary rocks near granite masses).
- **Rhyodacite** (a hard acid volcanic rock).
- Harder **sedimentary rocks**: These are generally of lower grade, used for road base and general fill.

The main types of **soft rock** include:

- **Sand and gravel**. These are categorised according to uniformity and grain size. Fine sand is used in the preparation of mortar and other specialised products. Coarse sand is usually washed and mostly used in the manufacture of concrete and concrete products. Gravel is mainly used for fill.
- **Limestone**, used in agriculture and for manufacture of lime and cement.
- **Clay** and **clay shale**, used in the manufacture of bricks, pavers and roofing tiles.
- **Scoria** and **tuff**, mainly used as low-grade road material and for specialist uses such as light weight concrete, pavers and landscaping.

Stone is used in large quantities in construction and infrastructure projects. It is used directly (as fill, road base, railway ballast and in agriculture) and also in manufactured products including pre-mix concrete, pre-cast concrete products, asphalt, bricks and cement. Because stone has a low weight to value ratio, transport costs are a significant component of the final delivered cost to the consumer. **Hence quarry location has a major impact on the delivered price of stone.**

Hard rock and sand/gravel are the particular concern of CCAA and are therefore the focus of this report. CCAA membership includes the cement industry and, by extension, the extraction of limestone, but it does not cover clay, which is heavily transformed (into bricks, pavers etc.) before being used in construction. Nor does it cover minor specialist products such as scoria and tuff. CCAA represents the bulk of the Victorian extractive industries' activities. The hard rock and sand/gravel which it covers are either directly input to building, construction and infrastructure projects, or else are only simply transformed into pre-mix concrete or asphalt. The economics of hard rock and sand/gravel are determined by those of (A) quarrying and (B) road transport. Issues and policies associated with quarry siting, relative to market location, quarry operation and road transport, are crucial to the economics of the industry.

1.2 DISTRIBUTION OF QUARRIES IN VICTORIA

Hard rock and sand/gravel quarries are reasonably evenly distributed across the state in a pattern dictated by the locations of the resource and the markets.

Of the 854 operating and non operating quarry sites in Victoria, 206 are located in the Metropolitan Supply Region[4]. Since regional markets are generally much smaller, non-metropolitan quarries have much lower average output.

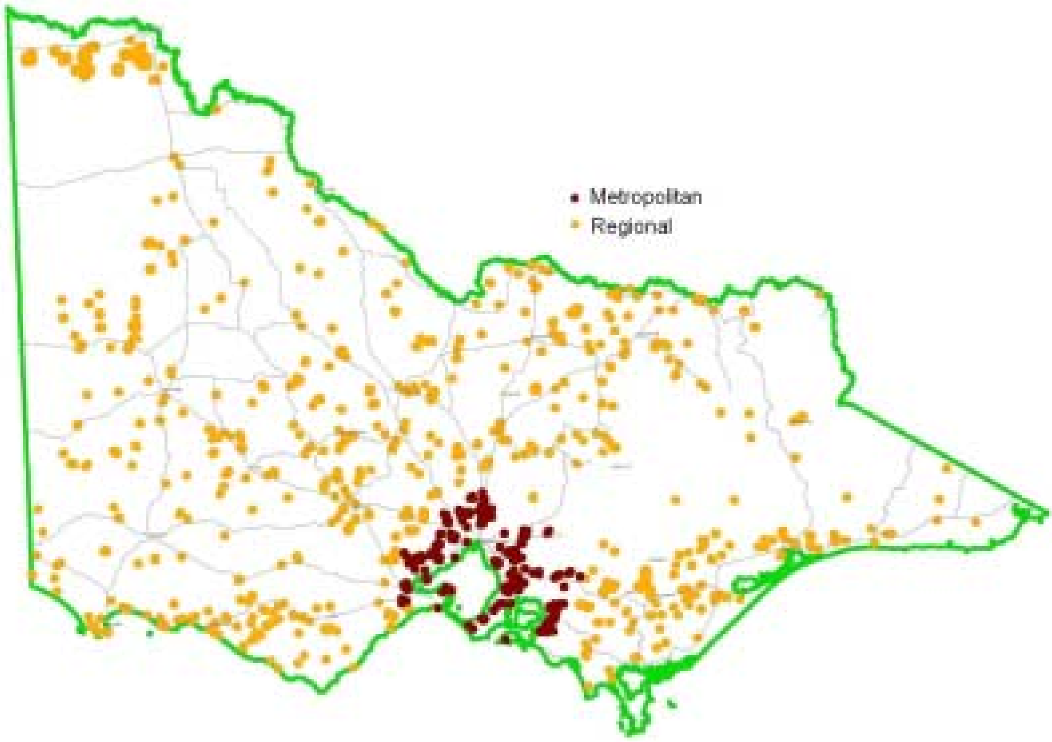
TABLE 1-1 VICTORIAN EXTRACTIVE INDUSTRIES WORK AUTHORITIES

	Metropolitan	Regional	Total
Hard Rock			
Basalt	30	39	69
Granite	6	26	32
Slate	0	8	8
Dolerite	0	2	2
Gneiss	0	1	1
Hornfels	3	18	21
Quartzite	5	9	14
Rhyodacite	1	2	3
Sedimentary	7	80	87
Tracgyte	0	1	1
Hard Rock Total	**52**	**186**	**238**
Soft Rock			
Clay	25	23	48
Limestone	5	76	81
Sand	109	321	430
Scoria	5	23	28
Soil	8	7	15
Tuff	2	12	14
Peat	0	1	1
Soft Rock Total	**154**	**463**	**617**
Total	206	649	854

Source: DPI Unpublished (2005)

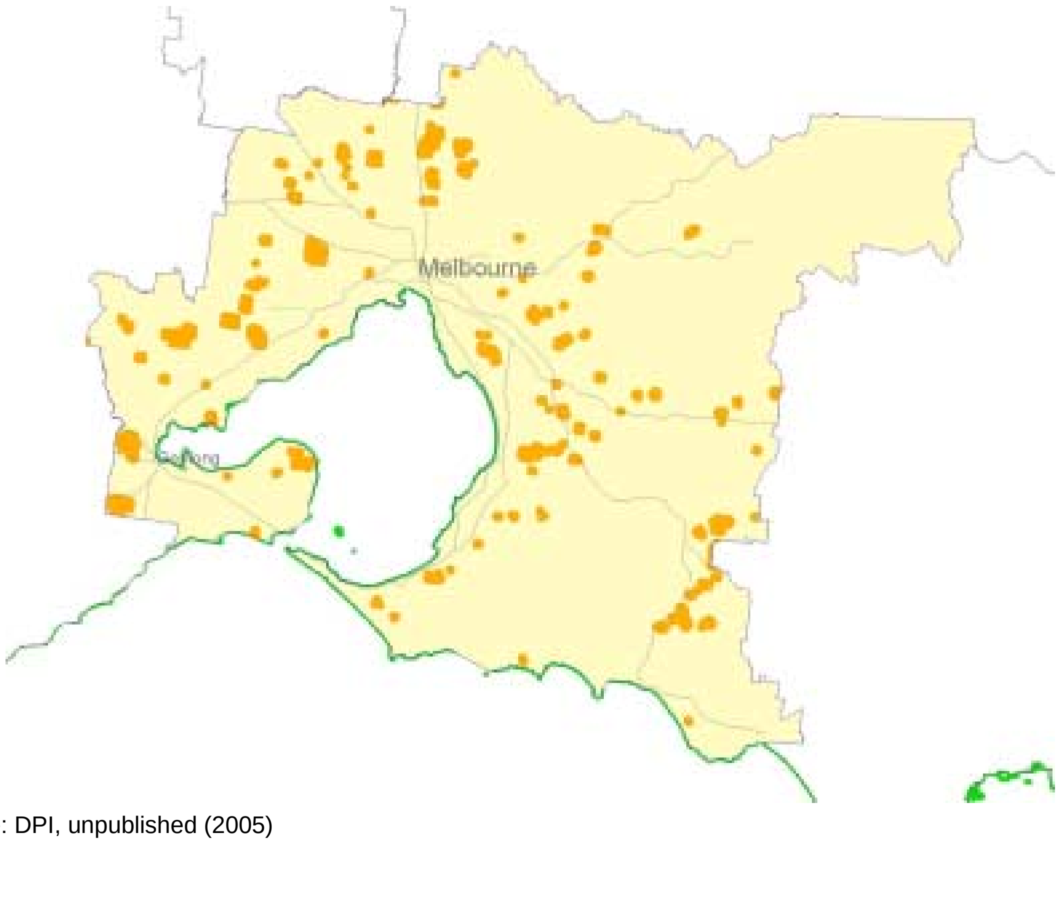
[4] Based on the number of current work authorities issued by the Department of Primary Industry. Not all quarries are operational. The boundaries of the Metropolitan Supply Region are determined by DPI to correspond with the area from which stone supplies for Metropolitan Melbourne are drawn. See Olshina and Burn (2003)

FIGURE 1-1 VICTORIAN QUARRIES METROPOLITAN AND REGIONAL



Source: DPI Unpublished (2005)

FIGURE 1-2 VICTORIAN METROPOLITAN QUARRIES



Source: DPI, unpublished (2005)

Summary

Hard rock and sand/gravel are the focus of this report. These products are used in large quantities in building, construction and infrastructure projects. They are used directly (as fill, road base or railway ballast) and indirectly in simply transformed manufactured products including pre-mix concrete, pre-cast concrete products and asphalt.

Because stone has a low weight-to-value ratio, transport costs are a significant component of the final delivered cost to the consumer. **Hence quarry location relative to market location has a major impact on the delivered price of stone.**

Of the 854 operating and non operating quarry sites in Victoria, 206 are located in the Metropolitan Supply Region.

2. THE ECONOMIC CONTRIBUTION OF THE EXTRACTIVE INDUSTRIES

This section sets out key economic facts about the Victorian extractive industries and explores their economic contribution.

The **'economic contribution'** of an industry is the direct and indirect revenue, value-added, employment and other expenditures that are associated with the given industry. Studies of economic contributions are historical accounting exercises that describe the industrial and geographical linkages that characterise all economic activity. The information is interesting on its own, and as a basic input to more sophisticated analyses that attempt to answer "what if?" questions such as "what would be the consequence of varying the location of an industry or its cost structure?"

However, "economic contribution" studies **do not** take account of the market responses caused by any given change in the industry's circumstances. They do not measure short term responses such as "crowding out" or mobilisation of under utilised resources. Nor do they take account of longer term responses as the economy responds to changes in the structure of prices, wages and expected rates of return. Specifically, economic contribution studies do not provide an answer to extreme hypothetical questions, such as "what would happen if the industry disappeared?"

