BHP

MT ARTHUR COAL MINE
MODIFICATION 2

Modification Report

Appendix J
Economic Assessment

Resource Strategies

AnalytEcon

MT ARTHUR COAL MINE MODIFICATION 2 – ECONOMIC ASSESSMENT

Economic Assessment prepared for
Hunter Valley Energy Coal Pty Ltd

September 2023

ACN 140 021 450

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Abbreviations

ABS	Australian Bureau of Statistics
ACCU	Australian Carbon Credit Unit
ACHA	Aboriginal Cultural Heritage Assessment
AHD	Australian Height Datum
AHMP	Aboriginal Heritage Management Plan
BC Act	NSW Biodiversity Conservation Act, 2016
CBA	Cost-benefit analysis
CEEC	Critically endangered ecological community
CER	Clean Energy Regulator
$CO_{2\text{-}e}$	Carbon dioxide equivalent
CHPP	Coal handling and preparation plant
CME	Chicago Mercantile Exchange
EA	Economic assessment
EA Guidelines	Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals (2015)
EA Technical Notes	Technical Notes supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals (2018)
EC	Electrical conductivity
EEX	European Energy Exchange
EIS	Environmental impact statement
EPBC Act	(Commonwealth) Environment Protection and Biodiversity Conservation Act, 1999
ETS	Emissions Trading System
EUA	European emission allowance
FTE	Full-time equivalent

FY	Financial year
GDE	Groundwater dependent ecosystem
GDP	Gross domestic product
GHG	Greenhouse gas
GWMP	Groundwater Monitoring Program
HVEC	Hunter Valley Energy Coal Pty Ltd
IPC	Independent Planning Commission
km	Kilometres
LEA	Local effects analysis
LGA	Local Government Area
LOS	Level of service
LQ	Location quotient
M	Metres
MAC	Mt Arthur Coal Mine
Mt	Million tonnes
Mtpa	Million tonnes per annum
NMP	Noise Management Plan
NPV	Net Present Value
NSW	New South Wales
PM2.5	Particulate matter ≤2.5µm
PM10	Particulate matter ≤10µm
ROM	Run of mine
SEARs	Secretary's Environmental Assessment Requirements
SA3	Local region comprising the Upper Hunter Statistical Area 3
TARP	Trigger Action Response Plan
VLAMP	Voluntary Land Acquisition and Mitigation Policy

EXECUTIVE SUMMARY

The Mt Arthur Coal Mine (MAC) is an open cut thermal coal mine located approximately 5 kilometres south-west of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). MAC is owned and operated by Hunter Valley Energy Coal Pty Ltd (HVEC), a wholly owned subsidiary of BHP.

MAC is currently approved to operate until 30 June 2026, in accordance with Project Approval MP 09_0062. HVEC is seeking a modification of the MAC MP 09_0062 for a four-year extension of the MAC to 30 June 2030 (the Modification).

This Economic Assessment (EA) forms part of a Modification Report which has been prepared to support an application to modify MP 09_0062. This EA has been prepared on the basis of information provided by HVEC and in accordance with relevant NSW Government guidelines, including the '*Guidelines For The Economic Assessment Of Mining And Coal Seam Gas Proposals*' (EA Guidelines) and the '*Technical Notes supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals*' (EA Technical Notes). The EA Guidelines require the following analyses to be undertaken:

- a cost-benefit analysis (CBA) to assess the incremental net benefit that the Modification would deliver to the NSW community; and
- a local effects analysis (LEA) to assess the incremental net benefit that the Modification would deliver to the local region.

RESULTS OF THE COST-BENEFIT ANALYSIS

The EA Guidelines require that the benefits that would accrue to the NSW community if the Modification is approved be estimated by comparing the outcomes in a 'Modification' scenario with those in a counterfactual business-as-usual or 'Base Case' scenario (where the Modification is not approved and mining operations cease in 2026).

Table ES-1 summarises the estimated incremental net benefits of the Modification for NSW, taking into account recently announced changes to coal royalty rates. The net present value (NPV) of the net benefits of the Modification that would accrue to the NSW community if the Modification is approved is estimated at $1,033 million, consisting of:

- royalties of around $483 million in NPV terms and other NSW State and local taxes of $16 million in NPV terms;
- the NSW share of company income tax of around $144 million in NPV terms;
- the NSW share of the net producer surplus of around $181 million in NPV terms; and

- net economic benefits to NSW workers of around $210 million in NPV terms.

Table ES-1. Incremental net benefits of the Modification for NSW community ($2022)

Costs	NPV $ millions	Benefits	NPV $ millions
Direct costs		Direct benefits	
External effects that have not been internalised by HVEC (GHG emissions)	<$0.1	Royalties	$483
		NSW share of company income taxes	$144
		Other NSW state and local taxes	$16
		NSW share of net producer surplus	$181
Indirect costs		Indirect benefits	
Net environmental, social and transport-related costs	N/a	Net economic benefits to NSW workers	$210
Total costs	<$0.1	$1,033	$1,033
Net economic benefits to NSW			$1,033

Notes: The incremental royalty calculation incorporates the higher open cut coal royalty rate that will apply as of 1 July 2024 (NSW Government, 2023). Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars.

Source: AnalytEcon.

The results of sensitivities undertaken to establish the robustness of the net benefit estimates to the underlying assumptions suggests that the Modification would generate net benefits to NSW in a broad range of circumstances.

RESULTS OF THE LOCAL EFFECTS ANALYSIS

For the purpose of undertaking the LEA, the EA Guidelines require proponents to identify a local region or study area that should match a Statistical Area Level 3 (SA3) geographic definition. In the case of the Modification, the relevant SA3 area is the Upper Hunter SA3 Region, which includes Muswellbrook, Scone and the surrounding areas. The Upper Hunter SA3 Region does not represent a good approximation of the geographical area where local impacts are likely to arise, since only around 34 per cent of the existing MAC workforce (which would continue to be employed if the Modification is approved) are estimated to live in that Region. In contrast, around 86 per cent of the MAC workforce live in five local government areas (LGAs) in the Hunter Valley, consisting of Muswellbrook, Singleton, Cessnock, Upper Hunter and Maitland LGAs.

We have therefore adopted the following approach:

- adopting the Upper Hunter SA3 region ('the SA3 Region') as one local study region, consistent with the EA Guidelines; and
- analysing a second region (the 'MAC Region') that encompasses the five LGAs where the great majority of the MAC workforce live, which would therefore better capture the local employment and income impacts of the Modification.

Table ES-2 summarises the net effects of the Modification for the local region. If approved, the Modification would generate:

- on average 569 direct FTE jobs in the SA3 Region or 1,438 direct FTE jobs in the MAC Region between 2027 and 2030, as well as an additional 330 and 877 flow-on jobs in the SA3 Region and the MAC Region, respectively, in those years;
- additional aggregate net disposable income of $157 million in NPV terms in the SA3 Region or $396 million in NPV terms in the MAC Region, as well as additional flow-on income of $207 million in the SA3 Region and $550 million in the MAC Region, respectively;
- additional LGA rate payments of around $15 million in NPV terms in either region; and
- additional expenditures directed at local suppliers that are estimated at $219 million and $399 million in NPV terms for the SA3 Region and the MAC Region, respectively.

Table ES-2. Incremental net benefits of the Modification for the local region ($2022)

	Net direct local effects		Net flow-on local effects		Total net local effects	
	SA3 Region	MAC Region	SA3 Region	MAC Region	SA3 Region	MAC Region
Employment-related (FTEs)	569	1,438	330	877	898	2,316
Incremental benefits to the local region						
Disposable income ($ millions)	$157	$396	$207	$550	$364	$946
Local government rate payments ($ millions)	$15	$15	N/a	N/a	$15	$15
Incremental costs to the local region	N/a	N/a	N/a	N/a	N/a	N/a
Incremental net benefits to the local region						
($ millions)	$172	$411	$207	$550	$379	$962
Other benefits to the local region						
Benefits to suppliers ($ millions)	$219	$399	N/a	N/a	$219	$399

Note: Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars
Source: AnalytEcon.

1. INTRODUCTION

The Mt Arthur Coal Mine (MAC) is an open cut coal mine located approximately 5 kilometres (km) south-west of the town of Muswellbrook in the Upper Hunter Valley of New South Wales (NSW). MAC is owned and operated by Hunter Valley Energy Coal Pty Ltd (HVEC), a wholly owned subsidiary of BHP. MAC is currently approved to operate until 30 June 2026, in accordance with NSW Project Approval MP 09_0062.

1.1. PURPOSE AND SCOPE OF THE ECONOMIC ASSESSMENT

This EA of the Modification has been prepared in accordance with the '*Guidelines For The Economic Assessment Of Mining And Coal Seam Gas Proposals*' (NSW Government, 2015, 'the EA Guidelines'), the '*Technical Notes supporting the Guidelines for the Economic Assessment of Mining and Coal Seam Gas Proposals*' (NSW Government, 2018, 'the EA Technical Notes'), and the '*Cumulative Impact Assessment Guidelines for State Significant Projects*' (NSW Government, 2021). The EA Guidelines require the following analyses to be undertaken:

- a cost-benefit analysis (CBA) to assess the net benefit that the Modification will deliver to the NSW community; and
- a local effects analysis (LEA) to assess the net benefit that the Modification will deliver to the local region.

1.2. ABOUT THIS REPORT

This report is structured as follows:

- Section 2 describes the approved MAC and the Modification;
- Section 3 describes the CBA and various sensitivities to test the results;
- Section 4 describes the LEA and the local and flow-on impacts of the Modification; and
- Section 5 comments on the significance of the resource.

Supporting documentation is presented in the following appendices:

- Appendix A provides the detailed results for the CBA sensitivities.
- Appendix B describes the derivation of input-output multipliers and their interpretation.

2. MT ARTHUR COAL MINE

This section describes the approved MAC and the proposed Modification, as well as the relevant regional context.

2.1. MT ARTHUR COAL MINE OVERVIEW

MAC is an open cut coal mine situated approximately 5 kilometres (km) south-west of Muswellbrook in the Muswellbrook Local Government Area (LGA) in the Upper Hunter Valley of NSW (Figure 2-1). MAC is owned and operated by HVEC, a wholly owned subsidiary of BHP.

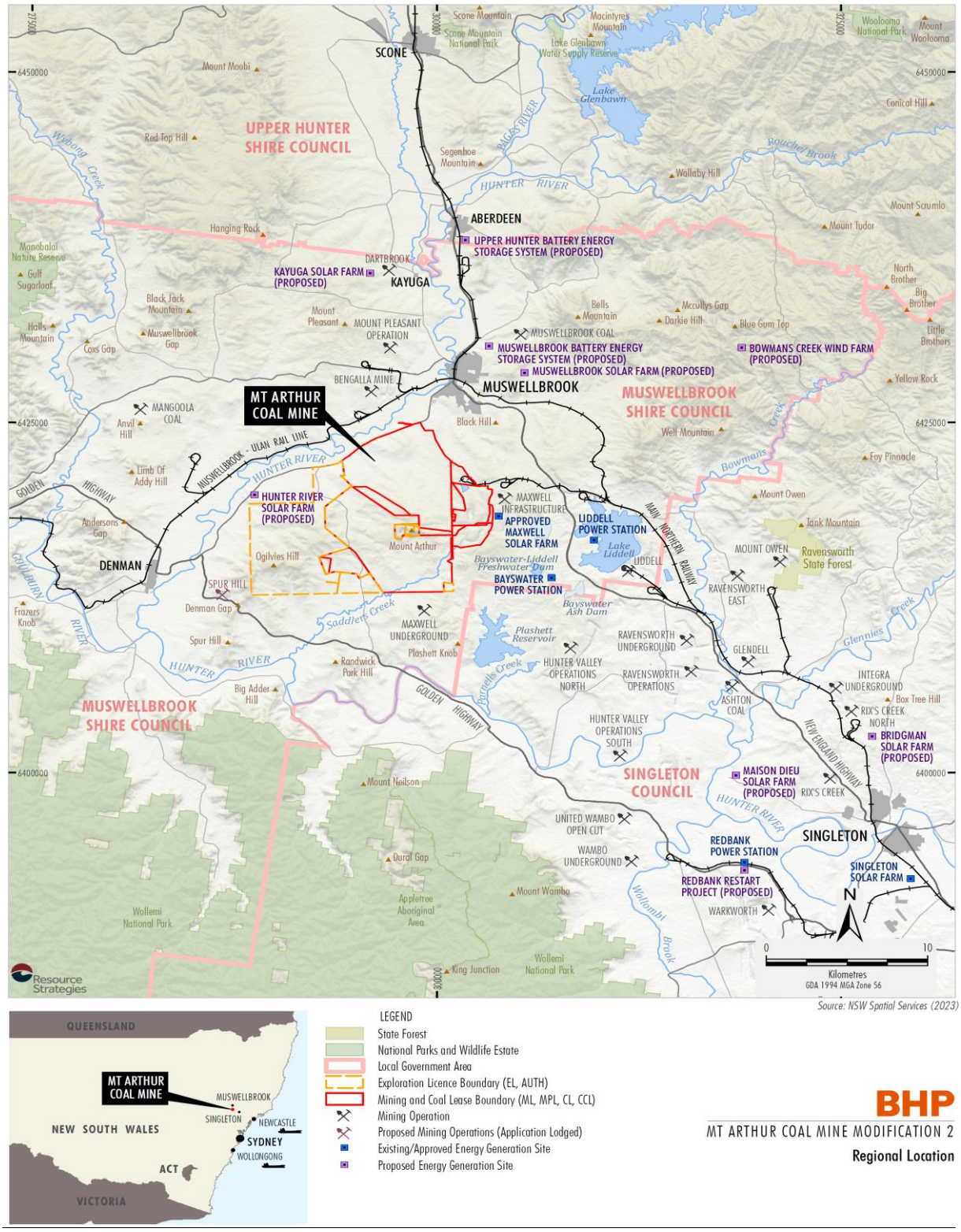
MAC is currently approved to operate until 30 June 2026, in accordance with MP 09_0062. In June 2022, HVEC announced a decision to cease mining at MAC in 2030, as part of a plan to provide a pathway to closure of the operation. Accordingly, HVEC is seeking a modification of the MAC MP 09_0062 for a four-year extension of the MAC to 30 June 2030.

2.2. MODIFICATION

HVEC is seeking to modify MP 09_0062 under section 4.55(2) of the *Environmental Planning & Assessment Act 1979*, and would include the following:

- a four-year extension of mining activities to 30 June 2030;
- a reduction in the approved open cut mining rate from 32 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal to a maximum of 25 Mtpa ROM coal (similar to current actual production);
- a reduction in the cumulative open cut and underground ROM coal handling rate from 36 Mtpa to 29 Mtpa;
- a reduction in maximum total (open cut and underground) coal rail transportation from 27 Mtpa of product coal to 20 Mtpa, and a reduction in train movements from 30 to 20 movements per day;
- a minor extension of the approved disturbance area in the north-west corner of the operation predominantly to allow for access and ancillary infrastructure (refer to 'Modification New Disturbance Area' within Figure 2-2);
- an overall reduction (387 ha) in approved disturbance, as some previously approved disturbance areas are no longer intended to be disturbed (refer to Impact Minimisation Area within Figure 2-2); and
- a revised final landform and final void configuration, including an overall reduction in the approved height of the northern overburden emplacement areas and the final landform (to reflect the current actual height).

