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Cost Benefit Analysis and Economic Impact Analysis of the Rocky Hill Coal Project

Gloucester Resources Limited

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23 October 2014

Dear Craig

Cost Benefit Analysis and Economic Impact Analysis of the Rocky Hill Coal Project

I am pleased to provide a cost benefit analysis and economic impact analysis of the Rocky Hill Coal Project. This report analyses, in detail, the costs and benefits of the development of the Rocky Hill Coal Project as well as an analysis of whether the Project would result in a net benefit for the NSW community.

The analysis has been prepared with a number of guidelines in mind, how these guidelines have been addressed is summarised in Appendix A. To ensure that all critical parts of the various guidelines have been adhered to, the Appendix contains a cross reference of each key aspect of the guidelines to the sections of the report where they are dealt with.

Yours sincerely,

Steve Brown
Director
Deloitte Access Economics Pty Ltd

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Glossary

ABS	Australian Bureau of Statistics
AHIMS	Aboriginal Heritage Information Management System
AIS	Agricultural Impact Statement
AUD	Australian dollar
BBAM	Biobanking Assessment Methodology
BCR	Benefit Cost Ratio
BREE	Bureau of Resources and Energy Economics
CBA	Cost Benefit Analysis
CDE	Constant Differences of Elasticities
CGE	Computable General Equilibrium
CHPP	Coal Handling and Preparation Plant
CPI	Consumer Price Index
CRESH	Constant Ratio of Elasticities Substitution, Homothetic
DAE	Deloitte Access Economics
DALY	Disability Adjusted Life Year
dB(A)	A - weighted decibels
DEEWR	Department of Education, Employment and Workplace Relations
DGR	Director General's Requirements
ECX	European Climate Exchange
EIA	Economic Impact Analysis
EIS	Environmental Impact Statement
EP&A	Environmental Planning and Assessment
EPA	Environment Protection Authority
EUA	European Union Allowance
EVRI	Environmental Valuation Reference Inventory
FOB	Free on board
FTE	Full Time Equivalent
GDP	Gross Domestic Product
GRL	Gloucester Resources Limited
GRP	Gross Regional Product
GSP	Gross State Product
ICE	Intercontinental Exchange
IO	Input Output
IRR	Internal Rate of Return
LGA	Local Government Area
LSC	Land and Soil Capability
NPV	Net Present Value

NSW	New South Wales
NVBA	Noise, Vibration and Blasting Assessment
OPOE	Out-of-pit overburden emplacement
PAD	Potential Archaeological Deposit
PM	Particulate Matter
QLD	Queensland
RBA	Reserve Bank of Australia
RBL	Rating Background Noise Level
RGEM	Regional General Equilibrium Model
RLA	Richard Lamb & Associates
ROM	Run-of-mine
RUM	Random Utility Maximisation
SCM	Stratford Coal Mine
SIOS	Social Impact & Opportunities Statement
SLA	Statistical Local Area
SUA	Significant Urban Area
TSP	Total Suspended Particulate Matter
UK	United Kingdom
VSL	Value of Statistical Life
WACC	Weighted Average Cost of Capital
WTP	Willingness to pay

Executive Summary

Deloitte Access Economics has been commissioned by McCullough Robertson to undertake a Cost Benefit Analysis and Economic Impact Analysis of the proposed Rocky Hill Coal Project ('the Project').

The findings of this report can be summarised as follows:

- The Project delivers net benefits of around $363 million over its life and generates a benefit cost ratio of around 1.53.
- Royalties generated by this Project, relative to the baseline, are estimated to be worth around $84 million in NPV terms to the NSW Government.
- It is estimated that the Project would generate a net benefit to those in the Gloucester local government area. The midpoint of the estimated range of benefits is $36 million (in NPV terms) over the life of the Project. The range of estimates depends on assumptions about alternative economic opportunities for local employees and suppliers.
- It is considered unlikely that the externalities treated qualitatively in this analysis would be of a scale that would exceed the net benefits of the Project.
- Over the life of the Project, the Hunter Region's Gross Regional Product (GRP) is projected to increase by around $483 million in NPV terms as a consequence of the project.
- NSW's Gross State Product (GSP) (including the Hunter) increases by around $662 million (NPV terms) as a consequence of the project.
- The economic impact analysis projects a state-wide employment peak in 2025 with almost 334 full time equivalent (FTEs) workers. This employment includes the direct employment, any employment from suppliers and crowding out of any economic activity. Of this, over 90 per cent are estimated to be employed in the Hunter region.

Through the Rocky Hill Coal Project (referred to as 'the Project'), Gloucester Resources Limited (GRL) proposes to establish an open-cut coal mining operation at a greenfield site within the Gloucester Basin, approximately 3.5 to 7 kilometres south-east of Gloucester, New South Wales. The Project will include open cut pits, a coal handling and preparation plant and an overland conveyor for transporting coal to a rail load-out facility.

This report presents a detailed assessment of the incremental costs and benefits of the Project, relative to a baseline, 'business as usual' case, as well as an analysis of whether the project would result in a net benefit for the NSW community. This report has been prepared to further assist the Department of Planning and Environment and the Planning Assessment Commission in their assessment of the Project, and in particular the likely costs and benefits of the Project. It should be noted that the analysis has drawn on information provided by GRL, the findings of the EIS and the Response to Submissions prepared following the public exhibition period of the EIS with verification of this data by Deloitte Access Economics where appropriate and possible.

Overall the project is expected to generate net benefits and is also expected to generate increased economic activity and employment within the NSW community.

Consideration of the costs and benefits of the Project is primarily done through a cost benefit analysis (CBA). The CBA compares the Project case to a baseline case where the proposed site continues to be used for its current purposes (i.e. grazing and conservation). The overall finding of the CBA is that the Project as a whole is likely to deliver net economic benefits. In the central case (which is based on a 7% discount rate) the Project delivers net benefits of around $363 million over its life and generates a benefit cost ratio of around 1.53.

In undertaking the cost benefit analysis we have had regard to the costs and benefits listed in Table i. These items have been drawn from a number of guidelines for cost benefit analysis published by the NSW Government as referred to in the Director General's Requirements for the Project.

As recommended in CBA guidelines such as NSW Treasury (2007), where it is difficult to place a value on a particular cost or benefit of the Project, a qualitative analysis has been undertaken. We consider that all of the potentially large externalities of the Project have been valued in quantitative terms. The remaining externalities which have been considered qualitatively, such as visual amenity, are identified in Table i and discussed thoroughly in Section 5.

The results indicate that, to fully offset the estimated net benefits of the Project, these non-quantified externalities would need to generate costs of around $44 million per year (in real terms) over the operational phase of the Project. This is equivalent to undiscounted costs of $623 million over the period. This is considered to be unlikely, given the nature of the evidence regarding these impacts. Furthermore, this annual value would represent more than a twenty three-fold increase in the level of externalities estimated.

It should also be noted that these CBA results do not explicitly identify benefits to particular groups (such as tax payments to the NSW government) as these are a transfer payment and do not sit within the scope of a CBA. However, the additional royalties generated by this Project, relative to the baseline, are estimated to be worth around $84 million in NPV terms to the NSW Government (this is equivalent to a total of $175 million in additional revenue over the life of the Project).

An estimation of the net benefits to the Gloucester community is also of interest. CBA calculations are not easily disaggregated into regional assessments. However, to do this we have assumed that payments to mine suppliers and employees are proportional to the share of employees from different geographic locations. In order to illustrate the range of outcomes that could be achieved in the absence of the Project, it was assumed that these businesses and workers could either earn the same level of income from alternative sources, or the current average level of income in Gloucester in the baseline case. Under these assumptions, along with a number of others regarding the share of externalities borne by the community, it is estimated that the Project would generate a net benefit to the Gloucester community of between $9 million and $62 million (in NPV terms) over the life of the Project. The midpoint of this estimated range of benefits is $36 million (in NPV terms) over the life of the Project.

Table i: Costs and Benefits – Rocky Hill Coal Project

	Costs	Benefits
Internal effects of production	Exploration costs	Gross mining revenue
	Capital investment costs	Other onsite revenue
	Operating costs excluding royalties, rates and taxes	Residual value of capital*
	Rehabilitation costs	
	Decommissioning costs*	
	Residual value of land forgone	
Externalities	Related public expenditure*	
	Offsite agricultural revenue*	
	Groundwater quality*	
	Surface water quality*	
	Air pollution – carbon emissions	
	Air pollution – particulate matter	
	Air pollution – other pollutants*	
	Noise pollution	
	Visual amenity*	
	Traffic impacts*	
	Biodiversity – flora and fauna	
	Conservation*	
	Quality of open space*	
	Rural amenity and culture	
	Aboriginal heritage*	
	Historic heritage*	
	Health*	

* Item has been considered qualitatively

Note: As the Project involves open-cut mining activity, there are no subsidence impacts which need to be valued in this analysis. Nevertheless, this item is discussed qualitatively in Section 5 in accordance with NSW Government Guidelines (2012)

Regional economic impacts

Consideration of whether the Project would result in a net benefit for the NSW community is done through the use of a computable general equilibrium (CGE) model. A CGE model represents the dynamic relationship between economic agents and can show how changes in one part of the economy (such as the production of more coal) flow through to other parts of the economy (such as effects on employment levels, exports and labour income).

We have modelled the overall economic impacts of the Project and find that, over the life of the Project , the Hunter Region's Gross Regional Product (GRP) is projected to increase by around $483 million and NSW's Gross State Product (GSP) (including the Hunter) is expected to increase by around $662 million (both of these are in NPV terms).

Table ii: Project economic impacts

	Total (NPV)
Coal sales ($m)	1,047
Hunter modelling region ($m GRP)	483
NSW total GSP ($m)	662

The report also provides an estimate of the projected employment impacts of the Project. State-wide employment peaks in 2025 with almost 334 full time equivalent (FTEs) workers. Of this, around 91 per cent are estimated to be employed in the Hunter region and 9 per cent in the rest of the state. These estimates are of total employment including that at the mine and further employment generated in the economy.

More detail on the year-on-year GSP and employment impacts are outlined in Section 6, along with more information on the Computable General Equilibrium modelling framework used.

Summary Report

Deloitte Access Economics has been commissioned by McCullough Robertson to undertake a Cost Benefit Analysis and Economic Impact Analysis of the proposed Rocky Hill Coal Mine Project ('the Project').

The Project comprises an open-cut coal mining operation near Gloucester, NSW. Approval has been sought for production of up to 2.5 Mtpa with projected annual ROM production expected to peak at 2.0 Mtpa. The lifetime of the project is expected to be between 16 to 21 years. In this analysis, it is assumed that the Project will involve a three year period following the receipt of development consent to account for the receipt of additional approvals, licences and leases required prior to the commencement of any work, as well as design and construction activities. This period, referred to as the design and construction phase, has been assumed to commence in 2015, followed by around 14 years of operation, concluding at the end of 2031.

In this report, the impacts of the Project are measured relative to a baseline case, whereby the Project does not proceed and the proposed site continues to be used for its current purposes (i.e. grazing and conservation). This comparison allows for an incremental analysis, to reach a clear conclusion on the net benefits of the Project.

The report is broadly split into four parts:

1. Background discussion on the region and the methodology employed in the report
2. Cost Benefit Analysis (CBA)
3. Economic Impact Analysis (EIA)
4. Appendices providing more detail on the methodologies used in the analysis.

Background – the coal mining region

Through the Project, Gloucester Resources Limited (GRL) proposes to establish an open-cut coal mining operation at a greenfield site within the Gloucester Basin, approximately 3.5 to 7 kilometres south-east of Gloucester, New South Wales. The proposed development is located within the Gloucester Local Government Area (LGA).

The economy of the Gloucester LGA has undergone change since operations began at the Stratford mine in 1995. Since 2001, the usual resident population in the LGA has increased by about 1.7%. Meanwhile, median household incomes in the Gloucester LGA have increased from about $564 a week in 2001 to almost $821 in 2011; a 45.6% increase.

Table i: Median household income ($/week)

	2001	2006	2011	2001-2011 Change
Gloucester	564	691	821	45.6%
New South Wales	826	1039	1233	49.3%

Source: ABS, 2011 Census Time Series Profile Cat. 2003.0
Note: All dollar values reflect nominal figures.

Operational activity

The Project will include open cut pits, a coal handling and preparation plant and an overland conveyor for transporting coal to a rail load-out facility. The proposed Project is estimated to produce approximately 13.5 Mt of saleable coal over the period from 2018 to 2031. It is anticipated that two distinct coal outputs will be produced: semi-hard coking coal, and thermal coal, with semi hard-coking coal expected to account for approximately [redacted] of the saleable coal produced.

Cost Benefit Analysis

A cost benefit analysis (CBA) involves obtaining a consolidated estimate of the net economic value of the Project by identifying the incremental costs and benefits of the project relative to the baseline case, and placing a quantitative value on these items wherever possible (NSW Treasury 2007).

The list of costs and benefits considered in this analysis are set out in Table ii.

Table ii: Costs and Benefits – Rocky Hill Coal Project

	Costs	Benefits
Internal effects of production	Exploration costs	Gross mining revenue
	Capital investment costs	Other onsite revenue
	Operating costs excluding royalties, rates and taxes	Residual value of capital*
	Rehabilitation costs	
	Decommissioning costs*	
	Residual value of land forgone	
Externalities	Related public expenditure*	
	Offsite agricultural revenue*	
	Groundwater quality*	
	Surface water quality*	
	Air pollution – carbon emissions	
	Air pollution – particulate matter	
	Air pollution – other pollutants*	
	Noise pollution	
	Visual amenity*	
	Traffic impacts*	
	Biodiversity – flora and fauna	
	Conservation*	
	Quality of open space*	
	Rural amenity and culture	
	Aboriginal heritage*	
	Historic heritage*	
	Health*	

* Item has been considered qualitatively

Note: As the Project involves open-cut mining activity, there are no subsidence impacts which need to be valued in this analysis. Nevertheless, this item is discussed qualitatively in Section 5 in accordance with NSW Government (2012)

In recognition of the broad range of impacts of the Project, the costs and benefits shown have been separated into two categories:

- internal effects of production – costs and benefits that affect the financial outcomes of the proponent; and
- externalities – the costs and benefits that affect others.

The approach to valuation has generally been hierarchical, relying on market prices where available, then using industry standard values, then making use of findings of a literature review and, finally, drawing on original research or dealing with the item qualitatively. It should be noted that the analysis has drawn on information provided by GRL, the findings of the EIS and the Response to Submissions prepared following the public exhibition period of the EIS with verification of this data by Deloitte Access Economics where appropriate and possible.

As recommended in CBA guidelines such as NSW Treasury (2007), where it is difficult to place a value on a particular cost or benefit of the Project, a qualitative analysis has been undertaken. We consider that all of the potentially large externalities of the Project have been valued in quantitative terms. The remaining externalities which have been considered qualitatively, such as impacts on visual amenity, are identified in the table above and discussed thoroughly in Section 5.

The results indicate that, to fully offset the estimated net benefits of the Project, these non-quantified externalities would need to generate costs of around $44 million per year (in real terms) over the operational phase of the Project. This is equivalent to undiscounted costs of $623 million over the period. This is considered to be unlikely, given the nature of the evidence regarding these impacts. Furthermore, this annual value would represent more than a twenty three-fold increase in the level of externalities estimated.

The results of this analysis for each item in the CBA is summarised as follows:

- **Gross mining revenue:** production estimates were combined with price forecasts provided by GRL, validated against BREE forecasts. In the Project case approximately 13.5 Mt of saleable coal is produced, generating total revenue of $1,047 million in present value terms. No mining revenue is generated in the baseline case.
- **Other onsite revenue:** Relative to the baseline case, the carrying capacity of some land beyond the disturbance area will be improved under the Project case through pasture improvement, soil topdressing and more intense grazing management strategies to be undertaken by the Speldon Partnership Dairy as part of lease agreements with GRL. This will make the land suitable for dairying purposes, earning more revenue than the alternative of beef grazing. At the same time, the Project will involve permanent removal of approximately 140 hectares of land suitable for low productivity grazing, due to the establishment of the Biodiversity Offset Area. Taking these impacts into account, it is estimated that the Project will generate an additional $5.45 million (NPV terms) in agricultural net revenue, relative to the baseline case.
- **Exploration costs:** under the baseline case, no exploration costs will be incurred. Under the Project case, a small allowance for exploration is included in the capital investment cost estimates for 2015 only. Beyond this, no ongoing exploration costs are anticipated.

- **Capital investment costs:** under the baseline case, no capital investment will be undertaken. Under the Project case, a total of $139 million in capital investment will be incurred during the construction phase of the Project, from 2015 to 2017. This is valued at $119 million in present value terms.
- **Operating costs excluding royalties, rates and taxes:** operating costs consist of free on board (FOB) costs associated with the extraction, processing and delivery of coal, as well as ongoing expenditure on the purchase and maintenance of equipment and machinery necessary for production. The FOB costs per tonne used in this analysis were provided by GRL, and validated against an econometric model of open-cut mining in Australia. It is estimated that FOB costs will range between [redacted] per tonne of product coal, with a weighted average of [redacted] per tonne over the life of the Project. The variation is due to factors such as changes in the stripping ratio and the average daily production rate from year to year. Estimates of ongoing equipment and machinery costs were provided by GRL, under the Project case. These are estimated at $62.5 million in undiscounted terms.

  Overall, total operating costs are estimated at $552.33 million in the Project case in present value terms.
- **Rehabilitation costs:** land rehabilitation will only be required under the Project case. This rehabilitation activity will occur progressively over the life of the mine. The ongoing rehabilitation costs are included in operating cost estimates.
- **Decommissioning costs:** at the completion of mining activity in the Project case, decommissioning costs will be incurred in 2032. Based on data provided by GRL, it is assumed that these costs will be fully offset by the residual value of capital, described below.
- **Residual value of capital:** GRL has provided indicative estimates of the residual value of capital at the conclusion of the operational phase of the Project. Due to the uncertainty associated with estimating the residual value of capital assets, it is conservatively assumed for the purpose of this analysis that any residual value will offset the decommissioning costs of the Project.
- **Residual value of land:** this item captures changes in the value that society places on the land within the proposed disturbance area, from 2014 onwards in the baseline, and at the conclusion of mining activity and land rehabilitation under the Project case. These values reflect the proportions of land used for different purposes, particularly open pasture and open woodland.

  Overall, the residual value of land is estimated at $3.56 million and $1.25 million in the baseline and Project case respectively, in present value terms. The difference of $2.31 million represents the cost of changes in land use over the life of the Project, relative to the baseline case.
- **Related public expenditure:** it is considered unlikely that the Project will generate any additional expenditure by any level of government, compared to the baseline case. Nevertheless, GRL has committed to an annual donation of 50 cents per tonne of product coal sold (approximately $480,000 p.a. on average over the life of the mine) to a community grants program. This is likely to offset any additional costs to government that might otherwise occur. As this is a transfer of funds it is not included in the CBA.

- **Offsite agricultural revenue:** within the Rocky Hill locality, privately owned agricultural enterprises include five dairies, including the Speldon Partnership Dairy noted above, a small number of small scale beef operations, the majority with very little land intensively developed, the Hillview Herb Farm and one non-commercial vineyard. The AIS has identified that the Project will have minor to negligible impacts on the agricultural resources and enterprises throughout the region and Rocky Hill locality, with any risks to be managed through GRL's water quality, air quality, noise and vibration and land management controls. Accordingly, it is considered appropriate to treat these potential impacts qualitatively in this analysis.
- **Groundwater quality:** the Groundwater Assessment provides detail on the likely impacts of the Project in terms of impacts on groundwater users, inflow to mine voids, impact on alluvium and impact on groundwater dependent ecosystems. Overall, the Assessment found that any groundwater impacts associated with the operations of the Project are negligible. Accordingly, no value has been assigned to this item in either the baseline or Project case.
- **Surface water quality:** the Surface Water Assessment describes the likely impact of the Project in relation to surface water volumes, quality and the cumulative impact on downstream water users. It is anticipated that the Project will not significantly impact on the availability of water to downstream users and that an increase or decrease in flows, depending on the location, to Oaky Creek and Avon River will be minimal. There is, therefore, expected to be no quantitative difference between the baseline and project case from an economic perspective.
- **Subsidence:** as the Project involves open-cut mining, there are no subsidence effects associated with either the baseline or Project cases.
- **Carbon emissions:** the Greenhouse Gas Assessment has provided estimates for the quantity of Scope 1 carbon emissions expected over the life of the mine in the Project case. These emissions have been valued at a constant price of $8.91 per tonne, derived from the current Intercontinental Exchange European Climate Exchange European Union Allowance (ICE ECX EUA) futures price of €6.17 per tonne, converted into Australian dollars using the exchange rate reported by the Reserve Bank of Australia (MarketWatch, 2014; RBA, 2014). This is the best available estimate of the social cost of carbon following the repeal of the carbon pricing mechanism. Overall, the cost of Scope 1 emissions is valued at $6.69 million in the Project case, in present value terms.

  Scope 2 and 3 carbon emissions are indirect emissions generated from the Project's consumption of electricity and other intermediary inputs and from the use of the Project's output. These emissions are not directly emitted by the Project. For both Scope 2 and 3 emissions, it is not clear, methodologically, to what extent these emissions should be incorporated in a CBA. For scope 3 emissions it is also not clear what a reasonable baseline case would be and the data requirements of calculating any baseline for scope 3 emissions is extensive. As such, carbon emission costs associated with Scope 2 and 3 emissions have not been included in the CBA.
- **Air pollution – particulate matter:** likely health costs to the Gloucester LGA associated with PM2.5 emissions were quantified based on cost estimates provided by a PAEHolmes report commissioned by the NSW Environment Protection Authority (2013).

These estimates have been adapted from damage costs produced by the UK Department for Environment, Food and Rural Affairs (Defra) which used an impact pathway approach to estimate the costs of various health endpoints associated with PM2.5 emissions such as respiratory and cardiovascular hospital admissions and death, for application in specific Australian locations.

In the absence of a specific cost estimate for Gloucester, the damage cost estimate reported for locations not in any Significant Urban Area in NSW was adjusted to reflect the Gloucester LGA population density, producing an estimate of $489 per tonne of PM2.5 emissions, updated to 2014 prices. This was then multiplied by forecasts of PM2.5 emissions under the Project case, estimated as a proportion of total suspended particulate matter (TSP) emissions reported in the Air Quality Assessment undertaken by Pacific Environment Limited. It was found that the additional health costs associated with air pollution under the Project case are estimated to be worth about $0.20 million in present value terms.

It is acknowledged that particulate matter can also result in non-health, quality of life effects. This potential effect was investigated using a hedonic pricing study, presented in Appendix D. No statistically significant effect was identified for Gloucester in the study.

- **Air pollution – other pollutants:** The EIS states that nitrogen dioxide emissions will be managed by limiting blasting activity during adverse weather conditions to ensure compliance with assessment criteria. As some health impacts produced by the emissions are correlated with PM2.5, and would be captured in the estimate of air pollution costs above, the potential for additional health impacts is not quantified as part of this item.
- **Noise pollution:** estimates of the noise exposure of residential properties, for representative years under the Project case, were obtained from the Noise Impact Assessment, from 2015 onwards. To account for the noise that would otherwise be experienced in the baseline case, a 30 dB(A) threshold was applied for most properties, being the minimum background level used in the EPA's Industrial Noise Policy. Higher thresholds up to 38 dB(A) in the daytime period, were applied for properties that were found to have significant exposure to traffic noise from Jacks Road and The Bucketts Way. These residual, Project case exposures were valued at $62.38 per dB per household per year (the upper range identified in Navrud, 2002, converted to current Australian dollars). This produced total estimates of the cost of noise pollution of $0.18 million in the Project case, in present value terms.

  It is noted that with use of the most conservative background noise measurements presented in Table 5.1 of the NVBA, these costs rise to around $0.50 million in present value terms. Given that this is a small increase relative to the magnitude of other costs and benefits of the Project, the assumptions used to obtain the estimate of $0.18 million are not expected to impact the conclusions of the analysis.
- **Visual amenity:** the likely visual impacts of the Project have been assessed by Richard Lamb & Associates (RLA) who conducted an analysis of a wide range of viewing places throughout the Gloucester Basin. It was found that there will be some significant visual impacts associated with the Project during the construction phase and the first six to seven years of operations. These impacts will be caused by the construction of the visibility barriers, to control the visibility of the mine itself. Through vegetation and re-contouring of the landforms it is considered that these visual impacts will be minimised.

Furthermore, GRL have committed to establishing a final landform that is similar to the existing landscape. In the absence of appropriate monetary values to quantify the short term visual impacts of the Project, these are acknowledged qualitatively in this analysis.

- **Traffic:** the main Project case impacts on road traffic will occur during the construction phase, given that product coal will be moved from the Mine Area to the Rail Load-out Facility via conveyor during operations.

  A number of road upgrades will be made as part of the Project, including construction of a bridge over the Avon River on Jacks Road (the current timber bridge is closed for structural integrity reasons). According to the Transport Assessment, implementation of these measures is anticipated to successfully mitigate against the traffic impacts of the Project. Therefore, no quantitative values are applied to this item in either the baseline or Project cases.

- **Biodiversity (flora and fauna):** a Biodiversity Offset Strategy that is consistent with State Government policies has been prepared for the Project. This means that although the Project is anticipated to disturb land currently inhabited by a number of species of flora and fauna, the strategy is designed to mitigate and offset potentially significant biodiversity impacts. Specifically, a 267ha offset area, east of the mine area has been nominated which holds a similar biodiversity value as the areas affected by the Project. Accordingly, no quantitative valuation is placed on the risks to biodiversity.

  However, these offsets do incur management costs. This analysis utilises a rate of $3,318 per hectare of land, as an estimate of the lifetime costs of offset management, consistent with estimates produced by the NSW Office of Environment and Heritage Credit Calculator (2012). Overall, these costs are estimated at $0.83 million in NPV terms in the Project case. There are no additional risks to biodiversity expected under the baseline.

- **Conservation:** the Terrestrial Biodiversity Assessment undertaken for the Project indicates that there is around 4.3 hectares of the Lower Hunter Valley Dry Rainforest Threatened Ecological Community with conservation significance located in the proposed disturbance area. However, as discussed under the Biodiversity item, this impact will be offset by the establishment of a Biodiversity Offset Area which incorporates approximately 50 ha of this community, i.e. approximately 44% more than required under the NSW Biobanking Assessment Methodology (BBAM). To avoid double counting against the treatment of these areas under the biodiversity item, no separate costs or benefits have been attributed to the conservation item in this analysis.

- **Quality of open space:** this item considers the impact of the Project on the ability of residents and visitors to utilise areas in the vicinity of the proposed disturbance area. The Socio-economic Assessment indicates that the Project is not anticipated to directly impact the use of the airstrip by the Gloucester Aero Club. As a result, no quantitative values are assigned to this item in either the baseline or Project case as part of the CBA.

- **Rural amenity and culture:** the Socio-economic Assessment has also found that the Project is likely to have mixed impacts on social infrastructure capacity, community sense of place and amenity and social cohesion. Although the extent to which the sense of community will be affected by the Project alone is uncertain, this analysis utilises an estimate of the willingness to avoid a decline in rural population published by Bennett, van Bueren and Whitten (2004) as a proxy for these costs.

This assumes that from 2018, four privately owned properties, relative to the baseline, are likely to meet the acquisition criteria in relation to the air quality and/or noise impacts of the Project. Although acquisition rights do not necessarily result in relocation, it does provide an indication of the number of people that could potentially relocate from the Gloucester LGA as a direct result of the Project, although not accounting for any additional residents from mine employment. Nevertheless, the cost of a decline in rural amenity and culture is estimated at $7.98 million in present value terms. As a number of assumptions were involved in this valuation, this cost should be considered an indicative, conservative estimate of the likely order of magnitude of any impacts on the sense of community and cohesion.

- **Aboriginal heritage:** nine sites (including a potential archaeological deposit or PAD) have been identified in the Study Area. All of these will likely be impacted directly during mine development or operations. It has been recommended that the 23 artefacts found at these sites be salvaged if the mine does proceed. In addition it is recommended that limited sub-surface investigation occur at three sites where there may be some potential for other artefacts to exist. Salvage and sub-surface investigation are the only Management Measures recommended. It has also been recommended that the McKinley 3 site (the only one assessed as having any significant research potential) be graded in 5cm units or splits to fulfil any research questions that may be asked. As a contingency measure it has been recommended that a fully qualified archaeological consultant and two Aboriginal stakeholder representatives conduct initial briefing of mine workers and staff, and that they produce a one or two-page hand-out, to be presented to every mine worker when they first sign on setting out clearly the procedures they must follow if artefacts are found and the penalties when the procedure is not followed. In addition, all staff that might be involved in disturbance of deposits are to be similarly briefed by a nominated representative of the Applicant as part of the Site Induction process and provided a copy of the hand-out.
- **Historic heritage:** there are no items with statutory protection in or in the vicinity of the Site. Affected views are not heritage views, but visual impacts have received consideration (including mitigation measures) elsewhere in this report.

  It is proposed that a Heritage Discovery Plan for the Site be instituted so that in the event that any items of potential heritage significance are discovered, work is stopped until such time as an appropriately qualified consultant can assess, and if necessary, record them prior to work re-commencing.
- **Health:** The cost of health impacts are explicitly captured in the valuation of air pollution, and to some extent, implicitly captured in the costs of noise pollution, it is not appropriate to place a separate value on the health costs arising from additional cases of various health outcomes.

The costs and benefits listed above give the following summary results:

Table iii: CBA results

Discount rate	Total net benefits ($m)	Benefit Cost Ratio
4%	535.94	1.605
7%	363.43	1.527
10%	245.32	1.448

Source: DAE calculations

As the outcomes in Table iii rely on a number of input assumptions, the sensitivity of the overall results to ranges of these inputs was tested. The results are shown in Table iv.

Table iv: Sensitivity Analysis – comparison of net benefits

Parameter	Variation in Parameter	Net Benefits ($m)		
		4%	7%	10%
Central CBA	N/A	$536	$363	$245
Coal price forecasts	+ 30%	$961	$678	$482
	- 30%	$111	$49	$9
Project capital investment	+ 25%	$504	$334	$217
	- 25%	$568	$393	$273
Operating costs per tonne	+ 10%	$466	$311	$205
	- 10%	$543	$369	$249
Social cost per tonne of carbon emissions	+ 10%	$535	$363	$245
	- 10%	$537	$364	$246
NSW share of national rural amenity and culture costs	- 31%	$544	$369	$249

Source: DAE calculations

In all cases the net benefits remain greater than zero, suggesting that the net economic benefits of the Project are resilient to a range of input assumptions.

Estimated Regional Net Economic Benefits

Although transfer payments, such as the payment of taxes to State Governments, are not normally included in a CBA, we estimate that the NSW Government will receive around $84 million in additional royalties in present value terms, which is equivalent to an additional $175 million in government revenue over the life of the Project.

While this estimate does take into account the allowable deductions for full cycle washing of product coal, it does not include potential further deductions for payment of levies, insurance, bad debts and bank commissions due to the difficulty in estimating the future level of these deductions.

An estimation of the net benefits to the Gloucester community is also of interest. CBA calculations are not easily disaggregated into regional assessments. However, to do this it has been assumed that payments to mine suppliers and employees are proportional to the share of employees from different geographic locations. In order to illustrate the range of outcomes that could be achieved in the absence of the Project, it was conservatively assumed that these businesses and workers could either earn the same level of income from alternative sources, or the average level of income in Gloucester in the baseline case. Under these assumptions, along with a number of others regarding the share of externalities borne by the community, it is estimated that the Project would generate a net benefit to the Gloucester community of between $9 million and $62 million (in NPV terms) over the life of the Project. The midpoint of this estimated range of benefits is $36 million (in NPV terms) over the life of the Project.

Subregional impacts of the project have been discussed in more detail in the Social Impact and Opportunities Assessment, which can be found in Appendix 5 of the EIS.

Economic Impact Analysis

The EIA measures the economic impacts of the Project over the whole of the life-cycle. The assessment covers the capital intensive phase, where about $139 million in capital (undiscounted) is installed from 2015 to 2017. It also covers the operational phase, where mining activity under the Project case differs from expected activity under the baseline case.

To model the economic impacts we have used our in-house Deloitte Access Economics – Regional General Equilibrium Model (or DAE-RGEM). DAE-RGEM is a Computable General Equilibrium (CGE) model that represents the dynamic relationship between economic agents. More detail on the model can be found in Appendix D.

The model has been customised for this analysis to incorporate three distinct Australian modelling regions. These include:

- Hunter Valley area — contains the localities of, Gloucester, Broke, Central Coast, Cessnock, Greta, Jerrys Plains, Kurri Kurri, Lake Macquarie, Maitland, Muswellbrook, Newcastle and Singleton
- New South Wales
- The rest of Australia

Economic impacts – Gross Regional Product

The modelling suggests much of the economic impacts are concentrated in the Hunter region. Approximately 13.5 Mt produced over the period 2018 to 2031 (approximately [redacted] of which is semi-hard coking coal) is projected to generate just over $1,047 million revenue (on an NPV basis, in 2014 dollars). Capital expenditures and activity in the operational phase of the Rocky Hill mine is projected to add just under $483 million to the Hunter region's GRP and a further $179 million to the rest of New South Wales (see Table v).

These projected impacts of the Project are measured against a reference case scenario where the mine does not proceed. The modelling incorporates both the increase to the capital stock and the continuation of coal output.

Partially offsetting the direct activity and increased demand in supply chains is the increase in competition for scarce resources, for example labour. This is reflected in the increased wage rate in the Hunter. This competition for resources may also crowd out economic activity in other sectors of the region and the state.

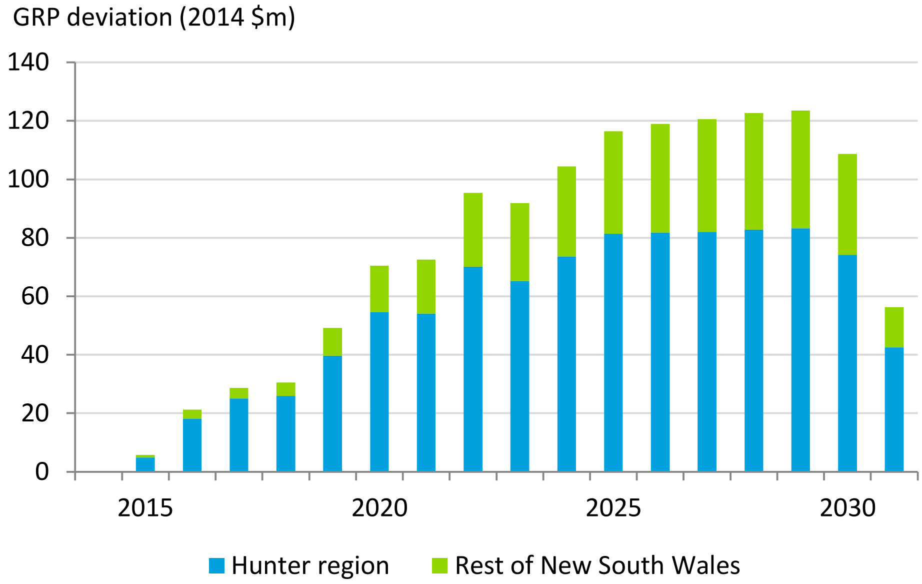
Table v: GRP and GSP impacts, NPV, 2014 – 2031 (real 2014 $m)

Regions	GRP/ GSP (NPV)
Hunter (GRP $m)	483
Rest of New South Wales (GRP $m)	179
Total NSW (GSP $m)	662

Source: Deloitte Access Economics; NPV uses 7% discount rate

Economy-wide impacts tend to follow the output of the Project. Chart i outlines the year-on-year GRP impacts to each of the modelling regions. Over the modelling period the returns to the Hunter tend to follow the direct output activity. The GRP impact to the region is highest in 2029 at about $83 million (in 2014 prices) to coincide with the peak in scheduled mine output.