2.1 KEY ECONOMIC FACTS

2.1.1 PRODUCTION

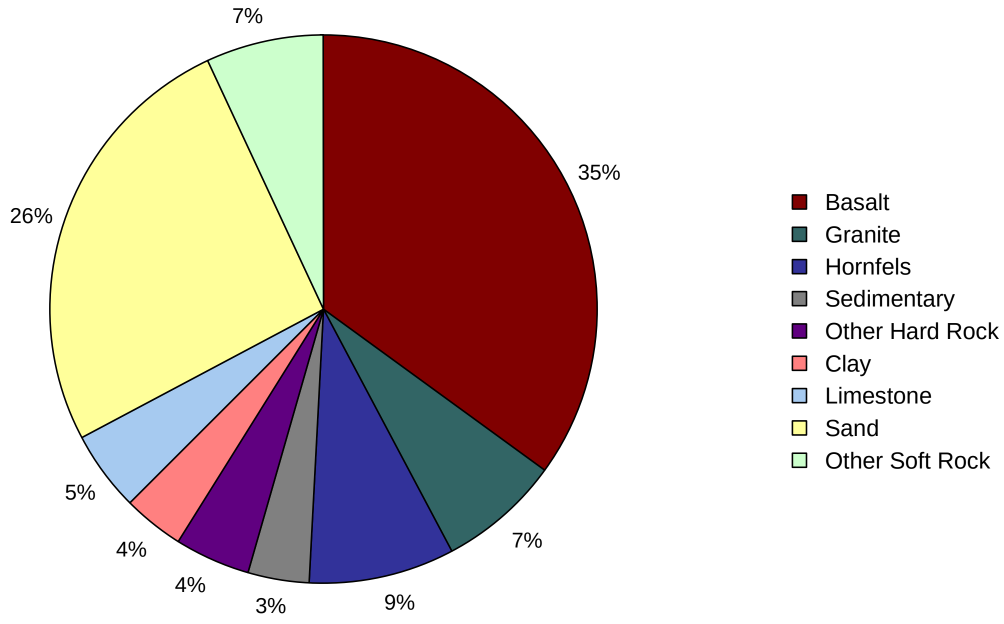
According to DPI (2004), Victorian quarries produced 38.8 million tonnes of stone in 2003-04 with an ex-bin value of $446.2m. As shown in Table 2-1 and Figure 2-1, the hard rock and sand/gravel that are CCAA's focus contributed 87% of the total tonnage, with a total ex-bin value of $406.2m (91% of the overall value).

Table 2-1 Victorian Extractive Industries Production and Sales, by Rock Type, 2003-04

	Sales (Million Tonnes)	Sales ($m)
Hard Rock		
Basalt	14.117	173.144
Granite	2.895	40.246
Slate	0.001	0.250
Dolerite	0.621	6.934
Gneiss	0.013	0.158
Hornfels	3.516	44.798
Quartzite	0.062	0.551
Rhyodacite	0.913	15.027
Sedimentary	1.404	9.791
Schist	0.199	2.523
Hard Rock Total	**23.743**	**293.422**
Soft Rock		
Clay	1.526	5.564
Limestone	1.909	21.192
Sand	10.425	113.735
Scoria	0.707	9.265
Soil	0.072	0.713
Tuff	0.448	2.391
Soft Rock Total	**15.088**	**152.860**
Total	**38.831**	**446.282**

Source: DPI (2004) p36

Figure 2-1 Composition of Victorian Extractive Industries Total Sales Revenue (Ex-Bin)



Source: DPI (2004) p36

2.1.2 Employment

The official statistics of Victorian extractive industries (DPI 2004) provide information only for total production and employment. Statistics of production are reported above.

According to DPI's statistics total employment in the whole of the extractive industries (for Workers Compensation purposes) was 2,218 (average full time equivalent basis) in 2003-04.

2.1.3 COMPARISON WITH OTHER TYPES OF MINING

The DPI's statistics allow us to compare production and employment in Victorian extractive industries with those in other types of mining. See Figure 2-2 and Figure 2-3

FIGURE 2-2 VALUE OF PRODUCTION IN TOTAL VICTORIAN MINING, 2003-04, $M

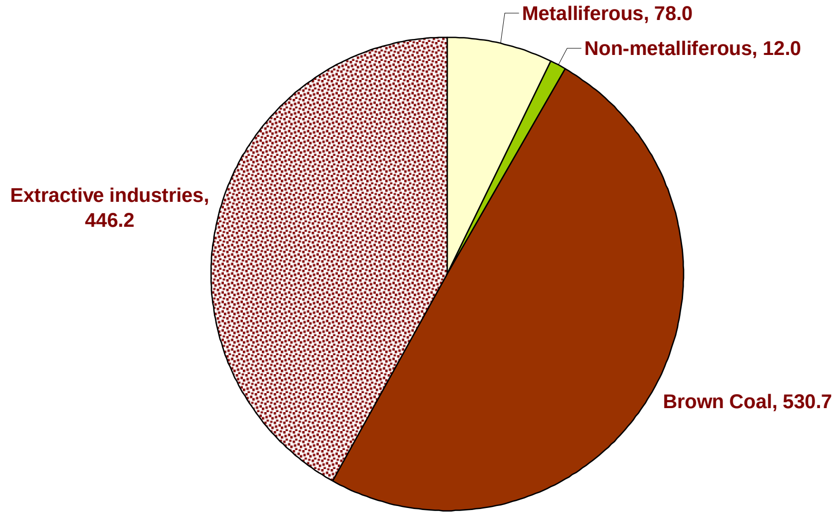
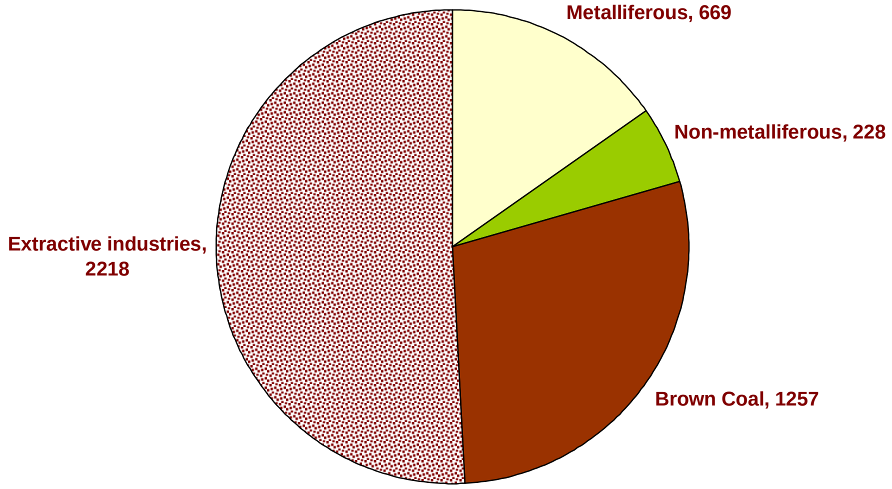


FIGURE 2-3 EMPLOYMENT IN TOTAL VICTORIAN MINING, 2003-04



In 2003-04 the extractive industries contributed:

- 42% of the total value of mining production in Victoria:
  - 5.7 times the value of production in metalliferous mining (mainly gold), and
  - 16% below the value of brown coal production.
- 51% of total employment in Victorian mining:
  - 3.3 times the level of employment in metalliferous mining, and
  - 76% more employment than in brown coal mining.

2.1.4 Industry Gross Product

To supplement the limited official data on the value of production, AE obtained detailed information from four major companies[5] extracting hard rock and sand/gravel in Victoria. By benchmarking these companies' value of sales in 2003-04 against the industry total published by DPI (See DPI 2005), it was possible to extrapolate the detailed information to derive corresponding estimates for the industry as a whole. Highlights of these estimates are as follows:

[5] The companies were Readymix Holdings Pty Ltd, Hanson Construction Materials Pty Ltd, Boral Resource (Vic) Pty Ltd, Barro Group Pty Ltd. Together these firms accounted for 69% of the total ex-bin value of hard rock and sand/gravel sold in Victoria in 2003-04.

Victorian Producers of Hard Rock and Sand/Gravel, Direct Economic Contribution 2003-04	
Total sales revenues:	**$500m**
Of which:	
Ex-bin sales	$410m
Other net revenue (mainly for cartage)	$90m
Purchases of intermediate inputs:	**$280m**
Of which:	
Cartage paid by producers	$90m
Business services	$50m
Maintenance	$30m
Fuel	$20m
Electricity, gas, water	$10m
Other inputs	$80m
Industry Gross Product in 2003-04:	**$220m**
Composed of:	
Wages, salaries, supplements	$50m
Gross operating surplus	$140m
Indirect taxes less subsidies	$20m
Commodity taxes less subsidies	$10m

Hard rock and sand/gravel quarries in Victoria directly contributed $220m to state gross product in 2003-04 (or 0.1% of total GSP). Direct employment in Victoria was 990 full time equivalent people (0.04% of total Victorian employment) at an average wage of $54,000.

2.2 INDIRECT ECONOMIC CONTRIBUTION

2.2.1 IMPACTS OF OPERATING EXPENDITURES

This section provides an estimate of the indirect contribution of hard rock and sand/gravel production through linkages with other sectors of the economy, based on the flows of value quantified in the input-output tables. 'Indirect' means the upstream value added associated with the production of goods and services used as inputs into Victorian quarry production. Once again, estimates of "indirect economic contributions" are historical accounting exercises that describe the type of normal industry linkages that characterise all economic activity. No 'what-if?', or counterfactual inferences, such as 'what would happen if the industry disappeared?' should be drawn from them.

To measure indirect value added requires expenditure on each item to be traced to each input used in its production, and the inputs used to create these inputs and so on. All of the intermediate input costs are allocated to the appropriate 34 ANZSIC industry categories:

- These costs to hard rock and sand/gravel producers represent revenues received by the supplying industries.
- In turn, these can be broken down into value added (wages, gross operating surplus and net indirect taxes *less* subsidies) plus intermediate inputs used by *those* industries.
- The same process is then applied to the intermediate inputs provided by *their* supplying industries.
- This process is continued further up the supply chain until all supplies are covered; using a matrix inversion process applied to input-output tables for Victoria for 2003-04, derived by AE and based on Australia-wide ABS input-output tables. (See Appendix for details).

Victorian Producers of Hard Rock and Sand/Gravel, Indirect economic contribution 2003-04

In 2003-04 hard rock and sand/gravel producers indirectly contributed a further $220m of industry gross product to the Victorian economy, over and above its direct contribution to GSP.

The total direct and indirect contribution to Gross State Product was an estimated $430m[6].

Direct and indirect employment accounted for 3,570 (full time equivalent) jobs.

These estimates of economic contributions are known to be slightly understated, in that they omit expenditure on (and employment in) cartage from quarries that is arranged and paid directly by customers themselves. The extent of this varies across quarries and product categories. According to industry sources, it may account for around 20% of the overall cartage task.

2.2.2 Impacts of Capital Expenditure

Based on estimates by the four leading suppliers, total gross fixed capital expenditure by hard rock and sand/gravel suppliers in Victoria totalled about **$30m** in 2003-04.

AE estimates the average annual indirect impacts of this expenditure would have been:

- a **$20m** contribution to Victorian gross state product (GSP); and
- **230** Victorian full-time equivalent jobs.

[6] After allowing for rounding

Summary

In 2003-04 Victorian quarries:

- Produced 38.8 million tonnes of stone;
- Had total sales of almost $450 million; and
- Employed 2218 full time equivalent (FTE) staff.

In 2003-04 Victorian quarries contributed:

- Just under half (42%) of the total value of mining production in Victoria, and
- Over half (51%) of total employment in Victorian mining.