Figure 2-1. Location of the Mt Arthur coal mine



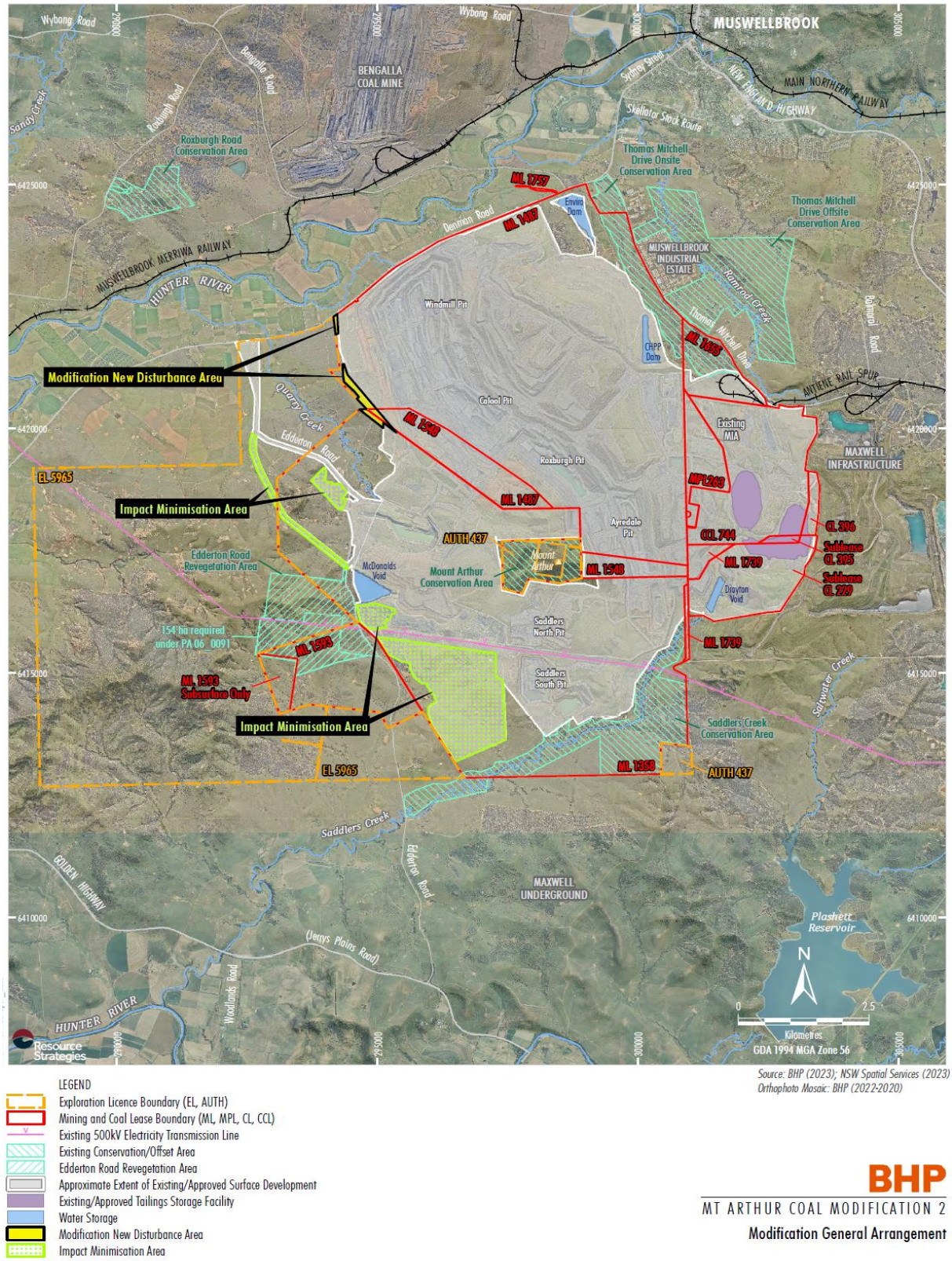
Source: Resource Strategies.

The Modification would involve no change to:

- existing mining tenements;
- existing coarse rejects and tailings management;
- the existing workforce;
- the existing explosives facility;
- existing site accesses;
- existing electricity supply and distribution;
- existing offset and rehabilitation objectives;
- existing services, plant and equipment; and
- the existing hours of operation and associated activities (undertaken 24 hours per day, seven days a week).

This EA forms part of a Modification Report which has been prepared to support an application to modify MP 09_0062 based on the four-year extension of mining activities and on the conceptual general arrangement of the Modification shown in Figure 2-2.

Figure 2-2. Modification general arrangement



Source: Resource Strategies.

2.3. COMPARISON OF THE APPROVED MAC AND THE MODIFICATION

Table 2-1 provides a comparison of the approved MAC and the Modification.

Table 2-1. Overview of the approved MAC and the proposed Modification

Component	Approved Mt Arthur Coal Mine MP 09_0062	Proposed Modification
Life-of-Mine	Approval for open cut mining to 30 June 2026.	Open cut mining for an additional four years until 30 June 2030
Site Entrance	Various site accesses off Thomas Mitchell Drive and Edderton Road.	Unchanged.
Mining Method and Resource	Continuation of conventional truck and shovel open cut strip and terrace mining in the Windmill, Calool, Roxburgh, Ayredale and Saddlers (north and south) Pits.	Unchanged.
Annual ROM coal production rate	Up to 32 Mtpa of ROM coal from the open cut mining operations.	Reduction in approved extraction, handling and processing of ROM coal from the open cut mining operations to 25 Mtpa (i.e., from 32 Mtpa).
Coal processing rate	Coal Handling and Preparation Plant (CHPP) processing of up to 36 Mtpa (including underground coal).	Continued use of the CHPP to facilitate the processing of up to 29 Mtpa of ROM coal from the total complex (i.e., reduction from 36 Mtpa to 29 Mtpa).
Mining areas	Open cut mining including the Northern Open Cut Pits (Windmill, Calool, Roxburgh and Ayredale) and Southern Open Cut Pits (Saddlers).	Minor extension of the Windmill Pit, predominantly for access and ancillary infrastructure.
Overburden emplacement	Development of northern overburden emplacement height to an average of 360 metres (m) Australian Height Datum (AHD) (maximum height of 375 m AHD). Development of Bayswater No 3 (Saddlers Pit) overburden emplacement height up to 250 m AHD. Development of Sublease Coal Lease (CL) 229 and Sublease CL 395 emplacement area up to 360 m AHD. Development of an out-of-pit overburden emplacement area up to 360 m AHD.	No requirement to develop the southern section of the out of pit emplacement. Reduction in height of the northern emplacement (from an average of approximately 360 AHD an average to an average of approximately 340 m AHD).

Disturbance areas	Total Mt Arthur Coal Mine disturbance area of approximately 6,710 ha.	Modification new disturbance area of 25 ha. Decrease in net total disturbance of approximately 387 ha (via the Impact Minimisation Area). The revised total for the Mt Arthur Coal Mine would be approximately 6,323 ha.
Mining tenements	Mining Leases 1548, 1487, 1358, 1655, 1739, 1757, and 1593, Mining Purpose Lease (MPL) 263, Sublease CL 229 and 395, CL 396 and Consolidated Coal Lease (CCL) 744.	Unchanged.
Coarse rejects and tailings management	Deposition of tailings in the tailings emplacement area at Bayswater No 2. Approval to dispose tailings in the void within Sublease CL 229. The tailings emplacement area up to 280 m AHD. Disposal of coarse reject within overburden emplacement areas.	Unchanged.
Product coal transport	Transport of up to 27 Mtpa product coal via rail. Maximum of 30 rail movements per day (i.e., 15-laden train departures).	Reduced transport of product coal to 20 Mtpa from the Mt Arthur Coal Mine. Maximum of 20 rail movements (or 10 laden train departures) per day.
Employment	Total workforce of approximately 2,600 full-time equivalent employees during peak production. A workforce of approximately 240 full-time equivalent employees during peak construction phases.	Continuation of a total workforce of approximately 2,200 FTE positions.
Hours of Operation	All coal operations and associated activities undertaken 24-hours per day, seven days a week. Construction on-site may be on a 24-hour, seven day roster consistent with operational requirements.	Unchanged.
Explosives Facilities	Fully bunded on-site explosives magazine for the storage of detonators and other materials.	Unchanged.
Progressive Rehabilitation	Progressive rehabilitation of areas consistent with the approved RMP and Rehabilitation Strategy (BHP, 2017).	Unchanged.
Final Landform	**Voids:** Approval for three final voids (i.e., Northern Open Cut Void, Belmont Void and McDonalds Void).	**Voids:** Retention of final voids. Reduction in number of final voids from three to two, comprising the Northern Open Cut Void and McDonalds Void. Change in location and shape of the Northern Open Cut Void due to proposed continuation of mining to 30 June 2030. The currently approved Belmont Void would be backfilled.

	Emplacements: Final landform associated with out-of-pit and in-pit waste rock emplacements. Requirement to rehabilitate waste rock emplacements consistent with the approved RMP and Rehabilitation Strategy.	**Emplacements:** No change to the requirement to rehabilitate waste rock emplacement areas. No requirement to develop or rehabilitate the southern out-of-pit emplacement area (Impact Minimisation Area). Reduction in final height of northern emplacement by approximately 20 m AHD.
	Tailings: Tailings dam dewatering and capping undertaken consistent with the RMP, Rehabilitation Strategy and Tailings Management Strategy approved at the time of closure.	**Tailings:** No change to tailings decommissioning and capping strategy.
	Infrastructure: All surface infrastructure decommissioned and removed unless a post-mining land use has been established and approved by the Resources Regulator in consultation with surrounding landholders (condition 41A of Schedule 3 of MP 09_0062).	**Infrastructure:** Unchanged. Surface infrastructure would be decommissioned and removed unless agreed upon by the Resources Regulator. This includes any additional infrastructure within the Modification Area.
Final Land Use	Supporting native ecosystem (woodland) and agriculture (pasture) meeting existing offset requirements.	No change to land uses comprising woodland corridors and pasture areas. Revised location of land use areas developed to meet existing offset and rehabilitation requirements.

Source: HVEC.

2.4. KEY ECONOMIC PARAMETERS

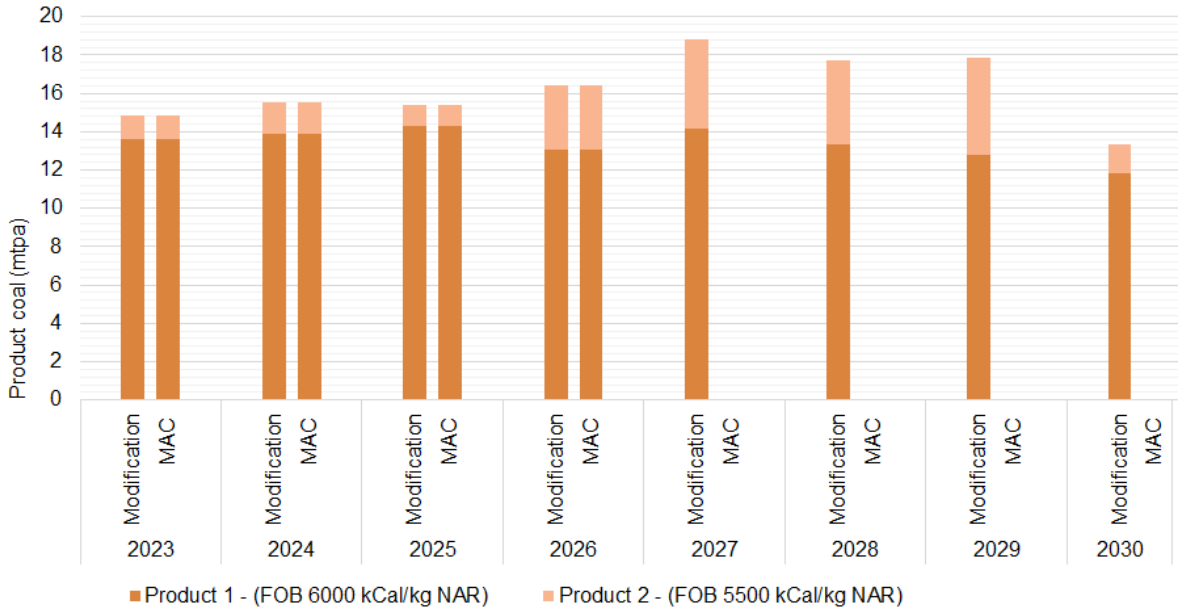
The following provides an overview of the key economic parameters used in the CBA.

2.4.1. Product coal production

BHP has advised that production increases for the Modification thereafter reflect a decreasing (waste / ROM t) strip ratio as the mine approaches its final landform.

Figure 2-3 shows the estimated product coal production profile of MAC and the Modification. The respective coal production profiles are the same between financial year (FY) 2023 and FY 2026. BHP has advised that production increases for the Modification thereafter reflect a decreasing (waste / ROM t) strip ratio as the mine approaches its final landform.

Figure 2-3. Product coal production profile (FY 2023 to FY 2030, Mtpa)

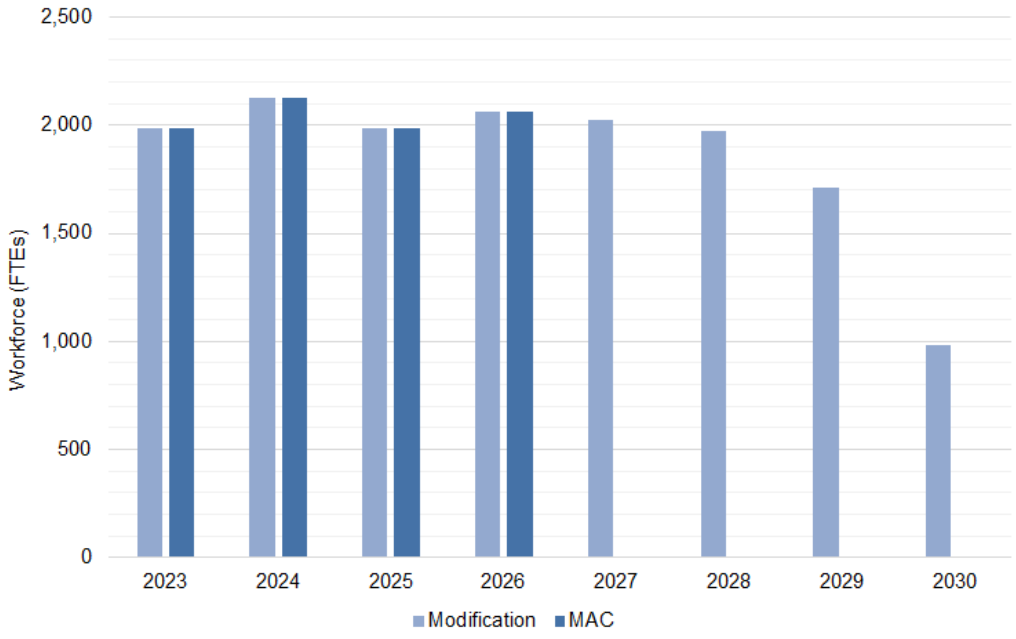


Notes: NAR = Net as received; FOB = Free on board; kCal/kg = kilocalories per kilogram
Source: HVEC.

2.4.2. MAC workforce

The workforce profile for MAC and the Modification is also the same from FY 2023 to FY 2026 (Figure 2-4). If approved, MAC would employ on average 1,672 full-time equivalent (FTE) workers between 2027 and 2030.

Figure 2-4. Workforce (FY 2023 to FY 2030, FTEs)

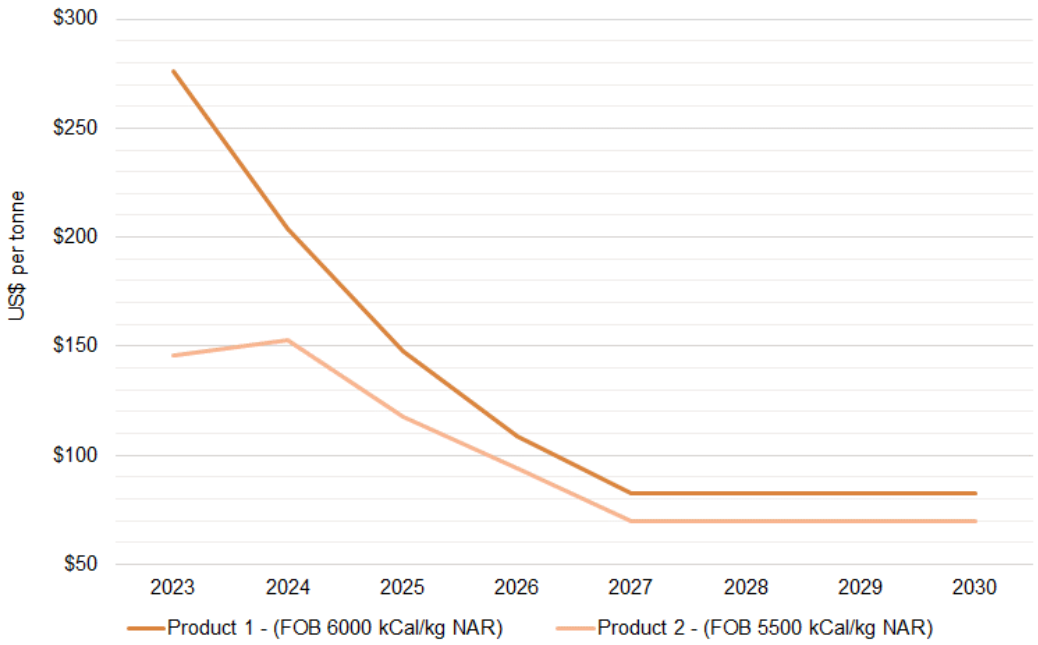


Source: HVEC.