Chart i: GRP/GSP impacts by region, 2014 – 2031 (real 2014 $m)



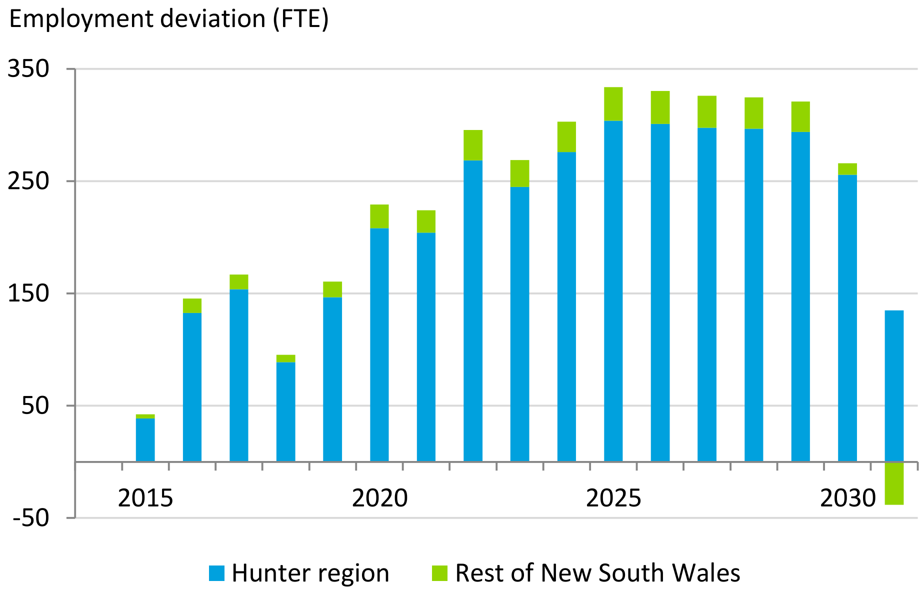
Note: All values are in real 2014 terms

Source: Deloitte Access Economics

Employment – Direct and flow on

The total regional employment generally follows the ROM activity of the Project. The total economy-wide regional employment in the Hunter peaks at nearly 304 FTEs in 2025 (see Chart ii). This includes employment at the mine and employment generated elsewhere in the economy and any projected crowding out. Over the remainder of the period to 2030 employment is projected to remain positive for the Hunter.

Chart ii: Employment impacts by region, Scenario 1, 2014 – 2031



Source: Deloitte Access Economics

Sensitivities

Our analysis also incorporated three sensitivities to take into account the uncertainty over future coal prices. To understand the potential implications of different coal price trajectories for the Rocky Hill Mine, the economic impact analysis was conducted for three modelling scenarios:

- Scenario 1 – Central estimate of coal price forecasts
- Scenario 2 – Lower price scenario (30% lower below central estimates)
- Scenario 3 – Higher price scenario (30% higher above the central estimates)

GRP impacts are proportionate to the coal price inputs. In the Hunter region GRP is modelled to decrease from about $483 million in the Central case to about $374 million in the low case and increase to almost $592 million in the higher price scenario (see Table vi).

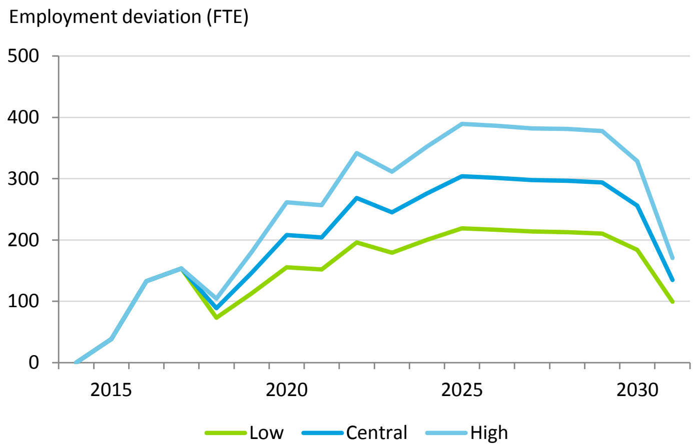
Table vi: GRP impacts, NPV, 2014 – 2031 (real 2014 $m)

NPV	Central	Low	High
Hunter	483	374	592
Rest of New South Wales	179	127	232
Total NSW	662	501	824

Source: Deloitte Access Economics; NPV uses 7% discount rate

Chart iii outlines the total regional employment impacts of the proposed mine development under the three modelling scenarios in the Hunter region. As with the central case outlined above, employment impacts increase over the construction phase before a slight decrease as the mine begins operations (after which employment impacts grow to their peak in 2025). The low and high coal prices are projected to decrease or increase the employment impacts of the mine by around 85 FTEs at the peak in 2025.

Chart iii: Employment impacts, Hunter region, 2014 – 2031



Source: Deloitte Access Economics

Deloitte Access Economics

1 Introduction

Deloitte Access Economics has been commissioned by McCullough Robertson to undertake a Cost Benefit Analysis and Economic Impact Analysis of the proposed Rocky Hill Coal Project ('the Project').

Through the Project, Gloucester Resources Limited (GRL) proposes to establish an open-cut coal mining operation at a greenfield site within the Gloucester Basin, approximately 3.5 to 7 kilometres south-east of Gloucester, New South Wales. The Project will include open cut pits, a coal handling and preparation plant, and an overland conveyor for transporting coal to a rail load-out facility as shown in Figure 1.1.

Approval has been sought for production of up to 2.5 million tonnes (Mt) of run-of-mine (ROM) coal per annum, although annual ROM extraction is expected to peak at 2 Mt.

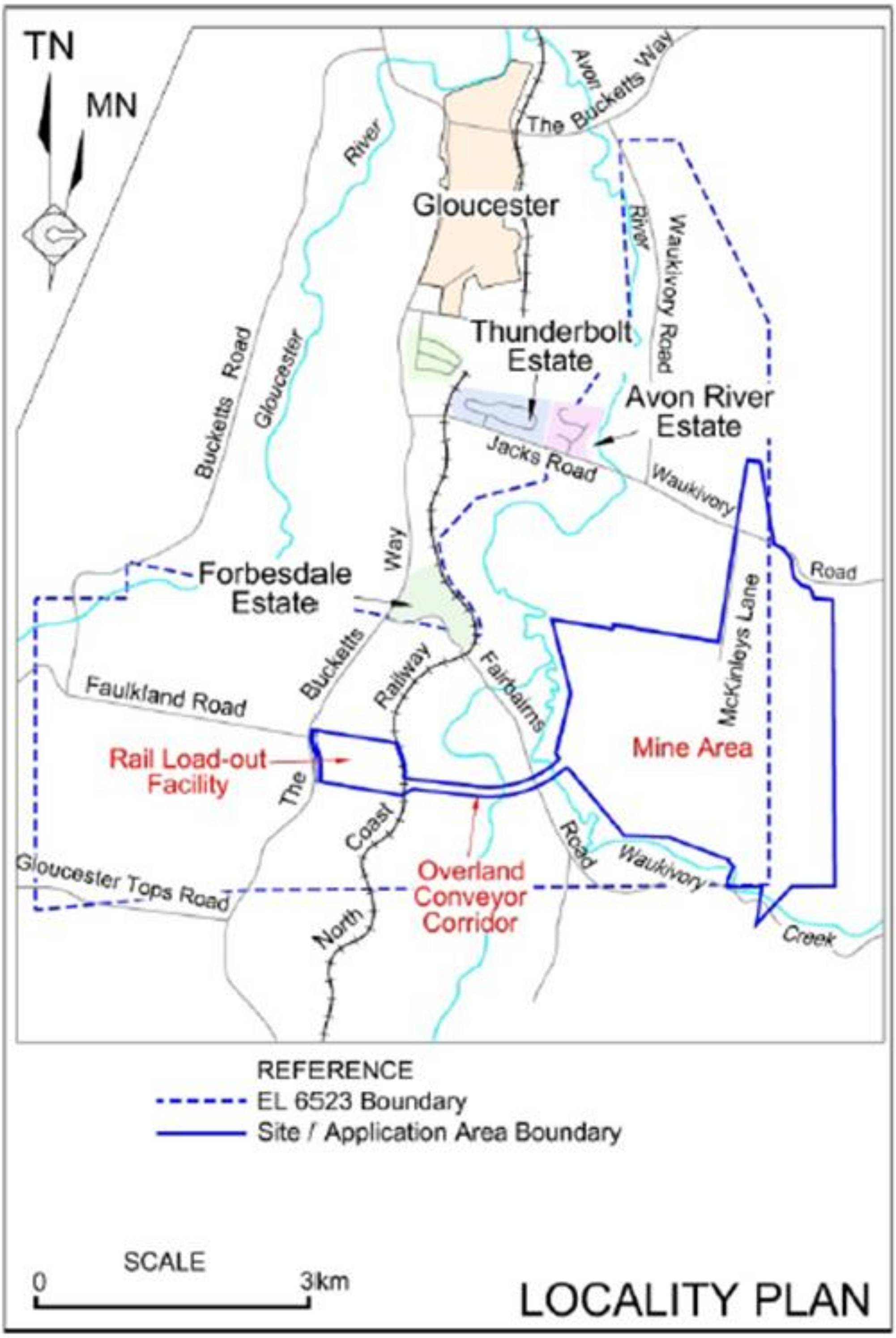
While the lifetime of the Project is expected to be between 16 and 21 years, for the purpose of this analysis, it is assumed that the Project will involve a three year period following the receipt of development consent to account for the receipt of additional approvals, licences and leases required prior to the commencement of any work, as well as design and construction activities. This period, referred to as the design and construction phase, has been assumed to commence in 2015, followed by around 14 years of operation, concluding at the end of 2031.

In accordance with the EP&A Act, an Environmental Impact Statement (EIS) was required for the Project. The objective of an environmental assessment is to ensure that approval bodies, government authorities (including local councils), the applicant and the broader public have sufficient material to properly consider the potential environmental consequences of a proposal (NSW Government, 2000).

The content and matters to be addressed in the Environmental Impact Statement (EIS) were identified in the Director-General's Requirements (DGRs) for the Project issued by the former Department of Planning and Infrastructure (DP&I).

A required component of the EIS is an analysis of economic issues. Specifically, the Director General's Requirements include the need for an assessment of the costs and benefits of the development as a whole, and whether it would result in a net benefit for the NSW community. The initial economic assessment for the Project was completed by Key Insights (Volume 4, Part 14 of the EIS) using a methodology commonly referred to as the 'input-output analysis'. This report has been prepared to further assist the Department of Planning and Environment and the Planning Assessment Commission in their assessment of the Project, and in particular the likely costs and benefits of the Project. It should be noted that the analysis has drawn on information provided by GRL, the findings of the EIS and the Response to Submissions prepared following the public exhibition period of the EIS with verification of this data by Deloitte Access Economics where appropriate and possible.

Figure 1.1: Application area for Project



Source: GRL

This report therefore undertakes an assessment of the impacts of the Project within a cost benefit analysis (CBA) framework to address the costs and benefits of the proposed development, relative to a baseline, 'business as usual' scenario. This baseline case involves continued use of the proposed mine area for grazing and conservation purposes, should the Project not receive approval. This framework allows for the measurement of the incremental costs and benefits of the Project, in order to determine the net economic value of the Project. A computable general equilibrium (CGE) model is then used to analyse the impact of this Project on the NSW community as measured by changes in economic activity and employment.

1.1 Report structure

The first four chapters of this report are structured in accordance with the general CBA guidelines. An additional analysis using Computable General Equilibrium (CGE) modelling is provided to outline the anticipated impact of the Project on the regional economy. The CGE analysis can be understood as an extension to the CBA. Accordingly, the CGE results may not be directly comparable to the CBA results or other projections outlined in the Environmental Impact Statement. This is because it encompasses a broader range of impacts than the initial economic, environmental, or financial analysis.

The structure of this report is as follows:

- Chapter 2 outlines the methodology employed in this report, including how the approach used aligns to the NSW CBA guidelines.
- Chapter 3 provides a background of the Gloucester LGA, presenting a brief demographic and employment profile of the region.
- Chapter 4 details the Project and defines the base case and the expected scenario under the Project case.
- Chapter 5 presents the results of the cost benefit analysis, including a disaggregation of all the anticipated impacts included in the analysis.
- Chapter 6 presents the results of an analysis of the impacts of the Project on the regional economy, using Computable General Equilibrium (CGE) modelling.
- Appendix A provides a checklist illustrating how this report has met the requirements of various guidelines.
- Appendix B outlines relevant valuation techniques that are often employed in CBA.
- Appendix C discusses the variety of approaches that may be used to value specific costs and benefits.
- Appendix D presents an overview of the CGE model.

2 Methodology

DAE have established a methodology for undertaking this CBA which relies on the range of guidelines and requirements set out by the NSW Department of Urban Affairs and Planning (2002), NSW Treasury (2007) and NSW Government (2012) in undertaking CBAs and applied to this Project in particular. This chapter reviews the guidelines and requirements before discussing how these have been applied to develop the methodology.

2.1 CBA guidelines

CBA is an extremely common and long standing approach and so there are a large number of guidelines available for both reference and compliance purposes. These guidelines cover conceptual issues such as how environmental consequences should be treated as well as practical issues, such as what discount rates should be used in what circumstances. The following documents have been used as the most relevant guidelines for this CBA:

- NSW Treasury (2007), "NSW Government Guidelines for Economic Appraisal";
- NSW Department of Urban Affairs and Planning (2002), "Guideline for economic effects and evaluation in EIA"; and
- NSW Government (2012), "Guideline for the use of Cost Benefit Analysis in mining and coal seam gas proposals"

These three documents move from high level issues around CBA through to how CBA should be applied to an EIA and then also cover the application of CBA to coal mines in particular. A full account of the requirements of these guidelines is given in Appendix A and the requirements are cross referenced to sections of this report.

2.2 Director General's requirements

In addition to the CBA focused guidelines listed above, there are also specific requirements set out in the Director General's Requirements (DGRs) for the Project that were issued in April 2012. Specifically, the Director General's Requirements include the need for an assessment of the costs and benefits of the development as a whole, and whether it would result in a net benefit for the NSW community. The initial economic assessment for the Project was completed by Key Insights (Volume 4, Part 14 of the EIS) using a methodology commonly referred to as the 'input-output analysis'.

This report has been prepared to further assist the Department of Planning and Environment and the Planning Assessment Commission in their assessment of the Project, and in particular the likely costs and benefits of the Project. It should be noted that the analysis has drawn on information provided by GRL, the findings of the EIS and the Response to Submissions prepared following the public exhibition period of the EIS with verification of this data by Deloitte Access Economics where appropriate and possible.

While the remainder of the requirements cover topics beyond the scope of an economic assessment, there are particular areas which are relevant to the methodology adopted, including impacts on land resources, water resources, biodiversity, heritage, air quality, greenhouse gases, noise, traffic and visual impacts. These are considered as part of the analysis in Section 5.

2.3 Implications of these guidelines

Together, the CBA guidelines set the baseline requirements for this economic assessment. While Appendix A contains an item by item reconciliation of how these guidelines have been addressed, it is firstly worth considering their implications qualitatively. Overall they require that the CBA should be carried out using a set of standard approaches and also must include consideration of certain topics.

Looking first at the standard approach, the guidelines suggest that the CBA should involve:

- identification of the characteristics of the proposal and any alternatives;
- defining the spatial boundaries of analysis (e.g. local, regional, state, national);
- identification of the environmental impacts of the Project;
- identification of costs and benefits, including:
    - economic resource costs (e.g. capital expenditure);
    - externalities;
    - base case benefits given up;
- quantification of costs and benefits, using market prices where available, otherwise using imputed prices or a qualitative assessment;
- consolidation of values by applying a discount rate; and
- applying decision criteria such as a benefit cost ratio.

This standard approach has been applied throughout this report. The definition of the proposal and spatial boundaries of analysis are covered in Section 4. Section 5 then covers the identification, discussion, quantification and consolidation of costs and benefits of the Project.

Moreover, the guidelines suggest that the CBA must contain an analysis of a broad range of issues, costs, benefits and distributional matters. Beyond the costs and benefits of the Project itself (such as revenue, capital investment and operating expenditure) the issues broadly fall into two main categories:

- **Externalities:** these externalities cover areas where the Project will create costs or benefits, which cannot be captured in current market transactions, for third parties not involved in the production, sale or purchase of coal. These are mostly relevant in areas where property rights are non-existent or difficult to enforce. Key externalities here include effects on agricultural productivity; surface and groundwater; carbon emissions; air pollution; noise pollution; visual amenity; traffic; biodiversity and ecosystem conservation; quality of open space; rural amenity and culture; heritage and health.
- **Regional and industry flow-on economic effects:** as with the externalities, flow-on effects involve parties who are not directly transacting in the production or consumption of coal, and encompass any market-based responses to the presence of the Project. Flow-on effects are indirect impacts due to adjustments in the economy,

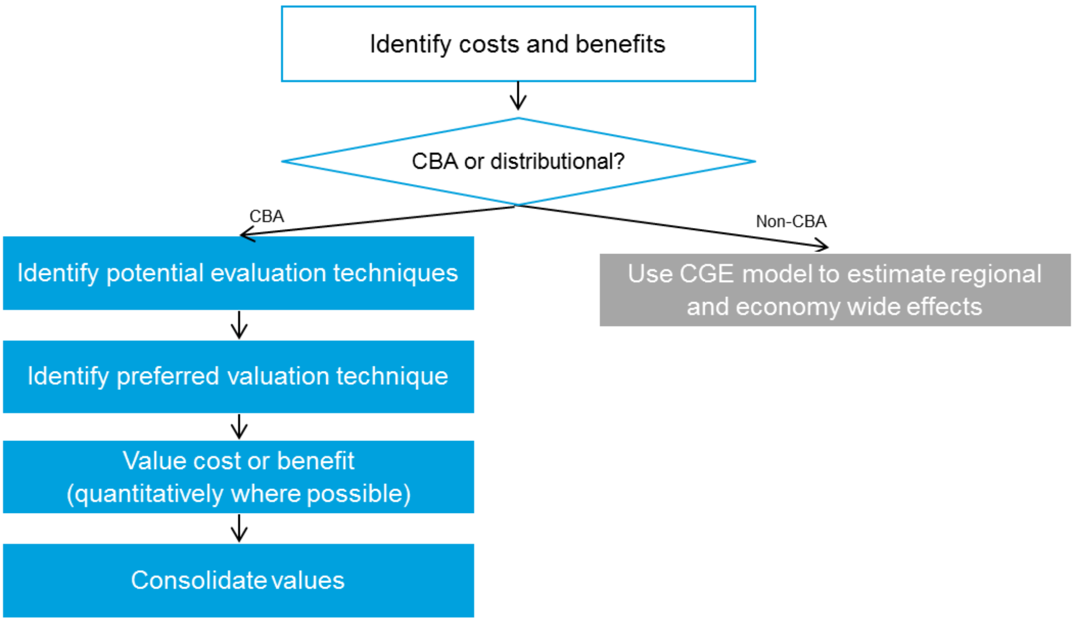
such as price movements. For example, if the Project increases demand for a certain type of labour this may affect the price of labour in the region which will have flow-on consequences for other local industries. These are not externalities, but are rather seen as the mechanisms by which the economy re-adjusts in response to changed patterns of supply and demand. Key effects here include: increases in wages; profits of mine suppliers; impacts on the agricultural industry; impacts on labour supply and local tourism effects.

A traditional CBA, which focuses mainly on the Project itself and then incorporates any quantifiable externalities, may not be able to provide sufficient analysis of the diversity of this range of issues. For example, a CBA, by its nature, does not take into account the general equilibrium flow-on effects described above as these are essentially benefits to some parts of the economy which are offset by costs elsewhere. The following section sets out our approach for ensuring that all the requirements are covered within this economic analysis.

2.4 Our Methodology

Taking the aforementioned guidelines together creates a complex set of requirements which encompass topics that are handled well by a traditional CBA as well as other issues which do not fit neatly into a CBA framework. To address this DAE has developed a methodology which first analyses items amenable to CBA modelling within a CBA framework and then applies CGE modelling to look at further issues, such as a circumstance where wages may increase in response to increased demand for labour or distributional effects, whereby the impact on wages differs across subregions or industries of the local economy.

Figure 2.1: Outline of methodology



The methodology has been designed to clearly separate the issues identified in the guidelines and requirements based on how they can be analysed from an economic point of view. For example, the issues covered under externalities are amenable to modelling within a CBA framework. These will therefore pass through the stages of having evaluation techniques identified, selecting one particular technique, valuing the externality in quantitative terms (where possible) and adding it into the consolidated value of the CBA (such as a NPV or cost benefit ratio).

This approach can be contrasted with an issue such as impacts on local labour supply. This issue is not amenable to a CBA framework, as it involves transfers of costs and benefits between groups within the economy which cancel each other out. As a result, issues like this will pass down the other arm of the methodology. The CGE modelling is used to determine the economy wide effects of the Project and provides a clear picture of benefits for NSW, especially the Hunter and Gloucester economy.

CGE modelling can be seen as an addition and extension of the CBA but with a particular focus. That is, the CBA focuses on the Project and its immediate external effects. The CGE model is then used to trace these immediate effects through the economy more broadly. For example, increased capital expenditure may lead to increased demand for steel and fuel as inputs. This, in turn, can increase demand for labour in iron ore mines and oil refineries. This chain of events will create complex interactions between supply and demand in each market which will ultimately be resolved by changes in prices and outputs across the economy. The CGE model provides a way to trace this chain of events through to its final resolution. It should be noted that the CGE model is, fundamentally, built on the national accounting system and so focuses on outputs that are traded in markets and contribute to GDP – it does not capture environmental and other externality costs that are captured as part of the CBA.

It should also be noted that CGE modelling is a substitute for Input-Output (IO) modelling. Both approaches can provide estimates of increases in economic output, value added and employment in the broader economy flowing from the Project. CGE modelling uses a more complex set of techniques and involves different assumptions about the state of the economy. One central difference between the two approaches is that IO modelling generally assumes that there is an unlimited source of resources available in the economy to meet increases in demand. In contrast, CGE modelling generally assumes that the economy and sectors within the economy are competing for the use of resources. This means that increases in demand from the Project may result in effects such as increased prices in other markets and crowding out effects (rather than just increased output). In this sense, CGE modelling provides more conservative estimates of economic impacts than those provided by IO modelling.

3 Background on Project Area location

This chapter provides an overview of the economic and demographic characteristics of the location of the Project. The Gloucester Local Government Area (LGA) is used as the unit of analysis in this chapter as it provides an appropriate scale on which to give a picture of local social and economic conditions. Later chapters of the report include detailed analysis on the broader Hunter region.

The Gloucester LGA is located in the Mid North Coast and Upper Hunter region of New South Wales, approximately 120km north of Newcastle, as shown in Figure 3.1. The LGA consists of a number of villages, including Gloucester, Barrington, Copeland, Craven and Stratford, as well as numerous surrounding smaller localities.

Figure 3.1: Gloucester LGA

Source: ABS (2013)

3.1 People

At the time of the 2011 Census, the population of the Gloucester LGA was 4,767, a 1.7% increase in population from 2001. This is lower than the population increase state wide which was 12.1%. The population is evenly split across sexes. The median age across the LGA is approximately 49 years, which is higher than the New South Wales average of 38 years.

Table 3.1: Population characteristics of the Gloucester LGA

	2001	2006	2011	2001-2011 change
Population (usual residence)	4,687	4,784	4,877	1.7%
Population (enumeration)	4,586	4,801	4,777	4.2%
Mean household size	2.5	2.3	2.3	
Median age	42	47	49	
Total occupied private dwellings	1,882	2,008	2,085	10.8%
Median monthly housing loan repayment	758	1,083	1,517	100.1%
Median rent ($/week)	100	120	165	65.0%
Median household income ($/week) - Gloucester	564	691	821	45.6%
Median household income ($/week) - NSW	826	1039	1233	49.27%

Source: ABS, 2011 Census Time Series Profile Cat. 2003.0
Note: All dollar values reflect nominal figures gathered in the census.
Note: There may be some small differences to sections of the EIS due to revisions by the ABS subsequent to preparation of the EIS.

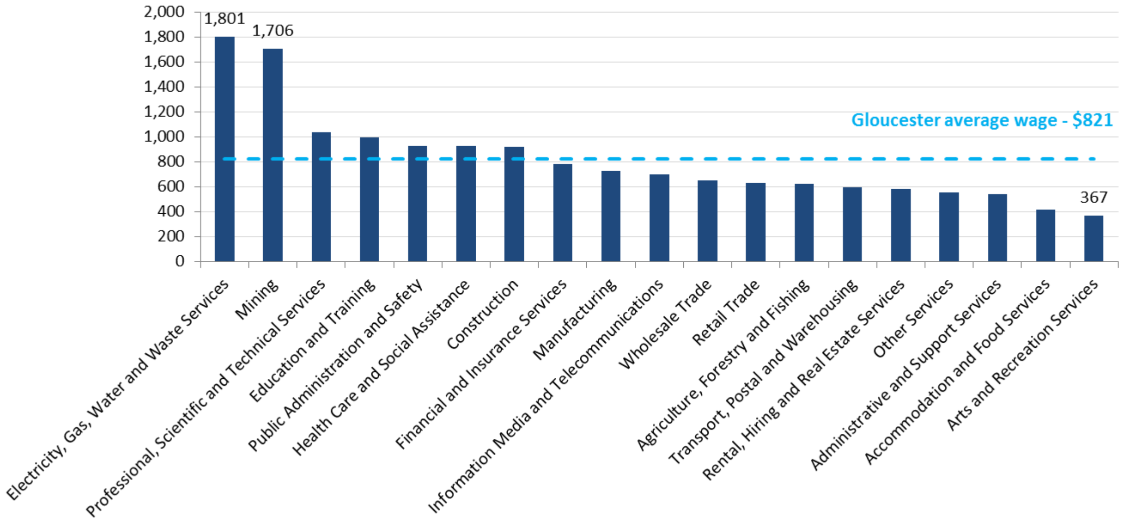
Based on the 2014 State and Local Government Area Population Profiles as forecast by the NSW Department of Planning and Environment, the population of the Gloucester LGA is expected to remain stable between 2011 and 2021, after which point it is anticipated to fall by an average of 0.2% per annum over the period to 2026, followed by a faster decline of 0.4% on average per annum out to 2031. These estimates imply an overall reduction in the population of the Gloucester LGA between 2011 and 2031 of around 3%.

The number of occupied private dwellings in the Gloucester LGA has increased by 10.8% over the last ten years, an average annual growth rate of 1.0%. Approximately 200 additional dwellings were established in the Gloucester LGA over the period from 2001 to 2011. This trend is a reflection of both the population growth in the region and the decline in average household size observed between 2001 and 2011.

In the 2013-14 financial year, there were 34 new residential dwellings approved in the Gloucester LGA. The value of residential building approvals over the financial year was $9.8 million and the value of total building approvals was $12.5 million (ABS Building Approvals, 2014).

The median weekly household income in Gloucester in 2011 was $821, lower than the NSW median of $1233. A breakdown of the average wage by industry is provided in Chart 3.1. As illustrated, 'electricity, gas, water and waste services' and mining are the two highest paying industries in the Gloucester LGA. However, mining employs 147 people in the LGA while 'electricity, gas, water and waste services' employ less than 20.

Chart 3.1: Gloucester average weekly personal income by industry – 2011 (in 2011 dollars)



Source: ABS (2014a)

3.2 Education

The average educational attainment in Gloucester is lower than the NSW average, as evidenced by Table 3.2. For example, in the 2011 Census, only 13.8% of the population indicated they held a tertiary level qualification, compared with 22.8% of the NSW population.

Table 3.2: Highest level of education attained

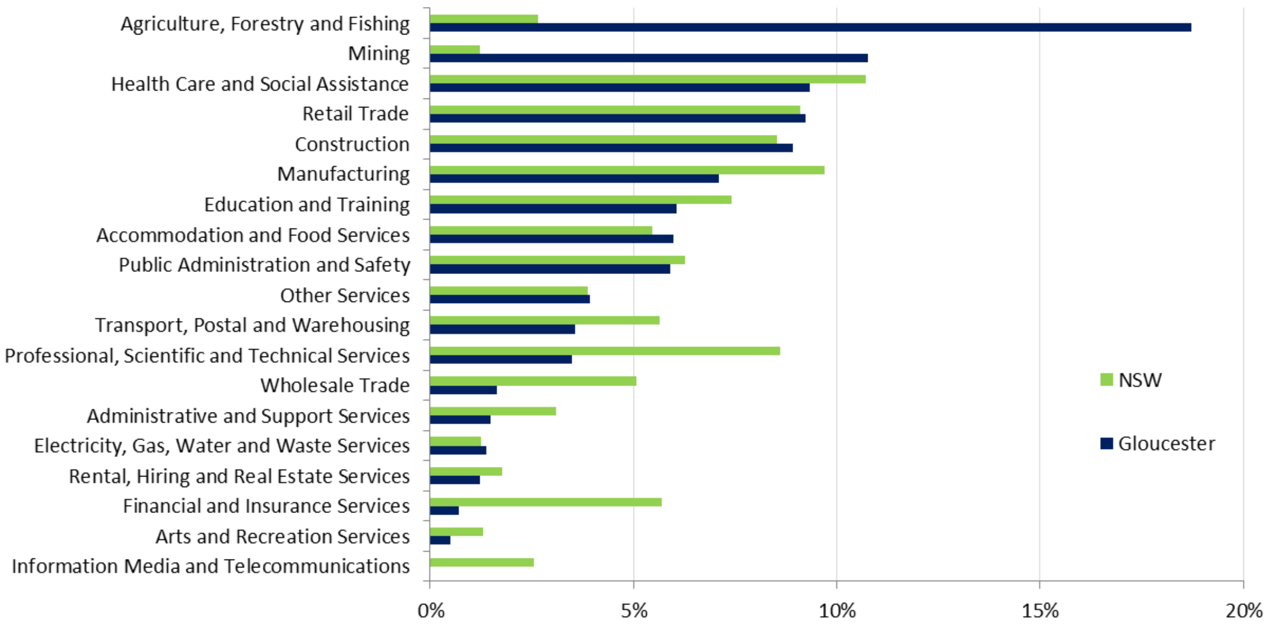
Highest level of education	Gloucester	NSW
Tertiary level		
Postgraduate degree level	1.0%	3.5%
Graduate diploma and graduate certificate level	0.9%	1.2%
Bachelor degree level	6.4%	11.4%
Advanced diploma and diploma level	5.5%	6.7%
Certificate level		
Year 12 or equivalent	22.2%	38.4%
Year 11 or equivalent	5.2%	4.8%
Year 10 or equivalent	31.5%	19.5%
Year 9 or equivalent	11.5%	5.9%
Year 8 or equivalent	7.9%	4.5%
Did not go to school	0.2%	0.8%
Highest year of school not stated	5.4%	6.9%

Source: ABS, 2011 Census (2014a)

3.3 Industries of employment

Agriculture is the major industry of employment in the Gloucester LGA, employing 18.7% of the employed population. This is much higher than in NSW, where just 2.7% of the employed population work in the agriculture sector. The mining and health care industries are the next highest employers, at 10.8% and 7.1% respectively.

Chart 3.2: Industry of employment in Gloucester LGA and New South Wales



Source: ABS Census, 2011

Note: There may be some small differences to sections of the EIS due to revisions by the ABS subsequent to preparation of the EIS.

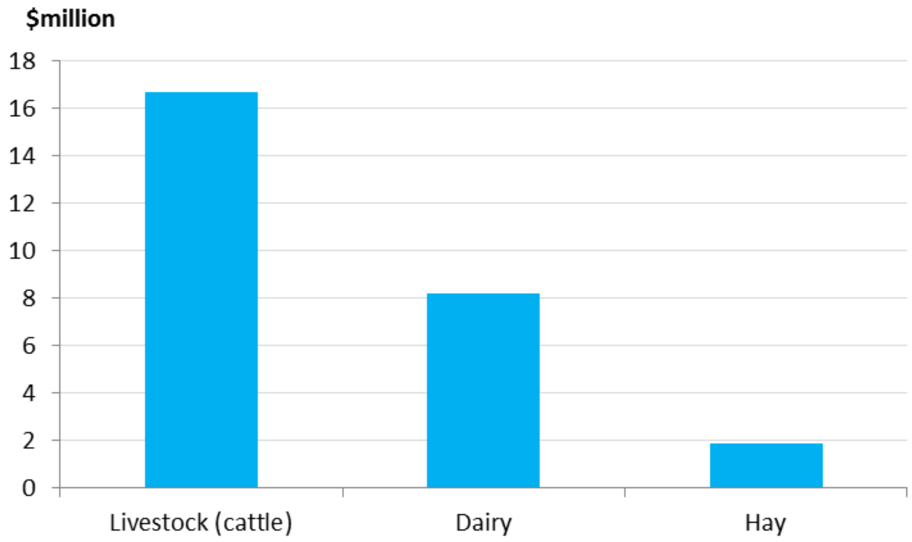
3.3.2 Mining

In the Gloucester LGA the mining industry employs 147 people. The majority of these jobs are in Coal Mining (58%), with the next highest sub-industry employment in Exploration (29%). The major mines and operations in the area are Duralie and Stratford Open Cut Operations.

3.3.3 Agriculture

In the year ended June 2011, the Gloucester LGA produced agricultural produce of a gross value of $28.6 million. The major contributing commodities were livestock, dairy and hay, illustrated in Chart 3.3.