Specifically, Victorian hard rock and sand/gravel producers:

- Produced 33.7 million tonnes of hard rock and sand/gravel;
- Raised $500 million in revenue ($410 million from ex-bin sales);
- Spent $280 million on inputs and $30 million on capital expenditure;
- Contributed around $220 directly to Gross State Product (GSP);
- Paid employee remuneration of $50 million; and
- Directly employed around 990 FTE staff.

Overall Victorian hard rock and sand/gravel producers, directly and indirectly:

- **Contributed around $450 million to GSP; and**
- **Accounted for around 3,800 FTE jobs.**

3. EXTRACTIVE INDUSTRIES' ROLE IN VICTORIAN CONSTRUCTION

The extraction of hard rock and sand makes a significant economic contribution particularly in regional Victoria. However, the main contribution of the industry is in providing a key input to Victorian construction.

3.1 TYPES OF PRODUCT

Hard rock is used directly, as road base and as fill, and also as an important constituent of concrete, concrete products and asphalt. Sand is used as fill, in concrete and cement mortar, and for specialised industrial purposes. Victorian extractive industries production and sales of the different grades of hard rock and sand/gravel are shown in Table 3-1

TABLE 3-1 PRODUCTION AND SALES, HARD ROCK & SAND/GRAVEL, 2003-04

	Sales (Million Tonnes)	Sales ($m)	Average value $/tonne ex bin
Single size products			
Aggregate Total	12.524	192.317	15.36
Armour	0.178	1.987	11.14
Total single size products	12.702	194.304	15.30
Multi size products			
Road base	5.794	69.675	12.03
Road sub-base	6.552	46.478	7.09
Fill	1.577	10.230	6.49
Total multi size products	13.923	126.383	9.08
Sand products			
Concrete sand	4.328	55.418	12.80
Fine sand	2.079	19.758	9.50
Total, all sand products[1]	6.884	79.869	11.60
Unallocated	0.659	6.601	10.02
Total hard rock & sand/gravel	**34.168**	**407.157**	**11.92**

Note (1) Total sales of sand products include foundry, industrial and glass sands.

Source: Derived from DPI (2004) p 37

In 2003-04:

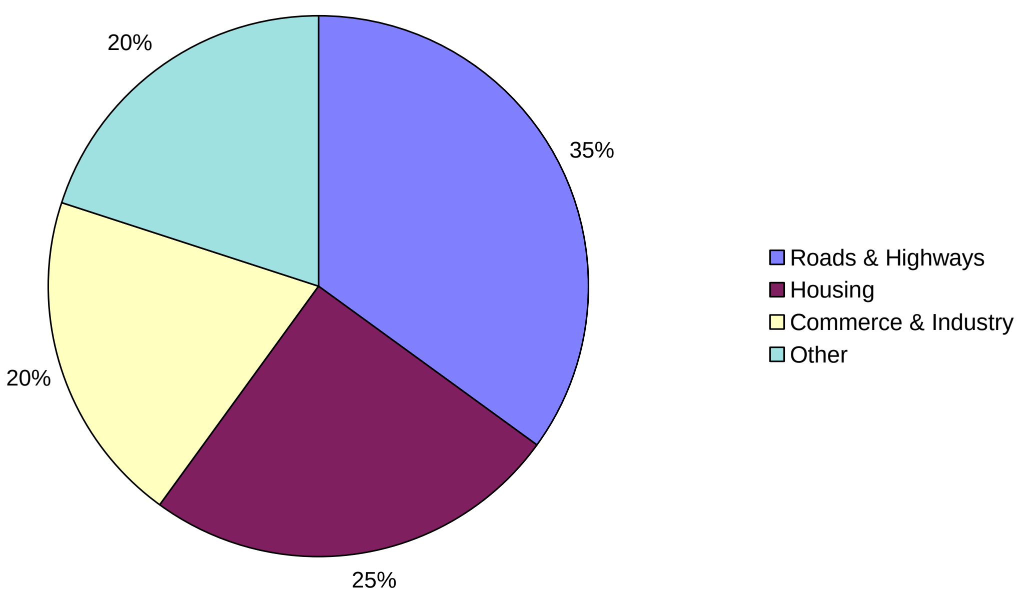
- Products mainly used in concrete (i.e. aggregate and concrete sand) contributed almost half (49%) of tonnage of hard rock and sand/gravel, and 61% of the value of sales;

- Products mainly used in road and pavement construction (i.e. armour, road base and sub-base) contributed over a third (37%) of tonnage and 29% of the value of sales;
- Fill contributed 5% of tonnage and 2% of the value of sales; and
- Fine sand (mainly used in cement mortar) contributed 6% of tonnage and 5% of the value of sales.

The average ex-bin values in these product categories were $14.70, $9.43, $6.49 and $9.50 per tonne respectively.

The Institute of Quarrying Australia has published a breakdown of national usage of aggregate in 2000 that is broadly consistent with these statistics (See Figure 3-1). The institute reports that 35% was used in road and highway construction, and the remainder in other types of building and engineering construction.

FIGURE 3-1 ESTIMATED USAGE OF AGGREGATE BY THE BUILDING AND CONSTRUCTION SECTOR



Source: The Institute of Quarrying Australia (2000) *Key facts about Aggregates and the Australian Quarrying Industry. Available*: www.quarry.com.au/page/key_facts.html

Through their use in roads and other transport infrastructure, and in the form of concrete and concrete products, hard rock and sand/gravel pervade Victorian building and construction.

3.2 CONTRIBUTION TO CONSTRUCTION COSTS

As reported in Section 2.1.4, the total estimated cost of hard rock and sand/gravel (including cartage paid to producers) was about $500m in 2003-04 – **equivalent to 0.6% of the sum of Victorian private construction investment and all public investment in 2003-04.**

While hard rock and sand are relatively small items in overall investment costs, they form a larger part of the costs of certain types of investment projects. AE analysis of typical project data provided by the industry suggests that:

- hard rock and sand are a substantial proportion of the cost of pre-mix concrete (33%) and asphalt (14%) delivered to metropolitan construction sites;
- hard rock and sand contribute between 5% and 15% of the total cost of a wide range of metropolitan civil engineering and infrastructure projects, including:
  - trunk sewer;
  - urban arterial road;
  - urban freeway; and
  - residential subdivision.

Any increases in the delivered cost of hard rock, sand, pre-mix concrete and asphalt will flow through strongly to the costs of such projects.

Pre-mix concrete is an essential part of most building projects. Hospitals, offices and shopping malls depend on concrete floors and structures. Low rise buildings sit on concrete slabs.

The Victorian Government's Five Star thermal rating system for housing has delivered a major endorsement of concrete slab on ground construction, with the inherent thermal mass of concrete earning significant credits under the rating system.

In 2005 1.3 million tonnes of asphalt and 4 million cubic metres of pre-mix concrete were delivered to Melbourne construction sites. The asphalt and pre-mix concrete contained a total of 5.2 million tonnes of hard rock aggregate and 3.6 million tonnes of sand.

Efficient production and distribution of these quarry products is crucial if the Victorian construction industry is to contribute effectively to the state's economic and social development.

Summary

In 2003-04, the total estimated cost of hard rock and sand/gravel ($500m) was equivalent to 0.6% of the sum of Victorian private construction investment and all public investment.

Hard rock and sand/gravel are widely used in construction and are a significant part of the costs of certain types of investment projects. Hard rock and sand:

- are a substantial proportion of the cost of pre-mix concrete (33%) and asphalt (14%) delivered to metropolitan construction sites;

- contribute between 5% and 15% of the total cost of a wide range of metropolitan civil engineering and infrastructure projects, including trunk sewers, urban arterial roads, urban freeways, and residential subdivisions.

Any increases in the delivered cost of hard rock, sand, pre-mix concrete and asphalt will flow through strongly to the costs of such projects.

Pre-mix concrete is an essential part of most building projects. Hospitals, offices and shopping malls depend on concrete floors and structures. Low rise buildings sit on concrete slabs. The Victorian Government's Five Star thermal rating system for housing has delivered a major endorsement of concrete slab on ground construction, with the inherent thermal mass of concrete earning significant credits under the rating system.

In 2005 1.3 million tonnes of asphalt and 4 million cubic metres of pre-mix concrete were delivered to Melbourne construction sites. The asphalt and pre-mix concrete contained a total of 5.2 million tonnes of hard rock aggregate and 3.6 million tonnes of sand.

Efficient production and distribution of these quarry products is crucial if the Victorian construction industry is to contribute effectively to the state's economic and social development.

4. DETERMINANTS OF DELIVERED COST

The delivered costs of hard rock and sand/gravel depend on production costs and market conditions (as reflected in the ex-bin price) and on transport costs. Market participants' responses to these costs and prices will determine the patterns of production and distribution from the various quarries. Where demand threatens to exhaust the resource available in particular quarries, it will signal the desirability of extending the available resource, or of opening new quarries to meet future demand.

However, road transport, quarry establishment and operation may also impose social costs, which are not directly reflected in the price signals that drive the decisions of market participants. It is important to identify and quantify these costs as far as possible. If they are significant, then government will need to ensure that land use and other regulation works to minimise the overall social cost of the quarry industry's development and operation.

In this section AE explores the available data on production and transport costs. We show that average production costs tend to be lower in larger quarries, but that there are significant up-front capital costs in establishing new quarries on greenfields sites. We also show that transport costs contribute significantly to the delivered cost of quarry products, and that there are substantial social costs associated with road transport that are not reflected in the prices charged by transport operators. Together this suggests that overall social costs may well be reduced by policies that facilitate the extension and/or expansion of production at well-located existing quarries.

We do not attempt to quantify in any general way the social and environmental costs associated with quarry establishment and operation. These are likely to vary across locations and are best assessed on a case by case basis during the planning process. There is some evidence, that these may often be small, in the economic assessments of the proposed quarry extensions discussed in Section 5. Strategic planning that keeps urban development from encroaching on valuable resources of rock and sand may help to reduce such costs.

Nor do we have data that would allow us to determine the mark-up of ex-bin prices over operating costs varies by quarry location, product category or the balance of supply and demand. As a general rule, however, such mark-ups are likely to be best kept in bounds if: (A) there is sufficient competition between well-located quarries to supply the main markets; and (B) the planning process minimises barriers to extension of existing quarries and the establishment of new ones.

4.1 TRANSPORT COSTS

4.1.1 PRIVATE AND SOCIAL COSTS OF ROAD TRANSPORT

The quarry industry is regionally focused, reflecting substantial road transport costs. Typical transport operator costs of around 15 cents per net tonne-kilometre are substantial relative to average ex-bin prices that, according to DPI's data (See Table 3-1) ranged from $6.49 to $15.36 depending on the grade of the product. In terms of transport operators' costs:

- This implies that a 35 km delivery run adds 34 - 81% to the ex-bin price of depending on the grade of the product.
- The price doubles for a distance somewhere between 43 and 102 km.

Road transport also has a well documented list of negative externalities affecting other road users and society as a whole. These include among others: environmental effects, road accidents, congestion and road wear. Ideally the costs of these externalities should be evaluated and added to the market cost of cartage.