2.4.3. Coal prices

Figure 2-5 show the product coal price projections used in this EA. These projections were derived from the UBS Consensus price forecast as of January 2023.

Figure 2-5. Product coal prices (US$ per tonne)



Notes: NAR = Net as received; FOB = Free on board; kCal/kg = kilocalories per kilogram
Source: HVEC.

2.5. OTHER RESOURCES PROJECTS IN THE REGION

As is also apparent in Figure 2-1, the MAC is located in a heavily mined area in the Hunter Valley, adjacent to the Maxwell Infrastructure and Underground Operations (formerly the Drayton Coal Mine), and proximate to a number of other operational mines, including the Bengalla Coal Mine, the Mount Pleasant Coal Mine, and the Mangoola Coal Project. The Bayswater power station and the Liddell power station (closed in April 2023, however has approval to construct a battery storage) are located to the east of the MAC. Further to the southeast, there are numerous open cut and underground coal mines in the adjacent Singleton Shire, including the Mount Owen, Ravensworth East, Glendell Mine, Ashton Coal Mine, Ravensworth Underground, Ravensworth Operations and the Hunter Valley Operations North and South.

As summarised in Table 2-2, a number of developments or modifications to existing coal mining operations are currently proposed within about a 10 km radius, including:

- approved coal mining projects, such as the Maxwell Underground Project, and the Dartbrook Mine (which has been under care and maintenance for 16 years but is approved for an additional 5 years until 2027, and which potentially may restart production);
- approved extensions of existing mining operations, such as the Mangoola Coal Continued Operations Project, the Bengalla Continuation Project, and the Mount Pleasant Optimisation Project; and
- proposed and approved energy-related projects, such as the Maxwell Solar Farm, the Bowmans Creek Wind Farm, and the Liddell Battery and Bayswater Ancillary Works.

Where relevant, these projects have been considered in the specialist assessments of potential (cumulative) environmental effects.

Table 2-2. Approved and proposed coal mining and other developments in the vicinity of MAC

Project	Overview	Status Summary
Approved and proposed new mining projects		
Maxwell Underground Project	State Significant Development (SSD) 9526 – underground mining to produce high quality coals primarily for the steel industry using existing and proposed new infrastructure. Extract and process up to 8 Mtpa ROM coal, mine life to 30 June 2047.	Approved 2020, construction commenced May 2022, operations not substantially commenced
Dartbrook Mine	DA 231-7-200 Mod 7 – underground mining, extract and process up to 6 Mtpa ROM coal, mine life to 5 December 2027.	Approved for 5-year extension. In care and maintenance, mining activity may recommence
Spur Hill Underground	SSD 6509 – development of a new underground coal mine and associated infrastructure to extract up to 8 Mtpa of ROM coal for up to 25 years.	SEARs Issued 2014
Modifications/extensions of existing coal mining projects		
Mangoola Coal Continued Operations Project	SSD 8642 – extension of open cut mining at Mangoola Coal Mine to a new mining area immediately north of the existing operation. Mine life to 31 December 2030.	Approved 2021, construction commenced December 2021, operations not commenced
Bengalla Continuation Project	SSD 5170 – extract and process up to 15 Mtpa of ROM coal, mine life to 28 February 2039.	Approved 2015, operational
Mount Pleasant Optimisation Project	SSD 10418 – extend the life of the open cut operation by mining deeper coal	Approved 2022, not commenced

Project	Overview	Status Summary
	seams, using existing and proposed new infrastructure. Extend mine life to 22 December 2048.	
Liddell Battery and Bayswater Ancillary Works	SSD 8889679 – construct and operate a Battery Energy Storage System, decouple Liddell and Bayswater power stations, facilitate improved performance of Bayswater Power Station.	Approved, not commenced
Other approved and proposed industrial proposals		
Maxwell Solar Farm	SSD 9820 – development of a 25 MW solar farm and associated infrastructure.	Approved 2020, not commenced
Bowmans Creek Wind Farm	SSD 10315 – construction and operation of a wind farm with up to 60 wind turbines and associated infrastructure	Environmental Impact Statement (EIS) exhibited, under assessment

Source: Resource Strategies.

3. COST-BENEFIT ANALYSIS – NSW COMMUNITY

This section describes the CBA that has been prepared to evaluate the economic impacts of the Modification on the NSW community.

CBA is a technique for assessing the economic merits of a development such as the Modification from the perspective of society; in this case, from the perspective of the NSW community. The CBA presented here examines the incremental (net) benefits that would accrue to the NSW community if the Modification is approved, referred to as the 'Modification Scenario', relative to the counterfactual or 'Base Case' if the Modification is not approved. The operational parameters of each scenario are described in Table 2-1:

- in the Base Case, the approved MAC would continue operating through to June 2026 subject to MP 09_0062; while
- in the Modification Scenario, the Proposed Modification would operate through to June 2030.

The EA Guidelines list the potential costs and benefits of a proposal that may be included in the CBA. These are derived in the following sections. A central discount rate of 7 per cent per annum has been used to discount all costs and benefits back to a common point in time. All dollar values are expressed in 2022 Australian dollars ($2022).

3.1. DIRECT BENEFITS TO NSW

3.1.1. Coal royalties

Taking into account the increase in the open cut coal royalty rate announced by the NSW Government (NSW Government, 2023), the incremental coal royalty payments attributable to the Modification are estimated at $483 million in net present value (NPV) terms (Table 3-1). Royalties were calculated by multiplying the product coal production schedules with projected quality-adjusted coal prices (Section 2.4.3). The ad valorem royalty rate for open cut coal mining of 8.2 per cent was applied to the net disposal value after allowable deductions in FY 2023 and FY 2024, and the revised royalty rate of 10.8 per cent in FY 2025 and thereafter.

Table 3-1. Incremental royalty calculation ($2022)

		Modification Scenario	Base Case	Difference
			NPV $ millions	
Assessable revenues		$17,586	$12,934	$4,652
Allowable deductions				
	Beneficiation	$409	$236	$173
	Levies	$27	$15	$12
Net disposal value		$17,149	$12,682	$4,468
Royalty		$1,629	$1,146	$483

Notes: Base Case includes years 2023 – 2026 in all scenarios. The open cut coal royalty rate is 8.2 per cent in FY 2023 and 2024, and 10.8 per cent from FY 2025 onwards. Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars.

Source: HVEC, AnalytEcon analysis.

3.1.2. Company income taxes attributable to NSW

Aggregate Commonwealth company income tax payments were derived by deducting capital and operating costs, royalties and other tax payments from gross revenues to derive taxable income, as shown in Table 3-2. The incremental share of company income taxes attributable to NSW on the basis of NSW's share of the Australian population is estimated at $144 million in NPV terms.

Table 3-2. Incremental company income tax calculation ($2022)

	Modification Scenario	Base Case	Difference
		NPV $millions	
Coal revenues	$17,586	$12,934	$4,652
Net of:			
Capital investment, incl. land purchase costs, residual land value	$367	$284	$82
Operating costs, incl. externalities	$5,940	$4,586	$1,354
Labour costs	$2,810	$1,693	$1,117
Royalties	$1,629	$1,146	$483
All other taxes, excl. company income tax	$217	$128	$88
Total assessable income	$6,624	$5,096	$1,528
Company income tax	$1,987	$1,529	$458
Share of company tax attributable to NSW	$624	$480	$144

Notes: Totals may not sum precisely due to rounding.$2022 refers to 2022 Australian Dollars. As of 30 June 2022, the NSW share of the Australian population was 31.4 per cent.

Source: HVEC; AnalytEcon analysis; https://www.abs.gov.au/statistics/people/population/national-state-and-territory-population/latest-release#states-and-territories.

3.1.3. Net producer surplus attributable to NSW

Table 3-3 shows the net producer surplus calculation. The share of the producer surplus attributable to NSW depends on the Australian ownership share of MAC. MAC is owned by HVEC, a wholly owned subsidiary of BHP, whose Australian ownership is estimated at 53.8 per cent. Assuming that the NSW ownership of BHP is distributed in line with NSW's share of the Australian population (31.4 per cent), the net producer surplus attributable to the Modification is $181 million in NPV terms.

Table 3-3. Incremental producer surplus calculation ($2022)

Revenues	NPV $millions	Costs	NPV $millions
Modification Scenario:			
Gross mining revenue	$17,586	Wages & salaries (labour)	$2,810
Residual value of land	$47	Operating costs, incl. mitigating externalities, excl. decommissioning costs	$5,338
Residual value of capital	$0	Capital costs, excl. land purchase costs	$397
		Decommissioning costs	$602
		Land purchase costs	$17
		Taxes & royalties, incl. company income tax	$3,832
Total	$17,633		$12,996
Producer surplus Modification			$4,637
Base Case:			
Gross mining revenue	$12,934	Wages & salaries	$1,693
Residual value of land	$62	Operating costs, incl. mitigating externalities, excl. decommissioning costs	$3,212
Residual value of capital	$24	Capital costs	$353
		Decommissioning costs	$1,374
		Land purchase costs	$17
		Taxes & royalties	$2,803
Total	$13,019		$9,452
Producer surplus Base Case			$3,567
Incremental producer surplus			$1,069
NSW share of the incremental producer surplus			$181

Notes: Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars.

Source: HVEC, AnalytEcon.

3.1.4. Other incremental tax revenues accruing to NSW

NSW STATE AND LOCAL TAXES

HVEC would continue to pay other taxes accruing to NSW between 2027 and 2030 if the Modification is approved:

- an additional $0.3 million in NPV terms in land taxes, which are levied on the value of NSW land owned by individuals and businesses and accrue to the State of NSW; and
- an additional $15.4 million in NPV terms in local government rates, which benefit the (local) NSW community.

PERSONAL INCOME TAXES

If the Modification is approved, the Commonwealth would additionally collect around $500 million ($326 million in NPV terms) in personal income taxes between 2027 and 2030, of which around a third or $157 million ($102 million in NPV terms) can be attributed to NSW (on a NSW share of the Australian population basis).

The 2015 Guidelines state that a development will also generate additional personal income tax payments, but say that most of these taxes would not represent a benefit to NSW, as people would have been employed elsewhere in the absence of the development. The additional personal income taxes generated in the Modification Scenario have therefore not been included as a benefit in the CBA calculation.

PAYROLL TAXES

If the Modification is approved, the State of NSW would receive around $93 million ($61 million in NPV terms) in payroll taxes between 2027 and 2030. The EA Guidelines similarly discount payroll taxes as an incremental benefit, and the additional payroll taxes generated in the Modification Scenario have also not been included in the CBA calculation.

3.2. INDIRECT BENEFITS TO THE NSW COMMUNITY

3.2.1. Economic benefits to existing landowners

The EA Guidelines note that existing landholders may gain an economic benefit if a project proponent purchases land to undertake economic activities. In the respective costings for the Modification Scenario and the Base Case, provision is made for the acquisition of land in 2026. This is a conservative assumption made for budgeting purposes; it presupposes that all properties within the existing zone of acquisition (as well as properties which potentially may be brought into the zone of acquisition), trigger their acquisition rights and are acquired by HVEC. The acquisition of these properties would therefore be contingent upon landowners triggering their acquisition rights.

In any case, given that the potential acquisition of land would take place in both the Modification Scenario and in the Base Case, the Modification would not generate an incremental benefit to existing landowners: any potential benefits to existing landowners would net to zero.

3.2.2. Economic benefits to NSW workers

In the Base Case, operational employment at MAC is projected to end in 2026. If the Modification is approved, it would offer continuous employment to the existing workforce of, on average, 1,672 FTEs from FY 2027 through to FY 2030. Relative to the Base Case, MAC's NSW workforce would earn an additional $1.7 billion (around $1.1 billion in NPV terms) in aggregate gross income, or around $1 billion (around $660 million in NPV terms) in aggregate disposable income.

The EA Guidelines define economic benefits to workers as the wage premium paid to workers on a specific project relative to the minimum or 'reservation' wage that those workers would earn working elsewhere in the mining sector. The EA Guidelines say that, as a general matter, a zero wage premium should be assumed, reflecting the hypothesis that higher wages reflect such factors as the demanding nature of the work or relocation costs. Yet, while labour markets are complex, there is near universal agreement and considerable empirical evidence in the economic literature that over a longer timeframe, the fundamental determinant of wages is labour productivity: the amount of output produced by a worker over a unit of time, say an hour. The fact that there are wage differentials for otherwise similar jobs therefore substantially reflects differences in workers' productivity across different industries, and is not indicative of some form of personal opportunity cost or disutility that effectively negates a wage premium.[1] This finding is also recognised in the '*NSW Government Guide to Cost-Benefit Analysis*' (2017), which states (P.13): *If an initiative increased hourly wage rates, the incremental increase would be a benefit.*

Notwithstanding these conceptual concerns, we have adopted the approach set out in the EA Guidelines and have assumed a reservation wage corresponding to the average full-time adult earnings in the Australian mining sector (Australian Bureau of Statistics [ABS 2022a]). This approach assumes that upon closure of MAC in the Base Case in 2026, no share of the existing workforce would retire or become unemployed. Instead, the existing MAC workforce would immediately be reemployed at the average Australian mining wage.[2] On that basis, the incremental disposable income that would be generated in the Modification Scenario relative to the Base Case between FY 2027 and FY 2030 is estimated at $324 million ($210 million in NPV terms).

[1] See also: Australian Government, 2017; Productivity Commission, 2019.

[2] As of November 2022, average full time adult total earnings in the Australian mining sector were $150,436. Total earnings are assumed to increase by 1 per cent in real terms over the forecasting horizon.

3.2.3. Economic benefits to suppliers

The EA Guidelines note that NSW suppliers may benefit from a mining project by achieving higher surpluses. Determining the magnitude of this benefit to suppliers poses practical difficulties, given that there are no statistics as to which businesses are NSW-owned, and whether the goods and services supplied by these businesses are produced in NSW, or imported from elsewhere in Australia, or from overseas. Therefore, the contributions made by MAC towards any NSW surplus cannot generally be measured reliably, and have not been included in the CBA.

However, a component of the economic benefits to suppliers that can be estimated is the wholesale and retail margin, that is, the markup over the cost of supplying goods and services. In 2022, around 31.5 per cent of MAC's operational expenditures was directed at NSW suppliers. If the share of NSW expenditures remains the same going forward, an additional $706 million ($426 million in NPV terms) would be directed towards NSW suppliers between FY 2027 and FY 2030.

It can be assumed that a large buyer such as HVEC would purchase most of its inputs from wholesalers. Consistent with the most recent analysis of average wholesale margins undertaken by the Reserve Bank of Australia (RBA) (RBA, 2012), around 2 per cent of these additional NSW expenditures could be expected to be the additional net margin accruing to wholesalers with a NSW presence (around $9 million in NPV terms).[3]

3.3. INDIRECT COSTS TO THE NSW COMMUNITY

3.3.1. Net environmental, social, and transport-related costs

This section reviews the predicted net environmental, social and transport-related costs of the Modification (referred to as 'externalities' or 'external effects'). These impacts are summarised in Table 3-4.

[3] The RBA found that, as of 2007-08, wholesalers' 'cost of doing business' (CODB) was around 14 per cent of final sales prices, while the net margin was additionally around 2 per cent. The CODB consists of expenses paid to staff, landlords and freight providers, and the holding cost of inventory.