Chart 3.3: Gross value of primary agricultural commodities – Gloucester 2010-11

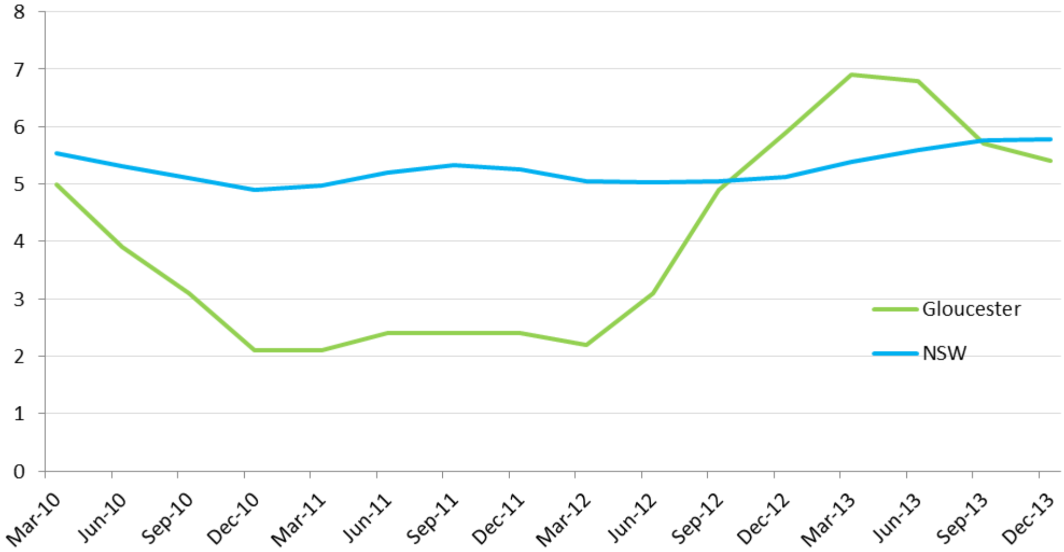


Source: ABS, Cat. 7503

3.4 Unemployment

According to Department of Education, Employment and Workplace Relations (DEEWR) small area labour markets data, the unemployment rate for the quarter preceding December 2013 in Gloucester was 5.4% (this is the most recent quarter for which data is available). This was an 8.5% decrease from the unemployment rate of December 2012 (5.9%) and was similar to the NSW rate at the time. Chart 3.4 below illustrates a general trend of unemployment being fairly steady in NSW over the past 3 years. The unemployment rate in Gloucester has been more volatile over the period.

Chart 3.4: Unemployment rate in Gloucester and NSW, %



Source: DEEWR 2013, Small Area Labour Markets Data, ABS Cat. 6202

4 The Rocky Hill Coal Project

As described above, the purpose of a CBA is to provide a structured approach to assessing whether or not a project is likely to result in overall benefits to the economy. To carry out this economic assessment, the costs and benefits associated with the Rocky Hill Coal Project are compared to those under a baseline, 'business as usual' case. This comparison allows for an incremental analysis, to reach a clear conclusion on the net benefits of the Project.

Accordingly, for the purposes of the CBA, it is important to clearly define the baseline case and the Project case. This chapter defines both the baseline case and Project case for the Rocky Hill Coal Project in turn.

4.1 Baseline case

The proposed location for the Rocky Hill Coal Project is approximately 3.5 to 7 kilometres south-east of Gloucester, NSW. The Project site has an area of around 856 hectares, of which around 510 hectares constitutes the mine disturbance area.

The Agricultural Impact Statement (AIS) undertaken for the Project by R.W. Corkery & Co. and Essential Solutions Consulting (2013) indicates that 90% of the proposed mine disturbance area currently consists of cleared open pasture, with the remaining 10% consisting of areas of dry sclerophyll forest, riparian forest, rainforest and a small pine plantation. The AIS confirms that this land is predominantly moderate / moderate – low capability land, according to the NSW Office of Environment & Heritage's land and soil capability (LSC) assessment scheme.

Historically, this land has been used for beef cattle grazing and growth of native vegetation. Accordingly, in the absence of the Project, the baseline case assumes that these historical uses of the Project site will continue in perpetuity from 2014.

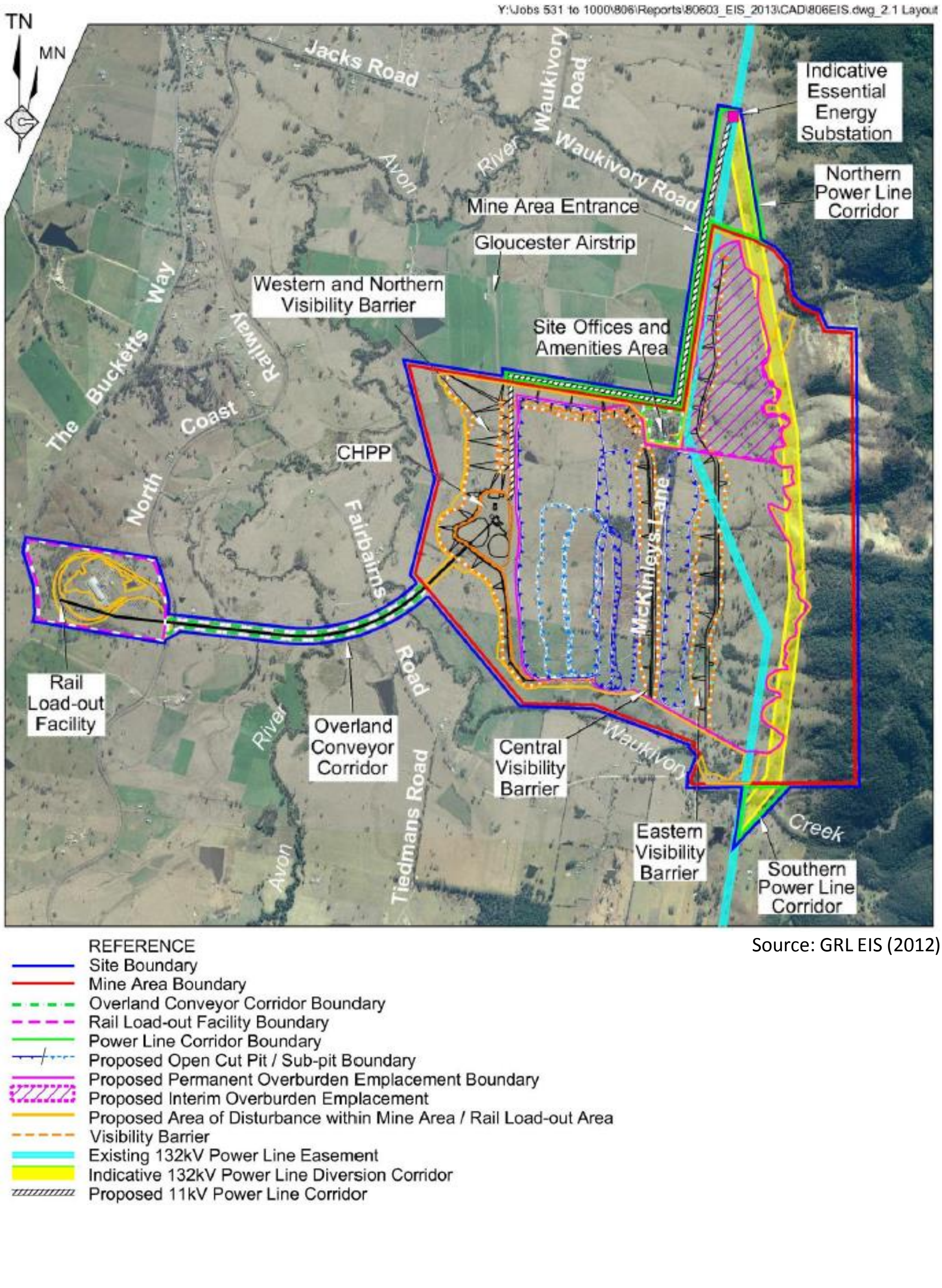
It is expected that this agricultural activity will coexist with Stage 1 of the AGL Gloucester Gas Project, which was granted approval in February 2011. This Project involves development of 110 coal seam gas wells, pipelines and related infrastructure within the Gloucester Basin, and is a feature of both the baseline and Project case in this analysis.

4.2 Project case

Should the Rocky Hill Coal Project receive approval, GRL will establish open-cut coal mining operations at the proposed Project site, as illustrated in Figure 4.1.

The Project will commence with a three year design and construction phase. For the purposes of this analysis, it has been assumed that this phase will commence in 2015, and conclude at the end of 2017.

Figure 4.1: Proposed operations within the Project Area



Source: GRL EIS (2012)

The main activities that will take place during this period include construction of:

- the Mine Area access road to the site offices and amenities area;
- additional offices and amenities area buildings and light vehicle car parks, with demolition of existing buildings that are not required;
- water management structures;
- the coal handling and preparation plant (CHPP) and related infrastructure;
- the overland conveyor for transporting product coal to the rail load-out facility within a 50 metre wide corridor, including a crossing of Fairbairns Road;
- the rail loop and train loading infrastructure; and
- a new low voltage power line to the CHPP from a sub-station on the existing 132kV line and relocation of a 6km section of the existing 132kV power line.

In addition, GRL have also committed to construction of three visibility barriers in order to reduce the impacts of the Project on air quality, noise levels and visual amenity. The western and northern visibility barrier will be constructed using materials excavated from the initial mining areas and a pre-strip area within the boundary of the Main Pit and will remain for the life of the operational mine. The central and eastern visibility barriers will be progressively developed later, to coincide with movement of mining operations, with both barriers subsumed into the constructed final landform.

GRL will also undertake a number of off-site construction activities that upgrade nearby public road infrastructure. This includes construction of a new bridge on Jacks Road across the Avon River and upgrading a number of nearby intersections and sections of roads, including Jacks Road, Waukivory Road and McKinleys Lane. Further details are outlined in Section 5.2.20.

This analysis assumes that mining will take place over the period from 2018 to 2031, involving the development of mining pits over the course of the Project. While approval has been sought for a maximum extraction rate of 2.5 million tonnes of ROM coal per annum, projected annual ROM production is expected to peak at 2.0 million tonnes.

Land will be rehabilitated progressively over the life of the mine, to allow for gradual re-introduction of agricultural activities. GRL have committed to backfill the final void, such that the final landform of the mine disturbance area will be comparable with the existing landform at the conclusion of rehabilitation activities.

As assumed in the baseline case, the Project case will also involve development of coal seam gas wells and other related infrastructure, as part of the approved AGL Gloucester Gas Project Stage 1. Given that this activity features in both the baseline and Project cases, it is not considered further in this analysis, as it does not impact the incremental benefits or costs of the Project.

Overall, it is expected that the Project will employ a peak of 100 FTE employees during the construction phase, between 96 and 148 FTE over the operations phase, and around 50 FTE during the two year rehabilitation period. GRL has nominated a target of 75% local employment by the end of the third year of operations.

4.3 Project options and scope of CBA

In addition to clearly defining the baseline case and the Project case, completion of the CBA also requires a consideration of other Project options and the geographic scope of the analysis.

In terms of considering other Project options the following alternatives were considered, but were not identified as the preferred case, due to feasibility and/or the nature of broader impacts. Accordingly, these options were not incorporated in the CBA.

- **Mine area:** development of an additional open cut pit targeting the Clareval Seam was proposed, but subsequent geological and coal quality investigations established that this was not economical;
- **Mining methods:** underground mining was not found to be technically or safely feasible given the steeply dipping nature of the coal seams within the Mine Area;
- **Overburden disposal:** overburden emplacement design has been varied from traditional approaches to minimise the visual impacts of the Project;
- **Final void:** GRL has committed to backfill the final void to allow the land to be returned to its former grazing use, and avoid any adverse impacts on groundwater, rather than retaining the void with various side slopes and depths of water;
- **CHPP location:** a number of options for locating the CHPP were considered, but not chosen as they involved sterilisation of a proportion of the open cut resource;
- **Disposal of fine rejects:** a method of co-disposal of fine and coarse CHPP rejects and overburden into the active waste rock emplacement and/or exhausted open pits was chosen, rather than development of tailings dams or direct disposal to mine voids as a slurry, due to feasibility issues and impacts on end of Project land use and the timing for its achievement;
- **Product despatch to the Rail Load-Out facility:** a conveyor was chosen as the transportation method for product coal to the train loader, rather than use of trucks, to avoid negative traffic and visual amenity impacts, as well as feasibility issues associated with construction of a dedicated haul road on private property; and
- **Overland conveyor design and location:** a low profiled curved conveyor was selected over other options to minimise visibility, noise, dust and power issues, and it was located in an area that would minimise the extent of riparian vegetation trimming required where crossing Waukivory Creek and the Avon River.

The second issue that must be clarified is the geographic scope of the CBA. This is important as it draws a line for which benefits and costs are included in the analysis and which are excluded. For example, if the scope of the CBA is defined as the State of NSW, rates payable to the Gloucester Shire Council, and royalties payable to the NSW Government should not be included in the analysis. As the cost to GRL is offset by the benefits to the government, these transfer payments cancel out.

As the CBA is being developed to assist with NSW Government assessment processes, the scope of the CBA will generally be the State of NSW. However, the fact that the guidelines and requirements discussed in Section 2 do not fit neatly into a traditional CBA framework means that the analysis will sometimes require consideration of effects for particular groups within the scope. Whenever this is the case, which parties are being analysed and where they are likely to be located has been clearly identified.

5 Cost benefit analysis

This section presents the first stage of our methodology, consisting of a cost benefit analysis (CBA) of the Project. This involves identifying the incremental costs and benefits of the Project relative to the baseline case and quantifying those items wherever possible to obtain a consolidated estimate of the net economic value of the Project.

Overall, it is concluded that the Project leads to a total net benefit of approximately $363 million (in 2014 NPV terms) and provides a benefit cost ratio (BCR) of 1.53. The steps involved in this analysis are described in the following sub-sections.

5.1 Identifying costs and benefits

The economic, environmental and social costs and benefits considered in this analysis are set out in Table 5.1.

Table 5.1: Project Direct Costs and Benefits

	Costs	Benefits
Internal effects of production	Exploration costs	Gross mining revenue
	Capital investment costs	Other onsite revenue
	Operating costs excluding royalties, rates and taxes	Residual value of capital*
	Rehabilitation costs	
	Decommissioning costs*	
	Residual value of land forgone	
Externalities	Related public expenditure*	
	Offsite agricultural revenue*	
	Groundwater quality*	
	Surface water quality*	
	Air pollution – carbon emissions	
	Air pollution – particulate matter	
	Air pollution – other pollutants*	
	Noise pollution	
	Visual amenity*	
	Traffic impacts*	
	Biodiversity – flora and fauna	
	Conservation*	
	Quality of open space*	
	Rural amenity and culture	
	Aboriginal heritage*	
	Historic heritage*	
	Health*	

* Item has been considered qualitatively

Note: As the Project involves open-cut mining activity, there are no subsidence impacts which need to be valued in this analysis. Nevertheless, this item is discussed qualitatively in Section 5.2 in accordance with NSW Government Guidelines (2012)

In recognition of the broad range of impacts of the Project, the costs and benefits shown have been separated into two categories:

- internal effects of production – costs and benefits that affect the financial outcomes of the proponent; and
- externalities – the broader implications of the Project for third party stakeholders, such as residents and external businesses from the Gloucester community, the broader region, and beyond.

Section 5.2 describes the techniques used to value each of these items and provides the justification behind the classification of each as a cost or benefit.

As recommended in CBA guidelines such as NSW Treasury (2007), where it is difficult to place a value on a particular cost or benefit of the Project, a qualitative analysis has been undertaken. The items considered qualitatively are identified in Table 5.1 and are discussed thoroughly in Section 5.2. In some cases these items have been considered qualitatively because there is expected to be no significant difference in outcomes under the baseline and Project case (such as related public expenditure, groundwater quality and surface water quality) or because there is no reliable method available to value them in these particular circumstances (such as visual amenity).

5.2 Valuing costs and benefits

This section details the approach taken to provide a value for each of the costs and benefits identified in Table 5.1. For the costs and benefits that fall within the production category, a market value can usually be assigned using the financial information provided by GRL, with validation from other sources where possible. In contrast, it is generally more difficult to attach a monetary value to the non-priced externalities.

The approach to valuation taken in this analysis is described below. Further discussion on the advantages and disadvantages associated with the different valuation techniques mentioned can be found in Appendix B.

Firstly, in cases where there is a market price available, this price is used. Alternatively, if a standard industry approach is available, then this value is used. For example, transport costs are outlined in publications from Transport for NSW (2013). When neither of these options are available, there are then two alternative possible approaches. The first is to undertake a literature review and apply benefit transfer techniques to the local context if required. This can be achieved using databases of non-market values such as 'Envalue', which was maintained by the NSW Department of Environment and Climate Change up until 2004, or its more recently updated international equivalent, the Environmental Valuation Reference Inventory (EVRI) developed by Environment Canada. These databases can be augmented by a direct review of the relevant literature for non-market valuations. Current literature on non-market valuations involves a number of specialised methodologies (e.g. the travel cost method, contingent valuation or choice modelling), which all require extensive surveys or, alternatively, empirical analysis such as hedonic pricing, which uses existing market data from an affected sector (e.g. residential property market).

In the event where there is insufficient literature available, a final alternative is to undertake original research into non-market values.

The discussion throughout the chapter draws on the findings in Appendix C, which reviews the unit value evidence for each item considered in this report.

5.2.1 Gross mining revenue

Gross revenue from mining activity at Rocky Hill is calculated using forecasts of annual production quantities and annual prices for each coal product.

As noted in Section 4.2, while approval has been sought for a maximum extraction rate of 2.5 million tonnes of ROM coal per annum, projected annual ROM production is expected to peak at 2.0 million tonnes. This analysis is based on this projected production profile.

For each year of operation under the Project case, GRL has provided production quantity forecasts of semi-hard coking coal and thermal coal. These forecasts have been based on detailed coal quality analyses for the seams to be mined in each production year.

As illustrated in Chart 5.1, under the Project case, approximately 13.5 Mt of saleable coal will be produced between 2018 and 2031 in total. For semi-hard coking coal this production will increase gradually before stabilising in 2025, followed by a decline in 2030. [redacted].

Chart 5.1: Project case forecast production profile – 2014 - 2031

[redacted]

Semi-hard coking coal Thermal coal

Source: GRL

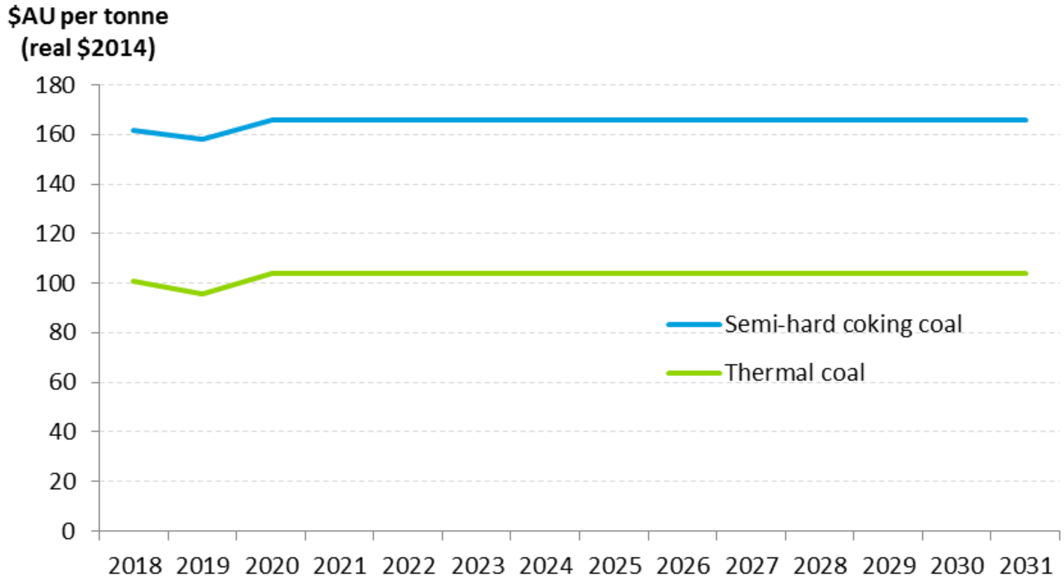
The prices used in this analysis were based from the forecasts for thermal and semi-hard coking coal provided by GRL, which are in turn drawn from broker consensus forecasts [redacted] These are estimated in real Australian dollars.

The forecast price for thermal coal used here remains below the nearest equivalent forecasts made by the Bureau of Resource and Energy Economics (BREE) from 2018 onwards, in its March 2014 publication (BREE 2014).

GRL has estimated that the semi-hard coking coal produced from the Project will be valued at around [redacted] of the broker consensus forecasts for high quality hard coking coal. This assumption has been made following an analysis undertaken by Coal Quality Consultant, Ken Wilson in June 2014. This analysis indicates that semi-hard coking coal is likely to be sold at a premium (relative to semi-soft coking coal) as it can be blended with other coals to create higher quality product. It also describes how there is currently limited supply of semi-hard coking coal in NSW which is likely to support somewhat higher prices relative to semi-soft coking coal.

The coal price forecasts used in this analysis are illustrated in Chart 5.2 below.

Chart 5.2: Coal price forecasts – Rocky Hill, 2018 – 2031



Source: GRL

In recognition of the inherent difficulties associated with forecasting coal prices over the long term, the sensitivity analysis presented in Section 5.4 includes scenarios that vary the coal price by a factor of 30%.

Applying these values and assumptions gives a central present value estimate of $1,047 million for gross mining revenue. In undiscounted terms, gross mining revenue is estimated at [redacted].

5.2.2 Other onsite revenue (e.g. agriculture)

It is also necessary as part of the CBA, to incorporate the impact of the Project case on any additional net revenue streams derived from land owned by GRL.

In the context of this analysis, the first impact to be considered is the effect of the Project on other revenue earned from land within the disturbance area. The Agricultural Impact Statement (AIS) completed by R.W. Corkery & Co. and Essential Solutions Consulting (2013) indicates that the Project will involve temporary removal of land from beef cattle grazing, within the disturbance area. This is expected to reach a maximum area of 544 hectares in 2020, the third year of mining operations. However, as the value that would be lost from disturbance of such grazing activities is quantified as part of the residual value of land estimates, presented in Section 5.2.9, this impact is not considered further here to avoid double counting.

Nevertheless, it is also important to value the impacts of the Project on net revenue earned from other land owned by GRL, beyond the disturbance area. For most of the landholdings owned by GRL in the vicinity of the mine, it is assumed that there will be no change in the level of net revenue generated under the baseline and Project cases. However, the AIS and further information provided by GRL indicates that there are two main impacts to consider, being:

- additional net revenue from land to be made suitable for dairying purposes as a result of favourable lease arrangements with GRL; and
- loss of net revenue from beef cattle grazing due to permanent establishment of the Biodiversity Offset Area.

These are considered in turn below.

Additional dairying revenue from lease arrangements

GRL has advised that it has entered into lease agreements with the Speldon Partnership dairy (Speldon), located adjacent to the Rocky Hill mine. The terms of these lease agreements has made it viable for Speldon to undertake investments to improve the carrying capacity of land beyond the disturbance area through pasture improvement, other management measures and more intense grazing management strategies (AIS 2012:86; Response to Submissions 2014:66).

Under the baseline case, it is assumed that GRL would sell its landholdings within and around the mine disturbance area at commercial rates. While the terms of sale would ensure that existing lease agreements with Speldon would be honoured, it is assumed that the investments noted above would not take place, due to uncertainty around future pricing of the lease.

Accordingly, the additional net revenue generated by Speldon through this investment, over and above that which would be generated under the baseline case, should be attributed as a benefit of the Project.

Specifically, this analysis focuses on the net revenue to be generated from around 250 hectares of GRL-owned land adjacent to the mine disturbance area, which, under the Project case, is to be made suitable for dairying purposes rather than beef cattle grazing, the expected land use under the baseline (Table 2.3.1 of the Response to Submissions).

While additional investment is also anticipated to make further land within the mine disturbance area suitable for dairying purposes, rather than beef cattle grazing, the additional revenue generated here is not included in this analysis as the availability of the land may cease upon the commencement of the design and construction phase of the Project, in 2015. This analysis also excludes the benefits of additional investment to be made in areas used for beef cattle grazing, to ensure a conservative approach.

Consistent with the AIS, it is assumed that the 250 hectares of land adjacent to the mine disturbance area could accommodate 1.4 head of dairy cattle per hectare (Table 6.1 of the AIS) under the Project case. It is also assumed that the land would generate Project case revenue of around $2,752 per head per annum, being the average dairy production value in Gloucester (Table 2.3.1 of Response to Submissions). This implies that around $963,200 in annual net revenue[1] would be generated in the Project case for the lifetime of the lease.

However, in order to calculate the additional revenue associated with the Project, it is also necessary to quantify the revenue foregone from a removal of beef cattle grazing on that land. Consistent with the AIS, it is assumed that under the baseline case, the land could accommodate 0.5 head of beef cattle per hectare, with net revenue in the order of $300 per head (Table 6.1 of AIS). This is equivalent to net revenue foregone of $37,500 per annum.

Therefore, it is estimated that additional net revenue of around $925,700 p.a. would be generated in the Project case. This is applied between 2015 and 2022, on the assumption that the productivity improvements would not be realised before the commencement of the design and construction phase of the Project, and would be likely to remain in place for at least half of the Project life. In present value terms, using a 7% discount rate, this additional net revenue is valued at around $5.8 million.

It is noted that if the lease was to be extended for the duration of mining, the present value of the additional net revenue would rise from $5.8 million to $9.4 million, using a 7% discount rate. Nevertheless, to present a conservative estimate, the lower bound is used for this analysis.

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[1] While this is based on gross revenue estimates, derived from production values published by official sources (i.e. ABS Census data), in the context of this analysis, Essential Solutions Consulting have advised that this is close to the net revenue likely to be derived by Speldon, due to efficiencies reported by dairy producers. The specific net revenue figures likely to be earned by Speldon have not been utilised in this analysis due to commercial sensitivities.

Loss of beef cattle grazing revenue from Biodiversity Offset Area

However, the benefits described above will be offset to some extent by the permanent removal of approximately 140 hectares of land suitable for low productivity grazing, on the eastern side of the mine disturbance area, for the purposes of establishing the Biodiversity Offset Area. The AIS states that at least 80% of this land is LSC Class 7, land with extremely severe limitations and incapable of sustaining most land uses, with the remaining areas a mixture of Class 4 and 5 land. The loss of the net revenue from low productivity grazing activity on this land should be attributed as a cost of the Project.

Given the low productivity of the land, it is conservatively assumed that this land could accommodate approximately 0.5 head of beef cattle per hectare for grazing purposes. Assuming a net production value of $300 per head, per annum, drawing from Table 6.1 of the AIS, it is estimated that the Project case will cause a loss of net revenue of around $21,150 per year, in perpetuity. On the basis that the Biodiversity Offset Area would be established in 2015, the lifetime losses are estimated at $0.30 million in present value terms, using a 7% discount rate.

Overall impact

Combining these two estimates, it is expected that the Project will generate a net benefit in terms of impacts on other onsite revenue, in the order of $5.45 million, in present value terms.

5.2.3 Exploration costs

Exploration expenditure consists of any costs associated with preparatory activities before extraction commences. Where these costs are yet to be incurred, it is appropriate to include them in a CBA.

For the Project, GRL has advised that any exploration costs associated with either the baseline or Project case have been incorporated in the capital expenditure estimates. Therefore, to avoid double-counting, these are not considered separately under this item.

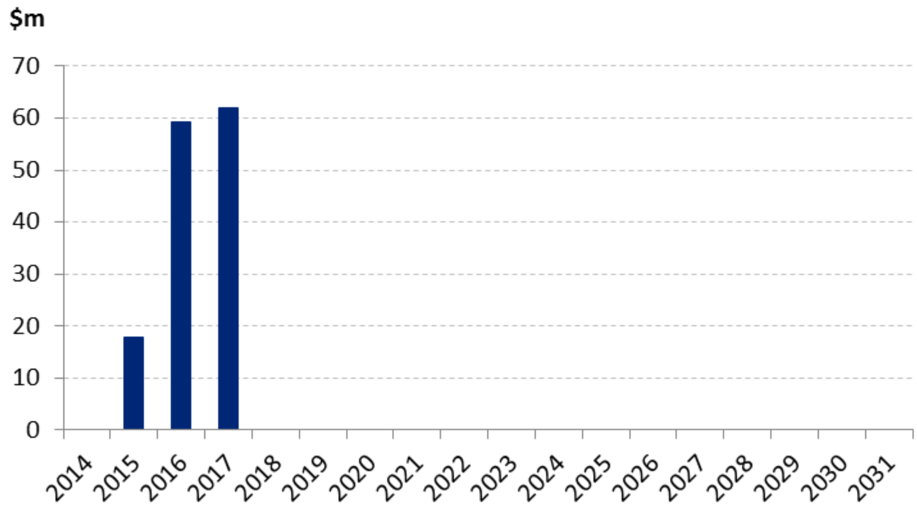
5.2.4 Capital investment costs

In this analysis, capital investment costs encompass all expenditures on infrastructure associated with the existing and proposed operations.

Should the Project receive approval, capital investment of approximately $139 million is expected to be incurred between 2015 and 2017. This includes expenditure on proposed roads, rail loop, rail loading and storage facilities, an overland conveyor and a coal handling and preparation plant. DAE has undertaken a basic benchmarking review of the capital expenditure estimates based on data in Shafiee *et al* (2009) and Gillespie (2012). This analysis indicates that the capital expenditure estimates are higher than expected given past experience. It should be noted that this basic benchmarking review does not take into account factors such as fluctuations in the level of Project capital costs over time and costs specific to the location of the Project. In the event that capital expenditure is lower than forecast, the net benefits and Benefit Cost Ratio realised from completing the Project will be higher than shown in this report.

The anticipated timing of this investment is illustrated in Chart 5.3. Overall, this Project case capital investment has been valued at $118.95 million in present value terms, using a 7% discount rate.

Chart 5.3: Project case capital investment, 2014 - 2031



Source: GRL

5.2.5 Operating costs excluding royalties, rates and taxes

Operating costs encompass the expenditure incurred as a direct result of extracting ROM coal, processing it into saleable product and delivering it to a port before loading (known as free on board (FOB) costs) as well as ongoing expenditure on the purchase and maintenance of equipment and machinery necessary for production.

For this analysis, estimates of Project case FOB costs (excluding royalties and applicable taxes) have been provided by GRL. No operating costs are assigned to the baseline case, given that it does not involve mining activity.

As shown in Chart 5.4, it is estimated that FOB costs will range between [redacted] per tonne over the life of the Project. The variation is due to factors such as changes in the stripping ratio and the average daily production rate from year to year. High levels of variation in operating costs are common in coal mining.

These costs have been validated based on econometric modelling undertaken by Shafiee, Nehring and Topal, using data on open cut coal mines in Australia (2009). The authors define per tonne operating costs as a function of deposit average thickness, the stripping ratio, capital cost and the daily production rate. The estimates of FOB costs produced using this method are very similar to those provided by GRL.

Any royalties, councils rates or taxes should be excluded from these estimates for the purpose of this cost benefit analysis, as they are a transfer of funds with the expense incurred by the company offset by a gain for government. It is, however, unclear whether the operating cost estimates produced by Shafiee, Nehring and Topal's model incorporate such transfers. Our experience over a number of similar projects indicates that they do not. As a result, given the close proximity of the FOB cost estimates provided by GRL and the estimates produced by the model, the GRL cost estimates used in this analysis we have not explicitly adjusted the GRL cost estimates to attempt to thoroughly exclude all potential transfers. To that extent, this analysis utilises a conservative estimate of FOB costs per tonne.

Chart 5.4: FOB costs per tonne, 2018 - 2031

[redacted]

Source: GRL

Estimates of ongoing expenditure on mobile equipment including sustaining capital and exploration were also provided by GRL. The anticipated profile of this expenditure under the Project case is presented in Chart 5.5.

Chart 5.5: Ongoing expenditure on equipment, 2018 - 2031

[redacted]

Source: GRL

[redacted]. The time series of these total cost estimates are presented in Chart 5.6.

Chart 5.6: Total operating costs, 2018 - 2031

[redacted]

Source: GRL

5.2.6 Rehabilitation costs

Under the Project case, land rehabilitation works will be undertaken progressively over the life of the mine. As the costs of rehabilitation have been included in the operating cost estimates, to avoid double-counting they are not considered further here.

5.2.7 Decommissioning costs

Decommissioning costs comprise costs associated with the conclusion of mining operations and the removal of old assets or infrastructure – in general, the costs involved in the closure of the mine within the Project Area.

Under the baseline case, there are no decommissioning costs to be incurred as the proposed mine area is a greenfield site. Under the Project case, data provided by GRL indicates that any decommissioning expenses are likely to be more than offset by the residual value of capital, discussed in the following section.

Accordingly, the decommissioning costs of the Project are assumed to be zero for the purpose of this analysis.

5.2.8 Residual value of capital

Upon completion of mining, companies often generate additional revenue from the sale of remaining capital goods.

In the context of this Project, GRL has advised that a number of assets are likely to have remaining productive capacity at the conclusion of the operational phase. While the value of such assets should be attributed as a benefit of the Project, this analysis conservatively assumes that the residual value of capital will offset any decommissioning costs under the Project case. This assumption has been made to account for the uncertainty about the precise value of the capital stock at the end of its life.

Accordingly, this item is also treated qualitatively in this analysis.

5.2.9 Residual value of land

As part of a CBA, it is also important to take account of changes in potential land use as a result of a project. This value primarily depends on the ability of the land to support future activities of economic or social value, whether it be in terms of revenue-generating potential or other broader uses such as conservation. The focus here is not the monetary exchange that accompanies sales, as these transactions are transfer payments which cancel out between the buyer and seller. Rather, the focus of this item is on valuing the changes in land use, when comparing the baseline and Project case.

In the context of this analysis, the Agricultural Impact Statement (AIS) undertaken for the Project by R.W. Corkery & Co. and Essential Solutions Consulting (2013) indicates that 90% of the proposed mine disturbance area currently consists of cleared open pasture, with the remaining 10% consisting of areas of open woodland, riparian forest, rainforest and a small pine plantation[2]. The AIS confirms that this land is predominantly moderate / moderate – low capability land, according to the NSW Office of Environment & Heritage's land and soil capability (LSC) assessment scheme (2012). Historically, this land has been used for beef cattle grazing and growth of native vegetation.

[2] See Table 4.4 of the Agricultural Impact Statement.

In addition, it should be noted that GRL has entered into lease agreements with the Speldon Partnership dairy (Speldon), adjacent to the Rocky Hill mine, as described in Section 5.2.2.

Under the baseline case, it is assumed that GRL would sell its landholdings within and around the mine disturbance area at commercial rates. While the terms of sale would ensure that existing lease agreements with Speldon would be honoured, due to uncertainty around future pricing of the lease, it is assumed that these areas would continue to be used for their existing purposes from 2014 onwards.

Under the Project case, the land within the mine disturbance area would be progressively disturbed from 2015, as a result of the construction and operational phases of the Project. The AIS indicates that the land removed from agricultural production will vary over the life of the Project, peaking at 544 hectares in 2020, the third year of operations[3]. The mine disturbance area will be rehabilitated progressively, culminating in the backfilling of the final void, so that all land within the disturbance area is returned to the same type and land capability classes as those prior to mining.

While the AIS notes that cattle would be reintroduced to revegetated land after a maintenance period of at least three years, this analysis conservatively assumes that, under the Project case, the land within the disturbance area would not be available for agricultural production until the end of 2033, once the closure phase of the Project is finalised. The anticipated final landform within the mine disturbance area in the Project case is expected to consist of pasture with tree lots (279ha), open woodland (188ha) and native vegetation fauna corridors (24ha). This pasture land and open woodland is assumed to be suitable for beef cattle grazing, at the same level of productivity as under the baseline case.