These transport costs vary with the type of heavy vehicle used (for example, the amount of emissions and road wear) and the transport route (for example, in rural or urban areas and the type of road traveled on). Section 5 documents three case studies and estimates the total costs (including externality costs) associated with sourcing the quarry products from further away (methodology is contained in Appendix 1). Table 4-1 summarises these externality cost estimates in terms of cost per net tonne kilometre.

TABLE 4-1 ADDITIONAL TRANSPORT COSTS PER NTK ($)

	Point Wilson	Pakenham	Montrose	Average[7]
Transport Operator Costs	0.1500	0.1500	0.1500	**0.1500**
Road Accident Costs	0.0084	0.0097	0.0098	**0.0093**
Environmental Costs	0.0148	0.0200	0.0196	**0.0181**
Net Additional Road Maintenance	0.0001	0.0003	0.0005	**0.0003**
Total Transport Cost	0.1733	0.1801	0.1798	**0.1778**

Applying the average of these cost estimates implies that transport operator costs represent only around 84% of the total cost to society of transporting quarry products to metropolitan Melbourne. In terms of total costs to society, relative to average ex-bin prices as published by DPI,

- A 35 km delivery run adds 41 - 96% to the ex-bin price of depending on the grade of the product.
- The price doubles for a distance somewhere between 37 and 86 km.
- Increasing the transport distance by 50 km would increase the cost to society by nearly $9 per tonne of hard rock or sand/gravel delivered (an additional 58% to 137% of the ex-bin price).

4.1.2 IMPLICATIONS FOR QUARRY PRODUCTS DELIVERED TO MELBOURNE

As shown in Table 4-2, aggregate and sand delivered in metropolitan Melbourne currently move some 30-60 km from quarry to point of use.

TABLE 4-2 COST OF QUARRY PRODUCTS, PER TONNE OF PRODUCT, MELBOURNE

	Class A Aggregate	Fine sand*	Class B Aggregate
Typical Ex-bin Price	**$19.75**	**$17.50**	**$14.50**
Transport Distance (km)	35	60	30
Transport Operator Cost	$5.25	$9.00	$4.50
Delivered Price to Customer	**$25.00**	**$26.50**	**$19.00**
Road Accident Costs	$0.33	$0.56	$0.28
Environmental Costs	$0.63	$1.09	$0.54
Net Road Maintenance	$0.01	$0.02	$0.01
Transport Social Cost	$0.97	$1.66	$0.83
Total Price to Society	**$25.97**	**$28.16**	**$19.83**

* for cement mortar. Source: Industry

[7] unweighted average over the three case study quarries

Over these distances transport operator costs are typically adding some 27%-51% to the delivered cost of sand and aggregate. Including the additional environmental and social costs would raise these percentages to the range: 31%-61%.

However, transport costs depend crucially on distance. If supply from existing quarries ceased, and were replaced (say) by that from quarries 50km further from the city, then transport operator costs would rise by $7.50 per tonne and total private and social costs of transport by $8.89 per tonne.

Implications of increasing transport distances for quarry products by 50 km[8]

Increasing the distance over which quarry products are transported by 50 km would raise transport operator costs by $7.50 per tonne and total social costs (externalities) associated with road transport by $8.89 per tonne.

- transport operator costs would rise by between 1.8 and 2.7 times (to between $12.00 and $16.50 per tonne), and
- the price of the delivered product would increase by between 28% and 39%, depending on the type of product.

When the social costs (externalities) associated with road transport are included:

- the total social cost of the delivered product would increase by between 32% and 45%, depending on the type of product.

If the 8.8 million tonnes of hard rock and sand embodied in the premix concrete and asphalt annually delivered to metropolitan Melbourne had to cover this additional distance, the additional transport operator cost would be $66m annually. The total cost, including externalities, would be $78m annually.

Quarry location is a key influence on delivered cost and on the total cost paid for by society.

4.2 PRODUCTION COSTS

AE analysis of data provided by the industry shows that larger quarries tend to have lower average operating costs than do smaller quarries. However, there are also substantial up-front capital costs in establishing new quarries in greenfields locations.

[8] The additional distance of 50km is hypothetical. It is chosen following advice from the industry to illustrate possible implications following large-scale replacement of production from existing quarries with supply from more distant sources.

4.2.1 ECONOMIES OF SCALE

Production costs vary considerably from quarry to quarry, depending on the ease of accessing and extracting the stone.

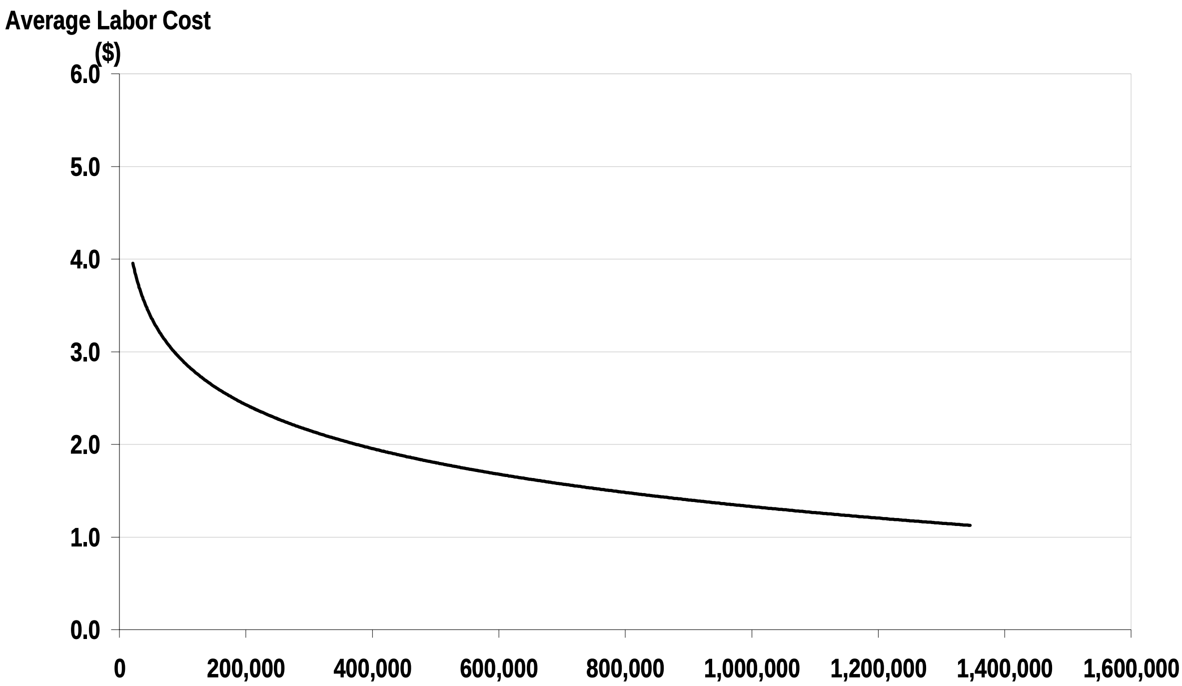
The following section details an analysis of variation in the average costs of a sample of rock and sand quarries[9].

Costs were divided into labour costs and other costs, excluding capital costs and depreciation. The quarry's size is measured as total quarry production (tonnes per year).

When interpreting the following charts and equations it is useful to note that the majority of quarries producing less than 400,000 tonnes are in non-metropolitan areas. Average costs vary more in these smaller rural quarries.

Chart 4-1 displays an estimated relationship between average labour cost (total labour cost divided by annual production in tonnes) and quarry size (annual production in tonnes). Actual data points have been suppressed for confidentiality reasons. However, we provide summary statistics. This chart displays a clear negative relationship between average labour costs and quarry size. In other words it gives evidence of economies of scale in quarry production. At annual production of one million tonnes, the elasticity of average labour costs with respect to production is estimated to be -0.51.

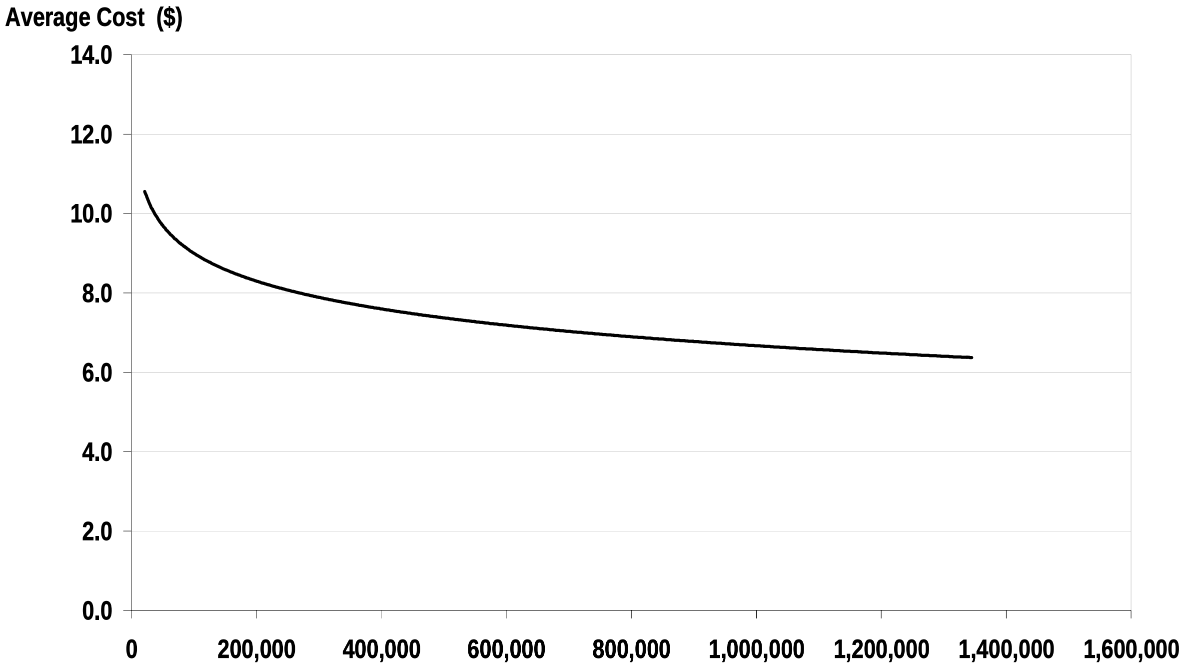
CHART 4-1 AVERAGE LABOUR COST AND QUARRY SIZE



Average Labour Cost = -0.6837Log$_e$(Production) + 10.775
Adjusted R^2 = 0.476

[9] The sample comprises 25 quarries owned by major companies participating in this study. For each of these quarries data on costs, revenue and production were obtained from financial statements, averaged over two financial years.

CHART 4-2 AVERAGE COST AND QUARRY SIZE



Average Cost = -1.0119Log$_e$(Production) + 20.648
Adjusted R^2 = 0.233

Chart 4-2 displays a similar relationship between average operating cost and quarry size, although this relationship is somewhat weaker.

At annual production of one million tonnes, the elasticity of average operating costs with respect to production is estimated to be -0.15. This suggests that non-labour costs are less flexible than labour costs, despite the exclusion of capital and depreciation costs in our analysis. This may partly be because capital can be progressively substituted for labour as the scale of production increases.

