ASSESSING THE CUMULATIVE IMPACTS OF MINING ON REGIONAL COMMUNITIES: AN EXPLORATORY STUDY OF COAL MINING IN THE MUSWELLBROOK AREA OF NSW

David Brereton, Chris Moran, Gillian McIlwain, James McIntosh, Kailee Parkinson
CENTRE FOR SOCIAL RESPONSIBILITY IN MINING, CENTRE FOR WATER IN THE MINERALS INDUSTRY, UNIVERSITY OF QUEENSLAND
DISCLAIMER

No person, corporation or other organisation ("person") should rely on the contents of this report and each should obtain independent advice from a qualified person with respect to the information contained in this report. Australian Coal Research Limited, its directors, servants and agents (collectively "ACR") is not responsible for the consequences of any action taken by any person in reliance upon the information set out in this report, for the accuracy or veracity of any information contained in this report or for any error or omission in this report. ACR expressly disclaims any and all liability and responsibility to any person in respect of anything done or omitted to be done in respect of the information set out in this report, any inaccuracy in this report or the consequences of any action by any person in reliance, whether wholly or partly, upon the whole or any part of the contents of this report.
ACARP Project C14047

Assessing the Cumulative Impacts of Mining on Regional Communities:
An Exploratory Study of Coal Mining in the Muswellbrook Area of NSW

Prepared by:
Centre for Social Responsibility in Mining
Centre for Water in the Minerals Industry
University of Queensland

February 2008

Total Expenditure: $157,390
ACKNOWLEDGEMENTS

This was a challenging project which has been a valuable learning experience for all involved. We are grateful to Ian Tredinnick, now with Xstrata Copper, but formerly of Mt Arthur Coal, for his leadership in getting the project off the ground. We also wish to acknowledge the ACARP industry monitors, Narelle Wolfe (formerly Community Relations Superintendent Mt Arthur Coal) and Carl Bagnall (former Environment and External Affairs Manager Mt Arthur Coal) and the other members of the Industry Steering Committee for their assistance, forbearance and willingness to provide detailed feedback on multiple drafts of the report. Finally, we would like to thank all of the interviewees and focus group participants, plus the members of the project reference group, for giving so freely of their time and for helping advance our understanding of the complex phenomena of cumulative impacts.

David Brereton

Chris Moran

Research Team

Project Leaders
Professor David Brereton
Professor Chris Moran

Senior Researcher
Dr Gillian McIlwain

Research Assistants
James McIntosh and Kailee Parkinson
ABBREVIATIONS

ABS       Australian Bureau of Statistics
ACARP     Australian Coal Association Research Program
AEMR      Annual Environmental Management Report
CCC       Community Consultative Committees
CHPP      Coal Handling and Processing Plant
CSRM      Centre for Social Responsibility in Mining
CWiMI     Centre for Water in the Minerals Industry
DEWR      Department of Employment and Workplace Relations
DIPNR     Department of Infrastructure, Planning and Natural Resources
DUAP      Department of Urban Affairs and Planning
EC        Electrical Conductance
EIA       Environmental Impact Assessment
EIS       Environmental Impact Statement
HRSTS     Hunter River Salinity Trading Scheme
HSEC      Health, Safety, Environment and Community
ICMM      International Council on Mining and Metals
LGA       Local Government Area
MCA       Minerals Council of Australia
Mtpa      Million tonnes per annum
NIEIR     National Institute of Economic and Industry Research
NGO       Non-Government Organisation
NSW       New South Wales
ROM       Run of Mine
SEIFA     Socio-economic Indexes for Areas
SMI       Sustainable Minerals Institute
TAFE      Technical and Further Education
UHCIS     Upper Hunter Cumulative Impact Study
UHRRRI    Upper Hunter River Rehabilitation Initiative
CONTENTS

EXECUTIVE SUMMARY ................................................................. xii

Study context......................................................................................... xii
Study scope ........................................................................................... xiii
Research Approach ................................................................................ xiv
Study Limitations .................................................................................. xv
Definitional Issues ................................................................................... xvi
Stakeholder Perspectives on Cumulative Impacts .................................. xvii
Community consultations: key findings ................................................. xviii
Findings from other studies ................................................................... xix
Project reference group workshop ...................................................... xix
Complaints analysis ............................................................................... xx
Impact analyses: key findings ............................................................... xxi
Economic Impacts .................................................................................. xxi
Visual Amenity ....................................................................................... xxii
Water Quality ......................................................................................... xxiv
Social Changes ....................................................................................... xxv
Managing Cumulative Impacts in Muswellbrook ............................... xxvi
Lessons .................................................................................................. xxviii
Future Applications ............................................................................... xxviii

Recommendations to ACARP ............................................................ xxx