In terms of the agreement with Speldon Partnership, it is noted that under the Project case, there is likely to be some improvement in the productivity of land (predominantly outside the mine disturbance area) compared to the baseline case, due to the terms of the lease agreements. A conservative assessment of this additional net revenue generated is discussed in Section 5.2.2, under the item for other onsite revenue.

Table 5.2 presents details of the anticipated breakdown of the proposed mine disturbance area as at 2014 in the baseline, and as at 2034 in the Project case. Note that for the purpose of this analysis, the mine disturbance area has been expanded by 35 hectares to account for the agricultural land adjacent to the disturbance area that will be temporarily removed from production in 2020.

[3] It is noted that this area (544 ha) consists of an additional 35 hectares of land adjacent to the mine disturbance area, but within fenced management areas.

Table 5.2: Comparison of land use in the proposed mine disturbance area

Land use	Baseline case – 2014	Project case - 2034
Pasture suitable for beef cattle grazing	*507.1 hectares	**314.0 hectares
Open woodland (some of which is also used for grazing)	***46.4 hectares	188.0 hectares
Riparian forest (some of which is also used for grazing)	1.1 hectares	-
Rainforest	4.3 hectares	-
Pine plantation	0.4 hectares	-
Native vegetation fauna corridors	-	24.0 hectares
Other areas	-	33.3 hectares
Total	**559.3 hectares**	**559.3 hectares**

Source: AIS

* 473.1 ha within disturbance area, plus the additional 34 ha adjacent to the disturbance area, within fenced management areas, that will be impacted by the Project from 2020.

** 279 ha of pasture with tree lots within disturbance area, plus the additional 34 ha adjacent to the disturbance area.

*** It is noted that this area is effectively 35.7 ha for the purpose of biodiversity valuation

This information can be utilised to ascertain the residual value of the proposed disturbance area under each case. While the land uses can be valued in perpetuity from 2014 onwards in the baseline case, this analysis assumes that, under the Project case, the economic and social value of the mine disturbance area will not be realised until 2034. This is an extremely conservative approach, assuming that the agricultural productivity of grazing land and social value of vegetation areas are likely to be minimal until mining activity has ceased and the closure phase is complete. In reality, limited grazing will commence from three years after landform creation and rehabilitation in any area with the grazing intensity increasing over time with pasture sward development.

As set out in Appendix C, where available, market prices should be used as a proxy for the future economic value that can be derived from landholdings. Drawing from the AIS and further information provided by GRL, it is assumed that approximately 0.5 head of beef cattle could be accommodated per hectare of pasture, open woodland and riparian forest, under both the baseline and Project case. An annual production value of $150 per hectare was then applied, an estimate reported in Table 6.1 of the AIS.

Meanwhile, the social value of vegetation areas has been estimated using data from the NSW Office of Environment and Heritage's BioBanking scheme. Specifically, the BioBanking public register provides information on biodiversity credit transactions and agreements. The value of ecosystem credits is determined by a range of factors including the type of vegetation on the land. Details from the register can be used as an estimate for the social value of conservation land.

The first step in this valuation process is to estimate the equivalent number of BioBanking credits for the vegetated land within the disturbance area. In this regard, this analysis relies on estimates of the equivalent credits per hectare presented in the Terrestrial Biodiversity Assessment undertaken for the Project.

These are outlined in Table 5.3, alongside the estimated number of credits associated with each vegetation type under the baseline and Project cases, based on the areas reported in Table 5.2.

Table 5.3: Biodiversity credits attributable to the proposed mine disturbance area

Vegetation type	Equivalent credits / ha	Total area (ha)		Total equivalent credits	
		Baseline	Project	Baseline	Project
Open woodland	34.87	35.7	188.0	1,618	6,556
Riparian forest	25.45	1.1	-	28	-
Rainforest	67.67	4.3	-	291	-

Source: Ecotone Ecological Consultants Pty Ltd (2013) Table 27, DAE estimates

Next, it is necessary to estimate the value per credit for each vegetation type. A search of the BioBanking Credits Register found that the most recent prices for the open woodland and rainforest areas, based on the equivalent biometric vegetation types reported in the Terrestrial Ecological Assessment, were $1,100 and $1,462 per credit, respectively. These prices are based on transactions made in mid-2013. In the absence of any transaction history for the riparian forest vegetation type, a conservative value of $1,462 per credit was applied. Due to the small area of riparian forest affected by the Project, this assumption is not expected to significantly alter the findings of the analysis. These prices are assumed to represent the lifetime value of a credit. Under the Project case, these biodiversity values were discounted by 50%, to take into account that the quality of the revegetated areas may be less than the values ascribed under the baseline case.

Overall, applying these values to the areas of land in the baseline in 2014, and to the Project case areas in 2034 (see Table 5.2) produced an estimate of the residual value of land of $3.56 million and $1.25 million in present value terms, for each case respectively, shown in Table 5.4.

Table 5.4: Final residual value of land estimates (proposed mine disturbance area)

Land use	Baseline case value from 2014 ($)	Project case value from 2034 ($)	Baseline case (NPV $m)	Project case (NPV $m)
Land suitable for beef cattle grazing	$83,190 p.a.	$75,300 p.a.	$1.27	$0.30
Open woodland	$1,816,736*	$3,680,456*	$1.82	$0.95
Riparian forest	$40,929*	-	$0.04	-
Rainforest	$434,251*	-	$0.43	-
Pine plantation	-	-	-	-
		Total	**$3.56**	**$1.25**

Source: DAE estimates
* Lifetime value
Note: NPVs are calculated using a 7% discount rate

The residual value of land foregone, of $2.31 million under the Project case is included as a cost in the CBA. This represents the cost of changes in land use over the life of the Project, relative to the baseline case.

5.2.10 Related public expenditure

In some cases, a project may generate additional costs for government. Where this is the case, these external costs should be included in a CBA.

In the context of this analysis, it is considered unlikely that the Project will generate any additional expenditure by any level of government, compared to the baseline case. While the Gloucester Shire Council will be responsible for maintaining the public infrastructure to be constructed or upgraded by GRL as part of the Project (see Section 5.2.20 for more details), these costs are unlikely to be significant.

It is worth noting that GRL has committed to an annual donation of 50 cents per tonne of product coal sold (approximately $480,000 p.a. on average over the life of the mine) to a community grants program over the life of the Project. As this is a transfer of funds it is not included in the CBA.

5.2.11 Offsite agricultural revenue

Mining activity can potentially affect the productivity of agriculture in surrounding areas, ultimately reducing the revenue earned by these activities. Where appropriate, it is important to account for these impacts in a CBA. The method of valuing the impacts of mining on agricultural revenue is described in Appendix C.

Given that the impact of the Project on agricultural revenue on land owned by GRL has been examined in Section 5.2.2, this item focuses on the impacts of the Project on other privately owned agricultural operations.

According to the Agricultural Impact Statement (AIS) undertaken for the Project, other land uses in the vicinity of the Project are dominated by the beef and dairy industries, with some smaller niche livestock operations, as well as growth of fruit, herb, vegetable, grape and olive crops, and a fish farm adjacent to Bucketts Road. Specifically within the areas closest to the mine, defined in the AIS and Response to Submissions as the Rocky Hill locality, privately owned agricultural enterprises include four further dairies (Green, Reeves, Fraser and Harris), a small number of small scale beef operations, the majority with very little land intensively developed, the Hillview Herb Farm and one non-commercial vineyard.

Potential impacts on the productivity of these surrounding agricultural areas have been considered in the AIS. However, the AIS has identified that the Project will have minor to negligible impacts on the agricultural resources and enterprises throughout the region and Rocky Hill locality, with any risks to be managed through GRL's water quality, air quality, noise and vibration and land management controls. Accordingly, it is considered appropriate to treat these potential impacts qualitatively in this analysis.

5.2.12 Groundwater quality

Mining activity can potentially impact the quality and quantity of groundwater supplies, with implications for other users that are not adequately captured in market transactions. As a result, it is necessary to assign a value to the costs borne by third parties as part of a CBA.

In the context of this Project, the hydrological regime of the Project area includes:

- a Quaternary Alluvial groundwater system associated with the Avon River and Waukivory Creek;
- shallow weathered bedrock (regolith) with associated colluvial deposits (at the base of the steep slopes and the margins with the Quaternary Alluvium);
- the Permian coal seams, overburden and interburden.

An assessment of the potential groundwater impacts of the Project on these hydrogeological features was prepared by Australasian Groundwater & Environmental Consultants Pty Ltd in accordance with the DGRs and relevant water planning policies and guidelines. The findings from the assessment, which were peer reviewed by Kalf and Associates Pty Ltd, are summarised in the EIS and indicate that any environmental impacts associated with the operations of the Project are negligible. These impacts are summarised in Table 5.5.

Table 5.5: Summary of groundwater impact predictions

Category	Project impact summary
Impact on groundwater users	• There is no expected drawdown of surrounding bores and no private groundwater users affected. • It is possible but unlikely groundwater may be encountered during exaction of the rail loop cutting. This may result in the localised drawdown of approximately 3m in the Permian strata. This is considered negligible.
Inflow to mine voids	• The predicted average groundwater inflow is 640ML/year over an approximate 14-year mine life. This accumulates to 8,990ML over the life of the mine. • Groundwater inflow stabilises around Year 7 with an average rate of 1ML/day to 2ML/day. This is driven by the concentration of active mining within the Main Pit.
Impact on Alluvium	• The overall reduction in groundwater flow from the Permian strata to the Quaternary Alluvium due solely to the Project ranges from 0.05ML/day to 0.3ML/day. The flow reaches a peak in year 6 of 0.3ML/day and declines to 0.1ML/day in year 14. • The cumulative reduction of groundwater flow from the Permian strata to the Quaternary Alluvium directly attributable to the Project is 772ML.
Groundwater dependent ecosystems	• Only very low populations of stygofauna were sampled from the coal seam groundwater. Therefore the depressurisation of the coal seam is unlikely to be a significant impact. • The riparian zone along Waukivory Creek and the Avon River is predominantly River Oak, Cabbage Gum and Broad-leaved Apple. These species are likely to rely on groundwater. The predictive modelling indicates the Project will not result in significant drawdown of groundwater levels in the Waukivory Creek and Avon River alluvium. Hench the riparian vegetation will not be impacted.

Source: Australasian Groundwater & Environmental Consultants Pty Ltd (2013)

5.2.13 Surface water quality

Changes in the quality of surface water should also be valued as part of a CBA where those changes are caused by a project and generate substantive impacts on third parties and the surrounding environment. The impacts of the Project on surface water were assessed by WRM Water & Environment Pty Ltd.

The main water resources surrounding the Project site are the Avon River and Waukivory Creek. The Surface Water Assessment notes that the Project will not significantly impact on the availability of water to downstream users and that increases or decreases in flows, depending on the location, to Waukivory Creek, Oaky Creek and the Avon River will be minimal. As such the price of these impacts has not been included in the CBA.

The Surface Water Assessment describes the likely impact of the Project in relation to surface water volumes, quality and the cumulative impact on downstream water users.

The main findings are that:

- The Project may need to extract water from the Avon River during the construction phase. However, based on predicted groundwater and catchment inflow rates, it is expected that all site water demands can be met by water captured on site. However, if adequate water is not available in dams and groundwater inflows are not as high as anticipated, it may be necessary to draw on additional water supplies from the Avon River Water Source. This would be capped at 267ML/a as per GRL's Water Access Licenses.
- Water captured on site would result in a decrease in the catchment area of Waukivory Creek and Avon River. This would be largest in year 2.5 and 4.25 of the Project when it wold be 2.0% and 1.2% for Waukivory Creek and Avon River respectively.
- Overburden emplacements are likely to result in additional water infiltration until they are topsoiled and revegetated, resulting in reduction in runoff from the overburden areas. The total reduction in mean flow over 14 years of operation is estimated to be 272ML.
- The Project would primarily impact downstream users by marginally increasing the frequency and duration of low flow periods. Over the period of historical stream flow record since 2004, the Project would have caused the number of cease-to-flow events to have increased from 3 to 5 and the total duration of no flow days to have increased by 20 days. Therefore, it is unlikely the Project will impact downstream users' ability to access their annual water entitlement.
- Cumulative impacts of the Project and the Stratford Coal Mine (SCM) and the SCM Extension Project is estimated to be a reduction of up to 5.2% of mean annual flow to the area of the Avon River immediately adjacent to the Project. Two-thirds of this impact will be caused by SCM and the SCM Extension Project.

These findings indicate that the impact of the Project on surface water quality is anticipated to be negligible. The implications of the Project on surface water supplies are acknowledged, but not considered quantitatively in the CBA.

5.2.14 Subsidence

In instances where mining activity is likely to lead to subsidence, the implications of this effect should be included in a CBA.

In the context of this analysis, the Project is an open cut mine and therefore there would be no subsidence. Accordingly, no costs have been included for this item in the CBA.

5.2.15 Carbon emissions

The proposed mining activities at Rocky Hill will also generate carbon emissions, the cost of which should be incorporated into the CBA. This requires estimates of the quantity of emissions in each scenario, along with an appropriate unit value of the social cost of an emission.

This analysis focuses on the valuation of 'Scope 1' emissions only. These incorporate all direct emissions from sources owned or controlled by GRL, such as emissions from fuel consumption during mining operations, release of fugitive CH_4 emissions during the mining process and emissions related to vegetation stripping.

The other categories of emissions which encompass indirect emissions generated from use of electricity at the mine (Scope 2) or from the use of the coal produced (Scope 3) are not valued in this analysis. This is because it is not methodologically clear how the costs of these emissions should be treated within a CBA.

Scope 2 emissions are more appropriately attributed as Scope 1 emissions associated with specific power sources, and should be captured in the EIS and CBAs for those developments, rather than the developments where the electricity is used. In addition, given the nature of the electricity network, if these were to be included they would need to consider the emissions from the marginal electricity generator in the National Electricity Market, rather than the producer of the actual electricity used by the Project. It is not evident that this marginal producer would necessarily be located with NSW, and hence may be outside the scope of this CBA.

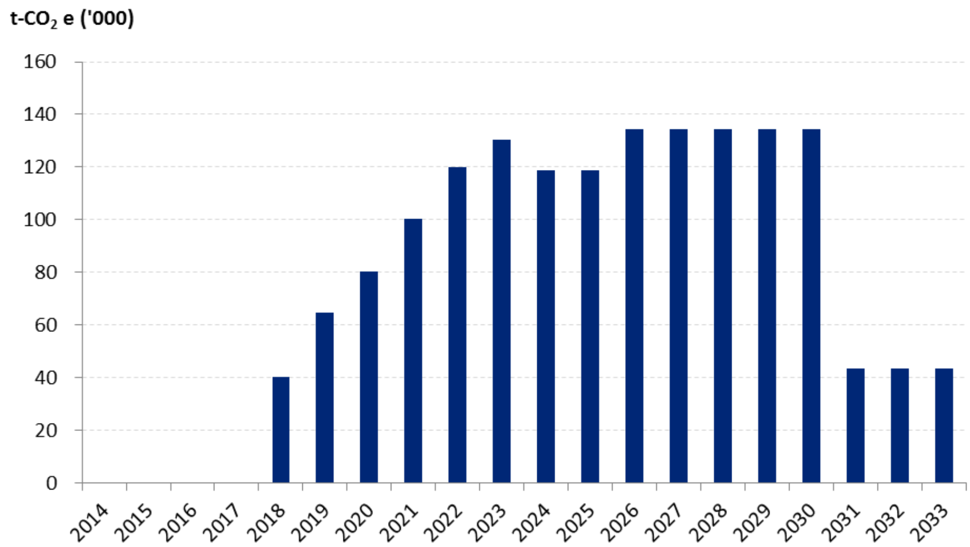
Scope 3 emissions managed by third parties were not assessed as:

- it is methodologically unclear to what extent they should be included in a CBA (particularly where the scope of the CBA is New South Wales);
- there is great difficulty in establishing a realistic baseline case for emissions; and
- there is a lack of data on emissions throughout the mining value chain.

A time series of Scope 1 emissions associated with the Project were obtained from the Greenhouse Gas Assessment undertaken by Pacific Environment Limited. Specifically, it is expected that the Project will generate around 1.5 million t CO_2-e of Scope 1 emissions over the period from 2018 to 2033. Emissions are expected to peak at 134,310 t CO_2-e p.a. between 2026 and 2030, before falling to 43,605 t CO_2-e in the final year of operations in 2031. Emissions for two additional years, beyond the completion of mining activity, are included to account for the final rehabilitation stage.

This series is illustrated in Chart 5.7.

Chart 5.7: Predicted carbon emissions, 2014 - 2033



Source: Pacific Environment Limited (2013)

As described in Appendix C, it is appropriate to value carbon pollution using the observable market prices of carbon permits. Following the repeal of Australia's carbon pricing mechanism, this study utilises the December 2014 futures price for carbon emissions in the European Union as the best available estimate of the social cost of carbon.

Specifically, a constant price of $8.91 per tonne of emissions was derived from the current Intercontinental Exchange European Climate Exchange European Union Allowance (ICE ECX EUA) futures price of €6.17 per tonne, converted into Australian dollars using the exchange rate of €0.6926/AUD reported by the Reserve Bank of Australia[4] (MarketWatch, 2014; RBA, 2014).

Applying this value, the overall cost of carbon emissions is valued at $6.69 million under the Project case, in present value terms, using a 7% discount rate.

5.2.16 Air pollution – particulate matter

The air pollution produced by mining activity and its impact on the built and natural environment, and the health of people in the surrounding area, is a key issue in the assessment of any mining project. Given that the health impacts of reduced air quality are generally considered to be most significant, the quantification of health costs is the focus of this analysis.

Particulate matter (PM) is often classified into one of the following three size ranges:

- TSP – total suspended particulate matter, which refers to all suspended air particles, with an aerodynamic diameter typically up to 30-50 micrometers;
- PM_{10} – coarse particulate matter, which includes all particles with an equivalent aerodynamic diameter of less than 10 micrometers; and

[4] Closing price and exchange rate as at 22 July 2014

- $PM_{2.5}$ – all particles with an equivalent aerodynamic diameter of less than 2.5 micrometers, often referred to as fine particles.

As described in Appendix C, these pollutants are strongly correlated. To bypass the difficulties associated with attributing health costs to the emissions of each pollutant, and avoid the risk of double-counting, this analysis values the health externalities associated with $PM_{2.5}$ emissions.

This approach has been taken on the basis that the best available unit damage cost estimates for particulate matter in Australia, developed for use in economic appraisal and policy assessment, relate to $PM_{2.5}$ emissions (PAEHolmes, 2013). It is also noted that $PM_{2.5}$ has been considered to be the best index for quantitative assessments of the effects of particulate matter in international research (PAEHolmes, 2013). In any case, this approach indirectly encompasses part of the costs associated with other correlated pollutants, such as PM_{10}.

The first step in this valuation approach is to estimate the quantity of $PM_{2.5}$ emitted under the Project case.

The Air Quality Assessment undertaken by Pacific Environment Limited reports estimated TSP emissions for five representative years of the Project, and reports that $PM_{2.5}$ are estimated to account for roughly 4.7% of these emissions (Pacific Environment Limited, 2013:54). The resulting estimates of $PM_{2.5}$ based on this assumption are presented in Table 5.6.

Table 5.6: Estimated Project case $PM_{2.5}$ emissions

Air Modelling Year	Estimated TSP emissions (t)	Estimated PM2.5 emissions (t)
Construction Phase	674	32
Year 2.5	778	36
Year 4.25	913	43
Year 7.75	797	37
Year 13	683	32

Source: Pacific Environment Limited (2013)

These emission estimates were then attributed over the life of the Project, according to the schedule presented in Table 5.7. Linear changes in emissions were assumed for interim years. No $PM_{2.5}$ emissions are attributable to Rocky Hill under the baseline case.

Table 5.7: Application of air quality modelling to Project timelines

Air Modelling Year	Project Year/s
Construction Phase	2015, 2016, 2017
Year 2.5	2018
Year 4.25	2021
Year 7.75	2024
Year 13	2030

Next, an estimate of the health costs associated with $PM_{2.5}$ emissions in the Gloucester LGA was generated using the unit damage cost estimates presented in a PAEHolmes report undertaken for the NSW EPA (2013). This report presents estimates of the health costs per tonne of $PM_{2.5}$ emissions for different Significant Urban Areas (SUAs) across NSW, accounting for differences in population density. For the purpose of this analysis, the damage cost estimate of $360 per tonne of emissions was utilised, being the value for locations not in any SUA. This was converted to 2014 prices, and adjusted to take account of the slightly higher population density in Gloucester LGA to the reference for this cost estimate (1.66 people per km^2 compared to 1.3 people per km^2). This produced a unit damage cost estimate of $489.21 per tonne of $PM_{2.5}$ in 2014.

As recommended by PAEHolmes (2013), this cost estimate was indexed over time to account for changes in population in Gloucester and rising willingness to pay for health over time. For this purpose, the analysis utilised the population forecasts for Gloucester to 2031 produced by NSW Planning & Environment (2014) and assumed that willingness to pay would rise by 2.5% per annum, in line with the forecast real growth in GSP reported in the NSW Intergenerational Report (2012).

Although air dispersion may impact health in other regions in the Hunter beyond Gloucester, it would be difficult to isolate the overall impact of the Project from other $PM_{2.5}$ sources, such as transport. Therefore, this estimate should be considered as a conservative value of $PM_{2.5}$ health impacts.

The Health Risk Assessment for Rocky Hill Coal Project report (2013) identified the following health outcomes in the surrounding properties of the Project having significant linkages due to increased exposure to $PM_{2.5}$ in Gloucester, in the worst case scenario:

- increased risk of annual mortality of 1.9 per 100,000 people;
- increased risk of daily mortality of 0.009 per 100,000 people;
- increased risk of daily hospital admissions for cardiovascular disease of 0.009 per 100,000 people; and
- increased risk of daily hospital admissions for respiratory conditions of 0.017 per 100,000 people.

In addition the Response to Submissions sets out analysis of further health risks to the Forbesdale Estate, although it is noted that these are less than for Gloucester noted above (see Response to Submissions Table 2.18.6). While these annual health outcomes have been quantified, an economic estimate of the health system costs associated with each of these outcomes was not provided.

Overall, these health impacts from $PM_{2.5}$ amount to $0.20 million for the Project case in present value terms. As there are no health impacts under the baseline case, this implies that total additional health costs associated with air pollution from the Project in the Gloucester area are worth about $0.20 million.

In considering the air quality impacts of the Project, it is also useful to note the results of the Air Quality Assessment which accompanies this analysis. Table 5.8 lists the number of properties likely to experience exceedances in relation to various assessment criteria, when considering the five representative years used in the air quality modelling noted above.

Overall, the modelling indicates that a total of two privately-owned receptors are predicted to experience maximum 24-hour average PM10 levels above the criterion of 50 µg/m^3 across all mining years. There are no privately-owned receptors predicted to experience annual average PM10, TSP or dust deposition above the assessment criteria, either from the Project alone or cumulatively. There are no receptors that are predicted to experience PM2.5 concentrations above the advisory reporting standard.

In addition to health costs, particulate matter can also result in other adverse effects on quality of life and may be reflected in property prices in the surrounding region. This potential effect was investigated using a hedonic pricing study, presented in Appendix D. No statistically significant effect was identified for Gloucester in the study.

In any case, it is noted that the worst case air quality impacts of the Project would be managed on a day to day basis using a network of real-time monitoring stations, which will enable mine personnel to respond to elevated dust levels prior to reaching approved levels and modify activities, their location or increase controls as required (Pacific Environment Limited, 2013).

Table 5.8: Air Quality Assessment results – number of exceedances

Assessment criterion	Expected exceedances
Project only PM_{10} - 24 hour maximum	Two privately-owned receptors, across all mining years.
Project only PM_{10} - annual average	No exceedances for privately-owned receptors.
Project only $PM_{2.5}$ - 24 hour maximum	No privately owned receptors that are predicted to experience 24-hour average $PM_{2.5}$ concentrations above the 24-hour advisory reporting standard.
Project only $PM_{2.5}$ - annual average	No exceedances for privately-owned receptors.

Assessment criterion	Expected exceedances
Project only TSP - annual average	No exceedances for privately-owned receptors.
Project only dust deposition - annual average	No exceedances for privately-owned receptors.
Cumulative PM_{10} - 24 hour average	For all receptors except receptor 18, there is a very low probability that cumulative 24-hour PM10 concentrations would result in any additional days over 50 µg/m3 than would occur anyway due to background in the absence of the Proposal. There are no predicted cumulative impacts over 150 µg/m^3.
Cumulative PM_{10} - annual average	No exceedances for privately-owned receptors.
Cumulative $PM_{2.5}$ - 24 hour average	Very low probability that cumulative 24-hour average PM2.5 concentrations would result in any additional days over the advisory reporting standard of 25 µg/m^3.
Cumulative $PM_{2.5}$ - annual average	No exceedances for privately-owned receptors.
Cumulative TSP - annual average	No exceedances for privately-owned receptors.
Cumulative dust deposition - annual average	No exceedances for privately-owned receptors.

Source: Pacific Environment Limited (2013)

5.2.17 Air pollution – other pollutants

Mining activity is also associated with emission of other air pollutants, such as nitrogen dioxide, sulfur dioxide and carbon monoxide. Common sources of these pollutants include blasting fumes, diesel powered equipment and vehicle exhausts.

A study of blast fume emissions using air quality dispersion modelling by Pacific Environment Limited indicates that potential nitrogen dioxide (NO_2) concentrations are predicted to exceed the 1-hour NO_2 standard of 246 micrograms/m^3 during a maximum of 9 hours per year from a possible 2,920 available blasting hours, when using a sample of six receptors in the vicinity of the site. This maximum is expected to occur in Year 4.25 of the Project. Note that these results should not be fully attributed to the Project, as some monitoring units for pollutants would include background concentrations that are affected by industrial or non-industrial sources. Nevertheless, the modelling suggests that the majority of predicted impacts will be well below the impact assessment criteria.

Management measures to minimise the potential for the formation of NO_x emissions will include limit blasting activity during adverse weather conditions, which generally increases the likelihood of exceeding air-quality standards.

As some health impacts produced by nitrogen oxides (NO_x) and sulfur oxides are partly correlated with particulate matter, it is reasonable to expect that some of the impacts described above would be captured by the externalities calculated in Section 5.2.16.

While nitrogen oxides also interact with volatile organic compounds (emitted mostly from chemical processing) increasing ozone formation and leading to additional health impacts, these effects are expected to be minimal as chemical industries are not located within the surrounding mining region. Other air pollutants and sulfur oxides may affect the natural and built environment, however there are limited economic estimates for the region that would be applicable to quantify these additional impacts.

For these reasons, the potential costs of additional nitrogen dioxide, sulfur dioxide and carbon monoxide are acknowledged, but not considered quantitatively in this analysis.

5.2.18 Noise pollution

As part of the CBA, it is necessary to place a value on the level of noise pollution expected to be borne by local residents.

The first step of the valuation process is to estimate the level of noise pollution associated with mining activity at Rocky Hill under the Project case, compared to the baseline where the Project does not receive approval. This analysis utilises operational noise level predictions provided by Wilkinson Murray from the Noise, Vibration and Blasting Assessment (NVBA). The assessment reviewed the noise impacts associated with the Project in terms of construction, mining operations and road and rail transportation.

Modelling undertaken by Wilkinson Murray has produced estimates of the noise levels associated with the construction and operational stages of the Project, measured in A-weighted decibels (dB(A)), for 146 residential properties in the vicinity of the mine. Due to variations in the location and level of mining activity over time, and variations in the level of background noise by time of day and season, the noise estimates for each property were determined:

- for day, evening and night periods;
- for each of the four seasons of the year (summer, autumn, winter and spring);
- for each of the following cases:
  - mine operation without operation of either the overland conveyor or the rail load-out facility (case 1);
  - mine operation in conjunction with the overland conveyor (case 2); and
  - mine operation in conjunction with the rail load-out facility (case 3); and
- for a number of time periods, representative of different phases of the Project.

The following steps were taken to convert this data into estimates of the general noise level likely to be experienced at each property in any given year under the Project case:

- First, for each scenario, in each year, annual average day, evening and night noise estimates for each property were produced by taking the average values across the four seasons.
- Next, the maximum noise level across these annual average day, evening and night periods was selected, to represent the worst case scenario of the level of noise experienced by each property over the course of the year.

- These maximum noise levels were then compared across the three cases. Although case 1 represents the majority of the operating time, the highest noise level, i.e. the highest noise exposure estimate for each property was selected for use in the analysis to present a conservative valuation of the costs of the Project.

Next, for each property, the noise level which could be directly attributed to mining at Rocky Hill was estimated by subtracting the corresponding rating background noise level (RBL) for each property and time period, applied by Wilkinson Murray. The purpose of this adjustment is to account for the level of background noise which is likely to be experienced by residents in the baseline case, which should not be attributed to Rocky Hill activities. A RBL of 30 dB(A) was applied for most properties, being the minimum background level used in the EPA's Industrial Noise Policy. Higher RBLs, up to 38 dB(A) in the daytime period, were applied for properties that were found to have significant exposure to traffic noise from Jacks Road and The Bucketts Way. In these cases, the RBLs were based on the results of noise monitoring undertaken by Wilkinson Murray for the Assessment[5].

Under the Project case, the total additional dB(A) exposure of the 146 residential properties over time was then calculated by adding together these estimates of property-level noise exposures attributable to the Rocky Hill Coal Project, for each noise modelling year. These aggregated exposure estimates were then attributed over the life of the mine, according to the schedule presented in Table 5.9. This includes a two year allowance for the final rehabilitation and decommissioning phase of the Project, in 2032 and 2033. Linear changes in noise exposure were assumed for interim years. No noise levels are attributable to Rocky Hill under the baseline case.

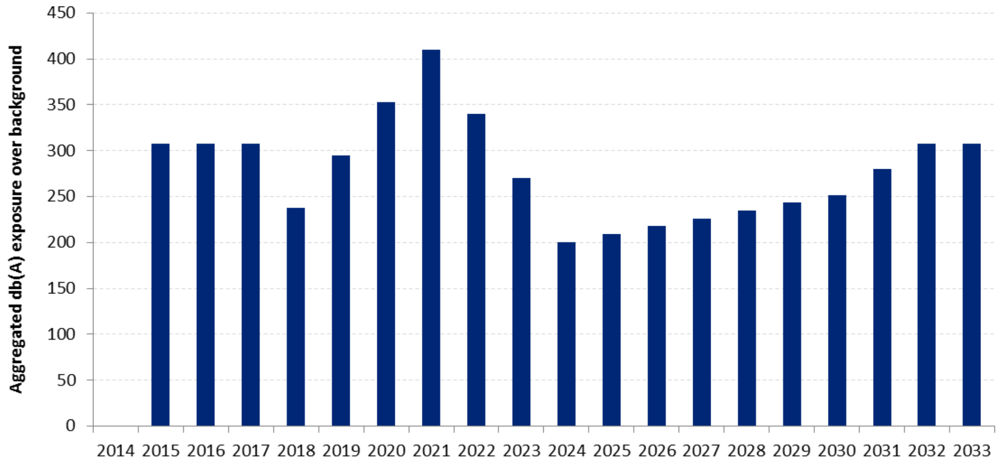
Table 5.9: Application of noise modelling to Project timelines

Project phase	Noise modelling year	Project year
Preconstruction	Year 0.5	2015
Construction	Year 0.5	2016, 2017
Operations	Year 2.5	2018
	Year 4.25	2021
	Year 7.75	2024
	Year 13	2030
Decommissioning	Year 0.5	2032, 2033

The final time series of the noise impacts of the Project is presented in Chart 5.8.

[5] The RBLs used in this analysis are calculated as 5dB(A) less than the Intrusiveness Criteria reported in Table 5.1 of the Noise, Vibration and Blasting Assessment.

Chart 5.8: Total Project case household dB(A) exposure estimates experienced by all households (over background noise)



Source: DAE estimates, inputs from Wilkinson Murray (2013)

It should be noted that these aggregated values do not have a meaningful physical interpretation, as decibels are measured on a logarithmic, rather than a linear scale. Instead, the aggregates provide indicative estimates of the additional noise impacts that could be associated with the Project, relative to the baseline. The variation in exposure over time is the result of changes in the location and level of mining activity over the life of the Project.

Having identified the ‘quantity’ of noise pollution likely to be experienced in the Project case, it is then necessary to apply a monetary value, representing the cost of an additional decibel of noise borne by a household.

While it would be most appropriate to utilise a monetary value derived specifically for the context of the areas surrounding the Rocky Hill Mine, a hedonic pricing study, described in Appendix D, was not able to identify statistically significant results for Gloucester. As such, the value utilised in this analysis relies on a value identified in the literature review presented in Appendix C.

Specifically, this study applies a value of $62.38 per dB(A) per household per year, based on the upper limit of the range recommended by Navrud (2002), converted to 2014 dollars. The recommendation was made to the European Commission DG Environment based on the results of a comprehensive literature review. This value was chosen due to its broad evidence base. The chosen value should be considered as indicative of the scale of noise related externality costs, not a precise valuation, particularly as it relates to traffic noise rather than the noise impacts of mining.

Applying this value to the aggregated dB(A) exposure estimates yields a noise pollution cost of $0.18 million in present value terms in the Project case. This value is used in the central case of this analysis.

However, it is noted that with use of the most conservative background noise measurements presented in Table 5.1 of the NVBA, these costs rise to around $0.50 million in present value terms. Given that this is a small increase relative to the magnitude of other costs and benefits of the Project, the assumptions used here are not expected to impact the conclusions of the analysis.

Beyond this, there are also expected to be some additional noise impacts in the Project case on non-residential properties, and also as a result of road traffic and rail movements. While these are not quantified here, it is acknowledged that these further Project case impacts include:

- some additional noise impacts from mine-related traffic on Jacks Road and Waukivory Road (north of Jacks Road) in the site establishment and construction phase. These impacts will vary prior to, and following the construction of the Jacks Road Bridge, but are expected to comply with the relevant noise level criterion for traffic;
- an increase in noise of 0.6 dB(A) and 2.7 dB(A) in day and night periods respectively for the closest residences to Jacks Road (setback by 13m) during the operational phase of the Project, a level compliant with noise criterion;
- an increase in noise of 0.8 dB(A) and 3.1 dB(A) in day and night periods respectively for the closest residences to Wauikovory Road (north of Jacks Road, setback by 17m) in the operational phase of the Project, levels compliant with noise criterion; and
- negligible increases in cumulative rail noise levels, of up to 1.1 dB(A), although it is noted that the current rail noise levels associated with the Stratford and Duralie Coal Mines, in the absence of the Project, already exceed the EPA criteria.

It is noted that the data provided in the NVBA suggests that any Project noise experienced at churches, public parks, schools and health care facilities in the Gloucester township would be unlikely to exceed and commonly less than the measured background levels.

Overall, it is anticipated that four residential properties will fall within the Project's Noise Affectation Zone.