4.2.2 MARGINAL COSTS OF EXPANDING PRODUCTION

There are also considerable differences between the *marginal* costs of:

A expanding production at quarries that currently have excess capacity in quarry layout, plant, equipment and production labour;

B expanding production at quarries where there is an unexploited geological resource, but a need for further investment to expand the rate of production; and

C expanding production by opening a new quarry on a greenfields site.

Quarries with excess capacity (A) will usually be in this situation temporarily, reflecting fluctuations in market conditions, or a decision by the owner to invest in capacity in anticipation of future growth in the market, or to strengthen its position relative to potential competitors. However, such quarries are favourably placed to exploit any short-run market opportunities.

Over a longer period, the main ways of meeting a shortfall in supply are (B) and (C). While circumstances will differ between quarries, the additional costs in opening a greenfields quarry are likely to include: costs of investigating and acquiring sites; costs of the approval process; fixed costs of investment in access roads; site preparation and drainage facilities; site offices and maintenance facilities; utility supplies; crushers; storage bins; as well as costs of investing in plant and equipment to extract the resource itself. Greenfields sites may well be located further from the market than existing quarries, implying an additional transport cost, to obtain inputs and deliver to customers.

Industry sources indicate that opening a greenfields quarry to produce one million tonnes annually from an old basalt resource might cost in the order of $84m. This includes:

- land and fencing $2 – 4 m
- fixed plant (including earthworks, footings, electricity) $69 m
- mobile plant $9 m
- office, weighbridge, amenities $5.55 m
- other infrastructure $0.75 m
- roads & quarry development $4.7 m

There would be additional costs in planning the investment and in securing the necessary approvals.

Many of these costs would be reduced, or avoided altogether, in extending or expanding the operations of an existing quarry. This is therefore likely to be less costly than opening up a new quarry on an entirely new site.

Summary

For every kilometre a quarry is located from the investment project using the stone (usually in metropolitan areas) the higher the cost of the delivered product.

Aggregate delivered in metropolitan Melbourne currently moves 30-35 kms from quarry to point of use, while sand delivered currently moves around 60kms from quarry to point of use.

- This distance adds 27%-51% to the ex-bin price of the product (or $4.50 to $9.00 per tonne of product).

If supply from existing metropolitan quarries ceased, and were replaced (say) by that from quarries 50km further from the city, then

- transport operator costs would rise by between 1.8 and 2.7 times (an increase of $7.50 per tonne), and
- the price of the delivered product would increase by between 28% and 39%, depending on the type of product.

Transport costs contribute significantly to the delivered cost of quarry products, and that there are substantial social costs associated with road transport that are not reflected in the prices charged by transport operators, including additional road accidents, environmental costs (noise, air and water pollution, and greenhouse gas emissions), and additional road maintenance costs.

Consequently, if supply from existing metropolitan quarries ceased, and were replaced (say) by that from quarries 50km further from the city, then

- the total social cost (including externalities) of the delivered product would increase by between 32% and 45%, depending on the type of product.

If the 8.8 million tonnes of hard rock and sand embodied in the premix concrete and asphalt annually delivered to metropolitan Melbourne had to cover this additional distance, the additional transport operator cost would be $66m annually. The total cost, including externalities, would be $78m annually.

Thus quarry location is a key influence on delivered cost and on the total cost paid for by society.

Furthermore average production costs tend to be lower in larger quarries, and there are significant up-front capital costs in establishing new quarries on greenfields sites.

5. RESTRICTING EXTENSION OF EXISTING QUARRIES: CASE STUDIES

5.1.1 MOUNTAIN VIEW, POINT WILSON (BARRO GROUP) – NEW BASALT QUARRY

The Barro Mountain View Quarry is located 63 km west of Melbourne and is a major supplier of high-grade basalt aggregate in Geelong. There are no other regional quarries capable of significant extension. The quarry is currently producing at an annual rate of some 1.27 million tonnes with approximately 60% of output being sold into the Geelong Region. The group has approval to extend production into an additional 113 hectares (Stage 1) and is seeking approval for a further extension of 377 hectares (Stage 2), which is estimated to extend the life of the quarry by approximately 40 years. If the Stage 2 Extension is not approved, it is anticipated that the Mountain View Quarry would close within some 5 – 10 years.

The economic analysis compared two scenarios: (A) the extension was approved and the quarry continued operation; and (B) the quarry closed, with the aggregate being sourced from further afield. If the quarry closed, there would be substantial additional transport costs. The price of aggregate in the Geelong region would rise, increasing investment costs and reducing the attractiveness of the region to investors.

Given the quarry's location, closure was not expected to result in an economically significant improvement in amenity of local residents, local environmental conditions, or the use-value of the land otherwise occupied by the quarry. There would, however, be substantial additional social and environmental costs associated with the increased road transport resulting from closure.

Making reasonable assumptions, the study estimated that the additional road transport would impose annual private and social economic costs on the region and Victoria totalling $5.8 million (equivalent to a net present value of $47.2 million at a 5% real discount rate). Costs associated with bringing forward closure of Mountain View Quarry and of opening a new greenfields quarry might add a further $5.6 million to the net present value of the overall cost.

5.1.2 MT SHAMROCK, PAKENHAM (READYMIX) – OLD BASALT QUARRY

The Mt. Shamrock quarry is located in Pakenham, a suburb in the south east of Melbourne, which is a region currently experiencing significant urban growth. The quarry is one of only two major volcanic basalt quarries serving Melbourne's south-eastern metropolitan area. The quarry's production rate ranges between 750,000 and 1.2 million tonnes of crushed products per year. The majority of this output (70-80%) is delivered to the Cardinia and Casey local government areas. The current proposal is to extend the Pakenham quarry work authority by 46.3 hectares on land owned by Readymix. In the absence of any extension it is estimated the quarry's resources would be depleted in five years time. The extension is expected to grant the quarry an additional 20 years of life.

The economic analysis highlights that there will be continued strong growth in demand for quarry products in the south-eastern metropolitan region, and that continued supply to satisfy this demand will be important for the planned growth and development of the region.

If the quarry continues operation there will be no increase in existing social and environmental impacts of operation. In particular there would be little detrimental impact on local tourism. The opportunity cost of lost agricultural production would be negligible.

If the quarry closed, there would be a significant reduction in the level and range of local job opportunities. There would also be substantial additional road transport costs, since the lost production would need to be replaced from further afield. For example, private road transport costs would rise by some $6.6 million annually ($8.78 per tonne) if lost production was replaced by supplies from the nearest alternative source.

5.1.3 MONTROSE (BORAL) – RHYODACITE QUARRY

The Boral Montrose Quarry is located 31 kilometres east of the Melbourne CBD, bordering the suburbs of Montrose and Kilsyth. The quarry produces rhyolite and rhyodacite, a hard abrasive and resistant material. In 2003-04 production was around 890,000 tonnes, however current forecasts predict future average annual production of one million tonnes per year. The quarry's production comprises aggregates (50%), fine aggregates (12%), 'specified' road base (11%); and 'unspecified' road base (27%). Montrose delivers these products to a large number of surrounding suburbs. Approximately 41% of the product serves is input to Boral concrete plants including those at Montrose (13.1%) and Clayton (12.3%). Boral proposes to extend the existing extraction area of the Montrose Quarry by 7.9 ha. In the absence of the extension the quarry's resource would be exhausted in approximately 12 years. The proposal would extend the productive life of the quarry by a further twelve years.

The analysis highlights the projected strong demand for high quality stone in the area served by the quarry, and the limited alternative sources of supply. If Montrose closed, the resulting shortfall in supply has the potential to increase costs to users, via either increases in prices from existing regional producers or increased transport costs of out-of-region supply.

In one illustrative scenario, the annual private cost of road transport would rise by some $4 million following the quarry's closure, or an increase in the marginal delivered cost of $1.18 per tonne.

Early closure would not yield significant economic benefits from bringing forward the release of the quarry site for alternative uses. The potential risks of the proposal to, and possible impacts on, local property values and tourism are assessed as "possible but minor" and "remote and insignificant" respectively.

5.1.4 COMPARISON OF EXISTING ECONOMIC ANALYSES

The three analyses identify and quantify the economic impacts associated with the proposed quarry extensions. They also attempt, to varying degrees, to estimate the net impact on Victorian economic welfare of a decision to deny permission for each quarry's extension.

The key additional economic cost identified by the three sets of economic analysts is that of additional transport, since closure would mean that supplies of aggregate would have to be brought from further afield.

The Mountain View study quantifies the social costs associated with additional road transport. It also estimates possible resource costs associated with: bringing forward the quarry's final closure; and the consequent need for earlier upfront investment in opening a new greenfield quarry.

The Pakenham study also estimates a net present value derived from the loss of quarry output, local jobs, wages and quarry purchases. However, it is not entirely clear from the study how this would translate to a **net** reduction in the welfare of Victorian households, since quarry output would also expand elsewhere.

The Montrose study does not essay a formal cost-benefit analysis. But it does discuss many of the elements that might feature if such an analysis were attempted. It identifies the additional (private) production and transport costs associated with replacing the lost quarry output with that of quarries less favourably located. There is also discussion of the possible value of the quarry site in alternative uses following closure, and of the effects of the quarry on local house prices (providing an implicit estimate of the value of any loss of amenity associated with the quarry). In neither case is there clear evidence of any negative impact. Likewise the potential impact on local tourism is assessed to be small.

A key impact in all the analyses is the additional road transport involved in replacing lost quarry output with alternative supplies from more distant quarries. But only the AE study of the proposed Mountain View extension seeks to quantify the overall social and economic costs.

To underline the importance of such costs, we use the AE methodology to generate comparable estimates of the additional social and economic costs of road transport in all three proposed quarry extensions. The resulting estimates are substantial, emphasising:

- the importance of this issue in considering each of the proposed quarry extensions; and
- the existence of a common thread that reinforces the case for the Victorian government's continuing to adopt policies that:
  - prevent urban encroachment on well-located resources of high quality stone and sand; and
  - facilitate the continued full exploitation of existing quarry resources.

5.2 ADDITIONAL TRANSPORT COSTS

The additional transport costs associated with the early closure of a quarry are difficult to predict precisely. However, the nature and overall scale of the private and social costs can be identified.

The lost production will not necessarily be replaced by increasing output at the next nearest quarry. When large quarries close, their lost production will most likely be spread over several alternative quarries – existing and possibly newly developed operations. The additional transport costs will determine how the market for quarry products rearranges itself. Real transport costs also may vary over time, and with the types of heavy vehicles used. Over longer distances, the use of large B-doubles and even road trains may become efficient, resulting in a need for terminals allowing a change over to smaller vehicles for final delivery.

Road transport has a well documented list of negative externalities affecting other road users and society as a whole. These include:

- environmental effects;
- road accidents;
- congestion; and
- road wear.

Ideally the costs of these externalities should be evaluated and added to the market cost of cartage. Although simplifying assumptions are required, there are accepted methodologies available for quantifying these social costs.

5.3 ACCESS ECONOMICS METHODOLOGY

5.3.1 CONSTRUCTION OF SCENARIO

To maximise comparability we have adjusted the analysis of the Pakenham and Montrose quarries to accord with that employed in the AE study of the proposed Mountain View extension. This is so that all case studies employ comparable methodology, as far as possible.

Estimates of the years of remaining quarry life and of the additional years of production resulting from extension are taken from the respective economic reports. Given these, and assuming that production continues at current levels (ignoring demand growth), the stream of lost production can be calculated.