Table 3-4. External effects associated with the Modification

Assessment component	Predicted residual impacts	Mitigation measures
Noise and blasting	As a result of the Modification: - Operational noise levels criteria would be met at all privately-owned receivers, with the exception of night-time noise impacts at three receivers. The three receivers already have mitigation or acquisition rights for air quality impacts and would be afforded rights to additional noise mitigation. - Assessments of potential noise impacts on vacant land were found to be compliant. - All cumulative noise level predictions comply with the amenity noise levels during the day, evening and night assessment periods. - The Modification would comply with a maximum night-time noise criterion for privately-owned residences. The Modification would not involve changes to the existing drill and blast program at MAC.	HVEC would continue to apply a comprehensive suite of noise mitigation and management measures on site, as described in MAC Noise Management Plan (NMP) including the existing Trigger Action Response Plan (TARP).
Air quality	The air quality assessment concluded that the Modification would result in air quality emissions to 2030 at a reduced rate relative to the approved MAC. No privately owned receptors are predicted to exceed the NSW EPA impact assessment 24 hour average particulate matter ≤2.5µm (PM2.5) or particulate matter ≤10µm (PM10) criteria for Modification-only impacts. One privately owned receptor (which currently has acquisition upon request rights for potential air quality impacts) is predicted to experience exceedances of the relevant cumulative annual average PM10 criteria.	Dust control measures set out in the approved MAC Air Quality Management plan would continue to be applied, as would be the TARP to trigger alarms and alert staff of the potential for dust impacts. HVEC would also continue to utilise a predictive system to supplement the reactive operational dust mitigation strategies.

Assessment component	Predicted residual impacts	Mitigation measures
	With the application of a reactive dust mitigation strategy and real-time management systems, no privately owned receivers are predicted to exceed the cumulative 24 hour average PM10 or PM2.5 criteria. No other adverse air quality impacts are expected	
Greenhouse gas emissions	The Modification is expected to additionally generate around 2.7 Mt CO_2-e of scope 1 and 2 greenhouse gas (GHG) emissions (excluding decommissioning).	HVEC undertakes regular reviews and monitoring of GHG emissions and energy efficiency initiatives to ensure that emissions per tonne of product coal are kept to the minimum practicable level.
Biodiversity	The Modification would not result in any new types of potential impacts on biodiversity, but an incremental increase in the surface disturbance area. The Modification would require the removal of approximately 24.6 ha of native vegetation, comprising mostly derived grasslands (23.7 ha), woodland (0.7 ha) and planted trees (0.2 ha). There are no prescribed biodiversity impacts relevant to the Modification.	The Modification requires a total of 566 ecosystem credits for clearance within the development footprint. HVEC is prepared to provide biodiversity offsets for Delma vescolineata should it be listed under the BC Act in the 12 months following determination of the Modification. The approved mitigation, management and monitoring measures in the approved Biodiversity Management Plan are considered appropriate for the Modification.
Aboriginal cultural heritage	Three known Aboriginal heritage sites of low archaeological significance would be directly impacted by the Modification, and one additional site may be indirectly impacted. Overall, the Modification is not expected to cause a loss of heritage resources considered very rare or unique or unlikely to exist elsewhere. The Modification would not therefore result in any significant cumulative impact on Aboriginal heritage in the region.	Artefacts within the Modification disturbance areas would be salvaged for safekeeping in accordance with stakeholders wishes, consistent with MAC's existing Aboriginal Heritage Management Plan (AHMP).

Assessment component	Predicted residual impacts	Mitigation measures
Visual impacts	The visual impact of the Modification at various viewpoints was assessed as negligible. The current visual magnitude of MAC would be reduced in a number of locations (i.e. relative to approved impacts), but the establishment of the rehabilitated landform would be delayed. As the visual impacts of the Modification are considered to be negligible, there would be a negligible increase in cumulative visual impacts from the Modification.	Visual impact mitigation and management measures would continue to be applied, including: - progressive rehabilitation, - vegetative screening, - measures to mitigate potential night-lighting impacts.
Surface water	The Modification is predicted to result in: - very limited changes in flow regimes in local creeks, - negligible impacts on water quality in local watercourses or the Hunter River. The likelihood that residents or other water users will be impacted by surface water changes associated with the Modification is very low.	Existing management and monitoring measures for potential surface water impacts are considered sufficient to identify and manage potential surface water impacts.
Groundwater	Minimal impacts predicted overall as a result of the Modification: - The Modification would not directly intercept groundwater from the Hunter Regulated River Water Source, or the Hunter Regulated River Alluvial Water Source and Unnamed Alluvium within Jerrys Water Source, under the 2016 and 2009 Water Sharing Plans. - No water is predicted to be lost from the Hunter River alluvium. - No changes in net flow in the Hunter River, Saddlers Creek, Ramrod Creek, Whites Gully, or other minor creeks. - No private bores are predicted to be impacted.	An effective cut-off wall has been constructed to minimise groundwater movement from the Hunter River alluvium to MAC mining area during and post mining. The mine plan for the Modification includes strategies to manage mine affected water in accordance with existing MAC operations. Groundwater monitoring is conducted in accordance with the Mt Arthur Coal Groundwater Monitoring Program (GWMP). No additional mitigation measures are warranted to inhibit impacts from mining to the alluvial groundwater system.

Assessment component	Predicted residual impacts	Mitigation measures
	- No areas of potential Groundwater Dependent Ecosystems (GDEs) are expected to experience drawdowns. - The vast majority of the predicted cumulative drawdown impacts result from other mining activities and are unrelated to the Modification. - No water quality impacts are predicted during and post mining operations.	
Road transport	Taking into account cumulative background growth and other developments in the region, the future operating conditions of the road network surrounding MAC are predicted to be acceptable, with no significant impacts identified on the performance, capacity, efficiency and safety of the road network.	No specific management or mitigation measures are considered to be warranted.

3.3.1.1 NOISE AND BLASTING

Appendix A of the Modification Report contains the Noise and Blasting Impact Assessment (RWDI, 2023) for the Modification.

Predicted noise impacts

The operational noise modelling conducted for the modification relied on a scenario using conservative assumptions that represented the combination of operations occurring at the westernmost extent of the site at (or very near) the maximum proposed production rate prior to closure.

The operational noise levels assessment found that noise predictions are expected to comply with the day and evening noise impact assessment criteria at all privately-owned receivers. The Modification would therefore not materially impact on the acoustic amenity of the surrounding community during those periods. Night-time predictions show exceedances of the noise impact assessment criteria at three privately-owned receivers. One of these receivers is already subject to acquisition rights for predicted air quality impacts associated with the approved operation, while the other two already have the right to additional air quality mitigation upon request and would be afforded the right to additional noise mitigation upon request should the Modification be approved.

A contemporary assessment of potential impacts on vacant land was conducted in accordance with the NSW Government's Voluntary Land Acquisition and Mitigation Policy (VLAMP). The noise generated by the Modification is predicted to comply with the vacant land noise assessment criteria on all privately-owned land.

If approved, the Modification would continue to operate concurrently with the Bengalla Continuation of Mining Project, the Mount Pleasant Operation, the Maxwell Underground Coal Mine Project and the Mangoola Coal Continued Operations Project. All cumulative noise level predictions comply with the amenity noise levels during the day, evening and night assessment periods.

The Modification would finally not involve any changes to the drill and blast programme and blast designs, although a minor extension of the Windmill Pit is proposed. HVEC has in place agreements with service providers allowing an increase in the ground vibration blast impact assessment criteria for public infrastructure along Denman road.

Mitigation measures

HVEC applies a comprehensive suite of noise mitigation and noise management measures on site which are described in the MAC Noise Management Plan (NMP). These include:

- contemporary technology fixed plant, including acoustic design such as cladding of bins, crushers, conveyors and the washery;
- noise suppression, currently fitted on all major mobile equipment where reasonable and feasible;
- mobile equipment being is operated in less exposed areas during the evening and night; and
- the implementation of additional proactive and reactive mitigation measures based on the predictive modelling system and real-time monitoring, and in accordance with MAC's Trigger Action Response Plan (TARP).

HVEC would continue to implement management and mitigation measures for the Blast Control Areas.

Valuation

The costs associated with the proposed noise mitigation measures have been incorporated in the Modification's operating and capital expenditure costings.

3.3.1.2 AIR QUALITY

Appendix B of the Modification Report contains the Air Quality and Greenhouse Gas Impact Assessment (Todoroski Air Sciences, 2023) for the Modification.

Predicted air quality impacts

The potential air quality impacts of the Modification were assessed using air dispersion modelling, on the basis of local weather and dust monitoring data, and incorporating activities at other nearby coal mining operations. Overall, the assessment concluded that the Modification would result in a continuation of air quality emissions to 2030 at a reduced rate relative to the approved Project. The results further indicate that:

- No privately owned receptors are predicted to exceed the NSW EPA impact assessment 24 hour average particulate matter ≤2.5µm (PM2.5) or particulate matter ≤10µm (PM10) criteria for Modification-only impacts.
- One privately owned receptor (which currently has acquisition upon request rights for potential air quality impacts and would continue to be afforded such rights) is predicted to experience exceedances of the relevant cumulative annual average PM10 criteria. However, given that the predicted exceedances would occur irrespective of

the Modification, the Modification would not contribute to an exceedance of the relevant cumulative criteria at any privately owned receptors.

- With the application of a reactive dust mitigation strategy and incorporation of real-time/predicted management systems, no privately owned receivers are predicted to exceed the cumulative 24 hour average PM10 or PM2.5 criteria.
- No parcels of land are predicted to exceed the relevant VLAMP criteria for privately-owned land.
- Predicted levels for the assessed dust metrics would be above the relevant criterion at a number of mine owned receptor locations.
- There are no likely adverse air quality impacts associated with rail transport for the Modification.
- Any blast fume impacts would be mitigated using existing management practices.

Mitigation measures

The approved MAC Air Quality Management procedure sets out the dust control measures for a range of activities for MAC, which would continue to be applied. Further, the TARP described in the MAC Air Quality Management Plan is a reactive dust mitigation strategy with alarms to alert staff of the potential for dust impacts. High dust concentration alarms trigger the implementation of dust management actions that appropriately modify any mining activities depending on weather conditions. Alarm triggers are set on a range of time intervals to ensure excessive dust levels do not occur.

A predictive system is also utilised to supplement the reactive operational dust mitigation strategies. This system provides daily forecast meteorological and dust dispersion predictions which allows the mine operators to make proactive operational adjustments and allow for the prospect of averting any triggering of the reactive controls due to excessive dust levels.

Valuation

The costs of implementing the existing Air Quality Management procedure, including the TARP, has been incorporated in the Modification's costings.

3.3.1.3 GREENHOUSE GAS EMISSIONS

Appendix B of the Modification Report contains the Air Quality and Greenhouse Gas Impact Assessment (Todoroski Air Sciences, 2023) for the Modification.

Predicted greenhouse gas emissions impacts

The Modification is expected to additionally generate around 2.7 Mt CO_2-e of scope 1 and 2 greenhouse gas (GHG) emissions (excluding decommissioning).

Mitigation measures

The costs associated with various mitigation measures to minimise the overall generation of GHG from the Modification have been incorporated in HVEC's costings.

MAC undertakes regular reviews and monitoring of GHG emissions and energy efficiency initiatives to ensure that GHG emissions per tonne of product coal are kept to the minimum practicable level. Given the relatively short duration remaining for operations, abatement measures involving large capital expenditure are not considered feasible by BHP. Reasonable and feasible emissions reduction and/or energy efficiency initiatives that would be implemented if the Modification is approved include:

- consideration of ways to reduce energy consumption during project planning phases and of more energy efficient alternatives;
- regular scheduled maintenance of equipment and plant;
- maintaining records of monthly electricity use and monthly ROM coal production to allow calculation of GHG emissions;
- reducing unnecessary lighting around the mine site; and
- participation in the Federal Government's Safeguard Mechanism under the National Greenhouse and Energy Reporting Act 2007.

Valuation – EA Technical Notes

The EA Technical Notes require the Scope 1 and Scope 2 emissions of a project to be reported and valued, given that these are under the direct control of a project proponent.[4] Where the valuation of GHG emissions is concerned, the EA Technical Notes (p.48) reference the 'NSW Government Guide to Cost-Benefit Analysis' (NSW Government, 2017), which state that market prices should be used as a basis for valuing the costs of carbon emissions, provided that those market prices are not significantly biased (p.61). The EA Technical Notes (p.48) further cite the 'Review of the NSW Energy Savings Scheme' (NSW Government, 2015), which state that the NSW Government expressed a strong preference for the use of market data in valuing GHG emissions (p.128).

Given that, at the time of writing the EA Technical Notes, there was considered to be (p.48) "*no identified carbon price in Australia*", future prices published by the European Energy Exchange (EEX) were suggested as a market-based option. However, since that time Australian Carbon Credit Units (ACCUs), have become increasingly accepted as a valid price for emissions

[4] The EA Technical Notes do not require Scope 3 emissions to be valued, noting that (p.45) "*.. the Scope 3 accounting framework is inconsistent with established national accounting rules established under the UN Framework Convention on Climate Change, and could potentially result in 'double counting' of emissions when applied to conjunction with Scope 1 and 2 because emissions 'ownership' would be attributed to both the producer and end-user of a product, service or fuel.*"

abatement, and are regularly traded in secondary markets in Australia. ACCUs represent an offset for one tonne of CO_2-e emissions that are stored or avoided by landowners and entities from other industry sectors in Australia.

The Emissions Reduction Fund which issues and credits ACCUs for eligible GHG abatement activities under the auspices of the Clean Energy Regulator (CER) has existed since 2014. Kyoto-compliant ACCUs are purchased by the Australian Government to meet Australia's climate change commitments, by industrial facilities that are covered by the Safeguard Mechanism, and by 'voluntary' purchasers, state and local governments or corporate buyers who have made voluntary emissions reductions pledges. The recent independent review of the ACCU scheme also confirmed the scheme's design and integrity (Chubb et al., 2022).

To value the projected GHG emissions in the Modification and Base Case scenarios, we have therefore relied on the clearing price for ACCUs, as determined by the most recent auction held by the CER in March 2023.[5] We have further assumed that ACCU prices will continue to increase by 3 per cent per annum in line with historic trends since ACCUs were first auctioned in April 2015.[6] On that basis, the estimated global cost of the incremental GHG emissions (Scope 1 and Scope 2) of the Modification would be $51 million ($33 million in NPV terms). The sensitivity analysis shown in Section 3.5 investigates the implications of higher or lower carbon prices.

The EA Technical Notes further say that only a share of the cost of GHG emissions should be attributed to a project (p.49):

> *The value of the externality is limited to the impact on NSW, consistent with the Guidelines and how all other costs/benefits are measured within the CBA.*

The Technical Notes do not prescribe a specific methodology for adjusting the overall externality cost of GHG emissions to reflect the impact to NSW. In the past, various approaches have been accepted by the NSW Government and the Independent Planning Commission (IPC), including allocating the cost of GHG emissions on the basis of:

- NSW' share of global gross domestic product (GDP), as in the EA for the Vickery Extension Project (AnalytEcon, 2018);[7]

[5] https://www.cleanenergyregulator.gov.au/ERF/auctions-results

[6] The future supply/demand balance and therefore future prices for ACCUs are uncertain. While some commentators predict rising ACCU prices (NAB, 2023), others consider the market for ACCUs to be oversupplied and do not anticipate significant prices rises (BCG, 2023).

[7] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-7480%2120190303T213440.399%20GMT.

- NSW' share of the global population, as in the EA for the Mangoola Coal Continued Operations Project (Cadence Economics, 2019);[8] and
- NSW' share of the Australian population, as in the EA for the Maxwell Underground Coal Mine Project (Deloitte Access Economics, 2019).[9]

The implications of all three methods for allocating the costs of the Modification's incremental GHG emissions are summarised in Table 3-5. For the purpose of determining the net benefits of the Modification to the NSW community (Section 3.4), we have attributed GHG emissions costs to NSW on the basis of the share of the NSW population of the world population. This approach results in incremental GHG emissions costs of $0.05 million to NSW ($0.04 million in NPV terms). Variations to the carbon price and apportionment method are considered in the sensitivity analysis in Section 3.5.