Furthermore, it is noted that GRL have committed to a number of noise mitigation measures to restrict the impacts of the Project to those described in this section. These measures include:

- designing the height of the proposed visual barrier to reduce noise impacts of operations on residences;
- selection of a fleet combination and mine operations plan that reduces the noise impacts during the operational phase of the Project, including larger and fewer items of equipment and loading bins for the trains with sufficient capacity to enable the loading of a train without the need to operate the overland conveyor;
- use of a curved conveyor to avoid the need for a transfer point and associated noise; and
- implementation of real time proactive noise management measures.

The additional costs associated with these actions have been incorporated in the operating cost estimates, to be borne by GRL.

5.2.19 Visual amenity

It is recognised that mining activity has the potential to detract from the visual amenity of a community. The visual effects of converting an existing landscape to an area featuring emplacement areas, machinery, vehicles and artificial light are therefore important considerations for a CBA.

The affected area is situated on the lower western side slopes of the Mograni Range. The Project area is characterised by a steep enclosing natural landscape, complex details of topography of the enclosing walls and manicured appearance of grazing land and floodplain. According to the Visibility Assessment undertaken for the Project by Richard Lamb & Associates (RLA), visual perception research would predict that a majority of people in the community would rank areas with these features as being towards the high end of scenic quality. That said, there are landscapes in the region that would rank of a higher scenic quality. The specific characteristics of the Project area are not confined to the locality and are widespread throughout the Gloucester Basin.

After conducting an analysis of a wide range of viewing places throughout the Gloucester Basin, RLA found that the visibility of the Project area is reduced by the topography, intervening features, locations of roads and settlement patterns. There is minimal visibility from the main urban areas of the Gloucester township. Various components of the Project site will be visible from areas of The Bucketts Way between its intersection Jacks Road and Gloucester Tops Road.

GRL have committed to a mitigation strategy and RLA expects this to be successful based on indicative mine plans and photomontages that show likely visual effects. These mitigation measures seek to achieve two key objectives – primarily, to minimise the effect of the final landform on the scenic quality of the site, but also, to control visibility of the operations.

These mitigation measures include the use of visibility barriers to shield the construction of the out-of-pit overburden emplacement (OPOE) and a final landform which is similar in appearance to that existing prior to mining. All visibility barriers and emplacements will be vegetated so that the ability to perceive the form, line and colour of the OPOE is limited. The visibility barriers will be progressively revegetated, including with a shrub cover, so that the perception is the most natural appearance possible.

Overall, the Assessment found that there will be significant visual impacts on public and private domains, primarily on sections of The Bucketts Way that provide views and in residencies to the west and northwest of the site. However, these impacts will be due to the longer term mitigation activities (visibility barriers and OPOE), rather than visibility of mining activity. These impacts will be most significant during the design and construction phase and first six to seven years of operations, but are expected to decline rapidly from Year 8.

The long term impacts of the final landform will be mitigated through two different forms of rehabilitation. The eastern part of the Project area is to be woodland while the western part will be grassland with tree lots. This will create a landscape that is in line with the typical character of the existing landform and the wooded hills backdrop in the locality.

Overall, the Project is expected to have some significant, but temporary visual impacts in the short term that will decline over the long term as the final landform is developed. Therefore, in the absence of appropriate monetary values to quantify the short term visual impacts of the Project, these are acknowledged qualitatively in this analysis.

5.2.20 Traffic

The effect of the Project on traffic constitutes another element for consideration in a CBA.

Based on the Transport Assessment undertaken for the Project by Constructive Solutions Pty Ltd, the first significant traffic impact which should be accounted for in this analysis is the increase in vehicles associated with the construction phase. During the operations phase, the transportation of product coal from the mine area to the rail-load out facility via conveyor will eliminate the need for coal trucks to use public roads. However, it is noted that there will be some additional traffic impacts over the Project life, caused by the delivery of earthmoving equipment, service trucks and employee vehicles.

Constructive Solutions Pty Ltd recommends that the Mine Area be accessed from the northwest by travelling along The Bucketts Way and leaving it at Jacks Road. Currently, this is not possible because the bridge across the Avon River along Jacks Road is closed due to structural integrity concerns - it has been recommended that a new bridge be constructed over the Avon River on Jacks Road (Option 1B in the Transport Assessment). Once this route is available, the only vehicles that would access the Mine Area via the Waukivory Road turnoff from The Bucketts Way would be those approaching Gloucester from the east and a small number of light vehicles travelling from Gloucester (Option 1A in the Transport Assessment).

Along with the construction of a bridge across the Avon River along Jacks Road the Transport Assessment has proposed a number of road upgrades, including:

- the construction of an upgraded intersection at the corner of Jacks Road and The Bucketts Way to provide deceleration lanes approaching the intersection
- upgrading and widening the pavement along the full length of Jacks Road
- upgrading the 1.3km section of Waukivory Road from Jacks Road to McKinleys Lane
- construction of an upgraded intersection at the junction of Jacks and Waukivory Roads
- upgrading the intersection of Waukivory Road and McKinleys Lane and the approximately 50m section of McKinleys Lane to the Mine Area access road; and
- modifying the existing entry/exit at the intersection of the access road to the Rail Load-out Facility and The Bucketts Way.

While increases in average daily traffic volumes throughout the construction phase will not be significant, daily and periodic variances will occur. The Transport Assessment recommended that a construction Traffic Management Plan should be developed that addresses issues associated with the mine area and overland conveyor (east), the overland conveyor central, the rail load-out facility and overland conveyor west, and road and bridge construction. These are detailed in the Transport Assessment.

Overall, it is considered that implementation of these management measures will mitigate against any traffic impacts of the Project, relative to the baseline case. Accordingly, this item is considered qualitatively in this analysis.

5.2.21 Biodiversity (flora and fauna)

It is also necessary to compare the risks to biodiversity in both the baseline and Project case as part of a CBA.

The majority of the Project area is cleared pastureland with scattered trees. However, there is also forest present on the upper slopes of the Mograni Range to the east, various small patches of vegetation in the centre of the Project area and narrow riparian corridors are present along the watercourses around the northern, western and southern boundaries.

A field survey of the area, conducted by Ecotone Ecological Consultants, found that the Project area included nine threated fauna species listed under the *Threated Species Conservation ACT 1995 (NSW)* and one Vulnerable Ecological Community, Lower Hunter Valley Dry Rainforest. No threated flora species or endangered population were identified in the area.

The nine threatened species that were recorded through the field surveys are:

- wompoo fruit-dove (*Ptilinopus magnificus*);
- squirrel glider (*Petaurus norfolcensis*);
- grey-crowned babbler (*Pomatostomus temporalis*);
- yellow-bellied sheath-tail bat (*Saccolaimus flaviventris*);
- little bent-wing bat (*miniopterus australis*);
- eastern bent-wing bat (Miniopterus australis);
- large footed myotis (*Myotis macropus/Myotis adversus*);
- hooded robin (*Melanodryas cucullata cucullata*);
- east coast freetail-bat (*Mormopterus norfolkensis*); and
- grey-headed flying fox (*Pteropus poliocephalus*).

In order to mitigate against residual impacts, GRL have proposed a comprehensive rehabilitant plan that incorporates progressive re-vegetation of the final landform to a combination of pasture, open woodland with scattered trees and a system of interconnecting native vegetation/fauna habitat corridors. There will also be a 267 hectare Biodiversity Offset Area established along the eastern side of the Project area. It is anticipated that the offset areas will be maintained in perpetuity from 2016 onwards.

The offset strategy is designed to mitigate against any loss in biodiversity which may occur as a result of the Project, relative to the baseline. Based on the information provided, the risks to biodiversity generated by the Project are considered qualitatively in this analysis.

However, there are costs associated with the management of these offset areas.

This analysis utilises a rate of $3,318 per hectare of land as an estimate of the lifetime costs of offset management, consistent with the NSW Office of Environment and Heritage Credit Calculator (2012), updated to 2014 prices.

Given that these costs are likely to be incurred from 2015, total offset management costs under the Project case are estimated at $0.83 million in present value terms, using a 7% discount rate.

5.2.22 Conservation

It is also important to recognise the extent to which the Project will affect conservation areas surrounding the mine.

The Giant Stinging Tree / Fig Rainforest Gullies within the proposed disturbance area has some conservation significance, classified as a Lower Hunter Valley Dry Rainforest Threatened Ecological Community. However, the establishment of a permanently conserved biodiversity offset area as part of the Project, which is in excess of that required under the NSW BBAM, has the effect of more than offsetting this impact.

As discussed above, the costs associated with managing these areas has been included in the CBA under the biodiversity item, while the social value of the land offsets the negative biodiversity impacts of the Project. Therefore, to avoid double-counting, no quantitative values have been assigned to the conservation item in the baseline or Project case.

5.2.23 Quality of open space

As described in Appendix C, valuation of impacts on the quality of open space incorporates two main elements – the visual amenity associated with the space, and the types of activities that are undertaken in the space. To avoid double-counting, this item is focused on the second component, since the visual amenity impacts of the Project have been discussed in Section 5.2.19 above.

In the context of this Project, it is noted that the proposed mine site is adjacent to the Gloucester Airstrip, utilised by the Gloucester Aero Club. This airstrip is located on land owned by GRL and is provided as a service and at no cost to the community. The Socio-economic Assessment undertaken for the Project notes that the ability of the Aero Club to use the airstrip is not expected to be impacted by the Project.

Based on this evidence, it is considered that the Project is unlikely to cause a material change in the ability of local residents or visitors to use the open spaces surrounding the Project Area for other activities. Accordingly, no quantitative values have been assigned to this item in the baseline or Project case.

5.2.24 Rural amenity and culture

The impact of a proposal on rural amenity and culture should also be considered where a project is likely to affect the composition of the community.

The Socio-economic Assessment undertaken for the Project includes an assessment of the social risks of the Project. The aspects considered relevant to rural amenity and culture include:

- impacts on social infrastructure capacity;
- impacts on community sense of place and amenity; and
- impacts on social cohesion.

The findings of the Assessment in relation to these three areas is summarised in Table 5.10.

Table 5.10: Summary of impacts on rural amenity and culture

Aspect	Assessment Findings
Social infrastructure capacity	• Some capacity issues related to the Ambulance Service and childcare services • Community recreation facilities and community groups would benefit from new families settling in the area
Community sense of place and amenity	• High level of community concern • Management of visual impact will help to minimise • Scale of Project is unlikely to overtake local economy • Other economic activities will continue to contribute to the sense of place
Social cohesion	• Some level of threat observed • Majority of existing tensions likely to subside upon approval or rejection of Project • Potential impacts on crime to be minimised through local employment target

While these findings are acknowledged, it is difficult to attribute a cost of this impact to the Project specifically. However, one potential approach is to quantify the costs associated with an additional family relocating out of the local area. While it is difficult to determine the number of people who would choose to relocate as a direct result of the Project, the number of additional residential properties which meet acquisition criteria due to noise and/or air quality impacts can be used as a proxy measure.

In the context of this study, GRL has indicated that four additional, privately owned residential properties are predicted to meet acquisition criteria in relation to air quality and/or noise pollution impacts of the Project.

It should be emphasised that this is a proxy measure only, as, in the first instance, it is very uncertain whether property owners would choose to trigger those rights and relocate, and further, how far away they would move. Secondly, GRL has indicated that should it acquire the property, it would attempt to lease it out for residential purposes, in which case residents may choose to stay.

Those points noted, the next step is to apply a monetary value. Appendix C describes some studies which have attempted to estimate the value of maintaining rural communities. This analysis utilises the results of a choice modelling study undertaken by Bennett, van Bueren and Whitten (2004). As this study was undertaken for a different policy context than that considered in this analysis (the effects of increased environmental protection on rural populations, rather than continued mining activity), it only provides an indicative value of the impact of the Project on rural amenity and culture.

As described in Appendix C, the study undertook a number of surveys to illustrate the variation in willingness to pay estimates for different policy contexts. Using a general survey at the national level, it was found that Australian households were willing to pay an average of $0.09 per year, over a twenty year period for every 10 people that are retained in country communities. A separate, region-specific survey of households in Rockhampton found that they were willing to pay $2.24 per year over twenty years, for every ten people retained in the Fitzroy Basin region.

The difference in these estimates is likely to reflect a combination of both higher costs borne by individuals that live in closer proximity to the country area under review, compared to the national average; and the impact of more specific questions used in the regional survey, compared to the general questions used in the national survey. As such, it is inappropriate to aggregate the values from the regional survey beyond a regional population.

In the context of this analysis, the results of the study present two options for valuation of the impact of the Project on rural amenity and culture. In the first instance, it is plausible to aggregate the national estimate for all households in Australia. Alternatively, the regional value can be aggregated for all households in the Hunter Valley / Newcastle area. This analysis uses the results of the former approach, as it generates a more conservative estimate of costs.

The first step in this valuation process is to convert the value of $0.09 per year over twenty years, into a one-off payment. Using a perpetuity formula and a discount rate of 7%, this was converted into a cost of $0.95 per household, measured in 2004 prices. Inflating this value to 2014 prices produced a value of $1.25 per household, for every ten people leaving a rural community. This was then converted into a cost per person leaving the community of $0.12 per household.

Based on the number of residential properties likely to meet acquisition criteria (four) and the average household size in the Gloucester LGA, based on 2011 Census data (2.3), it was estimated that, on average, 9.2 people might relocate from country areas as a result of the Project, again noting the qualifications described above. As the wording of the survey question used to derive the national cost estimate does not specify the relocation distance necessary to trigger these costs, it is conservatively assumed that movements to elsewhere in the Gloucester LGA or other nearby locations should be included in this valuation.

Using the household cost of $0.12 per person relocating, this approach implies a total cost of $1.15 per household in Australia. Applying this value to the number of households in Australia as at the 2011 Census (9.1 million) produces a national cost estimate of $10.46 million.

While the acquisition rights for each property could be triggered at Project approval, given the uncertainty around approval timelines, it is assumed that the rights would be exercised in 2018, the commencement of the operational phase assumed for this analysis. Accordingly, this cost was then discounted back to $7.98 million in present value terms, using a 7% discount rate. An alternative calculation of this item, focusing on a state-wide calculation, rather than national, is presented in Section 5.4. The results of this sensitivity analysis indicate that costs associated with rural amenity and culture fall by around $6m to total around $2 million in net present value terms.

It is evident that this valuation involves a number of assumptions. Accordingly, this final estimate should only be interpreted as an indicative value of the rural amenity and culture impacts of the Project, particularly for the following reasons:

- The context of the survey undertaken by Bennett, van Bueren and Whitten is quite different from the context of this study – trade off for a reduction in rural populations was the implementation of environmental protection strategies. In the context of mining activity, it is likely that the costs associated with a decline in rural communities would be higher.
- As noted above, it is possible that the Project would not directly cause any families in the local community to relocate compared to the baseline case.
- It is likely that the costs would be much lower where families relocated to another property in Gloucester, or even to Singleton or Muswellbrook, compared to relocation to Newcastle or Sydney.
- This calculation does not take into account the benefits associated with mine employees moving into the local area.
- This analysis assumes that the number of households in Australia in 2025 is the same as the number of households reported in the 2011 Census. This also has the effect of underestimating the social costs.
- It is also uncertain whether it is appropriate to apply the values obtained from the survey so far into the future. Assuming that the survey was undertaken in 2004, the twenty year time period for which the reported values apply to ends in 2024. Future generations might experience costs that are smaller or larger than those reported in this analysis.

5.2.25 Aboriginal heritage

Aboriginal heritage sites can be associated with substantial historical, cultural and scientific value. Where a proposal is anticipated to damage these sites, it is critical that these impacts be considered in a CBA to adequately account for the costs of the Project. Aboriginal heritage issues have been assessed in the Indigenous Archaeological Assessment prepared by Archaeological Surveys & Reports Pty Ltd. The assessment has provided an opportunity to find and record Aboriginal sites which would likely have not come about in the absence of the Rocky Hill mine proposal.

Nine sites (including a potentially archaeological deposit or PAD) have been identified in the Study Area investigated by Archaeological Surveys & Reports Pty Ltd. Three of these (including the PAD) have been previously recorded on the Aboriginal Information Management System (AHIMS) Site Register.

The previously unrecorded sites will be lodged with AHIMS for listing on the Sites Register. None have been assessed as having aesthetic value or being rare or unique.

The proposed Rocky Hill mine will impact directly on all nine sites, so it has been recommended that all artefacts should be salvaged. If the artefacts are put on display (for example, in a museum or Aboriginal Land Council Office), it has been recommended that GRL provide or pay for an interpretative display case and that the Aboriginal stakeholders and the archaeologist should combine to provide a simple pamphlet describing and interpreting the artefacts, and providing an Aboriginal cultural context for where they were salvaged.

It is also recommended that limited sub-surface investigation occur at three sites where there may be some potential for other artefacts to exist (Gloucester RY2, PAD1 (Gloucester), McKinleys 3). Salvage and sub-surface investigation address the issue of Management Measures.

As a contingency measure it has been recommended that a fully qualified archaeological consultant and two Aboriginal stakeholder representatives conduct initial briefing of mine workers and staff, and that they produce a one or two-page hand-out, to be presented to every mine worker when they first sign on, setting out clearly the procedure they must follow if artefactual material is found, and the penalties when the procedure is not followed. In addition, all staff that might be involved in disturbance of deposits are to be similarly briefed by a nominated representative of the Applicant as part of the Site Induction process and provided a copy of the hand-out.

The McKinley 3 site (E.404198. N.6451133) was the only site assessed as having any significance in terms of research potential. All other sites are of very low research potential. The finding of 10 artefacts at the McKinley 3 site does not warrant assessment of the site as being of scientific research potential, but it is recommended this site be graded in 5cm units or splits to fulfil any research questions that may be asked.

Overall, the impact of the Project on Aboriginal heritage is acknowledged qualitatively in this analysis.

5.2.26 Historic heritage

Similarly, it is also important to consider the impacts of a proposal on European heritage sites, relative to the baseline. To do so, this analysis relies on the findings of the Non-indigenous Heritage Assessment prepared by Richard Lamb & Associates.

The Assessment has found that there are no items with statutory protection in or in the vicinity of the Site, or any that have a view of or from it. Furthermore, neither the Gloucester nor Great Lakes Councils recognise the area as of heritage significance. The views affected by the Site are not heritage views, but the visual impacts have received consideration (including mitigation measures) elsewhere in this report, as informed by an assessment carried out on a specific site by site and view by view basis throughout the Stroud-Gloucester Valley.

In light of the findings of the Non-indigenous Heritage Assessment, no dollar values associated with historic heritage impacts are included in the CBA.

While there are no known heritage items on the Site, and little potential for archaeological artefacts, deposits, structures or occupation remains to exist or be discovered, it is proposed that a Heritage Discovery Plan for the Site be instituted so that in the event that any items of potential heritage significance are discovered, work is stopped until such time as an appropriately qualified consultant can assess, and if necessary, record them prior to work re-commencing.

5.2.27 Health

The final element which should be considered in a CBA is the impact of mining activity on the health of local residents and employees of the mine.

GRL engaged Toxikos Pty Ltd to perform an independent human health risk assessment of the emissions to air from the Project. This seeks to evaluate the impacts on human health from acute and chronic inhalation exposure. This assessment presented the dispersion modelling projections for annual average $PM_{2.5}$ ground level concentrations for a total of 150 private assessment locations in the vicinity of the proposal. The assessment noted that background contribution represents approximately 70% to 80% of the total cumulative concentration of $PM_{2.5}$ (based on a 24 hour averaging period) and 90% of the total cumulative concentrations of the annual $PM_{2.5}$.

The study used a $PM_{2.5}$ 24-hour average incremental concentration of 5.3ug/m^3 as the 97.5th percentile increment. In the case of annual concentration, the 97.5th percentile incremental $PM_{2.5}$ concentration is 0.51ug/m^3. These measures were used in order to provide a conservative estimate for the health risk assessment.

In examining the risk to the population of increased long-term exposure to $PM_{2.5}$ as a result of the Project, an increase in base incidence annual mortality from 658 to 660 per 100,000 was estimated. This increase is considered negligible. The estimated risk of short term exposure to $PM_{2.5}$ is also considered to be minor.

As such, no separate line item for the potential negative effects of health has been considered in this analysis.

5.3 Overall CBA results

Given the values assigned to each cost and benefit in Section 5.2, the next stage of the CBA is to compare the baseline and Project cases and obtain a consolidated estimate of the net economic benefit of the Project.

Table 5.12 presents the incremental benefits and costs associated with each item considered in Section 5.2, measured in NPV terms using a 7% discount rate. A 7% discount rate is the standard discount rate recommended by the NSW Government (2007).

The additional gross mining revenue expected as a result of the open cut mining is the main incremental benefit of the Project in relation to the baseline case.

On the other hand, some of the key incremental costs of the Project are the additional operating costs and capital investment borne by GRL, along with the externalities associated with carbon emissions and rural amenity and culture.

These outcomes lead to a total net benefit of approximately $363 million and a benefit cost ratio (BCR) of 1.527, as shown in Table 5.11.

Table 5.11: CBA results

Discount rate	Total net benefits ($m)	Benefit Cost Ratio
7%	363.43	1.527

Source: DAE calculations

It is important to note that the calculation of the benefit cost ratios (BCR) is sensitive to a number of assumptions.

For example, the preferred BCR outlined in the NSW Government Guidelines for Economic Appraisal (NSW Treasury, 2007) is calculated using initial capital costs in the denominator of the ratio, with ongoing costs subtracted from incremental benefits in the numerator. The purpose of this measure is to ensure that the return to scarce capital is maximised. However, when applied to this Project, this calculation method produces significantly higher results than a standard ratio which divides all incremental benefits by all incremental costs. As such, the BCR reported above are the more conservative estimates of the benefits delivered by the Project.

In any case, DAE considers that the total net benefit figures presented in this report are an appropriate measure for Project evaluation.

Table 5.12: Incremental benefits and costs

No.	Item	Baseline NPV ($m)	Proposal NPV ($m)	Incremental benefit ($m)	Incremental cost ($m)
1	Gross mining revenue	0.00	1,047.45	1,047.45	-
2	Other onsite revenue	0.00	5.45	5.45	-
3	Exploration costs	0.00	0.00	-	0.00
4	Capital investment costs	0.00	118.95	-	118.95
5	Operating costs excluding royalties, rates and taxes	0.00	552.33	-	552.33
6	Rehabilitation costs	0.00	0.00	-	0.00
7	Decommissioning costs*	-	-	-	-
8	Residual value of capital*	-	-	-	-
9	Residual value of land	3.56	1.25	-	2.31
10	Related public expenditure*	-	-	-	-
11	Offsite agricultural revenue*	-	-	-	-
12	Groundwater impacts*	-	-	-	-
13	Surface water impacts*	-	-	-	-
14	Subsidence	0.00	0.00	-	0.00
15	Air pollution – carbon emissions	0.00	6.69	-	6.69
16	Air pollution – particulate matter	0.00	0.20	-	0.20
17	Air pollution – other pollutants*	-	-	-	-
18	Noise pollution	0.00	0.18	-	0.18
19	Visual amenity*	-	-	-	-
20	Traffic*	-	-	-	-
21	Biodiversity	0.00	0.83	-	0.83
22	Conservation*	-	-	-	-
23	Quality of open space*	-	-	-	-
24	Rural amenity and culture	0.00	7.98	-	7.98
25	Aboriginal heritage*	-	-	-	-
26	European heritage*	-	-	-	-
27	Health*	-	-	-	-
				1,052.90	689.47

Source: DAE calculations – note numbers may not add due to rounding
NPV measured in real 2014 dollar terms, using a 7% discount rate
* Considered qualitatively

5.4 Sensitivity analysis

The CBA results presented in Section 5.3 are subject to the assumptions and valuations applied to each cost and benefit, as outlined in Section 5.2. Accordingly, it is necessary to test the sensitivity of the estimate of net economic benefit and the benefit cost ratio by also considering upper and lower bound discount rates, and varying the size of a number of parameters of interest. This provides an insight into the range of possible outcomes that could be expected from the Project, given a number of different scenarios.

The sensitivity analysis results reported in this section utilise a lower bound discount rate of 4%, and an upper bound discount rate of 10%. As noted in Appendix A, these are the values recommended in the NSW Government Guidelines for Economic Appraisal published by the NSW Treasury (2007). It is noted that this lower bound rate of 4% is recognised in the literature as a reasonable discount rate to use when there is an interest in incorporating intergenerational concerns (Arrow et al 2012).

Table 5.13 illustrates the variation in the results of the CBA using these alternative discount rates.

Table 5.13: Central CBA results

Discount rate	Total net benefits ($m)	Benefit Cost Ratio
4%	535.94	1.605
7%	363.43	1.527
10%	245.32	1.448

Source: DAE calculations

As shown, the BCR remains greater than 1 for all three discount rates, indicating that the costs of the Project, including the quantifiable externality costs, are more than offset by the expected benefits.

The estimate of net economic benefits range from around $245 million to $536 million, a respective 32% decrease and 47% increase on the central estimate produced using the standard discount rate of 7%.

The second necessary component of a sensitivity analysis is to also vary the estimates for different inputs. The importance of testing scenarios is also recognised in the NSW Government Guidelines for Economic Appraisal (NSW Treasury, 2007).

The variations undertaken as part of this analysis include:

- increasing coal price forecasts by 30%;
- decreasing coal price forecasts by 30%;
- increasing Project capital investment by 25%;
- decreasing Project capital investment by 25%;
- increasing the estimate of operating costs per tonne by 10%;
- decreasing the estimate of operating costs per tonne by 10%;
- increasing the social cost per tonne of carbon emissions by 10%;
- decreasing the social cost per tonne of carbon emissions by 10%; and
- reducing the national rural amenity and culture costs to those incurred in NSW (around 31%, based on the NSW share of households as at the 2011 Census).

The sensitivity ranges for the coal price were arrived at through an analysis of data over the period from January 1995 to August 2014. For the 30% range, around 66% of the range of historical coal prices are covered, with the lower sensitivity placed at the 17th percentile of historical coal prices, and the upper sensitivity around the 83rd percentile. In this sense, we consider that the 30% price sensitivity is conservative and represents extreme ranges of prices that could be experienced.

Furthermore, it is noted that around 90% of annual changes in the average annual coal price at the Port of Newcastle over the period from 1995 to 2014 have been under 30%. It should be noted that the low price scenario represents an extreme case whereby prices remain at historically low levels throughout the life of the Project (around the 17th percentile of historical coal prices).

A comparison of the total net benefits obtained in each of these scenarios, using a 4%, 7% and 10% discount rate is presented in Table 5.14.

Table 5.14: Sensitivity Analysis – comparison of net benefits

Parameter	Variation in Parameter	Net Benefits ($m)		
		4%	7%	10%
Central CBA	N/A	$536	$363	$245
Coal price forecasts	+ 30%	$961	$678	$482
	- 30%	$111	$49	$9
Project capital investment	+ 25%	$504	$334	$217
	- 25%	$568	$393	$273
Operating costs per tonne	+ 10%	$466	$311	$205
	- 10%	$543	$369	$249
Social cost per tonne of carbon emissions	+ 10%	$535	$363	$245
	- 10%	$537	$364	$246
NSW share of national rural amenity and culture costs	- 31%	$544	$369	$249

Source: DAE calculations

These results indicate that the benefits of the Project are likely to exceed the costs, including any externalities imposed on broader society in all scenarios. The impact of this reduction in coal prices on the Project financials is assessed in Section 5.4.2.

5.4.2 Sensitivity of Project financials

It is important to note the sensitivity of the Project financials to the assumptions used above, in order to gain an idea of the risks which are borne by GRL. For this analysis, we have assumed that the only benefit to the proponent is through coal revenues and that their only costs are capital investment and operating costs.

A consequence of these assumptions is that the Project financials are only sensitive to certain types of scenarios. Specifically, Project financials are only exposed to risks associated with changes in the operating expenditure, capital investment and coal price, but are not exposed to variations in the social cost of carbon or the scope of rural amenity and culture costs.

Table 5.15 shows sensitivities of the Project financials under the sensitivities discussed. It should be noted that the net benefits for the central CBA listed in this table differ from those in Table 5.13 as they do not incorporate any externalities of the Project.

Table 5.15: Comparison of net benefits of Project financials under multiple scenarios

Parameter	Variation in Parameter	Net Benefits of Project Financials ($m)		
		4%	7%	10%
Central CBA		$554	$376	$255
Coal price forecasts	+ 30%	$979	$690	$491
	- 30%	$129	$62	$18
Project capital investment	+ 25%	$522	$346	$227
	- 25%	$585	$406	$283
Operating costs per tonne	+ 10%	$484	$324	$215
	- 10%	$561	$381	$259

Notably, the net benefits of the Project financials are positive under each potential scenario.

5.5 Subregional Impacts

While a CBA provides a clear picture of the overall benefits and costs of the Project, it is not well suited to show that the costs and benefits are not evenly distributed between the different stakeholders. For example, some of the costs of the externalities are borne by the local community, while the benefits of increased taxation accrue to the NSW and Australian Governments. These regional benefits are considered in the following sections.

One important regional benefit is the generation of taxation revenue for the NSW Government. Although tax payments are normally treated as a transfer payment within a CBA model, we estimate that the Project would generate around $84 million (in NPV terms) in royalties for the NSW Government. In undiscounted terms, this is equivalent to an additional $175 million in government revenue over the life of the Project.

This estimate of royalties incorporates allowable deductions of $3.50 per tonne of product coal that is subjected to full cycle washing. However, the potential for further deductions related to payment of levies, insurance and other items such as bad debts and bank commissions have not been accounted for in this estimate, due to the variability in such payments and the difficulty to forecast them accurately over time. Further, these deductions are unlikely to have a large effect on the estimated royalties as they are removed from gross revenue before calculating royalties payable not removed from royalties payable (that is, only 8.2% of deductions are removed from royalty payments).

An estimation of the net benefits to the Gloucester community is also of interest. Although CBA calculations are not easily disaggregated into regional assessments, an estimate of the net benefits likely to be received by the community within the Gloucester LGA was produced based on the following methods:

- the community's share of the net benefits from capital investment was estimated using data provided in the Socio-economic Assessment in relation to the geographic distribution of capital expenditure during the construction phase of the Project, and a Frontier Economics estimate of the weighted average cost of capital in mining, which is borne by GRL;
- the community's share of the net benefits from operating costs was estimated using data provided in the Socio-economic Assessment in relation to the location of employees and geographic distribution of other costs during the operational phase of the Project. In order to illustrate the range of outcomes that could be achieved in the absence of the Project, it was assumed that these businesses and workers could either earn the same level of income from alternative sources, or the average level of income in Gloucester in the baseline case. As illustrated in Chart 3.1, the average level of income in Gloucester is approximately 48% of income from mining. Industries which provide this average level of income include construction and financial and insurance services;
- the community's share of the national costs of carbon pollution was estimated using the Gloucester LGA's share of the national population;
- the community was attributed 100% of the health costs associated with additional PM2.5 pollution, consistent with the regional level modelling approach;
- the community was attributed all of the costs associated with additional noise pollution;

- the community's share of the national costs of lost rural amenity and culture was estimated using the Gloucester LGA's share of national private residences using 2011 Census data; and
- calculation of the payments to the Gloucester community to be made by GRL over the life of the Project, as part of the community grants program, estimated at $0.50 per tonne of product coal sold.

These assumptions imply that, over the life of the Project, the Gloucester community will receive net benefits of between:

- $8.96 million, in NPV terms, assuming that in the absence of the Project, local employees and suppliers could earn the same level of income as they would if the Project went ahead; and
- $62.35 million, in NPV terms, under the assumption that, in the absence of the Project, local employees and suppliers would earn the average level of income in Gloucester.

The midpoint of this estimated range of benefits is $36 million (in NPV terms) over the life of the Project.

6 Impact on regional economy

This chapter examines the economic impact of the Rocky Hill mine operating to 2031 on both the local economy in the Hunter region and the New South Wales economy. The approach uses Computable General Equilibrium (CGE) modelling to estimate how the Project's capital investment, operational expenses and revenues are distributed across the broader economy over time.

Over the period 2015 – 2031 the Project is projected to impact the Hunter region economy by $483 million from almost $1.05 billion in coal sales (in NPV terms). The total Gross State Product (GSP) impact to NSW is projected to be $662 million over the same period. The Project is also projected to impact employment, with additional economy-wide employment peaking in 2025 at 304 FTEs in the region and 30 FTEs in the rest of NSW for a total of 334. These results capture the direct and indirect impacts of the development (accounting for any crowding out of other activity). More detail on the impacts to the Hunter region and NSW are outlined in the following sections.

6.1 Analytical methodology

This study adopts a bottom up framework to determine the likely size, timing and location of the additional activity generated by the design and construction and operational phases of the Project to the Hunter region and the rest of NSW. For this, we have relied on comprehensive Project data provided by GRL on the capital expenditure and the operational activity associated with the Project. This commercial information includes forward development and operational expenditures, production volumes and workforce requirements over the design and construction, and operational phases of the Project.

How we modelled the impacts

Two main techniques are used to measure the economic impacts of a major project, namely; Input Output multiplier analysis (IO) or Computable General Equilibrium Modelling (CGE).

CGE analysis is an extension of IO analysis, in that it is based on a database that incorporates input output tables and the transactional detail between economic agents. In addition, CGE models also incorporate a system of equations and modelling parameters, based on a widely accepted body of economic theory, that model competition for resources (particularly in labour and capital markets) between economic agents and allows for economy-wide modelling impacts incorporating any "crowding-out" impacts of the development.

Of particular importance to the Project, IO modelling would assume an unconstrained workforce which is an unrealistic assumption given the nature and region of this Project. Conversely, the CGE modelling framework captures the labour resource constraints that operate in a region.

The economy-wide impacts of the Project have been projected using the Deloitte Access Economics Regional General Equilibrium Model (DAE-RGEM). The model projects macroeconomic aggregates such as GDP, employment and wages for the Project scenario against a reference case for each of the modelling years from 2015 to 2031. More technical detail regarding CGE modelling can be found Appendix D.

The model has been disaggregated and customised to match the attributes of the Hunter Valley area regional economy. To disaggregate the Hunter modelling region from the rest of NSW, information was used from the most recent 2011 Census on the workforce population.