In each case study AE has made assumptions about the alternative sources of supply. This has involved identifying a list of alternative suppliers and the proportion of lost production attributed to each. This was done, taking into account, where possible, information on the relative quality and type of products produced and the existing capacity of alternative quarries. For the Boral Montrose quarry the assumptions of alternative supply are taken directly from the PWC (2005) report.

This approach is not designed to be a deterministic prediction of what will occur following the denial of a quarry extension. In practice alternative quarries are in turn forced to close early resulting in additional transport costs, short falls will occur and new quarries will need to be established. This approach abstracts away from these complexities representing an illustrative scenario for estimating additional transport costs.

In the absence of more detailed information the lost production is assumed to be delivered to a single location, a point which is representative of the centre of gravity of that quarry's delivery area. In the Barro/Point Wilson study this location is central Geelong. For the Montrose and Pakenham studies accurately estimating such a location is more difficult since product is being delivered in a large number of different directions. Following the approach of Essential Economics (2005) the Montrose and Pakenham quarries themselves are assumed to be the location of delivered product. This effectively assumes that their products are delivered in equal proportions in all directions[10].

Information on the types of heavy vehicles used, average loads and the proportion total of production they deliver is obtained from relevant traffic reports where possible. Distances between alternative quarries and the delivery location, are obtained from the on line mapping service **www.whereis.com.au**.

[10] The estimated transport costs are sensitive to this assumption. This assumption will tend to over estimate transport costs relative to; assuming a delivery location some distance from the quarry or identifying multiple delivery locations since quarries will tend to supply the areas that are closest to them.

5.3.2 Estimation of Costs

Given the stream of lost production and the proportion absorbed by each alternative supplier the total tonnes delivered on each route per year can be calculated. Given the types of vehicles used, their relative proportions and average loads the number of trips on each route by each truck can be calculated. Given the Net additional distance involved in each route the total number of additional kilometres travelled on can be calculated and in turn the total additional net tonne kilometres can be calculated. Estimates of transport costs are then based on a market price of cartage of 0.15c per NTK, as used in Essential Economics (2005). Additional travel is broken into Rural/Urban travel for the purposes of estimating environmental externalities.

Environmental externalities associated with road transport are valued using Austroads (2004) per NTK costs for climate change, noise, water and air pollution for heavy vehicles in rural and urban areas. In order to estimate road accident costs BTE (2000) crash costs are adjusted in line with AE approach to the valuation of health costs. The risk of a road accident occurring is estimated using Victorian data on the number of accidents involving rigid and articulated vehicles. Road wear is estimated using NRTC cost allocation unit values and netting out fuel excise with fuel consumption based on Austroads (2004) models.

5.4 RESULTS

On the whole the estimate transport costs for the Pakenham and Montrose quarries are similar to those estimated for the Point Wilson quarry. The Pakenham quarry involved a similar level of replaced production in tonnes and a similar level of additional transport operator costs (excluding externalities) estimated at $5.28m per year.

Table 5-1 Additional Transport Task per Year

	Point Wilson	Pakenham	Montrose
Replaced Production ('000 Tonnes)	763	754	922
Total Additional ('000) Kilometres	2,209	2,644	4,279
Total Additional ('000) NTK	33,195	35,210	56,979
Transport Operator Costs ($M)	4.98	5.28	8.55

Transport costs estimated for the Montrose quarry are significantly higher than those estimated for the other two quarries. This is due in part to a higher level of replaced production in tonnes; however it is also the result of higher average cartage distances in this scenario, particularly from the Seymour quarry (see the appendix for more details).

Table 5-2 Additional Transport Costs per Year ($'000)

	Point Wilson	Pakenham	Montrose
Transport Operator Costs	4,980	5,282	8,547
Road Accident Costs	280	343	556
Environmental Costs	490	705	1,117
Net Road Maintenance	4	12	27
Total	5,800	6,341	10,247

Each of the externality categories, road accident costs, environmental costs and road maintenance costs are highest in the Montrose case study, followed by the Pakenham and then Point Wilson. Environmental costs remain the largest component of the externality costs with environmental costs under the Montrose study estimated at $1.117m per year.

Perhaps the most useful measure of transport costs is on a per tonne basis. Transport operator costs (which are passed on to consumers) are around ($6.58/tonne) for the Point Wilson quarry similar to those of the Pakenham quarry (7.00/tonne), while closure of the Montrose quarry would result in much higher costs per tonne ($9.27/tonne).

TABLE 5-3 ADDITIONAL TRANSPORT COSTS PER TONNE ($)

	Point Wilson	Pakenham	Montrose
Transport Operator Costs	6.53	7.00	9.27
Road Accident Costs	0.37	0.46	0.60
Environmental Costs	0.64	0.93	1.21
Net Road Maintenance	0.01	0.02	0.03
Total	**7.6**	**8.4**	**11.1**

Summary

The total costs of additional road transport (including externalities) are estimated to rise by between $7.60 and $11.10 per tonne following closure, across the three case studies – Mountain View (Point Wilson), Mt Shamrock (Pakenham) and Montrose (Montrose) quarries.

6. RESTRICTING EXTENSION OF EXISTING QUARRIES: POLICY ISSUES

The case study analysis demonstrated that by restricting the extension of existing hard rock quarries, the total cost of delivering to metropolitan and Geelong customers has the potential to increase by $7.60 to $11.10 per tonne (including externalities).

Extrapolating, across the three quarries that formed the case study, the lost output following closure would have the potential to raise total delivered costs by some $20m-$25m annually. This ignores any consequential impacts on delivered prices to other customers as a result of the long term restriction in supply from the three quarries.

As noted in the AE study of the proposed extension of the Mountain View quarry, there would also be substantial upfront capital costs if closure of existing quarries meant that new quarries had to be opened on greenfields sites.

An increase in the delivered cost of quarry products would raise construction costs and reduce investment in infrastructure projects, consequently slowing growth in living standards in the future.

Furthermore increased taxes would be required to pay for the higher construction costs, as a large proportion of the investment in infrastructure is borne by the Victorian State Government – thus causing additional distortions and inefficiencies in the economy.

These costs need to be given full weight in the planning process in the course of assessing applications to protect or expand operations of existing quarries, or approve new quarries close to metropolitan areas.

The Victorian Government has recognised the importance of cost and ready availability of construction materials through its designation of **Extractive Industry Interest Areas (EIIAs)** in the Melbourne Supply Area (MSA). According to DPI [Olshina and Burn (2003)], the purpose of EIIAs is to:

- provide a basis for the long term protection of sand and stone resources from sterilisation by inappropriate land uses,
- provide a basis for ensuring the long term availability of sand and stone resources for use by the community and at minimal detriment to the environment,
- assist in considering extractive industry values in long term strategic planning and local strategic plans (such as Municipal Strategic Statements),
- ensure that planning or responsible authorities consult with all relevant agencies about land use proposals which may impact on the reduction of sand and stone resources within these areas, and
- create an awareness that extractive industry is a possible land use in these areas.

EIIAs do not however:

- provide statutory protection for sand and stone resources,
- allow extractive industry as-of-right unless specified by planning schemes,
- imply that future extractive industry will be confined to these areas, or
- preclude the use and development of land for other purposes.

More recent policy statements are consistent with the aims embodied in the EIIAs. For example the Key Directions of *Melbourne 2030* emphasise then need for:

- sustainability of development;
- integrated land use planning including strategies to identify where and how the need for housing will be met over a 30 year horizon,
- smoother operation of planning processes;
- adequate provision of affordable housing; and
- efficient coordinated timely provision of infrastructure.

Summary

A planning framework that delivers low cost supplies of quality construction materials where they are needed is essential to the achievement of the *Melbourne 2030* vision.

Access Economics

May 2006

7. REFERENCES

Access Economics (April 2005) *Economic contribution of the extractive industries in Victoria*

Australian Bureau of Statistics (2001) *Australian National Accounts: Input-Output Tables* 1996-97 (Cat. no. 5209.0), Canberra.

Australian Bureau of Statistics (1996) *Information Paper: Australian National Accounts: Introduction to Input-Output Multipliers* (Cat. no. 5246.0), Canberra.

Australian Institute of Health and Welfare (2003) *Health Expenditure, Australia, 2001–2002, Australian Institute of Health and Welfare,* Cat No HWE 24, Health and Welfare Expenditure Series No 17, September.

Austroads (2000) *Valuing Emissions and Other Externalities – A Brief Review of Recent Studies*, AP-R179

Austroads (2003) *Valuing Environmental and Other externalities Studies*, AP-R229/03

Austroads (2004) *Guide to Project Evaluation Part 4- Project Evaluation Data*, AP-G82 04

Bureau of Transport Economics (2000) *Road Crash Costs in Australia,* Bureau of Transport Economics, Report 102, Canberra.

Bureau of Transport Economics (2003) *Land Transport Infrastructure Pricing*

Cutler DM and Richardson E (1998) *The Value of Health: 1970-1990*, JCPR Working Paper 28, prepared for the AEA session on "What we get for health care spending" downloadable from www.jcpr.org/wpfiles/value.pdf

Department of Health and Ageing (2003) *Returns on investment in public health: An epidemiological and economic analysis*, Report to the Department of Health and Ageing by Applied Economics.

Department of Primary Industries, *Statistical Review 2003-04, Victoria's Minerals, Petroleum and Extractive Industries*, Melbourne, Victoria.

Essential Economics (April 2005) *Readymix Mt. Shamrock Quarry - Economic Impact Assessment of Proposed Quarry Extension*

Grogan Richards (2005) *Readymix Mt. Shamrock Quarry, Pakenham, Proposed Extension Traffic Engineering Effects Statement*

Infras/IWW (2000) *External Costs of Transport, Accident, Environmental and Congestion Costs of Transport in Western Europe*, March 2000,

Kniesner TJ and Leeth JD (1991) "Compensating wage differentials for fatal injury risk in Australia, Japan and the United States" in *Journal of Risk and Uncertainty* 4(1), 75-90.

Mathers C, Vos T, Stevenson C (1999) *The burden of disease and injury in Australia,* AIHW Cat. No. PHE17, AIHW Canberra.

Miller P, Mulvey C and Norris K (1997) “Compensating differentials for risk of death in Australia” in *Economic Record* 73(223), 363-372.

Murphy KM and Topel R (1999) *The Economic Value of Medical Research*, University of Chicago Business School.

Murray C, Lopez A (1996) *The Global Burden of Disease: a comprehensive assessment of mortality & disability from diseases, injuries & risk factors in 1990 & projected to 2020*, Volume 1, Global Burden of Disease & Injury Series, Harvard: Harvard School of Public Health.

Murray C, Lopez A, Mathers C, & Stein C (2001) *The Global Burden of Disease 2000 Project: aims, methods & data sources*, Discussion Policy Paper No. 36, WHO, November.

Nordhaus W (1999) *The Health of Nations: The Contribution of Improved Health to Living Standards*, research papers presented at a conference sponsored by Lasker/Funding First, December, Department of Economics, Yale University, downloaded 2 April 2003 from www.laskerfoundation.org/reports/pdf/ healthofnations.pdf

NSW Environmental Protection Authority (1999) *Preliminary Economic Analysis of Adopting New Vehicle Emission Standards,* p11.