SECTION 1: DEVELOPING THE FRAMEWORK ................................. 1

1.1: Introduction ................................................................................... 1
Project Administration/Project Management ....................................... 1
Project Background ............................................................................... 1
Project Objectives ............................................................................... 2
Project Structure ............................................................................... 3
Structure of the Report ....................................................................... 4
1.2: Methodology.........................................................................................................................5
  Stage 1 ........................................................................................................................................5
  Stage 2 ........................................................................................................................................6
  Stage 3 ........................................................................................................................................7
  Evaluation ...................................................................................................................................8
  Study Limitations .....................................................................................................................8

1.3: Definition, Literature Review and Typology of Cumulative Impacts ..................10
  Definition .....................................................................................................................................10
  Review of Literature ....................................................................................................................10
  Previous Research on Cumulative Impacts in the Hunter Valley .............................................12
  Cumulative Impacts Typology ....................................................................................................14
  Conclusion ...................................................................................................................................17

SECTION 2: THE MUSWELLBROOK CASE STUDY .........................................................18

2.1: Context.....................................................................................................................................18
  The Muswellbrook Local Government Area (Shire) ................................................................18
  Growth of Mining in Muswellbrook ..........................................................................................20

2.2: Stakeholders’ Perspectives of Cumulative Impacts ......................................................23
  Comparisons with Other Studies ..............................................................................................27
  The Project Reference Group workshop ..................................................................................28
  Summary .....................................................................................................................................31

2.3: Complaints Made to Mines in Muswellbrook .................................................................32
  Background ..................................................................................................................................32
  Approach .....................................................................................................................................32
  Spatial Distribution .......................................................................................................................33
  Temporal Changes .......................................................................................................................36
  Nature of Complaints ...................................................................................................................39
  Conclusions ..................................................................................................................................40

2.4: Prioritising Impact Areas for Investigation ....................................................................42
2.5: The Economic Contribution of Mining to Muswellbrook ..........43
   Employment .............................................................................................................. 43
   Direct Employment ................................................................................................. 43
   Indirect and Induced Employment ......................................................................... 46
   Summary .................................................................................................................... 48
   Implications ............................................................................................................... 49

2.6: Visual Amenity (visual exposure to mine lands) ..................50
   The Issues .................................................................................................................. 50
   Method of Measuring Visual Amenity ...................................................................... 51
   Findings ..................................................................................................................... 54
   Discussion .................................................................................................................. 57
   Summary .................................................................................................................... 58
   Implications for Policy and Practice ......................................................................... 59

2.7: Water Quality in Muswellbrook .........................................60
   The Issues .................................................................................................................. 60
   Findings ..................................................................................................................... 63
   Summary .................................................................................................................... 67
   Implications for Policy and Practice ......................................................................... 67

2.8: Social Changes in Muswellbrook .......................................69
   Introduction ............................................................................................................... 69
   Measurement Issues .................................................................................................. 69
     A Socio-Demographic Profile of Muswellbrook .................................................... 70
     Relocation of Households ...................................................................................... 74
     Levels of Community Participation ....................................................................... 76
     The Community Contribution of Companies ....................................................... 77
     Changing Sense of Place ......................................................................................... 80
     Trust Towards Institutions ...................................................................................... 80
   Summary .................................................................................................................... 80
FIGURES

Figure 1. Diagrammatic representation of the research plan......................................................xiv

Figure 2. Overall project structure.................................................................................................. 4

Figure 3. Diagrammatic representation of the research plan...................................................... 5

Figure 4. A summary representation of a typology of cumulative impacts.................................15

Figure 5. Example of a spatial extent impact. Image of the Muswellbrook town in which the areas coloured blue are the viewing locations from which disturbed land could be seen in 2004. ..........................................................15

Figure 6. Example of a spatial intensity impact. Areas marked with blue are the viewing locations from which disturbed land could be seen in 2004. The lighter the blue the more intense the impact, i.e. the more disturbed land can be seen. .......................................................................................... 16

Figure 7. Time series trends in water flow above and below the Muswellbrook study region. ...................................................................................................................17

Figure 8. Location of Muswellbrook region within the Hunter Valley........................................18

Figure 9. LGA of Muswellbrook and surrounding shires..............................................................19

Figure 10. Timeline of coal mining in Muswellbrook...................................................................20

Figure 11. Muswellbrook LGA showing mining leases (including planned mines). ...............22

Figure 12. Spatial units (sectors) of the township and surrounds into which complaints were allocated..........................................................................................................................34

Figure 13. Spatial distribution of complaints through time. Sectors are as illustrated in Figure 12. ................................................................................................................................. 35

Figure 14. Number of complaints across the study region and saleable coal production. ..........................................................................................................................36

Figure 15. Percentage and number of complaints that come from the town over time. ..........................................................................................................................37