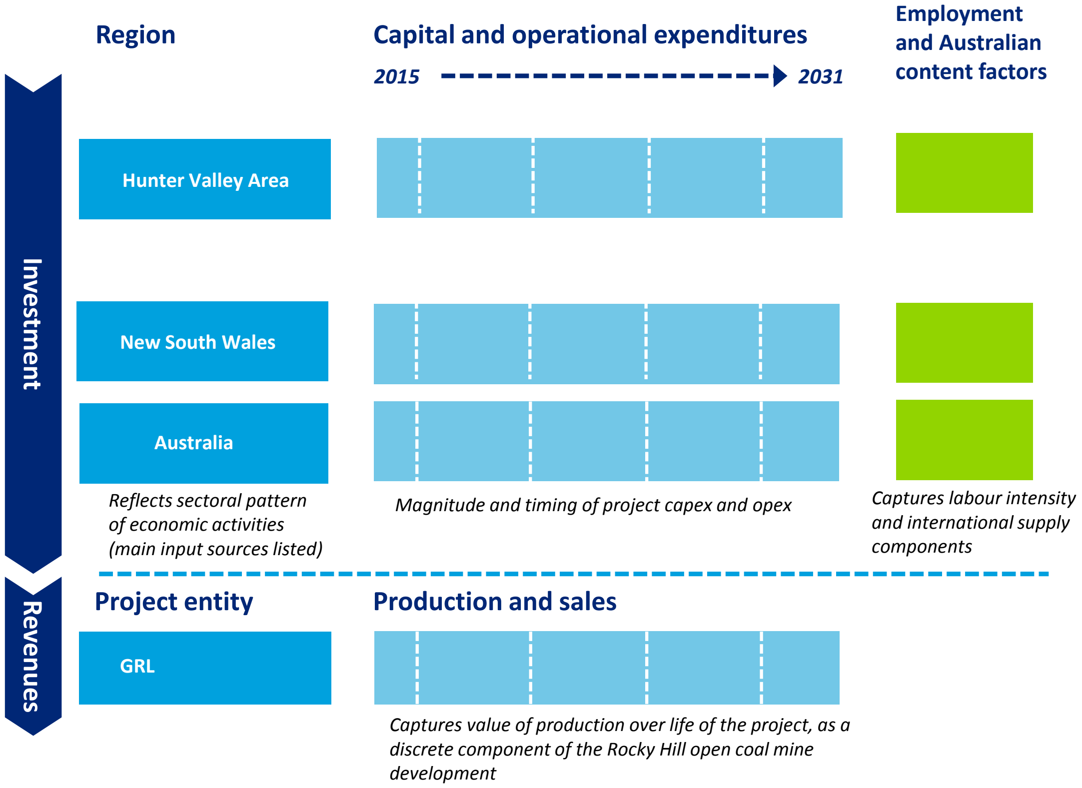
For the purpose of the modelling, the 'Hunter Valley area' includes the Hunter Valley geographical region and part of the Central Coast, as they both cover the main localities which would likely supply labour or intermediate inputs to the Project.

Modelling has been undertaken for the period 2015 to 2031 for the following economic regions:

- **Hunter Valley area** — contains the localities of Gloucester, Broke, Central Coast, Cessnock, Greta, Jerrys Plains, Kurri Kurri, Lake Macquarie, Maitland, Muswellbrook, Newcastle and Singleton
- **New South Wales** — includes the Hunter Valley area and rest of the State.

The results from the economic impact analysis are presented as percentage and absolute deviations in output, employment and wages from a baseline scenario in which the Project does not exist. The broad approach to the economic impact analysis is shown in Figure 6.1. The results are provided for the Hunter Valley, Rest of NSW and total NSW regions.

Figure 6.1: Modelling framework



Based on the capital and operational expenditures, the modelling gauges the wider economic impacts of the development and operation of the Project at two levels:

- **Direct impacts** — the economic gains associated with 'core' commercial operations, namely the coal extraction and processing, and revenues generated by sale of coal exports from the Rocky Hill mine.
- **Indirect, induced and crowding out impacts** — the economic gains in related upstream or downstream industries where the benefits associated with increased resource activity are typically the highest. As outlined above the CGE modelling also captures any crowding out of activity in other sectors of the economy as a result of the Project.

Because of these two distinct elements, the results presented in this Chapter may not necessarily be comparable to the output value and employment projections outlined in other areas of this Economic Impact Analysis, which take a narrower financial view.

6.2 Modelling scenarios

The analysis captures Project construction and the majority of production, including ramp up in the new mine area and stabilisation of resource extraction. The sale of semi-hard coking coal and thermal coal has been considered to assess the output of the Project.

One of the realities of an extended analytical horizon is that projections contain an element of uncertainty. Forecasting economic growth, advances in technology, external political dimensions and other dynamic factors, which are likely to impact on commodity prices and the investment climate over the long-term, is a complex task. In this Project the most significant source of uncertainty affecting the Project is export coal prices.

To understand the potential implications of different coal price trajectories for the Project, the economic impact analysis will be conducted for three modelling scenarios:

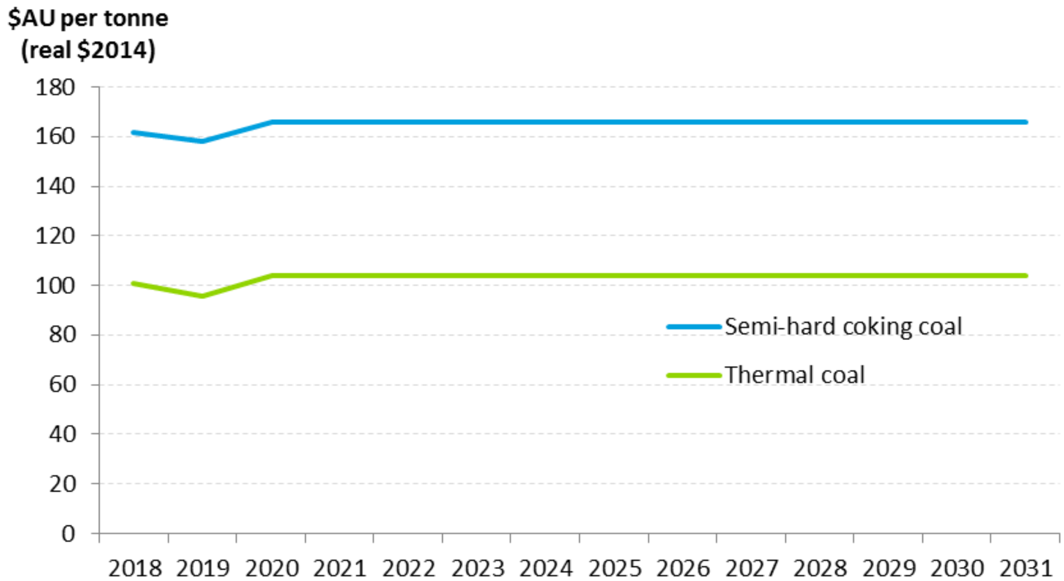
- Scenario 1 – Central estimate of coal price forecasts
- Scenario 2 – Lower price scenario (30% lower than the central estimates)
- Scenario 3 – Higher price scenario (30% higher than the central estimates)

All scenarios are based on the same assumptions around the design, construction and operation of the Project for which approval is being sought. The results for Scenario 1 are outlined in Section 6.4 while a discussion on the sensitivities is outlined in Section 6.5.

Coal price – revenue per tonne

Two series of price forecasts are required: semi-hard coking coal prices and thermal coal, as set out in Chart 6.1. These have been obtained from GRL, with reference to BREE forecasts, as described in Section 5.2.1.

Chart 6.1: Coal price forecasts, 2014 to 2031



Source: GRL

To gauge the economic impacts of varying levels of coal production, each scenario is compared against a baseline, or counterfactual. The baseline case sets out a story of how the economy would have evolved over time in the absence of the Project. Other planned and approved developments in proximity to the modelling area (and indeed across Australia) that are unrelated to the Project have been considered to form part of the baseline. In this respect, each scenario represents the incremental gains to the economy above and beyond what would have occurred without further capital and infrastructure investments from the construction and operation of the Rocky Hill mine.

6.3 Phases of the Project

Two distinct phases of economic activity drive the economic impacts of the Project: design and construction, and ongoing operations:

- **Design and construction phase** —involves the initial period where capital works are undertaken to develop the Rocky Hill mine. This includes the creation of production capacity supported by additional infrastructure (e.g. coal processing plant, roads and services, dams and water management, power infrastructure). Undiscounted total Project capital expenditure amounts to $139 million ($119 million discounted to today's dollars using a 7 per cent discount rate).
- **Operational phase** —involves the operational costs incurred over the life of resource production from the Project. In this phase, capacity is brought online and coal production commences at scale (e.g. processing operation, maintenance costs, water management systems, mobile fleet purchases etc).

The operational phase modelled in the economic impact modelling goes from 2018 to 2031 (inclusive). Total ROM over the period is around 21.9 Mt, with approximately 13.5 Mt of saleable coal. By weight, thermal coal makes up [redacted] of the total saleable coal mined in the Project. [redacted].

Chart 6.2 Project case forecast production profile, 2014 – 2031 (saleable coal)

[redacted]

■ Semi-hard coking coal ■ Thermal coal

Source: GRL

Chart 6.3 shows estimated total revenue from the Project from 2014 to 2031 (note that production does not commence until 2018). Sales increase steadily to nearly [redacted] million per annum by 2025 and remain around this level until 2029.

Chart 6.3: Project revenue

[redacted]

Source: GRL

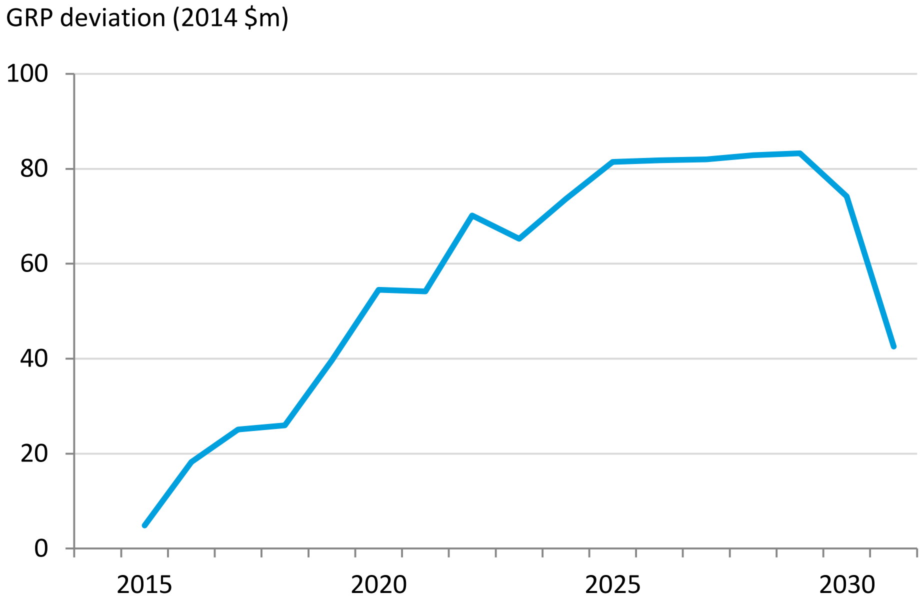
6.4 Economic impacts – Central case

The following discussion provides the economic impacts of the Project over the modelling period 2015 to 2031. As outlined above the period 2015 – 2017 is the capital expenditure phase, with operations commencing in 2018 and continuing to 2031. This section outlines the projected impacts to the regional Hunter economy and the NSW state-wide impacts.

Economic impacts – GRP

Chart 6.4 shows the economic output generated in the Hunter region in real 2014 terms as a result of the Project. Over the capital continuation phase, Hunter-region GRP is projected to increase by between $5 million and $25 million. From 2018 onwards, when production begins, GRP impacts increase significantly, peaking at over $83 million in 2029.

Chart 6.4: GRP impacts in the Hunter region, Scenario 1



Source: Deloitte Access Economics

In NPV terms, over the modelling period total Hunter-region GRP is projected to increase by just below $483 million from coal sales of about $1 billion (see Table 6.1). There is also an impact on the broader NSW economy – GSP is greater by $179 million in net present value terms over the period 2015-2031. Therefore, State-wide GSP is projected to be $662 million greater over the modelling period under the Project scenario.

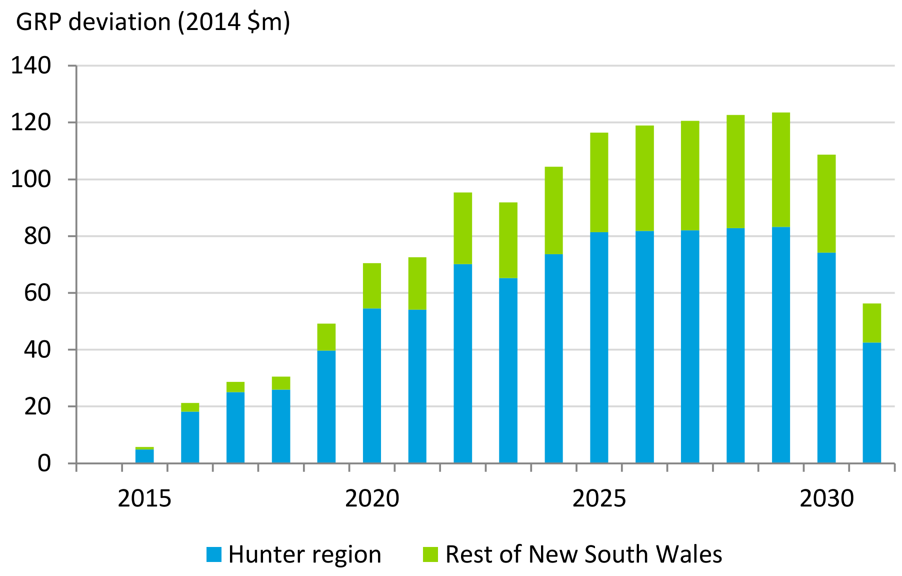
The full temporal profile of the impacts on economy output levels are represented in Chart 6.5. As Chart 6.5 shows, total annual state-wide impacts peak at around $124 million in 2029.

Table 6.1: Regional economic impacts (2014 $m)

	NPV	2016	2019	2023	2027	2031
Coal sales	1,047	0	[redacted]	[redacted]	[redacted]	[redacted]
GRP/ GSP/ GDP						
Hunter-region	483	18	40	65	82	43
Rest of NSW	179	3	10	27	39	14
Total NSW	662	21	49	92	121	56
Deviation from the reference case (%)						
Hunter-region		0.05	0.10	0.14	0.16	0.08
Rest of NSW		0.001	0.002	0.005	0.006	0.002

Note: All values are in real 2014 terms. The NPV discount rate is 7 per cent.
Source: Deloitte Access Economics

Chart 6.5: GRP impacts by region, Scenario 1



Note: All values are in real 2014 terms

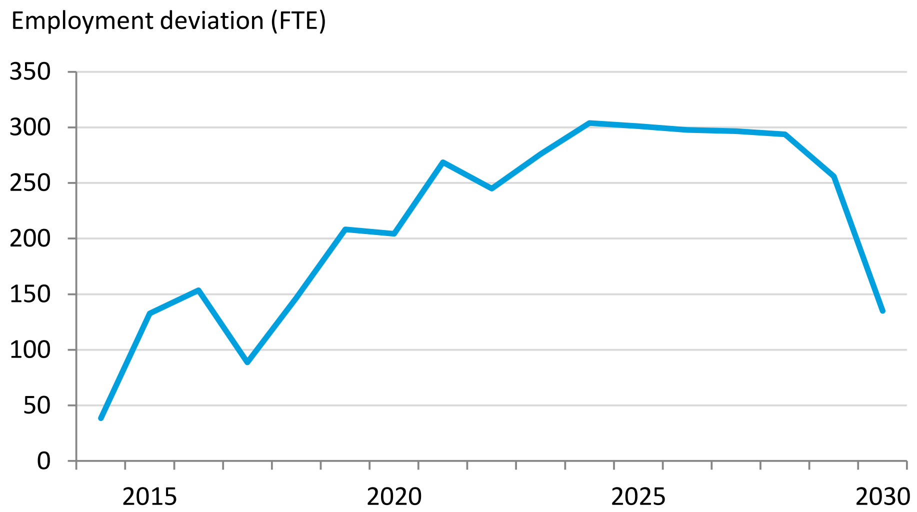
Source: Deloitte Access Economics

Employment

Chart 6.6 depicts the additional total regional employment generated by the Project in the Hunter-region. The employment includes those employed directly at the mine-site, contractors and Project suppliers and any crowding out in other sectors of the economy.

Total projected regional employment peaks around the middle of the operations phase, in 2025, at 304 FTEs. Employment impacts in the region remain positive throughout the modelling period.

Chart 6.6: Employment impacts in the Hunter region, Scenario 1



Source: Deloitte Access Economics

The employment impact of the Rocky Hill mine is projected to peak in 2025 at 334 FTEs (Table 6.2). The negative impact on employment outside the Hunter region in New South Wales in 2031 is an example of the type of dynamic effects that CGE modelling captures. Activity in one part of the economy (the Hunter region) has effects on the supply of labour, capital and other inputs throughout the economy. Note that total state employment is projected to be higher in all years of the modelling period under the Project scenario.

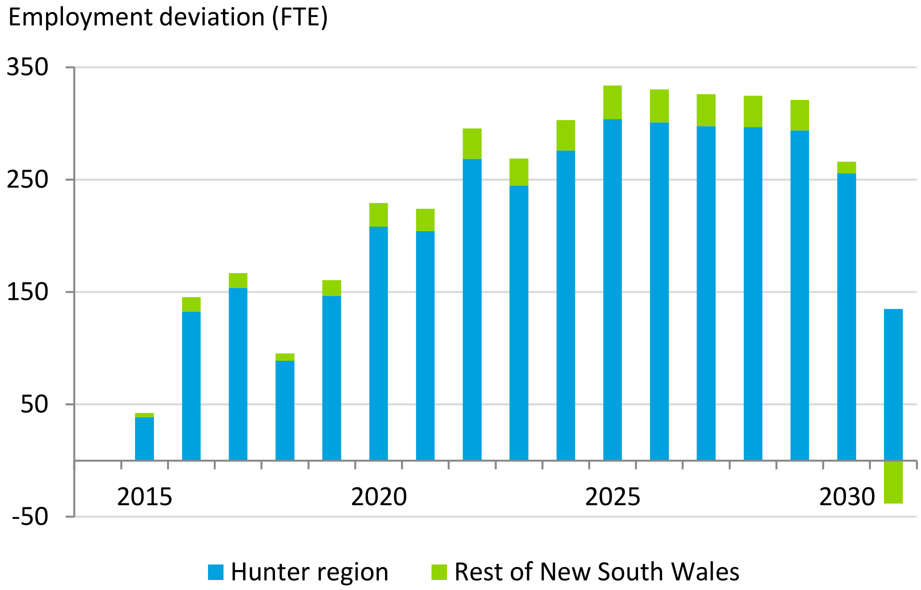
Table 6.2: Regional employment impacts, 2016 – 2031

	2016	2019	2023	2027	2031
Employment (FTE)					
Hunter-region	133	147	245	298	135
Rest of NSW	13	14	24	28	-38
Total NSW	145	160	269	326	97
Deviations from the baseline					
Hunter-region	0.04	0.04	0.07	0.08	0.03
Rest of NSW	0.000	0.000	0.001	0.001	-.0.001

Source: Deloitte Access Economics

The complete temporal profile of projected employment impacts in the Hunter region and the rest of New South Wales is shown in Chart 6.7. The Project's greatest impacts on employment come from around 2025 onwards as mine production peaks. There is also a decrease as the Project transitions from construction to operations, between 2017 and 2018.

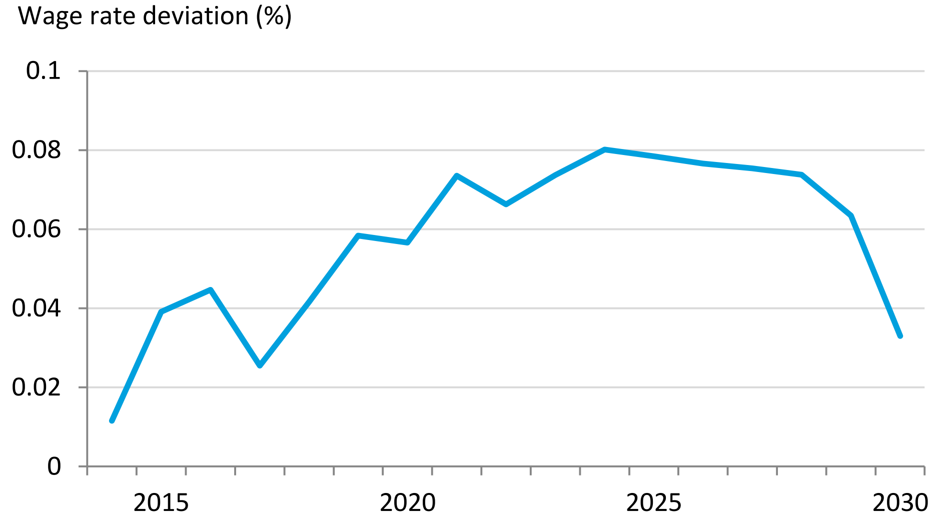
Chart 6.7: Total regional employment impacts by region, Scenario 1



Source: Deloitte Access Economics

Growth in employment is accompanied by an increase in real wages (see Chart 6.8). This result represents the increased competition for labour resources brought about by the Rocky Hill mine.

Chart 6.8: Hunter region wages impact

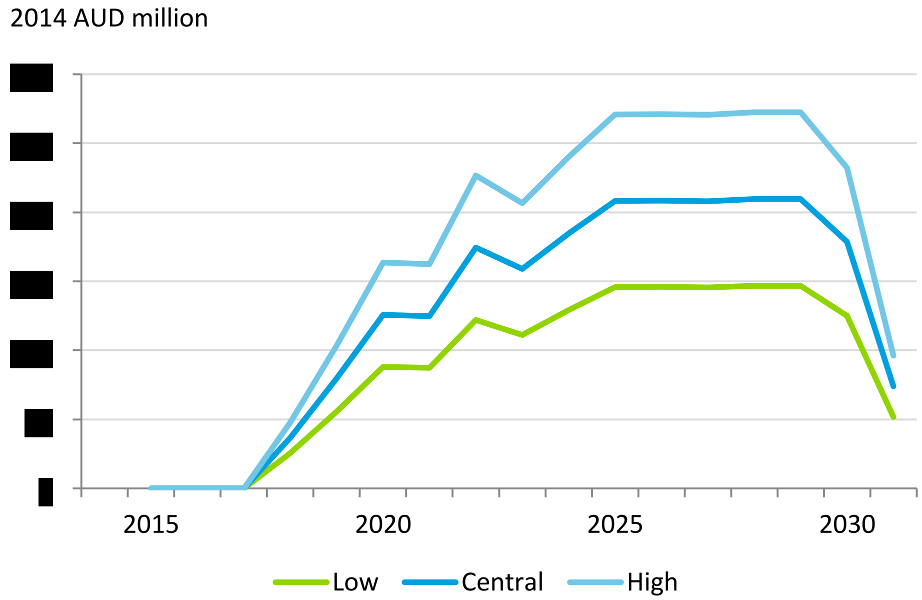


Source: Deloitte Access Economics

6.5 Sensitivities

This section outlines the economic impacts under three modelling scenarios. As outlined in Section 6.2, the additional scenarios are based on a 30% increase and decrease of the coal price sustained over the modelling period. Chart 6.9 shows the variation in projected Rocky Hill mine revenue under the central, high and low coal price scenarios.

Chart 6.9: Rocky Hill Coal Project mining revenue, alternative coal price scenarios



Source: Deloitte Access Economics

It should be noted that the low price scenario represents an extreme case whereby prices remain at historically low levels throughout the life of the Project (around the 17th percentile of historical coal prices).

Table 6.3 outlines the GRP impact of the three modelling scenarios. As expected the projected GRP impacts are proportionate to the coal price inputs.

The NPV of projected GRP impacts of the Project on the Hunter region range from $374 million the low coal price scenario to $592 million in the high coal price scenario. With the addition of impacts on the rest of the state, the impact on New South Wales GSP ranges from $501 million to $824 million.

Table 6.3: Rocky Hill mine GRP impacts, NPV, 2014-31

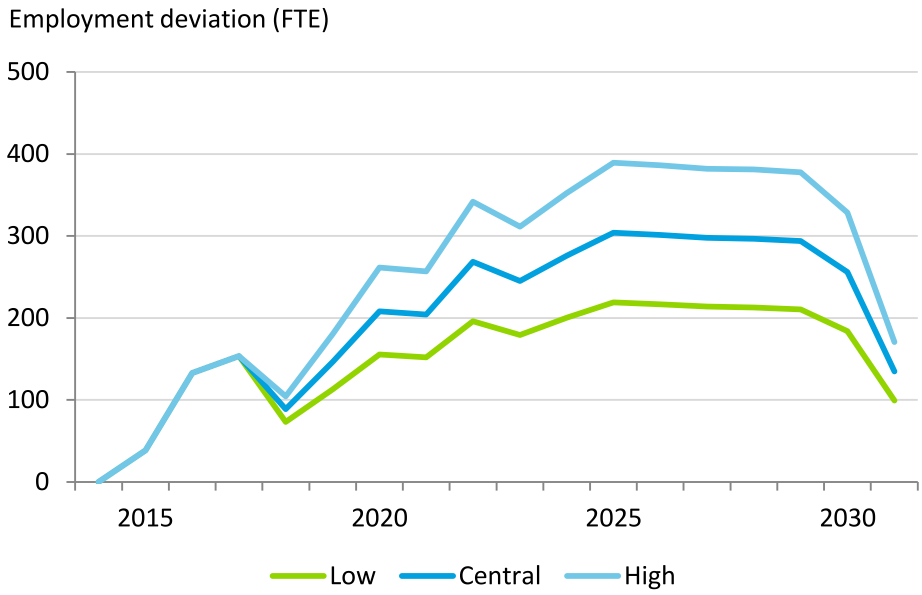
NPV	Central	Low	High
Hunter	483	374	592
Rest of New South Wales	179	127	232
Total NSW	662	501	824

Note: All values are in real 2014 terms. The NPV discount rate is 7 per cent.

Source: Deloitte Access Economics

Chart 6.10 outlines the Hunter region employment impacts of the Rocky Hill mine under the three coal price scenarios. In each scenario, employment impacts are relatively stable from 2025 to 2030 inclusive (in line with the profile of mine output).

Chart 6.10: Employment impacts, Hunter region, 2014 – 2030



Source: Deloitte Access Economics

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Appendix A: Checklist against guidelines

NSW Treasury (2007) NSW Government Guidelines for Economic Appraisal

Table A.1: Key issues mentioned in NSW Treasury (2007)

Draft Guidelines	Addressed	Reference
Identify Options		
"Do nothing" option	Yes	4.1
Option development	Yes	4.2
Identify Benefits		
Avoided Costs	Yes	5.1
Savings	Yes	5.1
Revenues	Yes	5.1
Benefits to consumers not reflected in revenue flows	Yes	5.1
Benefits to the broader community	Yes	5.1
Identify Costs		
Identify all relevant cost items	Yes	5.1
Stream of costs should cover full project period	Yes	5.1
Identify Qualitative Factors		
Identify costs and benefits that cannot be quantified	Yes	5.1
Other impacts include environmental considerations, industrial relations, social or regional impact, safety, public relations, resource availability	Yes	5.1
Assess Net Benefits		
Assessment of benefits in real terms	Yes	5
Discount at 7% rate, with 4% and 10% for sensitivity testing	Yes	5.3
Net Present Value	Yes	5.3
Net Present Value per $ of capital outlay	NA	
Benefit-Cost Ratio (BCR)	Yes	5.3
Internal Rate of Return (IRR)	NA	
Sensitivity Testing		
Projected outcomes under alternative scenarios	Yes	5.4
Emphasis given on pessimistic alternatives	Yes	5.4
Ecologically Sustainable Development		
Inter-generational equity principle	Yes	5.4
Identification of Environmental Impacts	Yes	5.1
Valuation of Environmental impacts	Yes	5.2
Sensitivity and Threshold Analyses	Yes	5.4
Use of ENVALUE	Yes	Appendix C

Note: NAs in this table reflect summary measures that were not assessed as being necessary to reach conclusions.

NSW Department of Urban Affairs and Planning (2002) Guideline for economic effects and evaluation in EIA

Table A.2: Key issues mentioned in NSW Department of Urban Affairs and Planning (2002)

Draft Guidelines	Addressed	Reference
Conduct Preliminary Assessment		
Review main elements of proposed projects, alternatives and surrounding environment	Yes	4
Review information on environmental impacts of proposal	Yes	5
Determine spatial and temporal boundaries for analysis	Yes	4.3
Specify relevant community and major groups affected	Yes	5
Specify the kinds of economic values affected	Yes	5.1
Obtain preliminary estimates of likely magnitude of benefits and costs	NA	
Assessment of scale of economic effects relative to regional or local economy	Yes	6
Determine whether an economic impact assessment is required	Yes	6
Scoping the economic study		
Consider environmental impacts and economic values predicted in preliminary analysis	Yes	5
Consider time, skills and budget for analysis	NA	
Determine values to be quantified in benefit-cost analysis, sources of information and methodology	Yes	5
Determine extent and approach to community consultation	NA	
Identify level and extent of other economic assessments	NA	
Derive economic values and conduct efficiency analysis		
Specification of baseline scenario	Yes	4
Valuation of direct benefits and costs of proposal and alternatives	Yes	5
Valuation of environmental effects	Yes	5
Set up benefit-cost assessment framework	Yes	5
Summarise all economic values	Yes	5
Calculate NPV and other criteria specified by State Treasury	Yes	5.3
Conduct incidence analysis identifying distribution of costs and benefits	Yes	5.5
If required, conduct economic impact analysis to assess economy wide-effect		
Specify economic boundaries for assessment	Yes	6
Specify linkages between project and economy	Yes	6
Apply relevant economic impact assessment model	Yes	6
Estimate results, including changes in output, employment and income for sectors of the economy	Yes	6
Incorporate any results into BCA	NA	
Apply ESD principles		
Ensure predicted changes in natural resources and environment have been comprehensively valued	Yes	5
Assess risk, uncertainty and irreversible environmental impacts	Yes	5
Address intra- and inter- generational equity issues	Yes	5.4, 5.5
Conduct integrated assessment of options		
Summarise results on economic efficiency	Yes	5.3
Summarise results on intra- and inter-generational equity	Yes	5.4, 5.5
Document and report main findings	Yes	Report as a whole

Note: NAs in this table reflect tasks completed elsewhere in the EIS

NSW Government (2012), "Guideline for the use of Cost Benefit Analysis in mining and coal seam gas proposals"

Table A.3: Key issues mentioned in the Guideline

Draft Guidelines	Addressed	Reference
Key features		
Scope: all first round impacts	Yes	5.1
Net public benefit or cost	Yes	5.3
Discount rate of 7% with sensitivity analysis	Yes	5.4
Appropriate timeframe	Yes	5
Risk Neutral approach	Yes	5
Discussion of unquantified factors	Yes	5
Stages of analysis		
Identify the Base Case	Yes	4.1
Define Project and Develop Options	Yes	4.2
Estimate the Impacts of the Project	Yes	5
Estimate the monetary value of these impacts	Yes	5
Estimate the Overall Net Value of the project	Yes	5.3
Test for Uncertainty and Risk	Yes	5.4
Prepare Report Including CBA Results and Qualitative Impacts	Yes	Whole of report
Distribution effects	Yes	**5.5**
CBA at the regional or catchment level	Yes	**5.5**
Costs and benefits		
Revenues from mining or CSG per annum	Yes	5.2.1
Any other revenues from the land use during or after mining	Yes	5.2.2, 5.2.9
Capital expenses	Yes	5.2.4
Exploration expenses	Yes	5.2.3
Infrastructure contributions	Yes	5.2.10, 5.2.20
Operating expenses per annum	Yes	5.2.5
Remedial costs post mining	Yes	5.2.6, 5.2.7
Value of rural output forgone	Yes	5.2.11
Value of residential amenity forgone	Yes	5.2.19, 5.2.23, 5.2.24
Cost of changes in infrastructure	Yes	5.2.10
Air quality	Yes	5.2.16, 5.2.17
Health	Yes	5.2.27
Groundwater	Yes	5.2.12
Noise	Yes	5.2.18
Biodiversity	Yes	5.2.21
Heritage	Yes	5.2.25, 5.2.26
Other economic impacts		
Increased wages for workers	Yes	6
Increased profits for suppliers to the mining sector	Yes	6
Changes in incomes in tourism or other local businesses	Yes	6

Appendix B: Valuation techniques

This appendix provides a general overview of the range of possible approaches to valuing items in a cost benefit analysis. This appendix is intended to provide background on approaches and techniques that could be used in the CBA itself. The approaches outlined below encompass a range of techniques including the use of:

- project financials;
- market prices;
- foregone revenue;
- hedonic pricing;
- stated preference;
- travel time costs;
- defensive expenditure; and
- value of statistical life.

These techniques cover direct approaches where either financial or market information is available as well as indirect approaches where values have to be discerned from behaviour. The application of these techniques to particular costs and benefits is discussed in Appendix C.

Project financials

Project financials or other information provided by a project's proponent can be used to value many of the expected inputs and outputs associated with the proposal. Minimal analysis is required to derive this data, as the values are usually stated explicitly and provided by a project's proponent. This approach is particularly useful when attempting to estimate values like the expected size of the work force, scale of operations or output produced.

However it is important to note and critique the validity of assumptions used to generate the projected values provided as the proponent has an interest in the implications of the data.

It should be noted that project financial data is sometimes chosen to serve as a "best estimate", and is therefore prospective in nature. Thus, in undertaking any critique of the information, it may be more valid to compare projected financials to other prospective data sources such as futures prices, rather than historical data.

Observable market prices

Market prices – the price of goods actually traded on the market – represent the revealed value of an object as determined by those who buy and sell it. For commoditised items (e.g. a tonne of coal), this price can be readily observed in the spot market. An idea of future price movements can also be gained through futures markets. For goods that are less commoditised (e.g. housing or land), market prices are derived by looking for comparable goods traded on the market and estimating a market price for a good. Market prices are thus best used for commodities that are regularly traded, or have comparable goods that are regularly traded.

Market prices are seen as the most reliable way to estimate the value of an item as, in the presence of a relatively efficient market, prices are empirically based; do not require the use of any theoretical assumptions; are normally free from extreme influence by any one individual or organisation, and involve actual cash transactions rather than statements of preference or policy.

An important property of market prices is that they are affected by future expectations. This means that prices can be affected by announcements or the perceived likelihood of future events happening. When calculating the impact of a project on market prices, it may be important to correct for the fact that prices may have already reacted to announcements regarding the project, and thus partially account for the expected future impact. A further implication of the forward looking nature of prices is that, if a project is likely to dramatically affect the cost of a good (e.g. wages in a local economy), it may not be appropriate to use pre-project prices to estimate the cost of such a good.

A constraint of market prices is that they necessarily reflect *effective* demand, that is to say, a person must be both willing and *able* to purchase a product for the market to reflect their valuation. Thus, if people's purchasing decisions are constrained then their valuation may not be reflected in market prices. For example, if people in an area experiencing pollution are unable to access credit to move away, the cost of pollution to such people may not be reflected in the market price of housing.

Having noted these considerations and limitations, it is still the case that a valuation on market prices is the most preferable way to value items within a CBA.

Forgone revenue or increased costs

Foregone revenue or increased cost are attempts to make a comparison between a proposal and a counterfactual, by observing the revenue that would have been earned by a particular entity (or entities) as a result of the proposal, or the increased costs faced as a result of the proposal. Both techniques require modelling scenarios with and without the proposal. Furthermore, they require explicit mention of the means by which the proposal could affect the party involved. As examples, a project could distort prices of inputs (price effects), create secondary consequences (externalities) or even compete directly with local entities (direct competition).