As a matter of economics, there is generally no single 'correct' approach for allocating or apportioning costs. In the current context, the alternative approaches for allocating or apportioning social costs are based either on production, as measured by GDP, which is a price dependent measure and hence only a proxy for physical production, or consumption, as proxied by population. As production and consumption are essentially equivalent, as measured by total GDP, the difference comes down whether the liability for social costs rests with producers or consumers, who are ultimately the beneficiaries of the production processes that give rise to emissions.[10]

Table 3-5. Incremental GHG emissions costs and cost attribution to NSW ($2022)

Global cost (Valuation on the basis of ACCUs)	NSW allocation of GHG emissions:		
	NSW share of global GDP	NSW share of global population	NSW share of Australian population
NPV $ millions			
$33	$0.12	$0.04	$10.3

Notes: As of June 2022, the NSW population was around 8.15 million, compared to the world population of around 7.9 billion. (ABS 2022; World Bank 2022).

Source: AnalytEcon.

[8] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-8642%2120190705T021704.991%20GMT.

[9] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=SSD-9526%2120190808T070816.162%20GMT.

[10] Given that both GDP and population are proxies for the physical activity that generate GHG emissions, neither are ideal in the sense of equity between countries and their populations.

Valuation – NSW Government Guide to Cost-Benefit Analysis

The NSW Government has recently released a revised Guide to Cost-Benefit Analysis and associated technical note (NSW Government 2023a, 2023b) that indicate the Government's preferred approach to valuing carbon in the context of a CBA to evaluate Government initiatives, such as infrastructure spending or policies and regulations. The recommended approach for valuing carbon emissions for public infrastructure projects is based on the market price of the EU Emissions Trading System (ETS) mechanism, escalated by 2.25 per cent per annum each year after FY 2023. The Guide further clarifies that each tonne of carbon that occurs in NSW should be counted as a whole and not pro-rated. On that basis, the cost of the incremental GHG emissions attributable to the Modification would be estimated at $339 million ($216 million in NPV terms). Variations to the carbon price are also considered in the sensitivity analysis in Section 3.5.

3.3.1.4 BIODIVERSITY

Appendix D of the Modification Report contains the Biodiversity Development Assessment Report (BDAR), (Resource Strategies, 2023). Hunter Eco (2023), Bolwarra (2023) and Future Ecology (2023) undertook flora and fauna surveys of the potentially affected land and wider area around MAC.

Predicted flora impacts

The flora surveys investigated the flora and vegetation communities across a study area encompassing the additional surface works associated with the Modification. Two vegetation communities were mapped across the study area with both of these communities present in remnant vegetation and derived native grassland form. Two tree species indicative of threatened Box-Gum woodland were present in fragmented woodland clusters and scattered paddock trees; these would also potentially serve as koala habitat. Detailed targeted transect searches did not locate any threatened flora species, and there was no evidence of GDEs.

Where the threatened flora survey was concerned, it was noted that the typical ground layer condition within the study area associated with the Modification has been modified by cultivation, grazing and exotic species coverage, resulting in habitat that is unlikely to support any of the target threatened species.

The Modification would require the progressive removal of 24.6 ha of native vegetation, comprising mostly derived grasslands (23.7 ha), woodland (0.7 ha) and planted trees (0.2 ha). The Box-Gum woodland critically endangered ecological community (CEEC) in the development footprint were deemed not to be a good example of the community as the woodland has been heavily fragmented by past clearing and consists of small, isolated patches. The derived native grassland component of the community was deemed to be in low condition due to past clearing and the use of the paddocks for grazing livestock.

Predicted fauna impacts

Most fauna habitats showed evidence of historic and/or ongoing disturbance from grazing and mining infrastructure. The additional surface development for the Modification was found not to contain:

- nest trees (large stick nests built by raptors);
- additional threatened species that had either previously been detected with a low confidence level, or had been detected adjacent to the additional surface development area; and
- breeding habitat for certain bat species within a 2 km radius.

No threatened fauna species listed under the *Biodiversity Conservation Act (2016)* (BC Act) or (Commonwealth) *Environment Protection and Biodiversity Conservation Act (1999)* (EPBC Act) were recorded or were considered likely to use the habitat in the approximate extent of additional surface development.

Mitigation measures

The Modification involves a net reduction in approved disturbance (387 ha), as some areas previously approved for disturbance would no longer be disturbed. The development footprint (26.4 ha) is a contiguous extension of the existing/approved disturbance area and is relatively minor relative to the approved disturbance extent (6,710 ha). The Modification would therefore not result in any new types of potential impacts on biodiversity, but would instead represent an incremental increase in the surface disturbance area and continued activities. There is therefore considered to be no need to change the approved mitigation, management and monitoring measures in the approved Biodiversity Management Plan due to the Modification.

General biodiversity management measures outlined in the approved Biodiversity Management Plan that are relevant to the Modification include revegetation of the post-mine landforms, pre-clearance surveys, collecting and propagating seed, salvaging and reusing material from the site for habitat enhancement, controlling weeds, controlling feral pests and bushfire management.

Valuation

The Modification would result in the loss of approximately 0.3 ha of woodland and 22.5 ha of derived native grassland equivalent to the Box-Gum Woodland CEEC listed under the BC Act. As a result of running the BAM Credit Calculator, it was determined that the Modification would require a total of 566 ecosystem credits for clearance within the development footprint, and that a land-based offset in the order of 285 ha would be required at a cost of around $5 million. A cost of $5 million to account for the cost of a land-based offset has therefore been incorporated in the Modification's costings in FY 2024.

HVEC is cognisant that the new species of legless lizard *(Delma vescolineata*) has only recently been identified as a separate species, and may, in time, potentially be listed as a threatened species under the BC Act. On this basis, HVEC is prepared to provide biodiversity offsets for *Delma vescolineata* should it be listed under the BC Act in the 12 months following determination of the Modification.

3.3.1.5 ABORIGINAL HERITAGE

Appendix E of the Modification Report contains the Aboriginal Cultural Heritage Assessment (ACHA) for the Modification (Niche, 2023).

Predicted Aboriginal heritage impacts

The disturbance area associated with the Modification is of social significance to the Aboriginal community, but has been extensively cleared of vegetation. Its archaeological value is considered moderate. A total of three known Aboriginal heritage sites (each of low archaeological significance) are located wholly or partially within the disturbance area and would be directly impacted by the Modification. A further Aboriginal heritage site of low archaeological significance, located directly adjacent to the area that would be disturbed, may potentially be indirectly impacted from ancillary infrastructure activities. The ACHA concluded that all previously and newly recorded sites have no aesthetic values nor any specific educational opportunities.

Overall, the Modification is not expected to cause a loss of heritage resources that could be viewed as being very rare or unique or unlikely to exist elsewhere. The Modification would not therefore result in any significant cumulative impact on Aboriginal heritage in the region.

Mitigation measures

Management of the Aboriginal cultural heritage sites would be conducted under MAC's existing Aboriginal Heritage Management Plan (AHMP). The AHMP provides for the following steps to be taken to mitigate potential harm:

- Aboriginal community consultation with Registered Aboriginal Parties and field work engagement;
- the surface salvage collection prior to the disturbance occurring;
- a process of designation of areas approved for development; and
- the temporary storage of recovered materials in the approved Temporary Keeping Place.

The ACHA further recommends avoiding potential indirect impacts on the fourth potential site by fencing.

Valuation

Consistent with the EA Technical Notes, the costs of compliance with the recommendations in the ACHA, the ongoing application of the AHMP and all related processes have been included in the Project costings.

3.3.1.6 LANDSCAPE AND VISUAL IMPACTS

Appendix F of Modification Report contains the Landscape and Visual Impact Assessment (BHP, 2023).

Predicted visual and landscape impacts

The potential visual impacts of the Modification were assessed from six representative viewpoints. In all cases, the visual impact was assessed as negligible. Since the Modification would involve a reduction in final emplacement heights, the visual magnitude of MAC would be reduced in a number of locations relative to the approved MAC. However, given that the Modification would extend mining activities by an additional four years, the establishment of the rehabilitated landform would accordingly be delayed.

Other potential visual impacts were also assessed. The assessment found that there would not be direct views of night-lighting sources from public roads and residential areas, but that sky glow may occur as a results of vehicle and stationary work lights during overcast nights.

Where cumulative impacts are concerned, it was noted that the Modification involves various changes to a currently approved large-scale mining operations, which includes significant existing surface infrastructure and disturbance areas, and that MAC is located in an existing mining precinct. The Modification locality has therefore already been subject to considerable modification due to these existing mining operations. These existing mining and power generation operations would remain visually dominant if the Modification were to proceed. As the visual impacts of the Modification are considered to be negligible, there would be negligible increase in cumulative visual impacts from the Modification.

Mitigation measures

The mitigation and management measures that would be implemented to maintain the visual amenity if the Modification is approved reflect the measures currently in place at MAC:

- progressive rehabilitation, consistent with the MAC Rehabilitation Management Plan, Rehabilitation Strategy, and Annual Forward Program;
- vegetative screening along main and local roads surrounding MAC; and

- various measures to mitigate potential night-lighting impacts, consistent with the existing approval and the Visual Impacts Management Report, including compliance with relevant Australian standards, restrictions of night-lighting to the minimum required, the use of directional lighting techniques and the use of light shields.

Valuation

The costs of the landscape and visual impact mitigation measures have been included in the costings of the Modification.

3.3.1.7 SURFACE WATER

Appendix G of the Modification Report contains the Surface Water Assessment (ATC Williams, 2023) for the Modification.

Predicted surface water impacts

The impact of sediment dam overflows on downstream water quality is likely to be negligible. Such overflows would occur during wet weather when there is likely to be significant flow in the Hunter River and Saddlers Creek. Overflow from the sediment dams would therefore be highly diluted.

Licensed discharge of water from the environmental dam is unlikely to result in significant impacts on the Hunter River. The environmental dam typically contains low concentrations of environmentally significant metals, and controlled releases (in accordance with the Hunter River Salinity Trading Scheme [HRSTS]) from the dam are estimated to result in a less than 1 per cent increase in the electrical conductivity (EC) of the Hunter River.

Mitigation measures

Water management at MAC is undertaken in accordance with the Water Management Plan and the Erosion and Sediment Control Plan, which were developed to ensure that MAC complies with relevant license conditions and the HRSTS. The current surface water monitoring program for MAC is considered to be comprehensive and sufficient to enable potential surface water impacts associated with the Modification to be appropriately identified and managed.

Valuation

The cost of operating MAC's surface water management measures have been incorporated in the Modification's costings. No additional costs attributable to managing potential surface water impacts have been incorporated.

3.3.1.8 GROUNDWATER

Appendix H of the Modification Report contains the Groundwater Assessment (SLR Consulting, 2023) for the Modification.

Predicted groundwater impacts

All direct groundwater taken by the Modification is from the Sydney Basin North Coast Groundwater Source. The Modification does not directly intercept groundwater from the Hunter Regulated River Water Source, or the Hunter Regulated River Alluvial Water Source and Unnamed Alluvium within Jerrys Water Source, under the 2016 and 2009 Water Sharing Plans.

Predicted average inflows are comparable between the approved MAC and the Modification (i.e. the Modification would result in a continuation of these inflows for four years). The predicted maximum incremental drawdown for the water table is limited to areas immediately adjacent the western edge of MAC.

Where water impacts on alluvial groundwater or river flows are concerned, a cut-off wall has been constructed to minimise groundwater movement from the Hunter River alluvium to MAC mining area. No water is predicted to be lost from that alluvium as a result of the Modification, and there are predicted to be no changes in net flow in the Hunter River, Goulburn River, Saddlers Creek, Ramrod Creek, Whites Gully or other minor creeks. It is predicted that the average rate of seepage from the Hunter River and Saddlers Creek to the alluvium will not increase as a result of the Modification.

No private bores are predicted to be impacted as a result of mining activities from the Modification. Also, no areas of potential Groundwater Dependent Ecosystems (GDEs) are expected to experience drawdowns.

The groundwater assessment also considered cumulative impacts associated with approved and foreseeable open cut and underground coal mines surrounding MAC. The majority of the predicted cumulative drawdown impacts are not related to the Modification, but result from other existing and approved mining activities.

Finally, where potential impacts of the Modification on groundwater quality are concerned:

- During mining, the significant inward hydraulic flow gradients from the waste emplacement areas to the active open cut void would inhibit any outwards seepage to the surrounding groundwater environment, including to the alluvium and regolith. Any seepage emanating from the emplacement areas would be captured within pit voids and managed under the existing water management system.
- All workshops and storage areas at MAC are developed in accordance with current Australian standards. There is considered to be limited potential for groundwater contamination to occur in relation to workshops and fuel/chemical storage.

- Post closure, the proposed MAC final rehabilitated landform includes residual voids that would act as sinks to groundwater flow. The gradual increase in salinity of the residual void water bodies would not pose a risk to the surrounding groundwater regime as the residual void would remain a groundwater hydraulic sink in perpetuity.

Proposed mitigation measures

Mitigation measures have been put in place to address potential groundwater impacts:

- The cut-off wall noted above was extended in 2021 to minimise the movement of groundwater from the Hunter River alluvium into the active mining pit. That wall forms an effective hydraulic barrier, and predictive modelling demonstrates its future effectiveness throughout the Modification implementation and in the long term post-closure.
- The mine plan for the Modification includes strategies to manage mine affected water, in accordance with existing MAC operations.

Groundwater monitoring is conducted at MAC in accordance with the Mt Arthur Coal Groundwater Monitoring Program (GWMP). If the Modification is approved, the existing groundwater monitoring regime would continue as per the GWMP over the life of the Modification.

Valuation

The costs of operating the GWMP have been accounted for the in the Modification's costings. No additional management or mitigation measures are considered to be required to address potential groundwater impacts, and no additional costs have accordingly been included.

3.3.1.9 ROAD TRANSPORT

Appendix I of the Modification Report contains the Road Transport Assessment prepared by The Transport Planning Partnership (TTPP, 2023) for the Modification.

Predicted road transport impacts

The potential impacts of the Modification on traffic conditions were assessed in terms of the expected cumulative impacts arising from the Modification, in combination with changes to existing or approved projects, or potential projects the region, and for the final year of operations at MAC during maximum employment and coal production.

The assessment found that the future operating conditions of the road network surrounding MAC (taking into account the cumulative impacts of background growth, other developments in the region, and the Modification) would be acceptable, with no significant impacts identified on the performance, capacity, efficiency and safety of the road network:

- The distribution of traffic generated by the Modification would be consistent with that of the existing MAC operations.
- With one exception, during the peak hours for MAC-generated traffic, the level of service (LOS) experienced by drivers would generally remain consistent with that found during the 2021 traffic surveys. The predicted exception relates to a small deterioration in LOS, but is considered to represent acceptable conditions.
- The future intersection operating conditions were deemed satisfactory and did not raise concerns regarding the capacity, future performance and safety of the intersections, given cumulative future traffic demands.
- No inherent safety concerns were identified in relation to the design of the principal access roads and intersections used by MAC-generated traffic. The addition of heavy vehicles associated with the Modification was not expected to result in adverse impacts on road safety along principal access roads.
- The Modification would reduce the number of train movements and overall combined road and rail demands at the level crossing.

Mitigation measures

No specific management or mitigation measures are considered to be warranted by the future operations of MAC with the Modification and other mining operations in the region.

Valuation

Given that no road transport impacts are predicted, no additional costs have been incorporated in the costings for the Modification.

3.3.2. Net public infrastructure costs

No public infrastructure costs are expected to be incurred for the Modification.