Figure 16. Number of complaints per complainant in the town and region. .............................38

Figure 17. Nature of combined complaints made between 1994 and 2005...............................39

Figure 18. Complaint types made to Muswellbrook Coalmines; (a) 1994-2005; and (b) 2005. ..........................................................................................................................40

Figure 19. Percentage of the total workforce employed in the mining industry in Muswellbrook in 1996, 2001 and 2006................................................................. 44

Figure 20. Place of residence of mine employees (2004)........................................................... 45
Figure 21. Total number of employees (five study mines) and total coal production (five study mines)...........................................................................................................45

Figure 22. Delineation of the Muswellbrook town (impact zone) for visual impact assessment.......................................................................................................................52

Figure 23. Mapping of disturbed areas (yellow regions) on mine sites for the study region for years 1989, 1995, 2000 and 2004 (note this does not recognise mine rehabilitation areas that have been revegetated with these areas instead included within the mine disturbance area)..............................................53

Figure 24. Impact intensity for the Muswellbrook town from 1989, 1995, 2000 and 2004 (lighter blue indicates greater impact intensity – black indicates no impact)...........................................................................................................................54

Figure 25. The change in mean impact intensity for the period 1989-2004. The effect of inclusion of visual bunds (with and without completed rehabilitation) is shown for 2004......................................................................................................................55

Figure 26. Visual impact in the town in 2004 comparing the situations of (a) no visual bunds with (b) bunds treated as disturbed land and (c) bunds that are shaped and vegetated...............................................................................................56

Figure 27. Relationship between mean impact intensity and total complaints from the township through time..........................................................................................................................58

Figure 28. State government water quality monitoring locations and mine site lease boundaries in the study region....................................................................................................................61

Figure 29. Non-parametric cumulative probability density functions for Aberdeen and Liddell monitoring stations (daily water flow is shown). .................................................63

Figure 30. Probability density functions of EC for Aberdeen (red) and Liddell; Liddell has higher salt concentrations ......................................................................................................64

Figure 31. Salt concentration time trends at Aberdeen (red) and Liddell (blue). ......................65

Figure 32. Salt load (tonnes per day) time trends at Aberdeen (red) and Liddell (blue) ..........................................................................................................................65

Figure 33. Residual salt loads at Liddell after removal of upstream, tributary and mine discharge salt influences..................................................................................................................66

Figure 34. Distribution of income earners in Muswellbrook, Hunter Valley and NSW – 2001 ..............................................................................................................................71

Figure 36. Number of properties purchased in Muswellbrook 1992–2005 (including properties purchased by Mt Pleasant Mine)........................................................................75

Figure 37. Percentage of population aged 15 years and over engaging in voluntary work in the previous 12 months.............................................................................................................77

Figure 38. Proposed framework for assessing cumulative impacts of mining in regional communities..........................................................................................................................88
Figure 39. Raw production comparisons........................................................................................ 96

Figure 40. Outline of the impacted area overlain on the remotely sensed imagery. ..............112

Figure 41. Disturbed areas as mapped (shown in blue) for four time periods – 1989, 1995, 2000 and 2004 overlain on the remotely sensed image of that epoch. ....................................................................................................................113

Figure 42. Mapped disturbance and mine site reported disturbed area....................................114

Figure 43. Mapped disturbance and mine site reports of disturbed area and one-year-old rehabilitation. ..................................................................................................................115

Figure 44. Binary viewshed (single point).....................................................................................116

Figure 45. Total viewshed of impacted area .............................................................................116

Figure 46. Visual exposure map extracted through the mask of 2004 disturbed area..................117

Figure 47. Visual exposure, area of land disturbed and area not exposed over the period 1989-2004.......................................................................................................................118

Figure 48. Mean visual exposure..................................................................................................119

Figure 49. Total visual exposure..................................................................................................119

Figure 50. Viewshed from disturbed points in 2004................................................................120

Figure 51. 2004 Viewshed extracted through impacted area. Brighter areas indicate greater visual impact (more disturbed areas can be seen)......................................................121

Figure 52. Binary impact time series (excessive decimal places seem to be inherent in the mapping software)..................................................................................................122

Figure 53. Binary impact time series ..........................................................................................123

Figure 54. Impact intensity (km$^2$) time series (excessive decimal places seem to be inherent in the mapping software). ...............................................................................124

Figure 55. Mean impact intensity over time...............................................................................125

Figure 56. Exposed disturbed area under different bunding scenarios .....................................126

Figure 57. Mean visual exposure comparison.............................................................................126

Figure 58. Locations of State water monitoring sites on the Hunter River. ..............................128

Figure 59. Turbidity data from Muswellbrook state water monitoring station.........................129

Figure 60. Total P results from monitoring in the Hunter River 1988-2005 .........................129