It should be noted that measures such as foregone revenue and increased costs are not, necessarily, themselves measures of overall costs. Foregone revenue and increased costs can sometimes represent transfers of wealth between different segments in a community (such as a transfer from employees to employees) and may thus overstate the impact of a project on the overall community. In this case, an advantage consideration of foregone revenue or increased costs allows for an assessment of the distributional impact of a project.

Hedonic pricing

Hedonic pricing is a method of using observable market prices to value intangible goods or particular properties of goods. To do this, hedonic pricing tries to compare the price of goods that are similar in every respect except for the property being compared. An example would be an attempt to value the cost of discomfort from noise pollution, by comparing the market price of houses which are substantially similar except for the presence of noise pollution.

Hedonic pricing relies on observable market prices, and is thus considered revealed preference data (as opposed to stated preference data). It is therefore a more empirical approach as it relies on data from market transactions rather than just statements about preferences.

A critical drawback of hedonic pricing is that any attempt to value properties or goods in this way is dependent on the theoretical model used to determine the value of an object. As it is often difficult to find two items that are identical in all respects except for a given property, comparisons are made using a theoretical model that attempts to describe the way in which different properties are combined to produce a particular value. The most common method of doing so would involve assuming that the costs of different properties are independent and additive. For example, when valuing a house, one might assume that the decline in value from noise pollution and the decline in value from air pollution are independent of the other properties of the house and that the decline in value from having both noise pollution and air pollution together is the sum of the decline in value of noise pollution and air pollution.

Stated preference, willingness to pay, choice modelling and similar

As opposed to revealed preference approaches which are based on prices, such as hedonic pricing, this methodology determines the maximum value assigned by an individual, that is, their willingness to pay, using a structured survey. Stated preference approaches are particularly useful for the valuation of externalities – costs or benefits which are not incorporated in market transactions, such as the environmental, cultural and social impacts of economic activity.

Stated preference valuations are undertaken using one of two techniques – contingent valuation, or choice modelling (Fujiwara & Campbell, 2011). The main difference between the two is that contingent valuation surveys generally relate to the overall valuation of a non-market good, while choice modelling surveys aim to ascertain valuations of certain characteristics of that good. When multiple attributes are considered in choice modelling, an overall valuation can also be obtained (Fujiwara & Campbell, 2011). Both contingent valuation and choice modelling surveys can take a number of different forms. These vary according to the manner in which respondents are asked to indicate their preferences.

In the case of choice modelling, each survey question asks respondents to rank, rate or choose between multiple hypothetical scenarios, including a status-quo option. These scenarios vary according to the state of different attributes, generally including non-market impacts, such as the extent of the effect on flora, fauna or water quality, and an associated level of cost to be borne by the individual which limit the effects to this level. Depending on the complexity of the scenario, a large number of questions may be required. Statistical methods are then applied to quantify the trade-offs between each characteristic, establishing estimates of willingness to pay and implicit prices for marginal changes in each attribute. Specifically, discrete choice models such as multinomial, nested or mother logit models are utilised in this analysis process.

While stated preference methods can provide useful insights on the valuations of non-market impacts, they are associated with a number of important practical considerations. In particular:

- the process of developing an appropriate questionnaire involves substantial costs;
- the scenarios posed in question sets should be realistic and reflect local circumstances; and
- an adequate sample size of data must be collected to provide statistically significant results.

Even if these methodological challenges are overcome, the computation of model parameters and the resulting willingness to pay estimates is another complex process, which requires an understanding of underlying assumptions and the issues relating to aggregation of results for the entire population.

Further details regarding these matters are outlined in the summary guide prepared by the UK Department for Transport, Local Government and the Regions (DTLR) (2002) and the accompanying manual (Bateman et al, 2002).

Travel time costs

The travel time cost method is a surrogate market technique useful for valuing physical sites which are not subject to price mechanisms, such as recreational facilities (Parsons, 2003). The methodology is based on the assumption that the costs an individual incurs in travelling to a site provide an insight into the value they assign to that facility and the activities which they participate in at the location (Planning NSW, 2002). The aim is to use this information to derive a demand curve for the recreational benefits of a site.

Travel time cost valuation methods usually take the form of a single site or multiple site model (Parsons, 2003). Where there are minimal substitutes for a facility and the focus of valuation is to determine society's willingness to pay to access the site, a single site model will usually suffice. Multiple site models are particularly useful for capturing the effects of variation in site attributes on valuations, such as the effect of changes in environmental quality on willingness to pay. In this regard, multiple site models may be appropriate for valuing the environmental impact of mining activity. As the name suggests, multiple site models can also take substitution effects into account, providing simultaneous estimates of access values at a number of locations.

According to Parsons (2003), the process of estimating one of the most common multiple site models, the random utility maximisation (RUM) model, can be broken down into 11 steps. These are listed and briefly described in Table B.1.

Table B.1: Brief outline of modelling travel time costs with a random utility maximisation model

Step	Action	Brief description
1	Identify the impacts to be valued	• Identify the site characteristics of interest • Consider whether these can be measured objectively
2	Define the population of users to be analysed	• Identification of all current users and potential users of sites, with and without characteristic changes
3	Define the choice set	• Determining which sites an individual will be assumed to consider when making a visitation choice
4	Develop a sampling strategy	• Identifying the method for sampling and data collection
5	Specify the model	• Identifying variables for site characteristics and individual characteristics which influence their likelihood to make a trip
6	Gather site characteristic data	• Using data from primary/secondary sources • May involve results of an auxiliary regression, using observable features as inputs
7	Decide on the treatment of multiple purpose trips	• Choose to either identify and drop multiple purpose trips, or include dummy variables in site characteristics which account for other opportunities nearby
8	Design and implement the survey	• Obtain information from respondents on their frequency of trips over a defined time period, details of their last trip, and demographics
9	Measure trip cost	• Involves computation of distances travelled and travel time for every site in each individual's choice set
10	Estimate model	• Undertake a regression to estimate the parameters of the theoretical model
11	Calculate access and/or quality change values	• Ascertain access valuations, or valuations of changes in the attributes of site/s

Source: Parsons (2003)

It is evident that, like the stated preference approach, development of a travel time cost model involves many practical considerations and substantial costs. In particular, it can be difficult to obtain precise estimates of the value of travel time (Planning NSW, 2012) although estimates of travel time costs can be obtained from Austroads (2010).

Defensive expenditure

Another methodology useful for the valuation of externalities, such as environmental impacts, is the defensive expenditure approach (Planning NSW, 2012). This revealed preference technique utilises data on the expenditures that people make in order to protect themselves from some risk or impact (Whitehead et al, 2007). The extent of these defensive expenditures on market goods can be used as proxy values of associated non-market, environmental goods. For example, investments in double glazed windows can be used as an estimate of the value of reduced exposure to road traffic noise (Fujiwara & Campbell, 2011).

The defensive expenditure method provides a partial, or lower bound estimate of the valuation of environmental impacts (OECD, 2006). This is due to the fact that the expenditures may not be directly related to the impacts (Planning NSW, 2002). Rather, the accurateness of the valuation produced by this method is dependent on an interaction between environmental quality and the effectiveness of the defensive expenditure (Sotelsek, 1998). It is therefore generally assumed that that the costs incurred in protection reflect a minimum valuation of the environmental benefits (Planning NSW, 2002).

Meanwhile, recognition of broader benefits associated with defensive expenditure is critical to the accuracy of this methodology. Under these circumstances, it can be difficult to isolate a valuation that is specific to the environmental benefit of interest (Planning NSW, 2012).

Value of statistical life, DALY, wage differential and similar

The health impacts of economic activity can be valued according to human capital or willingness to pay approaches, although the latter is most common and is considered most appropriate (Jalaludin et al, 2009 & OBPR, 2008). There are also a number of health-specific valuation concepts useful for placing values on the cost of mortality and morbidity. These include the value of statistical life, and the disability-adjusted life year.

The value of statistical life (VSL) represents an "estimate of the financial value society places on reducing the average number of deaths by one" (OBPR, 2008). As noted by the World Bank (2003), the measure is not intended to reflect the fundamental value of human life. Although the VSL is a well established economic concept, there is a great deal of variability in estimates. According to the OBPR (2008), the most appropriate measurement technique for VSL is willingness to pay – that is "estimating how much society is willing to pay to reduce the risk of death". Using this framework, it was estimated that the VSL in an Australian context is approximately $3.5 million (OBPR, 2008).

An alternative health metric is the disability-adjusted life year (DALY). This is a measure of the burden of disease, incorporating the effects of mortality and morbidity, with a single DALY representing "one lost year of healthy life" (WHO, 2013). The inclusion of the mortality component in the DALY calculation implies that if used in a CBA, it should substitute, rather than complement VSL measures to avoid double-counting (BTRE, 2005). However, it appears that a number of practical issues constrain this transition, including a lack of data on DALY monetary valuations (Jalaludin et al, 2009).

Hedonic pricing analysis of wage differentials is another technique which has been applied to obtain valuations of health impacts. These models analyse wage differentials with the aim of ascertaining a value for risk exposure. Specifically, wages are modelled as a function of individual characteristics and job characteristics, to derive an estimate of the compensation paid for risk of fatal and nonfatal injury (World Bank, 2003). However, the accuracy of this technique relies on a number of theoretical assumptions relating to employee mobility and access to information which may not hold in practice (Jalaludin et al, 2009).

The final method used for valuing health impacts is the human capital approach (Planning NSW, 2002). This technique estimates the economic output foregone as a result of reduced productivity caused by "absenteeism, temporary or permanent disability and premature mortality" (Jalaludin et al, 2009). While this methodology is often used to value the health impacts of environmental degradation, such as pollution, the estimates are not alternative measures of the VSL (Planning NSW, 2002). However, lost earnings due to premature mortality could be considered as a minimum estimate of VSL (World Bank, 2003).

Appendix C: Approaches to valuing specific costs and benefits

This appendix provides a general outline of the available approaches to valuing the various costs and benefits identified in the guidelines for CBA published by the NSW Government, and summarises the evidence produced by quantitative valuations. It is intended as a guide to the approach taken in the CBA and to provide views on alternative data sources.

Industry impacts

Gross mining revenue

Gross mining revenue would be provided by the project proponent or evident in the project financials. This mining revenue would be based on the value of output, a factor of both the volume of output and the relevant coal price. Relevant coal prices can be estimated using the spot price of coal or through the price of coal futures. The volume of output is usually estimated by the project proponent themselves. It is important to note that the volume of output is selected to match the marginal cost of production with the current market price of coal.

Coal prices

Coal prices are observable market prices –Australian thermal coal was valued at $78.42 per metric ton in July 2014, measured in Australian dollars (Index Mundi 2014). The current price of coal is observable on the spot market. The future price of coal is observable in the futures market, although that may not be necessary as efficient commodities markets should result in current prices of coal taking into account future expectations.

Mine related costs

Mining exploration costs are also data which the project proponent would have on hand. Expenditure on mining capital investment and operating costs would be detailed on project financials. Rehabilitation expenses, such as landform reconstruction, revegetation would also be accounted for as project costs on financial statements.

Forgone agricultural revenue

Foregone agricultural revenue can be estimated based on financial information on agricultural land use prior to mine development. Open cut coal mining competes directly with agricultural land use as it removes land with agricultural potential to reach coal underneath. Furthermore, both open cut coal mining and underground coal mining can impact on the local water system and thus affect agriculture across a given water system.

The effect of a mining activity on agriculture can be assessed by first considering the productivity of the agricultural land in regions of interest. The first stage in this analysis was to find the agricultural productivity of the regions of interest. The results of this analysis are set out in Table C.1.

Table C.1: Average agricultural productivity by SLA

Area	Productivity of vegetables, fruit, nuts, grapes, berries ($2013/ha)	Productivity of dairy livestock ($2013/ha)
Cessnock	4,556.86	1,121.80
Gloucester	52,991.29	1,409.72
Muswellbrook	7,977.41	1,462.07
Singleton	57,561.72	1,429.15
Upper Hunter Shire	12,863.93	1,474.90

Source: ABS Catalogue 7125.0, DAE calculations

This land productivity data can then be combined with information on the area of land that is likely to be affected by mining activity to provide a decrease in agricultural activity that can be attributed to increased mining activity.

We believe that this process of estimating the effect on agricultural production from coal mining is likely to be generous. Previous analysis undertaken by DAE suggests that mining operations often take place in areas of grazing, cropping and forestry which will have significantly lower productivity than average.

Where land is used for grazing activity, revenue foregone can also be valued using the estimates of gross margins for NSW beef enterprises, published by the NSW Department of Industry and Investment (2012). As shown in Table C.2, the Department reports gross margins per hectare for a range of beef enterprises, inclusive of pasture costs.

Table C.2: Summary of gross margins for NSW beef enterprises, December 2012

Enterprise	Gross margin per hectare ($2012)
Inland weaners	75.54
North Coastal Weaners 1	46.95
North Coastal Weaners 2	126.57
Specialist local trade	131.38
Local trade / feeders (creep fed)	147.84
Yearling production (southern/central NSW)	164.62
Young cattle 15-20 months	112.61
Young cattle heavy feeder steers	100.75
Growing out early weaned calves 160-340kg in 12 months	207.11
Growing out steers 240-420kg in 12 months	196.69
Growing out steers 240-460kg in 12 months	229.19
EU cattle	174.22
Japanese ox (grassfed)	109.72

Source: NSW Department of Industry and Investment (2012)

As there is no empirical evidence on the relationship between agricultural productivity and the noise or dust impacts of mining activity, it is difficult to quantify the extent of these externalities in monetary terms. In addition, impacts are generally:

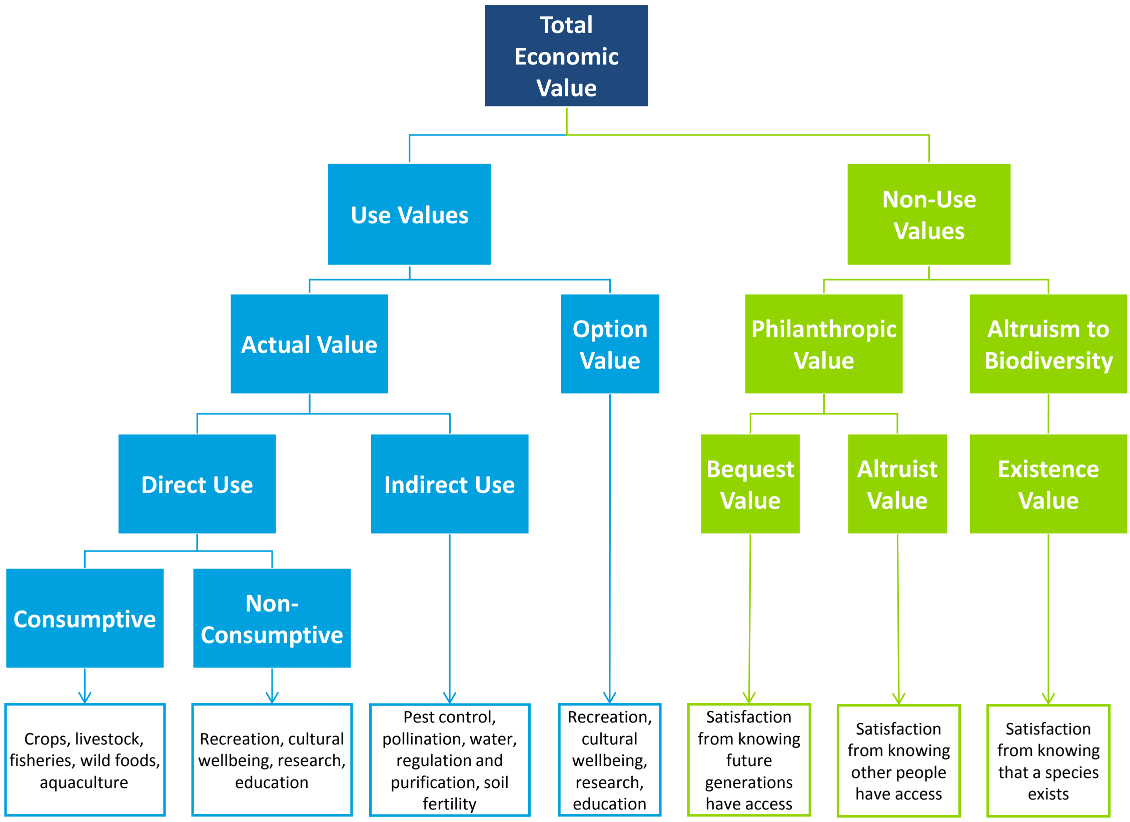
- highly dependent on the local geology;
- often manifests as a risk, rather than an event; and
- not clearly established in scientific literature.

Therefore, any estimates of declines in agricultural productivity should be seen as indicative, included to ensure that the issue is taken into account, without being interpreted as a precise quantification of the effects of mining on agriculture.

Externalities

A convenient method of accounting for the Total Economic Value of a natural environment is to disaggregate values into use values and non-use values. Chart C.1 represents in a diagram the breakdown of values used in this cost-benefit analysis.

Chart C.1: Breakdown of Total Economic Value



Source: Adapted from Kumar (2010)

Use values are values a person places on the benefits to themselves that are derived from the current or potential future use of a natural environment.

Direct value refers to benefits derived directly from the natural environment. For example, a use value of a river would include the value of irrigation water provided by the river.

Indirect use values refer to values that accrue as a side effect of the natural environment continuing to exist, such as the preservation of soil fertility on agricultural land that is next to a natural environment.

Option value refers to possible future use values that have yet to materialise. An example of this would be the possible future value that derives from research on the natural environment.

Non-use values are values a person places on a natural environment, other than those that benefit themselves.

Altruist value is the value that people place on knowing that other people who currently exist are able to access a natural environment. Bequest value is similar except that it relates to future generations being able to access a natural environment. Lastly, existence value is the value that people place on merely knowing that a natural environment is preserved, wholly apart from the fact that anyone derives other benefits from it.

When measuring externalities, it is often not possible to measure each component of the Total Economic Value separately. It is thus important to note which values are being measured and to note that different valuation methodologies may measure overlapping components of the total economic value.

Changes in related public expenditure

Changes in related public expenditure would be information specific to each project and would be provided by the project proponent. For example, public expenditure on water or sewerage may change, where a region is transformed from residential to mining. Further, public investment in transport or road infrastructure may change, with the possibility of increased spending on roads to facilitate movement of coal to ports in key mining areas.

This may also manifest as a potential benefit, as some mining projects may include upgrades or construction of new infrastructure. This infrastructure may be usable by the general public either during or after the operation of the mine.

Other externalities – use values

Water quality

The impact of mining on water quality varies according to the form of mining activity (open cut or underground), the proximity of the mine to water sources and the properties of aquifer systems. These factors influence the way in which fracturing of hard rock, mine runoff and dust pollution can lead to a reduction in the overall quality of ground and surface water.

This section reviews the literature on the use values of water quality, given its importance for households and industry. The valuation of groundwater and surface water are considered separately.

Quality of groundwater

Groundwater refers to water that has accumulated within soil or cracks or pores in rocks, known as aquifers (Geoscience Australia, 2013a). Some mining activity has been associated with the in-flow of saline groundwater, degradation of alluvial aquifers and an overall reduction in the quantity of groundwater supplies (Department of Planning, 2005; R.W. Corkery & Co, 2009; Smith, 2009). It is important to assess the implications of these effects for other groundwater users.

Groundwater is a critical source of drinking water in various locations across Australia, particularly in Western Australia (Geoscience Australia, 2013). The primary methods utilised to assess the value of drinking water quality are the contingent valuation and defensive expenditure approaches. As described by Koteen, Alexander and Loomis (2002:9), it is difficult to estimate household demand for water quality, 'as households cannot directly purchase water of varying quality'. Nevertheless, it is important to consider the benefits that individuals gain from the awareness that the water they receive is of high quality.

Table C.3 summarises the literature on the values that households assign to the quality of drinking water. It is noted that very little research has been undertaken in Australia, with the available evidence fairly dated. The appropriateness of these findings is contingent on relevance of the measures listed, which in turn depends on the nature of any anticipated change in water quality caused by mining activity.

There is also little evidence in an Australian context of the value of groundwater for agriculture, irrigation and other industrial uses, at different quality levels. Instead, the literature has focused on valuation of the costs that would be incurred by these commercial users of groundwater, in the instance that the groundwater supply was completely depleted (Marsden Jacob Associates, 2012). This is known as the deprival value approach, with values representing the cost of a worst case scenario where total degradation of water quality takes place.

Nevertheless, it may be possible to estimate the value of water in its existing state by observing prices in the water markets. In addition, it is important to note that the impact of a reduction in water quality on the agricultural industry is likely to be captured by estimates of foregone agricultural revenue.

In locations where groundwater sites also provide recreational opportunities, it is also necessary to value the impact of changes in water quality on the value of recreational trips. However, no studies have been undertaken in Australia which estimate these costs directly. Instead, the literature is concentrated around the recreational value of surface water.

However, a crude benefit transfer has been used to estimate the impact of reducing extractions of groundwater from the Great Artesian Basin (Rolfe, 2010). This study used an average of the estimated value of tourist trips to the Flinders Ranges, the Fairbairn Dam in QLD, and two locations along the Murray River as an estimate of recreation benefits of the basin (2010). This benefit transfer also relied on additional assumptions regarding visitor numbers, average trip length and, most importantly the impact of reduced water extraction on daily recreational benefits.

Due to the uncertainty behind the accuracy of this final assumption, the relevance of this estimate to the current context is uncertain. A contingent valuation study would be required to identify the benefits of groundwater in different quality states for recreational purposes.

In some parts of Australia groundwater is also used for other residential purposes, such as watering gardens, as well as other public purposes such as the maintenance of parks. Given that these purposes might also be captured in the value of open space or visual amenity, they are not considered in this section.

Table C.3: Drinking water quality values

Study & Context	Methodology	Measure	Value	Units
Edwards (1988) US - 1986	Contingent valuation	WTP to prevent uncertain nitrate contamination	$1,128 per household per annum	$ US (1986 dollars)
Abdalla, Roach & Ep (1992) US - 1988	Defensive expenditure	Preventive expenditure to protect against the effects of trichloroethylene contamination	$0.40 per household per week	$US (1988 dollars)
Schultz & Lindsay (1990) US - 1988	Contingent valuation	WTP to protect against nitrate contamination	Mean - $129 per household per annum Median - $40 per household per annum	$US (1988 dollars)
Jordan & Elnagheeb (1993) US - 1991	Contingent valuation	WTP for improved public water quality	Mean - $10.07 per household per month Median - $5.49 per household per month	$US (1990 dollars)
Carlos (1991) Australia - 1991	Contingent valuation	WTP for control and prevention of salinity and turbidity in the Yass district household water supply	Mean - $42.21 per person per annum Median - $40 per person per annum	$A (1991 dollars)
Dwyer (1991) Australia - 1991	Contingent valuation	WTP to indefinitely preserve water quality in Sydney	$54 - $67 per household	$A (1991 dollars)

Source: Envalue (2004)

Quality of surface water

Rivers, lakes, wetlands and other forms of surface water can also be affected by mining activity. The quality of water can be reduced as a result of runoff or dust pollution. It may also be affected as an indirect result of mining impacts on groundwater, although the interaction between groundwater and surface water varies according to topography, geology and climate (Geoscience Australia, 2013b).

The majority of Australia's water supply is derived from surface water. Therefore, changes to the quality of surface water will impact households and industry. Valuation of the impact of changes to surface water quality is subject to the same issues discussed above.

However, there is substantially more evidence on the value of water quality specific to recreation at surface water sites.

Within the Australian literature, stated preference approaches such as contingent valuation and choice modelling are the predominant methodologies employed. Table C.4 summarises the estimates obtained in some relatively recent Australian studies.

Table C.4: Recreational water quality values ($A)

Study	Methodology	Measure	Value
van Bueren & Bennett (2000)	Choice modelling	Average $ per household per annum for every 10km of waterway restored for fishing or swimming	National context: $0.08 Great Southern Region: $1.56 – Albany $0.91 – Perth Fitzroy Basin Region: $2.02 – Rockhampton $0.79 – Brisbane
Robinson et al (2002)*	Benefit transfer	$ per household per annum for a 'moderate improvement' in the health of the Bremer River in Queensland from the existing level	$36
Morrison & Bennett (2004)	Choice modelling	$ per household in form of one-off levy to increase water quality of the whole river to a fishable level	Within-catchment: $51.33 – Bega River $46.63 – Clarence River $45.26 – Georges Rive $48.94 – Gwydir River $54.16 – Murrumbidgee River Outside-catchment: $29.93 – Gwydir River $28.75 – Murrumbidgee River
Morrison & Bennett (2004)	Choice modelling	$ per household in form of one-off levy to increase water quality of the whole river to a swimmable level	Within-catchment: $100.98 – Bega River $72.77 – Clarence River $73.88 – Georges River $104.07 – Gwydir River $75.24 – Murrumbidgee River Outside-catchment: $59.98 – Gwydir River $86.46 – Murrumbidgee River
Bennett et al (2008)	Choice modelling	$ per household for a 1% increase in the length of river suitable for primary contact recreation	Within-catchment: $0 – Gellibrand River $2.12 – Goulburn River $0 – Moorabool River Outside-catchment (Melbourne): $1.64 – Goulburn River $0 – Moorabool River

* in Rolfe et al, 2005

When transferring these values to a new context, it is important to consider the similarity of waterway characteristics, population characteristics, the scale of the change in quality and whether the focus is on quality improvements or maintenance of existing standards (van Bueren & Bennett, 2004).

It is likely that in most instances these factors will not align exactly. In those cases, the use of benefit transfer values should be seen as indicative, included to ensure that the impact of changes in water quality is taken into account, rather than as a precise estimate.

Air pollution

Particulate matter

The main methods of valuing the costs of air pollution are hedonic pricing, stated preference techniques or through use of a direct costing approach.

Hedonic pricing is usually measured by examining the price differential associated with distance to a project, in order to determine the cost associated with the externalities generated. It is particularly useful as it is a form of revealed preference and is very difficult to manipulate. However, hedonic pricing, if undertaken without a direct measure of air pollution (e.g. measures of particulate matter in the air), cannot disaggregate the price difference caused by a project into its components such as air pollution, noise pollution, loss of visual amenity and convenience. Furthermore, hedonic pricing relies on the fact that individuals are aware of and can appropriately value the cost of air pollution to their utility (Abelson 2007). Therefore, hedonic pricing serves as a way to measure the aggregate impact of a variety of measures, a point that should be noted to avoid double counting costs or benefits.

Contingent valuation studies involve asking individuals regarding their willingness to pay to reduce the impact of air pollution. Similarly to hedonic pricing, this valuation methodology assumes that individuals are sufficiently aware of and can appropriately value the impact of air pollution to their utility. The life-satisfaction approach was used by Ambrey et al (2012) to estimate the cost of air pollution from particulate matter in South East Queensland. This study yields an implicit willingness to pay of $6,000 per household for a one day decrease in the number of days pollution exceeds health guidelines in their local area.

An alternative method of measuring the impact of air pollution is to measure its medical impact on health and life expectancy of the population exposed to it. One method of valuing health and life is use of Quality Adjusted Life Years (QALY). The effects of air pollution can thus be measured in the number of QALYs lost as a result of the pollution (Coyle et al. 2003). This value can then be combined with an appropriate monetary value placed on life as determined elsewhere. A current estimate that is useful to apply is $151,000 as the value of a statistical life year (OBPR 2008). Thus the number of QALYs lost can be multiplied by a per life year value to produce a total cost associated with additional air pollution. The difficulty with this approach is that it is not straightforward to ascertain the number of QALYs likely to be lost as a result of a specific project, relative to the baseline scenario.

Using a two stage approach, combining exposure-response estimates relating Coarse Particulate Matter and health endpoints from epidemiological studies, and estimates of the costs of those health endpoints, the Department of Environment and Conservation NSW (2005) calculated the health costs of air pollution in the Greater Sydney Metropolitan Region. The health endpoints considered in the study include mortality, chronic bronchitis in adults, respiratory hospital admissions, cardiovascular hospital admissions, acute bronchitis in children, asthma attacks for both adults and children, and the cost of lost productivity due to restricted activity days for adults.

The values reported by the Department allow for the health costs of air pollution of a project to be calculated in terms of total emissions levels (costs per tonne of PM10 emitted) or in terms of changes in annual average concentration levels (costs per 10 $\mu g/m^3$ increase in the PM10 concentrations).

The benefit of this study is that it produces estimates for three different subregions of the Greater Sydney Metropolitan Region, as listed in Tables C.5, C.6 and C.7. The costs allow for comparisons between a macro, 'regional level' approach (using the values in Table C.5 and Table C.6) and a micro, 'property level' approach (using the values in Table C.7).

Table C.5: Annual health costs of air pollution across selected regions, per tonne of PM10 - with 7.5 $\mu g/m^3$ threshold ($ 2003)

	Lower bound	Midpoint	Upper bound
Sydney	$28,000	$132,000	$235,000
Hunter	$8,000	$35,000	$63,000
Illawarra	$6,000	$26,000	$46,000

Source: Department of Environment and Heritage NSW (2005) – Table 6.3.1

Table C.6: Annual health costs of air pollution across selected regions, per tonne of PM10 – no threshold ($ 2003)

	Lower bound	Midpoint	Upper bound
Sydney	$45,000	$236,000	$427,000
Hunter	$13,000	$63,000	$112,000
Illawarra	$10,000	$47,000	$85,000

Source: Department of Environment and Heritage NSW (2005) – Table 6.4.1

Table C.7: Annual health costs of air pollution across selected regions, per 10 $\mu g/m^3$ increase in PM10 annual average concentrations – with 7.5 $\mu g/m^3$ threshold ($m 2003)

	Lower bound	Average	Upper bound
Sydney	$547.0	$2,598.5	$4,650.0
Hunter	$174.0	$767.0	$1,360.0
Illawarra	$69.9	$310.0	$550.0
Total	$791.0	$3670.5	$6,550.0

Source: Department of Environment and Heritage NSW (2005) – Table A.1

An important issue related to the valuation of health impacts of air pollution is whether or not to assume a threshold. The use of a threshold (as in Table C.5 and Table C.7) assumes that there are no health impacts below the threshold concentration. This has the effect of producing lower total cost estimates.

Given that the World Health Organisation has determined that there is no safe level of exposure to PM10, it is considered that the use of 'no threshold' cost estimates, such as those in Table C.6 is most appropriate, and sufficiently conservative for a CBA.

More recently, PAEHolmes published unit damage cost estimates per tonne of PM2.5 emissions in a report for the NSW Environment Protection Authority (EPA) (PAEHolmes, 2013). These estimates were developed for specific locations using the ABS Significant Urban Area structure for urban centres with more than 10,000 people. This analysis was undertaken to provide health cost estimates that take into account population-weighted exposure, for use in economic appraisals.

Cost estimates produced by this study are reported for a sample of Significant Urban Areas in NSW, in Table C.8. However, the full report by PAEHolmes also includes unit damage costs in other states. It is considered that these are the best available estimates of the cost of particulate matter for cost-benefit analysis in NSW.

Table C.8: Unit damage costs by SUA (rounded to two significant figures) - NSW

SUA code	SUA name	Population density (people/km^2)	Damage cost / tonne of $PM_{2.5}$ ($AU 2011)
1030	Sydney	991	$280,000
1035	Wollongong	470	$130,000
1023	Newcastle – Maitland	391	$110,000
1010	Cessnock	294	$82,000
1028	Singleton	127	$36,000
1021	Muswellbrook	45	$13,000
1000	Not in any Significant Urban Area (NSW)	1.3	$360

Source: PAEHolmes (2013)

Beyond total suspended particles, PM10 and PM2.5, a core component of the particulate emission of any coal mining project is dust. It is created by the disturbance of particles which occurs throughout the mining process by activities such as blasting, handling and transporting. However, mine dust rarely presents a serious threat to the wider environment. In the majority of situations the dust produced is chemically inert and deposition rates tend to decrease rapidly away from the source (Environment Australia, 1998). Buffer zones have evolved to become common practice in an effort to mitigate the effect of dust, noise and vibration on surrounding agricultural lands.

Carbon pollution

The cost of carbon emissions can be estimated in a variety of ways. It is important to note that the cost of carbon is usually measured as the marginal social cost of emitting one metric ton of carbon (or one metric ton of carbon dioxide). The main methods of pricing carbon emissions are based on modelling, observed market prices and defensive expenditure.

The predominant method of valuation relies on the use of Integrated Assessment Models (IAMs). These model the climate, the global economy and feedbacks between those two so as to determine the damage associated with carbon emissions.

The US Environmental Protection Agency estimated the social cost of carbon in 2010 as US$21 (24.86 AUD) per tonne of carbon dioxide, rising over time to US$26 per tonne in 2020 and US$33 per tonne in 2030 (prices are measured in 2007 dollars) (USG 2010). There is quite a large variation in the estimated cost of carbon emissions, with estimates depending heavily on the discount rate used (Tol 2008).

Table C.9: Estimates for Social Cost of Carbon

Study	Price terms	Cost of 1 ton of carbon dioxide (local currency)	Cost of 1 ton of carbon dioxide (AUD)
US EPA	2007	US$21	$24.86
UK Department of Energy and Climate Change	2011	£15.30	$23.04
Nordhaus	2011	US$12	$15.66
Wahba et al.	2006	US$5-$49	$6.60 - $64.70

Source: Nordhaus (2011), US EPA (2010), UK DECC (2011), Wahba et al. (2006)

The cost of carbon pollution in the environment can also be valued at market prices. While Australia no longer enforces a carbon pricing mechanism, there are market systems in place overseas, including the European Union. At present, carbon emissions are priced at around €6 per metric tonne of emissions (MarketWatch 2014).

It should be noted that valuing the social cost of carbon at a value higher than the market price for a carbon permit may open a cost-benefit analysis to manipulation. As the act of purchasing a carbon permit generates a net social benefit equal to the difference between the model price and market price for carbon, it is possible for a proposal that would otherwise fail a cost-benefit analysis to purchase carbon permits until it passes this analysis.

Noise pollution

Noise pollution can be measured in a variety of ways. It is important to note however, that most studies of noise pollution have looked at noise from a particular source (e.g. road traffic, rail). As annoyance varies depending on the type of noise produced and individual sensitivities, noise valuation studies usually vary by source.

A primary means of valuing noise pollution is to use hedonic pricing methods to compare house prices based on proximity to a source of noise (e.g. highway, airport). While this methodology is useful for assessing the marginal willingness-to-pay (WTP) associated with noise costs, there is no expectation that the marginal WTP will be stable across contexts. Thus, while hedonic pricing is very useful where applicable, it may not be appropriate to generalise the cost derived from hedonic pricing studies to a broader context. A US meta-analysis estimates a 0.50% to 0.60% decrease in house price per dB of noise. (Nelson 2004) This similarly matches estimates from Scotland of 0.20% per dB increase in noise level. (Bateman et al. 2001)

As an alternative, contingent valuation methods can be used to assess the cost of noise pollution. The values derived for contingent valuation studies however, vary quite greatly with estimates for road traffic noise varying between $3.82 and $189.05 per decibel per household per year. The Final Report to the European Commission DG Environment recommended valuing road traffic noise at $3.82 to $61.11 per dB per household per year (Navrud 2002).