3.3.3. Loss of surplus to other industries

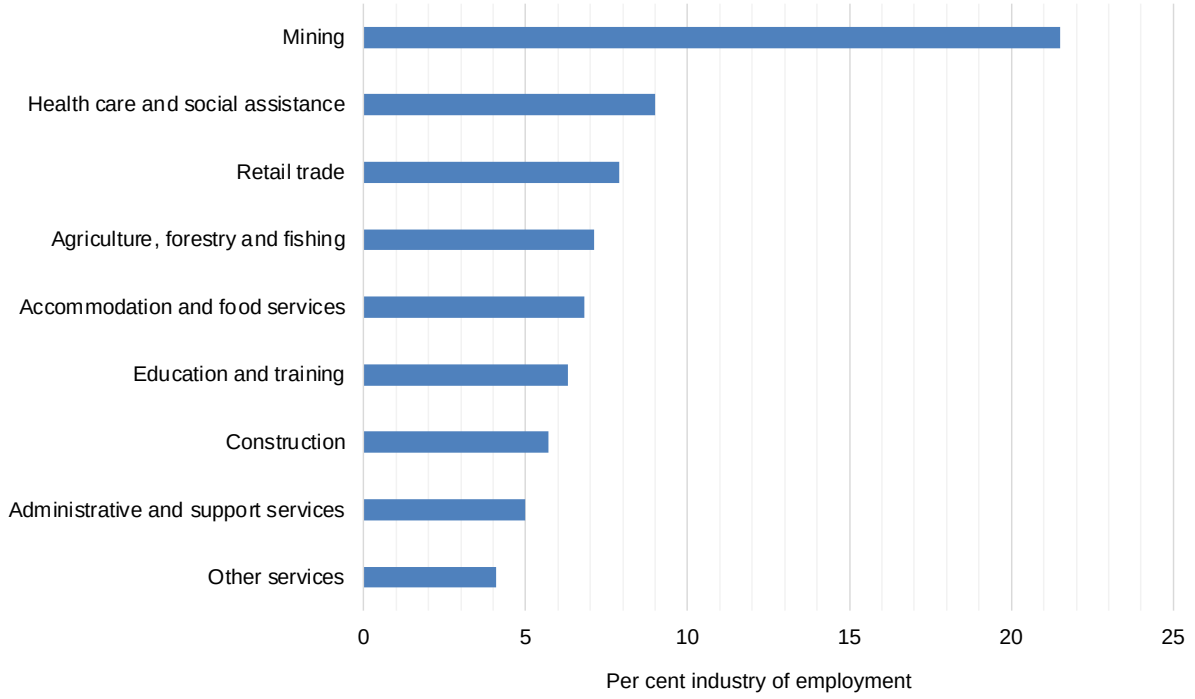
It is not apparent that the Modification would negatively impact other, for instance, tourism-related industries. As set out in Section 2.5, MAC is located in a heavily mined area in the Hunter Valley, adjacent to the Drayton Coal Mine, and proximate to numerous other Hunter Coalfield coal mines. The additional negative impacts on other industries would also be expected to be limited, given that the Modification is an extension of an existing mining operation.

Further, if the Modification is approved:

- ROM coal production, the amount of coal transported by rail, and the number of train movements would remain about the same as at present;
- there would be a minor extension of the disturbance area in the north-west corner of the operation, but an overall reduction in the approved disturbance area; and
- there would be an overall reduction in the approved height of overburden emplacement areas and the final landform.

Figure 3-1 below shows the top ten employing industries in Muswellbrook LGA in which MAC is located. Aside from mining, the top ten industries include agriculture, which also encompasses wineries and horse studs, as well as accommodation and food services, which includes tourism-related businesses (Figure 3-1).

Figure 3-1. Top ten employing industries in Muswellbrook LGA (2021 ABS census)



Source: https://dbr.abs.gov.au/region.html?lyr=lga&rgn=15650.

The Hunter Valley Wine Region is one of Australia's oldest and most renowned wine regions. However, most vineyards in the Upper Hunter wine region are located to the southwest of the town of Muswellbrook, or further north, towards Scone and Parkville.[11] Hollydene Estate Wines appears to be the closest winery to MAC at a distance of around 12 km. The mixed farming enterprise Pukara Estate is located approximately 5 km to the west of MAC.

[11] https://www.findawinery.com/huntupperfreg.html

It would seem unlikely that either of these enterprises would be affected by the relatively modest changes brought about by the Modification.

The equine industry in the Hunter Valley is centred around Denman and Scone, and there are also a number of studs located to the west of Muswellbrook, including Edinglassie Thoroughbred Stud is located about 500 meters to the north of MAC, and about 1.5km south of the Bengalla Coal Mine.

Edinglassie is a historic 500-acre heritage listed property on the banks of the Hunter River that was purchased by BHP Billiton Mt Arthur Coal in 1998 (NSW Minerals Council, 2012). It continues to be operated as a thoroughbred stud by its current lessees, and has continued to produce high quality thoroughbred race horses.[12] HVEC also monitors the potential impacts of the mine on the Edinglassie stud and homestead, including vibration from blasting, dust and noise, using a range of monitors located at the property. The Modification would not change the operation of the Edinglassie Thoroughbred Stud.

The range of scenic and tourism attractions in the Upper Hunter Valley includes national parks, nature reserves, wilderness areas and state forests, including Barington Tops National Park, Burning Mountain Nature Reserve, Goulburn River National Park, Towarri National Park, Wingen Maid Nature Reserve, Wollemi National Park, and Yengo National Park. However, all of these natural attractions are located at least 50 km away from MAC and the Muswellbrook mining precinct, and would not be impacted by the Modification.

3.4. INCREMENTAL NET BENEFITS OF THE MODIFICATION FOR THE NSW COMMUNITY

Table 3-6 summarises the estimated net benefits of the Modification for NSW. The NPV of the net benefits of the Modification accruing to NSW is estimated at $1,033 million in NPV terms, consisting of:

- royalties of around $483 million in NPV terms and other NSW State and local taxes of $16 million in NPV terms;
- the NSW share of company income tax of around $144 million in NPV terms;
- the NSW shareholders' share of the net producer surplus of around $181 million in NPV terms; and
- net economic benefits to NSW workers of around $210 million in NPV terms.

[12] https://edinglassiethoroughbredstud.com.au/; accessed 3 June 2023.

Table 3-6. Incremental net benefits for the NSW community ($2022)

Incremental direct and indirect costs	NPV $ millions	Incremental direct and indirect benefits	NPV $ millions
Direct costs		Direct benefits	
	N/a	Royalties	$483
		NSW share of company income taxes	$144
		Other NSW State and local taxes	$16
		NSW share of net producer surplus	$181
Indirect costs		Indirect benefits	
External effects that have not been compensated by HVEC (GHG emissions)	<$0.1	Net economic benefits to NSW workers	$210
Total costs	<$0.1	Total benefits	$1,033
Net economic benefits to NSW			$1,033

Notes: Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars.
Source: AnalytEcon.

As set out in Section 3.3, the Modification would potentially give rise to some limited external effects that may impact third parties. If the Modification is approved, HVEC would continue to maintain a range of approved procedures and mechanisms to mitigate these effects, or to compensate affected landowners (e.g., for potential surface water, Aboriginal heritage, biodiversity, noise and visual amenity impacts). The associated costs have been incorporated in the costings for the Modification in the CBA.

3.5. SENSITIVITY ANALYSIS

The purpose of the sensitivity analyses is to test the robustness of the results to changes in the underlying assumptions made to derive the results of the CBA.

3.5.1. Sensitivity to change in key CBA parameters

Figure 3-2 below summarises the results of the sensitivity analysis for key parameters:

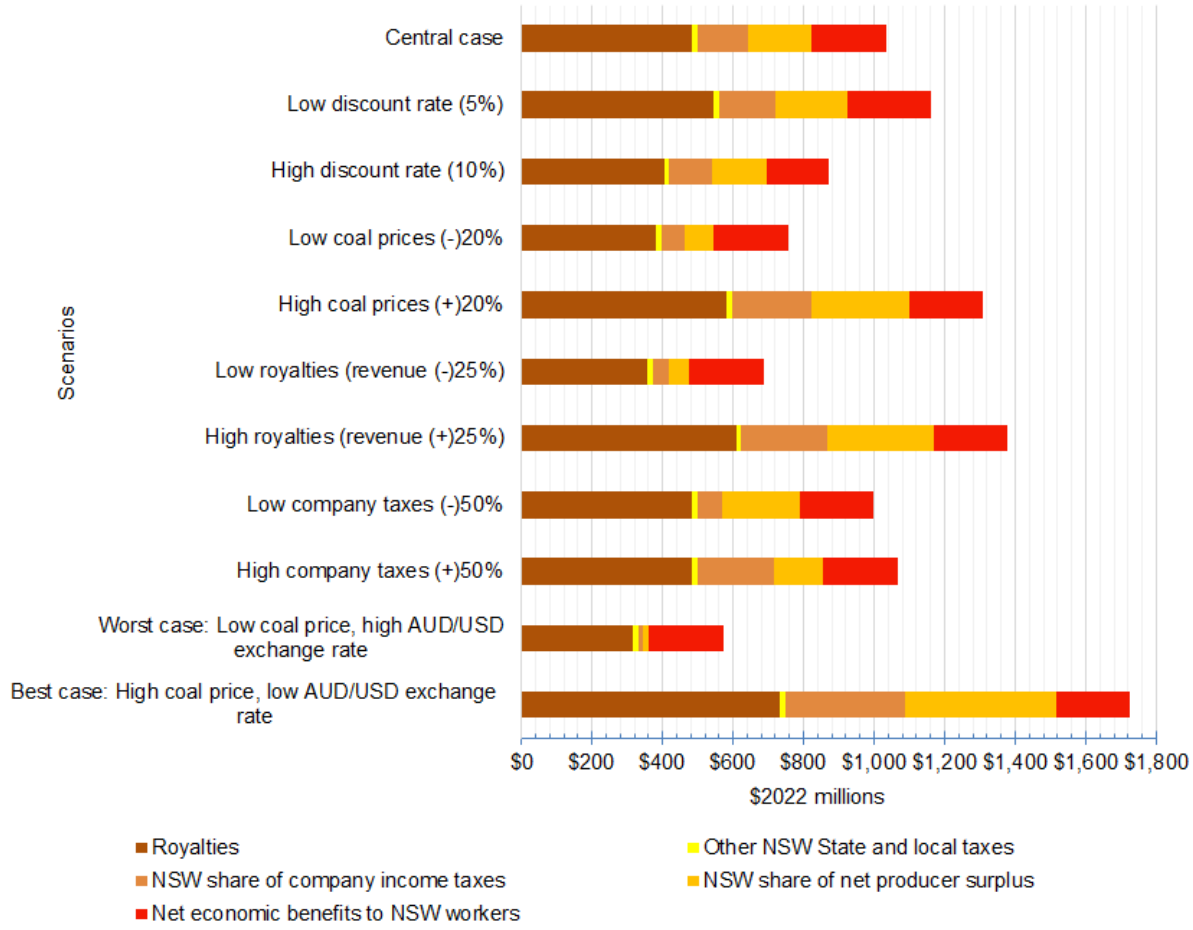
- variations in the discount rate – 5 per cent versus 10 per cent;
- variations in coal prices – all coal prices reduced and increased by 20 per cent between 2023 and 2030;
- variations in royalty payments – coal revenues reduced and increased by 25 per cent between 2023 and 2030;
- variations in the company tax rate of plus or minus 50 per cent;

- a 'worst case' scenario, which combines a 20 per cent fall in coal prices with an appreciation of the AUD/USD exchange rate by 20 per cent between 2023 and 2030; and
- a 'best case' scenario, which conversely combines a 20 per cent rise in coal prices with a depreciation of the AUD / USD exchange rate by 20 per cent.

The detailed results are shown in Appendix A.

The results of the sensitivity analysis suggest that the net benefits accruing to the NSW community remain positive in all the scenarios modelled here. Even in the 'worst case' scenario, the net benefit to NSW would remain at $572 million in NPV terms (including $315 million in NPV terms of royalties).

Figure 3-2. Summary sensitivity analysis of net benefits to NSW



Source: AnalytEcon.

3.5.2. Sensitivity to changes in carbon prices

3.5.2.1 EA TECHNICAL NOTES

The EA Technical Notes suggest undertaking a sensitivity analysis of anticipated Scope 1 and Scope 2 GHG emissions at carbon prices below and above the central estimate price. The prices to value GHG emissions have been derived as follows:

- The central price forecast relies on the price of ACCUs, as derived in Section 3.3.1.3.
- The high price forecast relies on the prices of European Union Allowance (EUA) futures, as published by the EEX (2023), which increases from around AU$134 per tonne of $CO_{2\text{-}e}$ (t $CO_{2\text{-}e}$) in 2023 to around AU$177 t $CO_{2\text{-}e}$ in 2030. Consistent with past trends, we have assumed that the price of EUA futures would continue to increase at 4.1 per annum.
- The low price forecast refers to nature-based carbon offsets, as traded in voluntary carbon markets. Nature-based offsets futures traded on the Chicago Mercantile Exchange (CME) are sourced from agriculture, forestry, and other land use (AFOLU) projects, and meet the Verified Carbon Standard and Verra Registry's Climate Community and Biodiversity Standard on climate change, local community/smallholder support, and biodiversity. May 2023 futures trading data indicates that nature-based offsets futures traded at around AU$2.52 t $CO_{2\text{-}e}$, increasing to around AU$8.43 t $CO_{2\text{-}e}$, in 2028 (CME, 2023). Consistent with past trends, we have assumed that the price of nature-based offsets would continue to increase at 28 per cent per annum.

Table 3-7 shows the results of a sensitivity to explore variations in the price used to value GHG emissions, as well as variations in the method used to attribute the imputed global costs of these emissions to NSW. As noted in Section 3.3.1.3, a range of approaches have been applied in the past to value GHG emissions from coal mining developments, including on the basis of NSW' share of global GDP, NSW' share of the global population, and NSW' share of the Australian population.

In summary, depending on the GHG valuation and attribution method that is adopted, the imputed costs of the Modification's incremental GHG emissions vary between $0.02 million and $261 million in NPV terms, and the resulting net benefit to NSW between $772 million and $1,033 million in NPV terms, respectively.

Table 3-7. GHG valuation sensitivity – EA Technical Notes, alternative GHG valuations and NSW attributions ($2022)

	Central price forecast: ACCUs	High price forecast: EUA futures	Low price forecast: Nature-based offsets
		NPV $ millions	
	Global GHG emissions costs allocated to NSW		
Incremental GHG costs	$33	$261	$22
NSW net benefit	$1,000	$772	$1,011
	Global GHG emissions costs allocated according to NSW share of global GDP		
Incremental GHG costs	$0.12	$0.80	$0.05
NSW net benefit	$1,033	$1,032	$1,033
	Global GHG emissions costs allocated according to NSW share of global population		
Incremental GHG costs	$0.04	$0.27	$0.02
NSW net benefit	$1,033	$1,033	$1,033
	Global GHG emissions costs allocated according to NSW share of Australian population		
Incremental GHG costs	$9.2	$73	$5.3
NSW net benefit	$1,023	$951	$1,028

Notes: As of June 2022, the NSW share of the Australian population was 31.4 per cent. As of December 2021, the NSW share of the world population was 0.1 per cent, and NSW' share of world GDP was 0.3 per cent. The €/AU$ exchange rate was assumed to be 1.5. Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars.

Sources: World Bank, 2022; ABS, 2022. AnalytEcon. EUA quotes from: https://www.eex.com/en/market-data/environmentals/futures; as of 14 February 2023. CEM quotes from: https://www.cmegroup.com/markets/energy/emissions/cbl-nature-based-global-emissions-offset.quotes.html#venue=globex; as of 14 May 2023.

3.5.2.2 NSW GOVERNMENT GUIDE TO COST-BENEFIT ANALYSIS

The technical notes to the NSW Government Guide to Cost-Benefit Analysis (NSW Government, 2023b) suggest that the 2022 calendar year high and low EU ETS spot price (converted to Australian dollars) may be used for sensitivity testing in a CBA. Table 3-8 shows the results of the analysis, noting that the entire global cost of the incremental GHG emissions attributable to the Modification have been allocated to NSW. Applying the carbon emissions values and approach recommended by NSW Treasury for public projects therefore yields an imputed cost of the Modification's incremental GHG emissions between $156 million and $262 million in NPV terms, and a resulting net benefit to NSW of between $771 million and $877 million in NPV terms, respectively.

Table 3-8. GHG valuation sensitivity – NSW Treasury technical notes ($2022)

	2022 EU ETS high spot price	NSW Treasury central estimate carbon emissions value	2022 EU ETS low spot price
		NPV $ millions	
Incremental GHG costs	$262	$216	$156
NSW net benefit	$771	$817	$877

Note: Global GHG emissions costs allocated according to NSW. $2022 refers to 2022 Australian Dollars.
Source: NSW Government 2023a, 2023b.