Olshina A and P Burn (2003) *Melbourne Supply Area – Extractive Industries Interest Areas Review*, Technical Record 2003/2, Geological Survey of Victoria

Price Waterhouse Coopers (May 2005) *Proposed Extension of Montrose Quarry – Economic Impact Assessment, Final Report*

Viscusi WK (1993) “The value of risks to life and health” in *Journal of Economic Literature*, 13:1912-46.

Viscusi WK and Aldy JE (2002) “The value of a statistical life: a critical review of market estimates throughout the world” *Discussion Paper No. 392*, Harvard Law School, Cambridge MA, November, downloadable from www.law.harvard.edu/programs /olin_center/

Sommer H., Seethaler R., Chanel O., et al (1999) *Health Costs Due to Road Traffic-Related Air Pollution, an impact assessment project of Austria, France and Switzerland, economic evaluation, technical report*, World Health Organisation, London 1999.

APPENDIX 1: ASSESSMENT OF CASE STUDIES

Road transport services have both a direct economic cost (reflected in the market price of road haulage) and a range of negative environmental and social impacts which affect external parties (and are not fully reflected in costs to the haulier). These externalities include: air pollution, noise pollution, additional road congestion, additional road pavement wear and an increased risk of road accidents. The costs of these externalities must be added to the market price of road transport to obtain the true economic cost of road transport.

A large amount of related literature exists on the valuation of road externalities and environmental externalities in particular. Previous economic studies have used a range of techniques to value them including:[11]

- Damage cost: economic cost to society, i.e. health impact on individuals resulting from air pollution
- Avoidance cost: the cost of reducing pollution to a certain level
- Willingness to pay: the individual's willingness to pay to avoid incurring the externality.

Transport statistics and externality estimates have been drawn from the literature in order to provide suitable estimates of external transport unit costs. To obtain quantitative estimates of the economic costs of additional road transport these unit costs, along with the market price per net tonne kilometre are applied to a suitable estimate of the size and nature of the additional transport task.

The amount and of additional transport activity occurring in each case study is estimated by way of a scenario involving assumptions about alternative sources of quarry product and the nature of the road transport undertaking the task. We stress that these scenarios are illustrative. However, we believe that they correctly identify the order of magnitude and the relative contributions of the various elements of cost.

[11] Austroads (2003) Valuing environmental and other externalities, AP-R229/03, prepared by ARRB Transport Ltd.

ESTIMATING THE ADDITIONAL ROAD TRANSPORT TASK

In all three case studies the denial of a quarry extension would result in the loss of a stream of production. This lost production stream is calculated given estimates of remaining quarry life and rates of production.

TABLE 7-1 PRODUCTION LOST WITHOUT EXTENSION

	Point Wilson	Pakenham	Montrose
Remaining years of production (No Extension)	5	5	12
Additional years of production (Extension)	35	20	12
Current Production ('000 Tonnes)	760	754	922
Total Lost Production ('000 Tonnes)	26,700	15,090	11,060

Source: Barro Group, Essential Economics (2005), PWC (2005)

Point Wilson Production refers exclusively to production delivered into the Geelong Region. In this case study it is assumed output delivered into Melbourne can be sourced from alternative quarries with out additional transport costs. Montrose output is based on the amount of production replaced by alternative quarries PWC (2004) in table 16 on page 50.

In order to calculate the amount of additional annual transport (in net tonne kilometres), assumptions are required on the alternative sources of supply. The Montrose quarry assumptions are based on the scenario developed in PWC (2005: 50)[12]. The Pakenham quarry Essential Economics (2005) report, presents a list of alternative quarries and their distances from Pakenham however it does not attempt to estimate the proportion of production likely to come from each quarry. For both The Point Wilson and Pakenham quarries these proportions have been estimated by AE based on information on the remaining resources, available capacity, grade of product, and the relative distances of alternative quarries.

For the three case studies alternative sources are assumed as follows:

TABLE 7-2 ALTERNATIVE SOURCES OF SUPPLY

Point Wilson	%	Pakenham	%	Montrose	%
Colac	22.5	Lysterfield (Boral)	30.0	Lysterfield – (Boral)	24.0
Werribee	45.0	Lysterfield (Pioneer)	25.0	Lysterfield – (Pioneer)	21.0
Ballarat	22.5	Coldstream	6.25	Yea	5.0
Deer Park	10.0	Montrose	10.0	Seymour	33.0
		Dromana	10.0	Castella	13.0
		Launching Place	6.25	Launching Place	4.0
		Tynong North	6.25		
		Yalourn North	6.25		

Source: Access Economics

Figures may not add due to rounding

For the Point Wilson case study vehicle configuration assumptions are based on information provided by the client, for Pakenham they are drawn from the Grogan Richards (2005) traffic report. These assumptions are summarised in the table below.

[12] PWC (2005) estimates aannual tonnages replaced by alternative quarries, these numbers have been converted into percentage values, for representation in the above table.

TABLE 7-3 VEHICLE CONFIGURATION ASSUMPTIONS

Vehicle Type	Point Wilson		Pakenham	
	Average Load	% by weight	Average Load	% by weight
Rigid Truck (Single Axle)	-	-	6.43	0.8%
Rigid Truck (Tandem Axle)	15	3%	13.95	9.9%
Truck and Trailer	30	87%	29.73	82.5%
B-Double	44	10%	46.72	6.8%

In the absence of other information the Pakenham vehicle assumptions are applied to the Montrose case study. These assumptions do not alter the market cost of cartage since it is based on a single per net tonne kilometre charge that does not vary with type of vehicle. These assumptions do impact on the estimation of road wear, total additional kilometres traveled and accident costs.

Based on the vehicle assumptions, the lost production stream and the alternative sources the additional number of round trips occurring on each route by each vehicle type can be estimated. Shown below is the number of trips by vehicle type for each case study.

TABLE 7-4 ESTIMATED ROUND TRIPS PER YEAR

	Point Wilson	Pakenham	Montrose
Rigid (Single Axle)	0	939	1,147
Rigid (Tandem Axle)	1,526	5,354	6,543
Truck and Trailer	22,120	20,934	25,585
B-Double	1,734	1,098	1,342
Total	25,379	28,325	34,618

Average route distances are based on the net distance between alternative quarries and a point designated as the centre of the market. In the Point Wilson study the typical route distance is estimated relative to the Geelong CBD. Net additional distance is the distance from each alternative quarry to Geelong less the distance from Point Wilson to Geelong. In the Montrose and Pakenham studies the actual quarry is designated as the center of its respective market. Net additional distances are therefore based on the distance from the alternative quarry to the Montrose/Pakenham quarry.

All of these distances are obtained from the online mapping service **www.whereis.com.au**. The proportion of this distance deemed freeway/local travel (for estimating fuel consumption) and the proportion of deemed urban/rural travel (for the estimation of environmental costs), are estimated based on maps from this service. Given these distances, and the number of trips by each vehicle on each route the additional kilometres traveled and the additional net tonne kilometres per year can be estimated for each route.

TABLE 7-5 ESTIMATED ADDITIONAL TRAVEL PER YEAR, POINT WILSON

	Additional Kms ('000)	Additional T-Kms ('000)	Cost of Cartage ($M)
Colac	685	10,292	1.54
Werribee	496	7,455	1.12
Ballarat	779	11,708	1.76
Deer Park	249	3,739	0.56
Total	2,209	33,195	4.98

TABLE 7-6 ESTIMATED ADDITIONAL TRAVEL PER YEAR, PAKENHAM

	Additional Kms ('000)	Additional T-Kms ('000)	Cost of Cartage ($M)
Lysterfield (Boral)	645	8,593	1.29
Lysterfield (Pioneer)	538	7,161	1.07
Coldstream	166	2,206	0.33
Montrose	302	4,024	0.60
Dromana	408	5,432	0.81
Launching Place	140	1,869	0.28
Tynong North	74	989	0.15
Yalourn North	371	4,937	0.74
Total	2,644	35,210	5.28

TABLE 7-7 ESTIMATED ADDITIONAL TRAVEL PER YEAR, MONTROSE

	Additional Kms ('000)	Additional T-Kms ('000)	Cost of Cartage ($M)
Lysterfield (Boral)	294	3,916	0.59
Lysterfield (Pioneer)	256	3,407	0.51
Yea	273	3,638	0.55
Seymour	2,989	39,801	5.97
Yarra Valley - Castella	387	5,155	0.77
Yarra Valley - Launching Place	80	1,062	0.16
Total	4,279	56,979	8.55

ROAD ACCIDENT COSTS

Additional road transport has the potential to increase the number of road accidents occurring. To estimate total accident costs both the increase in the accident risk and the economic cost per accident must be estimated. Not all accident costs are externalities – truck drivers are compensated for the additional accident risk through wage premiums. Consequently road accident costs incurred by truck drivers should be netted out of the total cost of an accident.

PROBABILITY OF A ROAD ACCIDENT

The number of accidents on Victorian roads involving heavy vehicles per kilometre travelled[13] is used as a proxy for the additional probability of a road accident occurring. The probability

[13] ABS (2002?) Survey of Motor Vehicle Use

of having a fatal, serious injury or minor injury is directly estimated using accident data from VicRoads[14] and Motor Vehicle use data from the ABS.

Statistics are not readily available for truck accidents in which participants receive no injuries (Property Damage Only (PDO) accidents). These numbers are imputed using the ratio of fatal to total accidents for rigid and articulated trucks sited in the BTE (2000) Road Crash Costs in Australia report, and sourced from ATSB (1999) unpublished data.

TABLE 7-8 ACCIDENT RISK IN VICTORIAN (ACCIDENTS PER 100 MILLION KM)

	Rigid Trucks	Articulated Trucks
Fatal	1.8	2.2
Serious Injury	14.8	8.8
Minor Injury	30.0	14.8
PDO	273.5	64.3

Source: Vicroads, *Crashstats* database, available: www.vicroads.vic.gov.au

Bureau of Transport Economics (2000) *Road Crash Costs in Australia,* Bureau of Transport Economics, Report 102, Canberra.

ATSB 1999b, Road Crash Database (Fatal and Serious) 1996,unpublished data.

Source: ABS 9208.0 Survey of Motor Vehicle Use (2003, 2002, 2001)

The proportion of truck accidents in which injuries were received only by external (non-truck) parties is used as an estimate of the proportion of accident costs borne by society. For example a Victorian fatal road accident involving a rigid or articulated truck will on average involve one truck and one other vehicle (car), 80 percent of the time the fatality(s) occur only in the other vehicle[15].

TABLE 7-9 SELECTED VICTORIAN TRUCK ACCIDENT STATISTICS, 2000-03

	Fatal	Serious Injury	Minor Injury
Average Vehicles per Accident	1.97	2.04	2.12
Average Trucks per Accident	1.06	1.07	1.07
Proportion of accidents in which injuries are received by external parties only	0.80	0.69	0.69

Source: Vicroads, *Crashstats* database, available: www.vicroads.vic.gov.au

COST PER ROAD ACCIDENT

Estimates of the cost per road accident were largely based on BTE (2000), which estimated the costs to the community of fatal, serious injury, minor injury and property damage only (PDO) crashes. This approach was slightly adjusted in order to include the recently developed burden of disease methodology which was developed by the World Health Organisation (WHO), the World Bank and Harvard University in 1990 and applied in Australia by the Australian Institute for Health and Welfare (AIHW).