Traffic

The costs and benefits associated with nearby traffic can be broken down into several categories. Traffic can produce several externalities, including noise pollution, air pollution and traffic congestion. Proximity to traffic however can also generate benefits due to the time and travel benefits associated with proximity to a mode of transport.

Valuations of the costs and benefits associated with traffic should also note that the costs and benefits do vary depending on mode of transport (Navrud 2002) and time of day (Carlsson et al. 2004). Traffic can also be measured in intensity, either by frequency of occurrence or through a measure of the traffic density on a route (Ossokina and Verweij 2011).

Valuing the net cost (or benefit) of traffic can thus be done using hedonic pricing by measuring property prices and proximity to particular modes of traffic, for example, railway lines, highways or airports (Ossokina and Verweij 2011). However, hedonic pricing based on proximity to a transport line is problematic as it does not necessarily disaggregate the costs and benefits into noise pollution, air pollution, congestion and convenience. Without actual measurement of noise or air pollution levels, hedonic pricing studies tend to measure the net cost or benefit associated with living close to a mode of transport. This is something to be noted, to avoid double counting costs and benefits, and may not be a problem if a study is only interested in the net effect of traffic.

An alternative method of valuation that is capable of disaggregating the effects of traffic on an area is through contingent valuation methodologies. Contingent valuation permits the measurement of variations in discrete components of the effects of traffic and can thus measure particularised values for each component independently. Furthermore, contingent valuation studies allow for the measurement of effects caused by infrastructure changes that have yet to occur.

Transport for NSW also provides a guide set of values for rural freight externalities on a 1000 tonne-km basis. It should be noted that this measure of externalities overlaps in part with the other environmental impacts. Furthermore, the “Upstream and Downstream Cost” listed is meant to include the cost to infrastructure associated with transport.

Table C.10: Rural Freight Externalities in $ per 1000 tonne-kilometre travelled

Externality Type	Light vehicle	Heavy Vehicle
Air pollution	0	0.24
Greenhouse Gas Emission	56.49	5.38
Noise	0	0.41
Water Pollution	0.27	1.45
Nature and Landscape	0.21	4.04
Urban Separation	0	0
Upstream and Downstream Costs	188.29	21.53

Source: Transport for NSW (2013)

Lastly, it is important to value the cost associated with delays or additional congestion arising out of a project. The value of $23.39/vehicle-hour is estimated as the value of travel time for occupants (Transport for NSW 2013).

Health

A consideration in the impact of a development, such as a coal mine, on an area is the impact of the development on the health of those that live near it. This cost is primarily borne by the residents that live near the mine. Most of this externality is likely to be picked up by measurements of other externalities, such as air pollution or through methods of valuation that aggregate across externalities such as hedonic pricing.

A recent study by Hendryx and Ahern (2008) identifies significant increases in a range of diseases due to coal production. According to Hendryx and Ahern (2008), living near a coal mine raises the incidence of Cardio-Pulmonary disease, diabetes, kidney disease, cancer and arthritis/osteoporosis. A summary of their findings can be found in Table C.11.

However, this valuation is based on data from West Virginia and does not appear to be easily translatable into the NSW context, particularly due to potential differences in the regulatory regimes between the two locations. Even if the health effects listed above could be translated into the Australian context, it is not clear how to convert the disease burden listed here into a comparable measure such as QALYs so that they can then be included in the cost benefit analysis.

Table C.11: Health Status and Rates of Disease Among Young Adults (N=16,493) by County Coal-Production Levels: West Virginia, 2001

	0 tons	≤3.9 million tons	≥4.0 million tons	P	Bonferroni P
Health Status, Mean Score	2.62	2.68	2.85	<0.001	0.002
Any cardiopulmonary disease, %	13.5	13.8	15.9	<0.001	0.007
Lung disease, %					
Any lung disease	4.2	4.6	5.7	<0.001	0.007
Chronic obstructive pulmonary disease	1.6	1.5	2.1	0.05	0.85
Asthma	2.6	2.6	3.1	0.27	0.999
Black lung	0.3	0.7	0.8	<0.001	0.003
Heart disease or stroke, %					
Any heart disease	10.4	10.6	12.3	0.004	0.068
Hypertension	5.6	5.5	7.6	<0.001	0.002
Congestive heart failure	0.9	0.7	0.6	0.17	0.999
Arteriosclerosis	0.3	0.4	0.3	0.57	0.999
Cardiovascular disease	1.3	1.2	1.4	0.9	0.999
Stroke	0.5	0.4	0.6	0.41	0.999
Angina or coronary disease	5.4	5.6	5.4	0.87	0.999
Diabetes, %	6.2	5.7	7.0	0.043	0.73
Kidney disease, %	0.4	0.4	1.0	<0.001	0.002
Cancer, %	2.3	1.8	2.2	0.26	0.999
Arthritis or osteoporosis, %	5.5	5.4	6.4	0.069	0.999

Source: Hendryx and Ahern (2008)

Visual amenity

The term 'visual amenity' is not clearly defined in the literature. This review applies Brodbeck's definition of scenic quality, being 'the degree to which the visual aesthetics of a landscape are valued from a human point of view' (2005). It is acknowledged that exposed spoil heaps and light emitted by mines can detract from the visual amenity of an area. In order to avoid overlap with the benefits of open space, discussed below, the valuation of visual amenity impacts could be restricted to those of properties that will have a direct view of the mining area.

The process of valuing visual amenity requires consideration of a number of factors including the visual characteristics of the site, the surrounding environment, the scale of the project and the current beneficiaries of the visual amenity aspects of the site. Hedonic pricing and stated preference techniques are the most common methods of quantifying visual amenity (Ambrey & Fleming, 2011).

In instances where local residents are the primary beneficiaries of visual amenity, hedonic pricing is the preferred method of valuing visual amenity (UHERO, 2013). Controlling for other factors that influence property prices, such as number of bedrooms, backyard size and proximity to schools and parks, this methodology can infer a value for the price impact of the presence or quality of a view.

Hedonic pricing techniques are commonly used to estimate the value of amenity. Within Australia, this method has been used to value the amenity of river views, ocean views, national parks and urban wetlands (Ambrey & Fleming, 2011). Since the values obtained directly reflect the visual characteristics of specific sites, they cannot be applied to the cost benefit analysis of mining Projects. Instead, the process of analysis would have to be replicated in the mining context.

Hedonic pricing studies that have considered the impact of mining activity on property prices in Australia have tended to place a focus on valuing the impact of pollution. For example, Neelawala, Wilson & Athukorala (2012) assessed the impact of mining- and smelting-related lead pollution on residential house prices. This highlights the difficulties associated with isolating the visual element of amenity from other aspects such as the level of noise or dust pollution.

Alternatively, stated preference surveys can be used to obtain estimates of the value of visual amenity. This methodology is most relevant when the view of the site is primarily enjoyed by visitors to an area (UHERO, 2013). While it might be possible to pose questions in a manner which will help provide a direct estimate of the value of the visual aspect of amenity, it should be noted that there may remain a difficulty in distinguishing the value of visual amenity from the value of biodiversity or conservation, in the case of natural environments. In addition, care should be taken to ensure against double-counting, given the visual amenity benefits of open space, discussed below.

Overall, the difficulties associated with obtaining quantitative estimates of the value of amenity are acknowledged by the NSW Government. It is noted in the 2012 Guidelines that these impacts may have to be considered qualitatively in a CBA. In that case, the likely size of impacts on visual amenity should be discussed relative to the overall net public benefit of the project.

Quality of open space

Where a proposed mining development or expansion is intended to impede on open space, it is necessary to account for the loss of benefits derived by individuals who use that space. The two main ways in which individuals benefit from open space are through the visual amenity of the space and the activities that take place in the area (McConnell & Walls, 2005).

The main methods used to value the quality of open space are hedonic pricing and stated preference techniques. After reviewing the literature on the topic, McConnell and Walls note that there is substantial variation in the estimated value of open space as a result of differences in location, the type of space, the services provided by the space and the methodology utilised by the study (2005).

It is recommended that values for the quality of open space be ascertained by considering the value of the activities that take place in potential areas of impact. In some cases, this value will be captured in measurements of foregone agricultural revenue, or the value of recreational activities that take place at water sites.

Rural amenity and culture

The development or expansion of a mine may also have negative social impacts through the reduction of rural amenity and culture. The noise, light and dust pollution generated by mining activity can alter the overall rural amenity of the surrounding area by establishing an industrial ambience. Where this change causes people to leave the area, the remaining residents may experience a loss of their sense of community.

Stated preference techniques are the main method used to value rural amenity and culture.

Bennett, van Bueren and Whitten (2004) present the results of two choice modelling studies investigating household willingness to pay to maintain rural communities, within the context of environmental protection strategies.

The first study considered the value of retaining farm populations in the Murrumbidgee River Floodplain, given different wetland protection strategies. Survey respondents from Wagga Wagga, Griffith, Canberra and Adelaide were told that implementation of these strategies might cause farmers to leave the floodplain region. The responses indicated that, on average, households were willing to pay a one-off sum of $5.73 to prevent a farmer from leaving. The 95% confidence interval for this estimate was $4.21-$7.35. It was found that this valuation did not vary significantly according to the different locations.

The second study undertook three different surveys. The first was framed to ascertain values at a national level, while the two others referred to case studies of the Great Southern region in WA and the Fitzroy Basin region in QLD. The national survey was distributed to samples of households from Albany, Rockhampton and the general population. The Great Southern survey was distributed to another sample of households in Albany, while the Fitzroy Basin survey was issued to a sample of households in Rockhampton.

Estimates of household willingness to pay to prevent rural populations from declining were ascertained from the responses in each survey-sample combination. These values were measured in terms of an annual payment to be made over a 20 year period, in order to prevent 10 people from leaving a rural community. The results are summarised in Table C.12.

Table C.12: Willingness to pay to maintain rural communities

Survey	Sample	Annual household cost of 10 people leaving rural communities
National	National	$0.09
	Albany	$0.11
	Rockhampton	$0.06
Great Southern	Albany	$0.56
Fitzroy Basin	Rockhampton	$2.24

Source: Bennett, van Bueren & Whitten (2004)

It is evident that the benefit of maintaining rural communities varies according to the context of the analysis, with regional-based surveys generating higher willingness to pay values. This is likely to be reflective of framing or scoping effects (Bennett, van Bueren &

Whitten, 2004). In addition, it is plausible that these values underestimate the value of rural culture in the context of mining, given that individuals might be more accepting of costs to the community as a result of environmental protection requirements than they are for mining developments or expansions.

A choice modelling survey was also undertaken by Ivanova et al (2007) to assess the social effects of coal mining in the Bowen Basin in Queensland. The authors found that while residents of Blackwater were not largely concerned by changes in the size of the population, a 1% increase in the 'proportion of jobs held by people who don't live in the town' was equivalent to a reduction in welfare of $41.88 per household.

The importance of rural amenity and culture in the Hunter region was identified in a choice modelling survey undertaken by Gillespie and Bennett (2012). A sample of households in NSW were distributed an online questionnaire about how they valued different impacts of the Warkworth Mine. From the 2,354 responses, the authors identified that, on average, a household was willing to pay $33.32 to prevent one rural family from being displaced from the community. The 95% confidence estimate for this estimate was $29.31-$37.72. This is likely to be the most relevant estimate for the value of rural amenity and culture in the context of mining activity.

Heritage – Aboriginal

The use values of heritage sites derive primarily from the value associated with visiting such sites. However, the value associated with such visitation often cannot be measured through a market price and thus relies on stated preference data. As a consequence, it is difficult in practice to separate the use and non-use values associated with a heritage site. Furthermore, the value of a particular heritage site will vary depending on the demographics of the community surveyed.

For example, in a study measuring the value of protecting an additional 1% of Aboriginal heritage sites in Central Queensland, the willingness to pay of various communities was determined as per Table C.13.

Table C.13: Willingness to pay for protection of Aboriginal heritage sites

Community	Rockhampton Indigenous Community	Rockhampton General Community	Brisbane General Community
Willingness to pay for protection of further 1% of Aboriginal heritage sites (2003 Dollars)	3.22	-2.08	-1.78

Source: Rolfe and Windle (2003)

It is important to note that the Indigenous community and the general population appear to value Aboriginal heritage sites very differently. Thus the assessment of the value of Aboriginal heritage sites necessarily presents issues of equity that involve balancing the interests of different groups in the community.

Previous studies of heritage valuations in the coal mining context have produced an estimate of $29.71 per household to avoid a highly significant Aboriginal site being destroyed, a value that was aggregated up to produce a community value of $33,558,730 to avoid such a site being destroyed (Gillespie Economics 2009).

Heritage – European

A national choice modelling study to value the Old Parliament House in Canberra for example, estimated the marginal willingness to pay for various alternative use-scenarios for Old Parliament House. The values were then multiplied up to produce an estimate of the aggregate willingness to pay across Australia for the scenarios presented which ranged from $561,258.21 to $65,790,289.29 in total (Choi et al 2010).

There is also an extensive literature valuing heritage sites that are residential buildings, commercial buildings and tourist places (Allens 2005). Results from choice modelling studies indicate that the average willingness to pay for the protection of additional places from loss is estimated to be $5.53 per person each year for every 1000 places protected (Allens 2005). This is equivalent to an annual willingness to pay of $0.007 per person per site protected, in 2013 dollars.

As mentioned in Appendix B, there are uncertainties involved with aggregating these individual valuations beyond the choice modelling survey sample. Table C.14 illustrates the variation in valuations according to three different levels of aggregation.

Table C.14: Variations in the value of protecting one local heritage site ($2014)

Aggregation level	Annual value of protecting one site ($m)	NPV of protecting one site in perpetuity ($m)
All residents in the Hunter and Central Coast region	0.01	0.09
All residents in NSW	0.05	0.67
All residents in Australia	0.15	2.14

It should be noted that the Productivity Commission’s Inquiry into the Conservation of Australia’s Historic Heritage Places (2006:145) found that these values are of little relevance for individual sites, due to the difficulty in interpreting these values and applying them in different contexts.

Other externalities – non-use values

Ecosystems (Water, Biodiversity, Conservation)

The non-use valuation of ecological systems requires the use of stated-preference valuations, the most common of which would be contingent valuation studies. It should be noted that while such studies may not produce consistent measures of values (Dutton et al. 2010), they are a useful way to measure non-use values of an ecological site. It should be noted that non-use valuations of ecological systems often do not disaggregate value into the components of an ecosystem. Thus the valuation of a water system, ecological habitat and the biodiversity supported by it will usually be lumped together in such a valuation.

Furthermore, to ensure that the items being valued can be understood by the general population, abstract properties of ecosystems such as clean water or an absence of pollutants are usually translated into more meaningful indicators such as the number of individuals of species saved (MacDonald et al. 2011).

By virtue of the contingent valuation methodology, it may not always be possible to separate non-use values from the declared valuations in a survey. People may implicitly value an ecological site due to a future use (e.g. visiting it in the future). Although surveys may attempt to disaggregate a declared value based on motivation (Subade 2005), not all of them do so. This is important to note to avoid double counting when summing values.

It is also important to note that the per person valuation of an ecological system is heavily dependent on the community being surveyed. Communities geographically closer to an ecosystem tend to value that ecosystem more highly (Kumar 2010). It is therefore important to discount per person values from surveys taken of communities close to a particular ecosystem when attempting to generalise the value of an ecosystem (Bennett et al 2007).

Lastly, an alternative means of valuing biodiversity is through the NSW Office of Environment and Heritage's BioBanking scheme. The valuations within that scheme rely on a fixed formula, as detailed in the Biobanking Assessment Methodology. (Department of Environment and Climate Change NSW 2008). A review of the BioBanking scheme found that credits were sold at a value between $2500 and $9500 per credit (Office of Environment and Heritage 2012). Assuming that the Office of Environment and Heritage has represented the preferences of the community in the Assessment Methodology, any damage to species or ecosystems can be offset through the program.

Heritage

Heritage sites often have significant non-use values. Locations or buildings of significant cultural value are often seen as worth preserving in and of themselves.

The fact that heritage sites often have value to particular cultures creates distributional concerns when valuing such a site. Thus a naïve valuation would value a heritage site that appeals to a more populous or dominant culture as more valuable than that of a minority culture. Furthermore, as valuation is sometimes affected by personal wealth effects, the wealth of a particular community can also influence the valuation of a heritage site. It should be noted that this is somewhat mitigated by the fact that people often do place value on the preservation of minority cultural heritage sites, regardless of their background (Rolfe and Windle 2003). As a result of this it is important to consider equity issues, or the distribution of heritage values, when considering the valuation of heritage sites.

Additionally, heritage sites are often considered unique and thus irreplaceable. It is thus often not possible to offset the damage to a heritage site through expenditures elsewhere.

The predominant method of valuing non-use value in heritage sites is through contingent valuation methods that examine alternatives involving the preservation of heritage locations or a number of heritage locations. As a result of the unique nature of most heritage sites, it is unlikely to create an estimate for the value of heritage generally.

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Appendix D: Hedonic pricing study

As noted throughout Appendix C, many externalities are best valued using a hedonic pricing study. Hedonic price modelling is a standard revealed preference method used to assess the impacts of pollution or other externalities, such as noise, on the value of residential properties. The strength of a hedonic pricing study is that it may be able to capture location specific values for externalities. For example, it can be difficult to translate the results of a literature review to the details of a specific geographic location for externalities such as noise, light, vibration, particulate matter and outdoor recreation value. A hedonic pricing study can help as it may be able to value these externalities by identifying their cumulative effect of local prices.

This appendix sets out the results of a hedonic pricing study undertaken by Deloitte Access Economics. The hedonic pricing study attempted to quantify negative externalities created by coal mines in the Upper Hunter by analysing house sale prices in the region. The analysis was undertaken using a standard linear regression model to estimate the impact of proximity to coal mines on house prices while holding other variables constant.

The hedonic pricing study is premised on the idea that externalities of coal mining directly affect the utility that home owners get from their property. This is then translated into a reduction in the price that buyers are willing to pay for a property in the area. In this way, coal mining could lead to a decline in the value of properties and this would be positively correlated with proximity to the mine itself.

Data

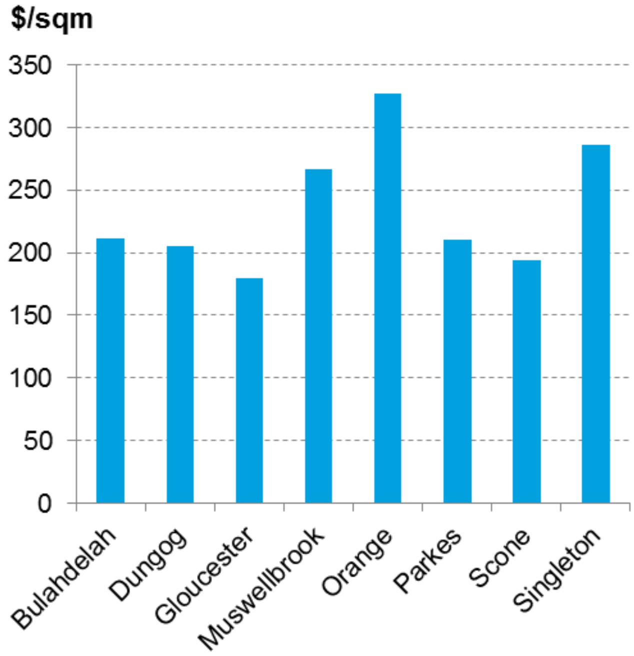
DAE gathered an extensive set of sales data for residential properties sold over the period from 2000 to 2012 from the website onthehouse.com.au. Data was gathered for the following locations in regional NSW:

- Bulahdelah
- Dungog
- Gloucester
- Muswellbrook
- Orange
- Parkes
- Scone
- Singleton

These locations were selected to provide a range of areas within NSW covering the Upper Hunter (with varying levels of coal mining activity), the lower Hunter and other regional centres. The data covered includes sale prices, number of beds, number of bathrooms, garage spaces, land size and property type.

The initial set of around 42,000 observations were reduced down to 5035 observations which contained full information on all variables and did not display data discrepancies (such as very high or low prices per unit area). That is, we selected roughly the 12% of the full data set, being the most complete observations, to ensure that it was reliable.

Chart D.1: Average house sale ($ per sqm from 2000-2012)



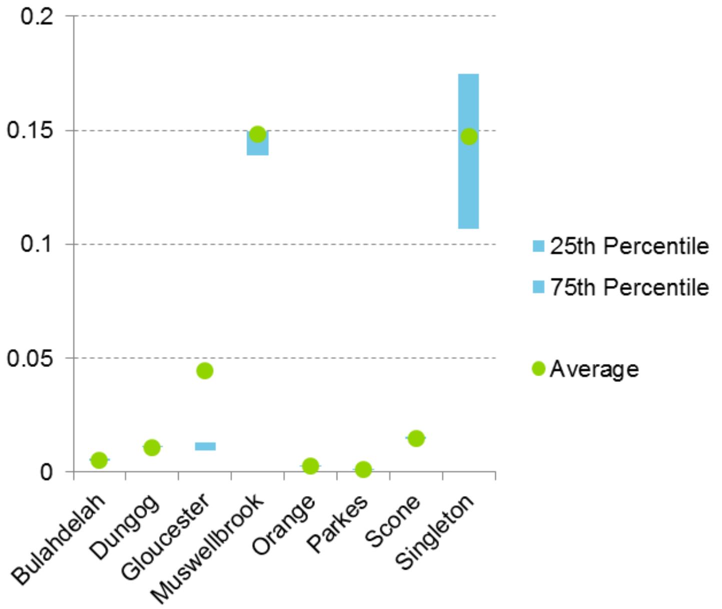
An additional variable was added if the property was located within 4km of Ravensworth, Camberwell or Glennies Creek in the Hunter area. This was in recognition of the fact that these townships may experience particular mining externalities.

This house price data was then combined with data on the location of coal mines in NSW. This data was sourced from the Australian Mines Atlas. This allowed for computation of the distance from each house to each mine in NSW and an assessment of the overall impact of mining on each property. The main variable used to measure the impact of mining was a constructed variable referred to as 'mine gravity':

$$mine.gravity_i = \sum_n \frac{1}{(distance\ from\ property\ i\ to\ mine\ n)^2}$$

Where *i* is a list of all properties and *n* is a list of all mines. Mine gravity provides a cumulative measure of overall exposure to mining – properties that are closer to mining activity have higher estimated mine gravity than those that are further away. The relationship is also linear so that, for example, properties that are twice as far away from a mine experience far less than half the mine gravity. This can be seen in the summary of mine gravity for each of the regions within the dataset:

Chart D.2: Average and range of observed mine gravity estimates



The information available from these two data sets was then used to estimate a series of linear regression models to analyse the potential effects of mining activity on house sales prices.

Variables used in modelling

The variables used in the modelling included

- The dependent variable was the natural log of house sale price (converted to real 2013 dollars)
- Independent variables were
  - Number of bedrooms
  - Number of bathrooms
  - Number of car spaces
  - Land size (natural log)
  - Year of sale
  - Indicator variables indicating region
    - Mount Owen (Ravensworth, Camberwell or Glennies Creek)
    - Dungog
    - Gloucester
    - Muswellbrook
    - Orange
    - Parkes
    - Scone
    - Singleton
  - Interaction terms between mine gravity and region

Results

The model provided the following results:

Table D.2: Regression model results

Variable	Estimated value	Standard Error
Beds	0.1282***	(0.0068)
Bathrooms	0.1711***	(0.0092)
Carspaces	0.0360***	(0.0043)
ln(land size)	-0.9317***	(0.0063)
Mount Owen, Broke	0.0122	(0.7118)
Dungog	-0.4333	(0.3674)
Gloucester	-0.9535***	(0.2663)
Muswellbrook	-0.6727*	(0.2718)
Orange	0.3655	(0.3607)
Parkes	-0.6721	(0.3827)
Scone	-1.3633***	(0.3118)
Singleton	-0.7157**	(0.2660)
Year of sale	0.0694***	(0.0012)
Mine gravity*Bulahdelah	-170.3030***	(50.9254)
Mine gravity*Mount Owen	-0.6477	(0.8384)
Mine gravity*Dungog	-35.3637	(23.3318)
Mine gravity*Gloucester	0.7168	(2.1654)
Mine gravity*Muswellbrook	-1.2485**	(0.4395)
Mine gravity*Orange	-464.2871***	(100.8129)
Mine gravity*Parkes	-335.8675	(278.2408)
Mine gravity*Scone	36.8905**	(11.2786)
Mine gravity*Singleton	0.0291	(0.2303)
Constant	-127.2922***	(2.3817)

Note: =* p<0.05 ** p<0.01 *** p<0.001

Source: DAE analysis

The linear regression model explained about 85% of the variation in the housing (R-squared). Heteroscedasticity in the error terms was identified, probably due to the large difference in prices between smaller and larger properties. To control for this, robust standard errors were used but, due to the large sample size, this did not greatly change the significance levels.

Key findings from the analysis are:

- Property prices per sqm have increased by an average of around 4% each year, over the last decade. Prices per sqm in 2013 were about 92.9% greater than prices paid in 2000.
- Impact of house features:
  - an additional bedroom increases prices by about 13%;
  - an additional bathroom increases property prices by 17%;
  - an additional car space leads to a price increase of 4%;
- Prices per sqm decrease at a faster rate in larger properties as compared with smaller properties. The analysis indicates that 1% increase in land sizes lead to an equivalent 0.9% decrease in prices per sqm.

Turning to the effect of mining on property values, a key aspect of this form of the model is that it separately identified the effect that being located in a particular region has on housing prices compared to the effect that being close to a mine has. The effect of mining is also differentiated for each region. This is important as mining activity in a region may work to increase house prices generally (due to demand effects) but may have negative consequences for those located particularly close to the mine itself.

The estimated effects of the mining externalities themselves are shown in bold in Table D.2. A negative sign here indicates that a negative externality has been identified. Statistically significant negative externalities have been identified in Bulahdelah, Muswellbrook, Orange and Scone.

In the region surrounding Gloucester, a statistically significant result has not been achieved. This suggests that either mining activity is not reducing property prices in the area or there is simply not enough data to definitively answer the question of whether there is any effect.

The conclusion of the hedonic pricing study is, therefore, that there is currently no statistically significant evidence to suggest that mining operations have had negative consequences on housing prices in the Gloucester area. This suggests that the best approach to valuing externalities in the area is likely to be through literature reviews, stated preference techniques and reliance on information provided by the project proponent.

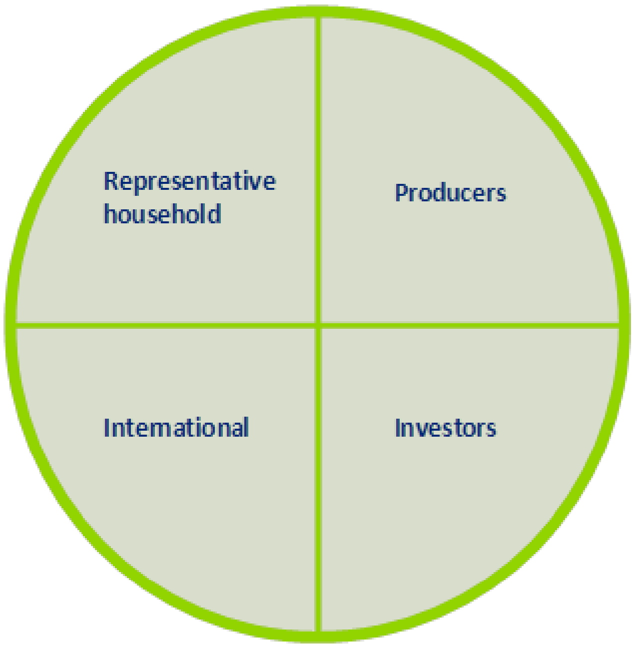
Appendix E: CGE modelling

The Deloitte Access Economics – Regional General Equilibrium Model (DAE-RGEM) is a large scale, dynamic, multi-region, multi-commodity computable general equilibrium model of the world economy. The model allows policy analysis in a single, robust, integrated economic framework. This model projects changes in macroeconomic aggregates such as GDP, employment, export volumes, investment and private consumption. At the sectoral level, detailed results such as output, exports, imports and employment are also produced.

The model is based upon a set of key underlying relationships between the various components of the model, each which represent a different group of agents in the economy. These relationships are solved simultaneously, and so there is no logical start or end point for describing how the model actually works.

Figure E.1 shows the key components of the model for an individual region. The components include a representative household, producers, investors and international (or linkages with the other regions in the model, including other Australian States and foreign regions). Below is a description of each component of the model and key linkages between components. Additional technical detail is also provided.

Figure E.1: Key components of DAE-RGEM



DAE-RGEM is based on a substantial body of accepted microeconomic theory. Key assumptions underpinning the model are:

- The model contains a 'regional consumer' that receives all income from factor payments (labour, capital, land and natural resources), taxes and net foreign income from borrowing (lending).
- Income is allocated across household consumption, government consumption and savings so as to maximise a Cobb-Douglas (C-D) utility function.
- Household consumption for composite goods is determined by minimising expenditure via a CDE (Constant Differences of Elasticities) expenditure function. For most regions, households can source consumption goods only from domestic and imported sources. In the Australian regions, households can also source goods from interstate. In all cases, the choice of commodities by source is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption for composite goods, and goods from different sources (domestic, imported and interstate), is determined by maximising utility via a C-D utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of creating capital.
- Producers supply goods by combining aggregate intermediate inputs and primary factors in fixed proportions (the Leontief assumption). Composite intermediate inputs are also combined in fixed proportions, whereas individual primary factors are combined using a CES production function.
- Producers are cost minimisers, and in doing so, choose between domestic, imported and interstate intermediate inputs via a CRESH production function.
- The model contains a more detailed treatment of the electricity sector that is based on the 'technology bundle' approach for general equilibrium modelling developed by ABARE (1996).
- The supply of labour is positively influenced by movements in the real wage rate governed by an elasticity of supply.
- Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. A global investor ranks countries as investment destinations based on two factors: global investment and rates of return in a given region compared with global rates of return. Once the aggregate investment has been determined for Australia, aggregate investment in each Australian sub-region is determined by an Australian investor based on: Australian investment and rates of return in a given sub-region compared with the national rate of return.
- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.
- Prices are determined via market-clearing conditions that require sectoral output (supply) to equal the amount sold (demand) to final users (households and government), intermediate users (firms and investors), foreigners (international exports), and other Australian regions (interstate exports).

- For internationally-traded goods (imports and exports), the Armington assumption is applied whereby the same goods produced in different countries are treated as imperfect substitutes. But, in relative terms, imported goods from different regions are treated as closer substitutes than domestically-produced goods and imported composites. Goods traded interstate within the Australian regions are assumed to be closer substitutes again.
- The model accounts for greenhouse gas emissions from fossil fuel combustion. Taxes can be applied to emissions, which are converted to good-specific sales taxes that impact on demand. Emission quotas can be set by region and these can be traded, at a value equal to the carbon tax avoided, where a region's emissions fall below or exceed their quota.

The representative household

Each region in the model has a so-called representative household that receives and spends all income. The representative household allocates income across three different expenditure areas: private household consumption; government consumption; and savings.

Going clockwise around Figure E.1, the representative household interacts with producers in two ways. First, by allocating expenditure across household and government consumption, this sustains demand for production. Second, the representative household owns and receives all income from factor payments (labour, capital, land and natural resources) as well as net taxes. Factors of production are used by producers as inputs into production along with intermediate inputs. The level of production, as well as supply of factors, determines the amount of income generated in each region.

The representative household's relationship with investors is through the supply of investable funds – savings. The relationship between the representative household and the international sector is twofold. Firstly, importers compete with domestic producers in consumption markets. Secondly, other regions in the model can lend (borrow) money from each other.

Some detail

- The representative household allocates income across three different expenditure areas – private household consumption; government consumption; and savings – to maximise a Cobb-Douglas utility function.
- Private household consumption on composite goods is determined by minimising a CDE (Constant Differences of Elasticities) expenditure function. Private household consumption on composite goods from different sources is determined by a CRESH (Constant Ratios of Elasticities Substitution, Homothetic) utility function.
- Government consumption on composite goods, and composite goods from different sources, is determined by maximising a Cobb-Douglas utility function.
- All savings generated in each region are used to purchase bonds whose price movements reflect movements in the price of generating capital.

Producers

Apart from selling goods and services to households and government, producers sell products to each other (intermediate usage) and to investors. Intermediate usage is where one producer supplies inputs to another's production. For example, coal producers supply inputs to the electricity sector or the steel manufacturing sector.

Capital is an input into production. Investors react to the conditions facing producers in a region to determine the amount of investment. Generally, increases in production are accompanied by increased investment. In addition, the production of machinery, construction of buildings and the like that forms the basis of a region's capital stock, is undertaken by producers. In other words, investment demand adds to household and government expenditure from the representative household, to determine the demand for goods and services in a region.

Producers interact with international markets in two main ways. Firstly, they compete with producers in overseas regions for export markets, as well as in their own region. Secondly, they use inputs from overseas in their production.

Some detail

- Sectoral output equals the amount demanded by consumers (households and government) and intermediate users (firms and investors) as well as exports.
- Intermediate inputs are assumed to be combined in fixed proportions at the composite level. As mentioned above, the exception to this is the electricity sector that is able to substitute different technologies (brown coal, black coal, oil, gas, hydropower and other renewables) using the 'technology bundle' approach developed by ABARE (1996).
- To minimise costs, producers substitute between domestic and imported intermediate inputs is governed by the Armington assumption as well as between primary factors of production (through a CES aggregator). Substitution between skilled and unskilled labour is also allowed (again via a CES function).
- The supply of labour is positively influenced by movements in the wage rate governed by an elasticity of supply (is assumed to be 0.2). This implies that changes influencing the demand for labour, positively or negatively, will impact both the level of employment and the wage rate. This is a typical labour market specification for a dynamic model such as DAE-RGEM. There are other labour market 'settings' that can be used. First, the labour market could take on long-run characteristics with aggregate employment being fixed and any changes to labour demand changes being absorbed through movements in the wage rate. Second, the labour market could take on short-run characteristics with fixed wages and flexible employment levels.

Investors

Investment takes place in a global market and allows for different regions to have different rates of return that reflect different risk profiles and policy impediments to investment. The global investor ranks countries as investment destinations based on two factors: current economic growth and rates of return in a given region compared with global rates of return.

Some detail

- Once aggregate investment is determined in each region, the regional investor constructs capital goods by combining composite investment goods in fixed proportions, and minimises costs by choosing between domestic, imported and interstate sources for these goods via a CRESH production function.

International

Each of the components outlined above operate simultaneously in each region of the model. That is, for any simulation the model forecasts changes to trade and investment flows within, and between, regions subject to optimising behaviour by producers, consumers and investors. Of course, this implies some global conditions must be met such as global exports and global imports are the same and that global debt repayments equals global debt receipts each year.

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