3.6. DISTRIBUTIONAL IMPACTS

The EA Guidelines recommend commenting on the distributional impacts of a proposal:

- The Modification would deliver significant direct net benefits to the NSW community as a whole in the form of royalty and direct State and local taxation payments, estimated at $483 million in NPV terms of royalty payments, $16 million in NPV terms of other State and local taxes, as well as via NSW's share of the net company income tax payments of $144 million in NPV terms.
- MAC's existing workforce would benefit from the ongoing availability of well paid, secure jobs between FY 2027 and FY 2030. In aggregate, the disposable income accruing to the workforce amounts to more than $1 billion, or around $663 million in NPV terms.
- NSW shareholders of BHP (which include superannuation funds) would benefit from the NSW share of the net producer surplus of around $181 million.
- Given the operating costs that would be incurred over the life of the Modification, local and NSW suppliers can be expected to benefit from additional sales. Incremental operating expenditures are projected to amount to around $1.35 billion in NPV terms if the Modification is approved, of which around $426 million in NPV terms would be directed to NSW suppliers if current trends continue.
- Finally, the assessments of the likely external effects associated with the Modification suggest that these are likely to be limited. The great majority of any impacts on third parties will be mitigated, and the corresponding costs borne by HVEC.

4. LOCAL EFFECTS ANALYSIS

This section describes the LEA that has been prepared for the Modification. The LEA is intended to complement the CBA by translating the net benefits attributable to NSW at the State level into local impacts.

4.1. LOCAL REGION

For the purpose of undertaking the LEA, the EA Guidelines require proponents to adopt a local study area that should match a Statistical Area Level 3 (SA3) geographic definition. That SA3 Region should contain the proposed development, but should also be capable of capturing local impacts. These local impacts particularly arise from local employment and income effects.

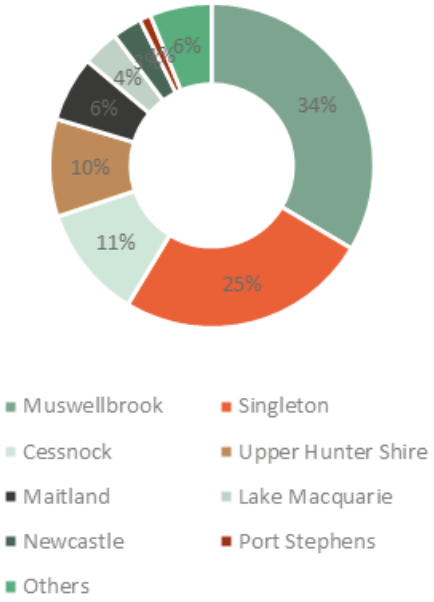
In the case of the Modification, the relevant SA3 area is the Upper Hunter SA3 Region, which includes Muswellbrook and Scone and the respective surrounding regions. The Upper Hunter SA3 Region does not, however, represent a good approximation of the geographical area where local impacts are likely to arise. Only around 34 per cent of the existing MAC workforce (which will continue to be employed if the Modification is approved) are estimated to live in the Upper Hunter SA3 Region. As set out in the Social Impact Assessment prepared for the Modification (Square Peg Social Performance 2023), around 86 per cent of MAC workforce live in LGAs in the Hunter Valley, consisting of Muswellbrook, Singleton, Cessnock, Upper Hunter and Maitland LGAs.[13]

For the purpose of preparing the LEA, we have therefore adopted the following approach:

- adopting the Upper Hunter SA3 region as one local study region, consistent with the EA Guidelines; and
- analysing a second region (the 'MAC Region') that encompasses the five LGAs where the great majority (around 86 per cent) of MAC workforce live (Muswellbrook, Singleton, Cessnock, Upper Hunter and Maitland LGAs). MAC Region is likely to better capture the local employment and income impacts of the Modification.

[13] We understand that information about workers' places of residence is available for employees only (i.e. does not include contractors). For assessment purposes, the data about employees' places of residence has therefore been extrapolated to total MAC workforce (i.e. all elements of the workforce, including contractors).

Figure 4-1. Places of residence of the MAC workforce (LGAs)



Source: Square Peg Social Performance 2023.

4.2. LOCAL EMPLOYMENT AND INCOME EFFECTS

If the Modification is approved, HVEC will continue to employ, on average, 1,672 FTEs of the existing workforce between 2027 and 2030. Of these, on average:

- 569 FTE workers are expected to reside in the SA3 Region; and
- 1,438 FTE workers are expected to reside in MAC Region.

Table 4-1 derives the incremental disposable income accruing to MAC workforce if the Modification is approved (consistent with Table 4.2 in the EA Guidelines). Table 4-1 derives the incremental disposable income relative to the median disposable employee income in the SA3 Region and MAC Region, respectively. The incremental disposable income is multiplied with the incremental employment in the Modification Scenario. The aggregate incremental disposable income over the years 2027 to 2030 is then estimated to be:

- $240 million in the SA3 Region ($157 million in NPV terms); and
- $606 million in the MAC Region ($396 million in NPV terms).

Table 4-1. Incremental disposable income attributable to the Modification, FY 2027 to FY 2030 ($2022)

				SA3 Region	MAC Region
(a)	Average incremental direct employment (2027 to 2030)		FTEs	569	1,438
(b)	Average annual disposable income MAC workers		$/FTE	$155,194	$155,194
(c)	Median annual disposable income local region		$/FTE	$46,007	$46,146
(d)	Average annual increase in net income	(b)-(c)	$/FTE	$109,187	$109,048
(e)	Aggregate increase in net income	(a)*(d)	$m ($m NPV)	$240 ($157)	$606 ($396)
(f)	FTE equivalent	(e)/(b)	FTEs	395	999

Note: $2022 refers to 2022 Australian Dollars.

Source: HVEC; AnalytEcon analysis. Population-weighted median local region employee income (2019) sourced from ABS (2023) and adjusted for inflation using the private sector wage price index (ABS 2022b).

4.3. FLOW-ON EFFECTS OF THE MODIFICATION FOR THE LOCAL COMMUNITY

This section describes the incremental 'second-round' or 'flow-on' effects that the Modification would generate for the local community. The choice of approach for deriving these flow-on effects, the necessary caveats, and the derivation of the relevant multipliers is detailed in Appendix B.

4.3.1. Approach

In this EA, input-output multipliers have been used to derive the flow-on effects of the Modification on the local economy. Economic flow-on effects can be measured using income, employment and value added multipliers. Multipliers are classified into 'types'. 'Type IA' multipliers refer to the 'initial' and 'first-round' effects arising from an increase in demand generated by a proposal; they essentially capture the immediate effects of additional expenditures on suppliers. Type IB and Type IIA multipliers capture subsequent impacts on all industries whose output is required to produce the additional output, and on households. These subsequent multipliers are calculated in a manner that compounds any measurement errors and breaches in the assumptions that underpin the analysis. A more conservative approach is therefore to rely only on multipliers that capture only first-round effects (Type IA multipliers), and this is the approach adopted here.

There are some specific issues that arise in deriving value added multipliers at a local level. Value added includes profits that are distributed on the basis of the ownership of capital assets, which becomes increasingly uncertain as the analysis becomes more granular. For instance, while a business may be located in a specific LGA, its owners may reside elsewhere in NSW or Australia, so that it is generally not possible to attribute value added at a local level.

4.3.2. Employment and income flow-on effects

Table 4-2 shows the estimated incremental flow-on effects from the Modification for the SA3 Region and the MAC Region, respectively. Table 4-2 indicates that these flow-on benefits amount to:

- additional disposable income of $207 million in NPV terms in the SA3 Region ($75 million per annum), or $550 million in NPV terms in the MAC Region ($199 million per annum); and
- additional annual average employment flow-on benefits of 330 FTE jobs in the SA3 Region, or 877 FTE jobs in the SA3 Region.

Table 4-2. Incremental flow-on effects (Type IA) of the Modification, 2027 to 2030 ($2022)

	Direct effect	Incremental aggregate flow-on effects	Annual flow-on effects
	SA3 Region		
Disposable income ($ millions)	$157	$207	$75
Employment (FTEs)	569	N/a	330
	MAC Region		
Disposable income ($ millions)	$396	$550	$199
Employment (FTEs)	1,438	N/a	877

Notes: Direct effects refer to the incremental disposable income and employment, as shown in Table 4-1.
$2022 refers to 2022 Australian Dollars.

Source: AnalytEcon.

4.4. LOCAL EFFECTS RELATED TO NON-LABOUR PROJECT EXPENDITURE

The EA Guidelines require proponents to quantify (non-labour) expenditures and to attribute those expenditures to the relevant local region. HVEC has prepared an analysis of the local operating expenditures by postcode which has been attributed to the SA3 Region and the MAC Region, respectively using suitable concordances (Table 4-3).

Table 4-3. MAC expenditure by local region ($2022)

	Percentage of operating expenditures by geography
SA3 Region	16.2%
MAC Region	29.5%
NSW	31.5%

Source: HVEC. AnalytEcon. ABS 2012. ABS 2012a.

Using the ratios derived in Table 4-3 it is possible to estimate the incremental local and NSW expenditures going forward in the Modification scenario if current purchasing patterns continue.

Table 4-4 suggests that the Modification would result in significant additional operating expenditures directed at NSW suppliers, as well as suppliers located in the SA3 Region and the MAC Region, respectively.

Table 4-4. Incremental NSW and local operating expenditures ($2022)

Geography	Operating expenditures (NPV $ millions)
SA3 Region	$219
MAC Region	$399
NSW	$426

Note: $2022 refers to 2022 Australian Dollars
Source: AnalytEcon.

4.5. ENVIRONMENTAL AND OTHER IMPACTS ON THE LOCAL COMMUNITY

MAC is an existing mine that has operated since 2002 (with mines previously operating at the site since the 1960s); the Modification would extend operations at MAC by four years. The potential external effects that have been identified are expected to be limited, and a

comprehensive system of monitoring and associated procedures is in place to minimise their potential impact (Section 3.3.1). Where necessary, HVEC would also make good negative impacts on affected landowners (e.g., by providing noise mitigation at receivers upon request).

It should also be noted that if the Modification is approved, employment at MAC would gradually decline through to 2030 (Figure 2-4). In this way, the negative effects of a sharp and significant reduction in MAC workforce that would otherwise occur post 2026 would be diminished and would be expected to be less abrupt in terms of their impact on the local community.

4.6. EFFECTS ON OTHER LOCAL INDUSTRIES

For the reasons discussed in the previous paragraph and in Section 3.3.3, it seems unlikely that the Modification would negatively affect other local industries. HVEC has comprehensive mechanisms in place to mitigate external effects that may affect third parties. It is also not apparent that the Modification would negatively impact local agricultural or tourism-related businesses. Those businesses that exist in close proximity to the mining precinct (such as the Edinglassie Thoroughbred Stud) appear to have successfully coexisted with MAC for some time.

4.7. NET BENEFITS OF THE MODIFICATION FOR THE LOCAL REGION

Table 4-5 summarises the net effects of the Modification for the local region, as derived in the previous sections. If approved, the Modification would generate:

- on average 569 direct FTE jobs in the SA3 Region or 1,438 direct FTE jobs in the MAC Region between 2027 and 2030, as well as an additional 330 and 877 flow-on jobs in the SA3 Region and the MAC Region, respectively, in those years;
- additional aggregate net disposable income of $157 million in NPV terms in the SA3 Region or $396 million in NPV terms in the MAC Region, as well as additional flow-on income of $207 million in the SA3 Region and $550 million in the MAC Region, respectively;
- additional LGA rate payments of $15.4 million in NPV terms; and
- additional expenditures directed at local suppliers that are estimated at $219 million and $399 million in NPV terms for the SA3 Region and the MAC Region, respectively.

Table 4-5. Incremental net benefits of the Modification for the local region ($2022)

	Net direct local effects		Net flow-on local effects		Total net local effects	
	SA3 Region	MAC Region	SA3 Region	MAC Region	SA3 Region	MAC Region
Employment-related (FTEs)	569	1,438	330	877	898	2,316
Incremental benefits to the local region						
Disposable income ($ millions)	$157	$396	$207	$550	$364	$946
Local government rate payments ($ millions)	$15.4	$15.4	N/a	N/a	$15.4	$15.4
Incremental costs to the local region	N/a	N/a	N/a	N/a	N/a	N/a
Incremental net benefits to the local region						
($ millions)	$172	$411	$207	$550	$379	$962
Other benefits to the local region						
Benefits to suppliers ($ millions)	$219	$399	N/a	N/a	$219	$399

Notes: Totals may not sum precisely due to rounding. $2022 refers to 2022 Australian Dollars
Source: AnalytEcon.

5. SIGNIFICANCE OF THE RESOURCE

The net benefits that are attributable to the Modification, as described in this EA, indicate the significance of the resource, in terms of the generation of taxation revenues including royalties, continued employment of a significant workforce for four years, and the share of the producer surplus attributable to NSW.

The incremental economic benefits of the Modification for NSW are estimated at around $1,033 million in NPV terms, consisting of:

- $483 million in NPV terms of incremental royalty payments;
- $16 million in NPV terms of incremental land taxes and local government rates;
- incremental disposable income payments to the workforce of $210 million in NPV terms;
- incremental company income tax payments attributable to NSW of around $144 million in NPV terms; and
- an incremental net producer surplus of around $181 million in NPV terms that is attributable to NSW shareholders of BHP.

If approved, the Modification would generate additional operating expenditures of $1,350 million in NPV terms. On current trends, around $426 million in NPV terms of those operating expenditures would be expected to be directed at NSW suppliers.

For NSW as a whole, the additional value added (or contribution to gross state product (GSP)) generated by the Modification is estimated at almost $1.1 billion in NPV terms, which would generate wider value added economic flow-on effects for the State of NSW of an estimated $219 million in NPV terms. The disposable income flow-on effects for NSW are estimated at $311 million in NPV terms, while the employment flow-on effects for the State are estimated to be 1,070 FTE workers per annum.

The Modification would deliver significant net benefits to the local region. For the Upper Hunter SA3 Region, where around 34 per cent of the current operational MAC workforce live, these incremental benefits are estimated at $379 million in NPV terms, consisting of direct and flow-on disposable income and local government rate payments. For the MAC Region, where 86 per cent of the workforce live, these benefits are estimated at $962 million in NPV terms.

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APPENDIX A. CBA SENSITIVITIES

Table A-1 provides the detailed results for the sensitivities show in Figure 3-2.

Table A-1. Incremental net benefits – detailed results for the sensitivity analysis ($2022)

	NSW royalties	Other NSW State and local taxes	NSW share of company income taxes	NSW share of net producer surplus	Net economic benefits to NSW workers	Total net benefits NSW
Central case	$483	$16	$144	$181	$210	$1,033
Low discount rate (5%)	$544	$18	$160	$201	$237	$1,160
High discount rate (10%)	$405	$13	$122	$153	$176	$870
Low coal prices (-20%)	$382	$16	$66	$82	$210	$756
High coal prices (+20%)	$583	$16	$222	$279	$210	$1,310
Low royalties (revenue (-25%)	$357	$16	$46	$58	$210	$687
High royalties (revenue (+25%)	$608	$16	$242	$303	$210	$1,379
Low company taxes (-50%)	$483	$16	$72	$219	$210	$1,000
High company taxes (+50%)	$483	$16	$216	$142	$210	$1,066
Worst case: Low coal price (-20%), high AUD/USD exchange rate (+20%)	$315	$16	$14	$17	$210	$572
Best case: High coal price (+20%), low AUD/USD exchange rate (-20%)	$734	$16	$339	$426	$210	$1,725

Note: $2022 refers to 2022 Australian Dollars.

Source: AnalytEcon.

APPENDIX B. DERIVATION OF FLOW-ON EFFECTS

This appendix describes the interpretation of input-output multipliers, the limitations of input-output analysis, and the methods used to calculate the flow-on effects of changes in the level of mining investment and production in NSW and the local SA3 Region.