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[14] VicRoads Crashstats, 2000/01,2001/02,2002/03

[15] For PDO Accidents the proportion of costs deemed to be external was assumed to be 70%.

The approach is non-financial, where pain, suffering and premature mortality are measured in terms of Disability Adjusted Life Years (DALYs), with 0 representing a year of perfect health and 1 representing death (the converse of a QALY or "quality-adjusted life year" where 1 represents perfect health). Each DALY is made up of a premature mortality (YLL) component and a morbidity (YLD) component. Total DALYs are then converted into financial costs using a value of a life year (VLY) of $162,561 (based on the conservative estimate by AE after extensive literature review[16]).

Total DALYs due to road and other transport accidents in Mathers et al (1999) are split between fatal, serious injury and minor injury crashes by assuming:

- the YLD component is incurred only by individuals in serious injury and minor injury crashes while the YLL component is incurred only by individuals in fatal, serious injury and minor injury crashes;
- the YLL component for fatal crashes is estimated by multiplying the number of deaths by age by the expected life left by age (discounted at 3%);
- the remaining YLL and YLD components are spit between serious injury and minor injury crashes based on the split estimated by BTE (2000) of total costs associated with medical, long-term care, labour in the workplace, labour in the household, and quality of life[17].

Due to the methodology used in calculating VLY[18], the total value of suffering and premature death, lost wages/income, and out-of-pocket personal health costs from road and transport accidents borne by the individual is calculated by multiplying the VLY by the total DALYs. It is assumed that 80%[19] of the health system costs estimated by BTE (2000) are born by society and thus are additional to the value of DALYs[20]. Using the GDP deflator, health costs not incurred by the individual and the remaining costs of road and transport accidents estimated in BTE (2000) are then inflated to 2003-04 dollars.

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[16] Access Economics (2005) "Arthritis - the bottom line: The economic imapct of arthritis in Australia" */Report for Arthritis Australia/*, January.

[17] The wage-risk studies underlying the calculation of the VSL take into account all known personal impacts – suffering and premature death, lost wages/income, out-of-pocket personal health costs and so on.

[18] Access Economics (2005) "Arthritis - the bottom line: The economic imapct of arthritis in Australia" */Report for Arthritis Australia/*, January.

[19] AIHW (2003)

[20] Except for PDO crashes in which all of the health system costs, namely ambulance costs which attend many crashes regardless of whether anyone is injured, are additional.

TABLE 7-10 TOTAL CRASH AND INJURY COSTS ($M)

	Fatal	Serious Injury	Minor Injury	PDO	Overall
BTE (2000) (1996 Dollars)					
Medical, long-term care, labour in the workforce, labour in the household, and quality of life costs	2,675	4,128	412	23	7,238
Other crash costs	245	3,022	2,058	2,417	7,742
Total crash costs	2,920	7,150	2,470	2,440	14,980
This Report (2003-04 Dollars)					
Value of DALYs	7,721	2,303	230	0	10,254
Health system costs borne by society	5	2,218	24	28	2,275
Other crash costs	295	3,646	2,483	2,916	9,341
Total crash costs	8,021	8,168	2,736	2,944	21,870

Other crash costs include legal, correctional services, workplace disruption, funeral, coroner, vehicle costs such as repairs, unavailability of vehicles, and towing, travel delays, insurance administration, police, property, and fire

TABLE 7-11 CRASH AND INJURY COSTS PER CRASH, 2003-04 ($)

	Fatal	Serious Injury	Minor Injury	PDO	Overall
Costs per crash ($)	4,536,728	466,435	15,262	7,008	35,354

ROAD MAINTENANCE COSTS

Road maintenance costs are based on calculations made by the National Road Traffic Commission (NRTC) when calculating National Heavy Vehicle Charges. Table 7-11 shows the expenditure directly associated with different measures of heavy vehicle road use on a per unit basis, which have been inflated to 2003-04 using the annual indexes used by the NRTC to adjust vehicle registration charges. The ESA-kilometre unit cost is the amount of expenditure that is directly related to ESA-kilometres divided by the total number of ESA-kilometres travelled.

TABLE 7-12 ROAD MAINTENANCE, UNIT COSTS (CENTS)

	2000	2004
Vehicle Kilometres Travelled (c/km)	0.370	0.408
Passenger Car Units (c/PCU-km)	0.126	0.139
Equivalent Standard Axles (c/ESA-km)	3.292	3.629
Average Gross Mass (c/tonne-km)	0.121	0.133
Non-separable costs (c/km)	1.809	1.994

Source: National Road Transport Commission (February 2000) Updating Heavy Vehicle Charges: Regulatory Impact Statement, page 35.

These unit costs are adjusted to take into account deviations from actual road maintenance costs based on estimates in BTRE (2003): 38% over-recovery for rigid trucks, 0% for articulated trucks, 10% under-recovery for b-doubles[21].

In order to recover road maintenance costs the NRTC uses a two part charge: a variable charge based on fuel consumption (a notional part of diesel excise, currently approximately 0.20c per litre[22]) and a fixed annual registration charge. We assume that no additional trucks are bought and registered in order to provide the additional road transport, and thus no additional registration charges are paid. However any additional diesel excise collected must be subtracted from the total additional road maintenance costs to avoid double counting (the diesel excise already forms part of the cartage costs per net tonne-kilometre).

Additional fuel consumption is based on an Urban Journey Speed Vehicle Operating Cost (VOC) Model[23] outlined in Austroads (2004) Guide to Project Evaluation Part 4. Austroads (2004) present two models, one for predicting the effects of average journey speeds on vehicle operating costs for operations over freeways and high quality arterials where average travel speeds are typically in excess of 60 km/h. The second model predicts the effect of average journey speed on vehicle operating costs in stop-start operations where average speeds are less than 60 km/h.

The models are based on assumptions that rigid or articulated trucks all have average gross vehicle mass (AGM)[24]. As many of the trucks used to transport Quarry products have higher AGM the models have been adjusted using regression analysis on data from the 2003 ABS Survey of Motor Vehicle Use on fuel consumption per 100kms.

ENVIRONMENTAL AND OTHER EXTERNALITIES

Environmental impacts of the additional transport are based on Austroads (2004) Guide to Project Evaluation – Part 4. The environmental impacts examined there include air pollution, climate change, noise pollution, water pollution.

Vehicle emissions contain many harmful substances which can directly contribute to illness and disease, as well as contributing to climate change through green house gasses. The most significant harmful substances emitted by road vehicles include carbon monoxide (CO), nitrogen oxides (NOx), hydrocarbons (HC), and fine particulate matter (PM_{10}). However the extent to which these substances have significant health effects depends greatly on their total air concentration. Consequently the marginal health impact of vehicle emissions in busy urban areas is likely to be much more significant than in sparse rural areas. On the other hand the impact of green house gas emissions is the same in both rural and urban areas. The level of vehicle emissions depends on the amount of congested stop-start traffic conditions and on vehicle type, with heavy vehicles producing more than passenger vehicles.

[21] BTRE (2003) Land Transport Infrastructure Pricing, page 14.

[22] On 12 April 2005 diesel excise was $0.38143 per litre for diesel minus a rebate of $0.1851 for road transport under the energy grants credits scheme. www.ato.gov.au

[23] Austroads AP-G82 (2004) Guide to Project Evaluation Part4 – Project Evaluation Data p13

[24] Rigid vehicles: 18.6 tonnes, Articulated vehicles: 48.4 tonnes.

Noise from road vehicles has the potential to disturb and annoy individuals. In the Austroads Pollution parameters, the cost of noise pollution is estimated to be zero for heavy vehicles traveling in rural areas.

Water pollution can arise from road transport in several ways including, the leakage of engine oil onto the road surface and the contamination of waterways through air pollution. The impact of water pollution is greater in urban areas.

Traffic congestion exacerbates road externalities such as those disused above; it also imposes a time cost on road users. This time cost is both an internal cost (as a well informed road user must be willing to bear the cost of the travel time) and an external cost (each road user adds to total road congestion). However, the extent to which additional road transport could add to congestion depends on the specific routes taken and the time of day. We do not attempt an estimate of any additional congestion costs, in the absence of more specific information.

Other road transport externalities that are not included in this study, since at the marginal level they are likely to be negligible, are:

- Land Costs: The loss of land due to road infrastructure. A reduction in the aesthetic quality of the landscape and land pollution.
- Urban separation: The extent to which road travel places constraints on pedestrian mobility[25].
- Nature: The impact of road transport on local ecology and biodiversity, including indirectly through noise/air pollution and directly through animal road kill.
- Indirect: The external costs associated with indirect road transport activities (for example, air pollution created in the production of road vehicles or parts and during road maintenance).

Environmental externality costs are valued using Austroads (2004) which provides estimates for rural/urban areas. The rural externality costs are identified separately for articulated trucks; however rigid trucks are grouped with light commercial vehicles. Large rigid truck and trailer combination vehicles are typically used for the transport of quarry products. As these vehicles have a gross vehicle mass closer to the average of articulated trucks than of light commercial vehicles, the articulated truck externality costs are applied to rigid trucks in rural areas. Using the GDP deflator, these costs are then inflated to 2003-04 dollars.

[25] Austroads (2003) Valuing Environmental and Other externalities Studies, AP-R229/03

TABLE 7-13 AUSTROADS ESTIMATED ROAD TRANSPORT EXTERNALTY COSTS, JULY 2004 ($/TONNE-KM)

	Rigid & Articulated Heavy Vehicles - Urban	Articulated Only - Rural
Noise	2.56	0.00
Air Pollution	24.47	0.24
Water Pollution	3.67	0.03
Greenhouse/Climate	4.45	4.45
Total	41.04	4.76

Source: Austroads (2003) Valuing Environmental and Other Externalities Studies, AP-R229/03, Austroads (2004) Guide to Project Evaluation Part 4- Project Evaluation Data, AP-G82 04, ABS 5220.0 Australian National Accounts

APPENDIX 2: THE ECONOMIC CONTRIBUTION

DIRECT CONTRIBUTIONS

The direct economic contribution (value added) is calculated as the gross output of goods and services produced, less the value of intermediate inputs (labour costs, GOS and indirect taxes less subsidies on production). Value added differs from gross domestic product because it is measured before net taxes on products are added (that is, gross output is measured at 'basic prices').

INDIRECT CONTRIBUTIONS

To measure indirect value added requires EIV expenditure on each item to be traced to each input used in its production, and the inputs used to create these inputs and so on. The mathematical technique used to sum this chain of inputs requires the inversion of a matrix of coefficients derived from the Australian input-output table.

INPUT OUTPUT TABLE

An input-output table for 34 industries by aggregating the 106-industry ABS input-output table for 1996-97 with direct allocation of imports was derived.

While an ABS input-output table for 1998-99 is available, the cost structures of input-output tables do not change greatly over five or ten years, so that the multipliers derived from 1996-97 input-output tables, such as value added per \$m of output, are applicable over such time scales. In the case of employment multipliers (persons per \$m of output) it is necessary to adjust for changes in prices and productivity between 1996-97 and 2003-04.