B.1. Input-output multipliers

Economic impacts can be measured in terms of income, value added and employment, which in turn gives rise to income, value added and employment multipliers. Multipliers are classified into 'types'. Type I multipliers refer only to flow-on effects in the production sectors, while Type II multipliers incorporate subsequent impacts on households:

- Type IA multipliers refer to the 'initial' and 'first-round' effects arising from an increase in demand from a proposal. The first-round effect captures the immediate subsequent impacts on income, employment or value added from all industries whose output is required to produce the additional output from the proposal.
- Type IB multipliers refer to the initial and 'production induced' effects, which encompass first-round effects and additionally 'industrial support' effects. Industrial support effects capture subsequently induced effects that occur after the first-round effects (since the initial output effect from a proposal will induce additional output in other industries, which will in turn lead to further rounds of effects and so on).
- Type IIA multipliers incorporate the effects of the initial increase in output from a proposal on households and refer to the sum of production induced and consumption induced effects. Consumption induced effects capture the fact that, as a result of the additional output from a proposal and subsequent production induced effects in other industries, wage and salary earners will earn extra income which they spend on goods and services produced by all industries in the state or region.

B.2. Limitations of input-output analysis

The principal advantage of the impact multiplier method is the simplicity with which levels of mining investment, employment and output can be translated into measures of changes in regional income and employment. However, the accounting conventions that form the basis of input-output models and hence how multipliers are derived impose several restrictive assumptions. Some of these assumptions pertain to input-output analysis generally while others relate to the use and interpretation of input-output analysis at a regional or state, as opposed to a national level.

The key assumptions used for the input-output analysis of flow-on effects are summarised in the following. Many of these assumptions can lead to an overstatement of the impacts of a proposal (Bess and Ambargis 2011, Coughlin et al. 1991). The implication is that the resulting regional impact estimates should be interpreted as an upper bound of the likely effects.

B.2.1. Fixed capital stocks

The National Accounts, on which input-output analysis is based, do not explicitly account for fixed capital stocks. This is an issue with input-output analysis generally, as fixed capital has a significant impact on how an industry adjusts over time. A corollary to this is that input-output analysis is static in the sense that it takes no account of the time required for the composition of inputs and outputs of production to shift to a changed level in output. Industries that require large amounts of fixed capital and labour adjust slowly, particularly when they are near full employment or when the supply of skilled labour is tight. These dynamics are hard to predict, but the implication over the short- to medium-term is that input-output effects will be overstated to varying degrees across industries.

The fixed nature of the capital stock is a critical issue in local impact assessments. In moving from the national to a state or local level, the location of fixed assets becomes increasingly important in establishing the goods and services that are supplied locally and those which are imported. Moreover, there is no information as to whether fixed assets are owned locally or whether the owners are located outside the region or state.

B.2.2. Supply constraints

Relatedly, when the initial impact considered is an increase in production, the assumption of fixed production patterns requires that there is a sufficient endowment of resources that is either available in (or able to migrate to) a local region to meet the increase in demand for inputs whose supply is fixed. These inputs include resources such as land and water, as well as labour with adequate skills.

B.2.3. Homogenous and fixed production patterns

The input coefficients that measure inter-industry flows between sectors are ‘fixed’ in input-output models; at any level of output, an industry’s relative pattern of purchases from other sectors is unchanged. These assumptions are likely to be inconsistent with production patterns in the local economy, since the local economy may not have on offer the range of inputs required for a given industry. Therefore, the impact of the change in output on the local economy will differ from that implied by a national multiplier.

B.2.4. Fixed prices

Input-output analysis assumes that prices in the economy in question are held constant, so that the additional material and labour inputs are available at existing prices and wage rates. In reality, prices of inputs may change with substantive changes in their demand. To the extent that there is an impact on prices, imputed output effects will be overstated. However, this is only a problem in input-output analysis for projects of a sufficient scale to materially shift the demand for production inputs and the total supply of industry output.

B.3. Derivation of multipliers

The following describes the various steps required to derive state and local input-output multipliers.

B.3.1. Concordance of the national accounts with census employment data

The Australian National Accounts input-output tables set out the flows of industry inputs (columns) and outputs (rows) for 114 industry classifications. The input output tables are for the year 2020-21 which were released in March 2023. The ABS census records employment at an aggregated level with 19 industry classifications. The employment data was drawn from the most recent, 2021, census. The ABS census records employment an aggregated level with 19 industry classifications. The concordance between the census and the accounts is set out in Table B-1.

Table B-1. Industry concordance between the industries in the National Accounts and industry level employment data in the 2021 Census

Aggregate Industry	ABS National Accounts industry codes	
	Starting from	Ending with
Agriculture, forestry and fishing	101	501
Mining	601	1001
Manufacturing	1101	2502
Electricity, gas, water and waste services	2601	2901
Construction	3001	3201
Wholesale trade	3301	3301
Retail trade	3901	3901
Accommodation and food services	4401	4501
Transport, postal and warehousing	4601	5201
Information media and telecommunications	5401	6001

Aggregate Industry	ABS National Accounts industry codes	
	Starting from	Ending with
Financial and insurance services	6201	6401
Rental, hiring and real estate services	6601	6702
Professional, scientific and technical Services	6901	7001
Administrative and support services	7210	7310
Public administration and safety	7501	7701
Education and training	8010	8210
Health care and social assistance	8401	8601
Arts and recreation services	8901	9201
Other services	9401	9502

Source: 5209.0.55.001 - Australian National Accounts: Input-Output Tables, 2019-20. 2021 ABS Census.

To construct the flows of industry inputs and outputs at the same level of the census, the rows and columns are summed. For example, there are seven industries classified as being part of the broader agriculture classification. Summing the seven rows aggregates the outputs of agriculture as a whole into each of the 114 industries. Summing the resulting new rows across the seven individual agricultural industries give the total input requirements for agriculture as a whole from each the 114 regions. The final result is a balanced flow table with 19 industry classifications.

The balancing items include rows and columns that are important for the regional impact analysis:

- there are rows for wages and salaries, imports and value added, respectively; and
- there are columns for household consumption, as well as for other final demands.

B.3.2. Requirements matrix and first-round (Type IA) output multipliers

The initial requirement for an extra dollar's worth of output of a given industry is called the initial output effect. It equals one in total for all industries since an additional dollar's worth of output from any industry will require the initial one dollar's worth of output from that industry plus any induced extra output. The first-round effect is the amount of output required from all industries of the economy to produce the initial output effect.

First-round effects can be measured by deriving the 'direct requirements matrix'. In this matrix, the coefficients in a given industry's column show the amount of extra output required from each industry to produce an extra dollar's worth of output from that industry. The requirements

matrix has been constructed from the Australian input-output (flows) table by standardising the inputs into each industry to produce one unit of output in each industry. This is achieved by dividing each row of the table by the total output on an industry-by-industry basis.

The first-round impact multiplier is then the sum of the standardised inputs for a given industry. For example, each element of the column for agriculture is divided by total agricultural output and then summed to obtain the total input requirement for one addition unit of output. The initial multiplier can be interpreted as the direct costs of an additional unit of production at current prices. Given these inputs are supplied domestically, the costs are other industry outputs and therefore contribute to total economic output. The sum of the initial output effect (which equals one) and the first-round effect is the Type IA output multiplier. This is simply the total first-round contribution of a project to the economy. For a project that is small when compared to the size of the industry, the first-round and Type IA impact multipliers are valid given the requirements are representative of those used in the project.

B.3.3. Simple output or Type IB multiplier

The simple Type IB multiplier takes into account the inputs required for the increased agricultural output (for example) that must also be produced, which requires the expansion of these industries and those that support them. These may be seen as series of flow-on effects that continue until the overall industry flows are again balanced.

Calculation of the simple multipliers requires solving a matrix equation. Let A be the 19 by 19 matrix of industry requirements (as discussed above), x a vector of inputs used in each of the industries and y a vector of net outputs from the economy. Net output can be standardised to 1 for each industry, giving rise to the simple linear input-output equation:

$$Ax - x = 1$$

Solving for the overall input requirement to one additional unit of output from each industry:

$$x = (I - A)^{-1}$$

where I is an identity matrix with ones along the main diagonal and zeros elsewhere, and the superscript -1 denotes the matrix inverse.

Summing the columns of $(1 - A)^{-1}$ gives the simple multipliers. For example, summing the agricultural column gives the total inputs from all industries needed to sustain the production of one additional unit of net agricultural output at the national level.

The simple multiplier represents a shift in the composition of industry output, as well as the total level of industry output assuming constant prices. This may be reasonably valid for a small increase in, for example agricultural output. However, for large change like what has occurred

in the Australian mining industry, output prices for most industries will adjust in an offsetting manner. That is, the relative prices for the outputs that are used more extensively in mining will rise, while prices for those that are less extensively use will fall. The implication is that the simple multiplier will, for a given increase in mining output, overstate the flow-on effects in industries where relative prices rise and understate flow-on effects where relative prices fall.

For a project that is small relative to the size of industry the price effects will be small and the bias in the simple multiplier may be ignored. However, the composition of flow effects will vary if the input requirements for the project differ from those of the industry.

B.3.4. The total or Type IIA output multiplier

The total multiplier takes into account the relationship between wages and household demand, that is, the increase (decline) in household demand that results from a rise (fall) in household income. This is derived by adding the wages row and the household expenditure column to the A matrix from the requirements table. Let the expanded matrix be denoted B. The total multipliers are analogous to the simple multiplier and given by the column sums of the matrix $(I - B)^{-1}$.

The key issue with the total multiplier is that wage rates and output price changes will tend to offset the effect. In a limiting case, an increase in wage rates will result in an increase in output prices and leave total output and real household expenditure unchanged. However, if the project is small relative to the size of the economy the effects on household income and wages can be ignored.

B.3.5. Employment, income, and value added multipliers

First-round, simple, and total employment, income and value add multipliers can be calculated in much the same way as the output multipliers. The caveat noted for wage rates and employment in the previous section applies.

EMPLOYMENT MULTIPLIERS

To calculate employment multipliers requires information about employment by industry that is provided in the ABS National Accounts (Table 20). For each industry, the FTE level of employment is divided by total industry output. This creates a vector of employment requirements per unit of output (denoted h) that can be used to convert the physical input requirements per additional unit of industry output into requirements for labour. The sum of these labour requirements constitutes the employment multipliers, written in matrix notation as:

Type IA: hA;

Type IB: $h(I - A)^{-1}$

Type IIA: $h(I - B)^{-1}$

These multipliers give the FTEs of employment needed to support an additional unit of output. These multipliers can be adjusted to Type IA, Type IIA multipliers by expressing the multiplier as the total employment needed per person directly employed on the project. This is done by dividing each of the multipliers above by the number of workers required per unit of output. They are not the number of jobs created as this will be impacted by the number of part-time workers that are converted to full-time workers or vice versa.

INCOME MULTIPLIERS

The calculation of the income multiplier is done in the same way. The wage and salary requirement per unit are given in the requirements table. Designating these as a vector w the income multipliers written in matrix notation are:

Type IA: wA;

Type IB: $w(I - A)^{-1}$

Type IIA: $w(I - B)^{-1}$

These multipliers can be adjusted to Type IA, Type IIA multipliers by expressing the multiplier as the total income per dollar of salaries and wages expended directly on the project. This done by dividing each of the multipliers above by the salaries and wages required per unit of output.

VALUE ADDED MULTIPLIERS

Value added is the value of industry output less the costs of inputs, whether produced domestically or imported. This can again be calculated, as a vector, v, from the requirements table as value added per unit of industry output. The multipliers are then calculated in an identical way to employment and income:

Type IA: vA;

Type IB: $v(I - A)^{-1}$

Type IIA: $v(I - B)^{-1}$

These multipliers can be adjusted to Type 1A, Type 2a multipliers by expressing the multiplier as the total income per dollar of value added by the project. This done by dividing each of the multipliers above by the valued added per unit of output.

B.4. Regional impacts

It is not possible to maintain the level of consistency that exists in national input output tables at a regional level. Comprehensive data on industry composition, household consumption and the flow of goods and services to and from regions is not available.

B.4.1. Location quotients

A standard approach that can be reproduced across different regional definitions in a consistent manner is to use employment by industry data to form what are known as location quotients (LQs). Employment based LQs are ratios that indicate the percentage of people employed in a particular industry at a state or regional level, relative to the percentage of people employed in that industry in the national economy. Employment based LQs are then used to proportionally adjust the contribution of an industry to the use of intermediate inputs in a state or region. The consequent shortfall in intermediate inputs is made up by increasing 'imports' from outside the state or region across all industries.

LQs are used to translate economy-wide input-output relationships into state or regional relationships. Hence the national input-output tables need to be adjusted to better reflect the characteristics of the local economy.

The use of employment LQs has a critical limitation. Input-output tables do not explicitly account for fixed capital, human or physical, although the returns to these assets are implicitly reflected in wages and operating surpluses (profits). As the impact analysis becomes more granular, the geographic location of these assets becomes increasingly important. A local region may simply not have the fixed capital needed to cost-effectively produce the input required by a local industry. The input is then 'imported' from other regions, states, or from overseas.

B.4.2. Adjusting regional/state industry composition and trade

A raw LQ is simply the percentage of FTE employment in a given industry and region, divided by the percentage of FTE employment in a given industry at the national level. This may be written for the ith industry and the jth region as:

$$LQ_{i,j} = \frac{\frac{\text{employment}_{i,j}}{\sum_j \text{employment}_{i,j}}}{\frac{\sum_j \text{employment}_{i,j}}{\sum_i \sum_j \text{employment}_{i,j}}}$$

The LQ has a natural interpretation for an industry within a region:

- if the LQ is less than one, the goods and services from that industry will tend to be imported into the region to meet demand; while
- if the LQ is greater than one, the goods and services from that industry will tend to be exported into the region to meet demand elsewhere.

Given that goods and services and labour requirements are the same in all regions, the relationship will tend to be proportional so long as the actual size of the labour force does not represent a constraint. These are standard assumptions in an input output analysis. However, at the regional level, the violation of these assumptions can often be more apparent. For example, specialised good or services demanded for a project may simply not be produced domestically and may have to imported, with a consequent reduction in regional flow-on effects. However, this can be addressed within the context of the requirements table if project information on where purchases are made is available.

Total employment may not be a constraint for a large region, such as a state. However, while a large proportion of people may be employed in an industry in a small region, the overall workforce in that industry may not be sufficient to meet labour requirements. While this may in part be offset by migration, it can simply be more efficient to import goods and services into the region.

It is recommended practice (Bess and Ambargis 2011) to adjust the raw LQs in small regions by the following formula:

$$LQ_{i,j} = \begin{cases} LQ_{i,j} & if \quad LQ_{i,j} < 1 \\ 1 & if \quad LQ_{i,j} >= 1 \end{cases}$$

LQs consist of the ratio of an industry's share of regional earnings to the industry's share of national earnings. This adjustment has the effect of holding constant or reducing regional flow-on effects. The basic idea is that industries in the region are not likely to produce all of the intermediate inputs required to produce the change in final demand. In these cases, local industries must purchase intermediate goods and services from producers outside the region, thereby creating leakages from the local economy.

B.4.3. Regional multipliers

Given LQ is a vector of location quotients, the regionally adjusted Type IA and Type IB input multipliers are calculated by multiplying the industry requirements by the quotients. The output multipliers are the column sums of:

Type IA: $LQ' A$;

Type IB: $(I - LQ' A)^{-1}$

Type IIA: $(I - LQ' B)^{-1}$

Where × denotes element-by-element multiplication of each column of A by LQ.

The income, employment and value add multipliers are calculated in the same manner as the national multipliers.

B.5. Mining multipliers

Table B-2 shows NSW multipliers derived from the 2019-20 National Accounts tables and employment data for income, employment (FTEs), and value added (contribution to gross domestic product).

Table B-2. NSW input-output multipliers - Mining

Multiplier	Type IA	Type IB	Type II
Income	2.48	4.83	8.08
Employment	1.64	3.18	4.30
Value Added	1.20	2.36	2.71

Source: AnalytEcon.

Table B-3 shows the multipliers for the SA3 Region.

Table B-3. Upper Hunter SA3 Region input-output multipliers – Mining

Multiplier	Type IA	Type IB	Type II
Income	2.32	4.33	6.92
Employment	1.58	2.98	3.85
Value Added	1.20	2.32	1.60

Source: AnalytEcon.

Table B-4 shows the multipliers for the MAC Region.

Table B-4. MAC Region input-output multipliers – Mining

Multiplier	Type IA	Type IB	Type II
Income	2.39	4.55	7.37
Employment	1.61	3.06	4.01
Value Added	1.21	2.35	2.65

Source: AnalytEcon.