Figure 61. Total P data for Hunter River as shown in Figure 60 but with different project codes highlighted by colour reference. .................................................................130
Figure 62. EC distribution at Aberdeen from 21/03/98 to 14/10/05 (left) and Liddell from 17/02/91 to 14/10/05 (right). ...........................................................130

Figure 63. EC distribution at Liddell and Aberdeen from 21/03/98 to 14/10/05............... 131

Figure 64. Distribution of the difference of the modes of the Liddell and Aberdeen EC data. .......................................................................................................132

Figure 65. Contour plot (left) and surface plot (right) of the estimated joint density of Aberdeen and Liddell EC data .................................................................132

Figure 66. Trends in Aberdeen and Liddell EC data using smoothing splines (left) and trends in EC data across all stations (right)...............................................133

Figure 67. Stream flow cumulative distribution functions (left) and stream flow densities on a logarithmic scale (right) at Aberdeen and Liddell.......................133

Figure 68. Joint density of the Aberdeen and Liddell stream flow data on a logarithmic scale........................................................................................................134

Figure 69. Trends in Aberdeen and Liddell flow data (left) and trends in flow across all monitoring sites (right). .................................................................135

Figure 70. Salt trends at Aberdeen and Liddell (left) and across all sites (right)........... 135

Figure 71. Discharge events superimposed on the stream flow data.............................136

Figure 72. Correlation between the Liddell and Aberdeen stream flow time..............137

Figure 73. Correlation between the Liddell and Aberdeen stream flow time series ..........137

Figure 74. Correlation between the Liddell and Muswellbrook (left) and Denman (right) stream flow time series .........................................................138

Figure 75. Empirical distribution of salt loads at Liddell with and without the discharges ...........................................................................................................138

Figure 76. Filtered stream flow data at Liddell, Wybong and Goulburn (left) and stream flow at Liddell and the contribution from Wybong and Goulburn (right). .................................................................139

Figure 77. EC data trends at Liddell, Goulburn and Wybong (left) and scatter plot of Liddell and Goulburn River (right) .................................................................139

Figure 78. Scatterplot of EC data of Wybong Creek and Goulburn River.......................140

Figure 79. EC trends for all monitoring sites (left) and distribution of EC data at Liddell, Wybong and Goulburn (right) .................................................................140

Figure 80. Stream flow trends for all monitoring stations .............................................141

Figure 81. Liddell stream flows with and without the Goulburn and Wybong contribution. .........................................................................................................141

Figure 82. Salt load trends for all monitoring stations ....................................................142
Figure 83. Liddell salt loads with and without the Goulburn and Wybong contribution (left) and a scatterplot of 'Liddell – Goulburn – Wybong' stream flow signal vs 'Liddell – Aberdeen – Goulburn – Wybong – mine discharges' salt load signal. ........................................................................................................142

Figure 84. Residual signal at Liddell after removal of all salt sources. .................................................................143

Figure 85. Magnitude of the frequency response (left) and unit impulse response of the filter (right). .................................................................................................................................144

Figure 86. Various levels of smoothing of Liddell salt loads..................................................................................145
TABLES

Table 1. Main Cumulative Impacts Identified in Community Consultations ........................................xviii
Table 2. Ranking of priority cumulative impact issues by project reference group ..................................xx
Table 3. Cumulative impacts perceived by stakeholders ............................................................................25
Table 4. Cumulative impacts most frequently identified as important by stakeholders ...........................................26
Table 5. Main cumulative impacts identified by the reference group .........................................................29
Table 6. Ranking of priority cumulative impact issues .................................................................................30
Table 7. Classification and coding of complaints made to five mines sites at Muswellbrook .................................................32
Table 8. Revenue contribution of Muswellbrook mines to state and regional government ........................................48
Table 9. Relative Wealth Indicator Values (100 – 0) for Muswellbrook and comparison LGAs .......................72
Table 10. Unemployment Rates (%) for Muswellbrook and comparative areas ............................................73
Table 11. Socio-Economic Indexes for Areas (SEIFA) for Muswellbrook and comparative areas .......73
Table 12. Types of support given by local coal mines to the community and environment of Muswellbrook ................................................................................78
Table 13. Classification and coding of complaints made to five mines sites at Muswellbrook .................................................109
Table 14. Summary of data acquired for the visual amenity analysis, its source and any specific pre-processing required .................................................................111
Table 15. Disturbed area .................................................................................................................................118
Table 16. Visual impact intensity as indicated by binary maps ........................................................................123
EXECUTIVE SUMMARY

Study context

The Australian mining industry, and the coal mining sector in particular, is required to operate in an increasingly challenging environment of changing community expectations, stricter regulatory controls and greater public scrutiny. In the case of coal, the heightened prominence of climate change has added a further layer of complexity.

Companies have responded to this changing external environment by strengthening their internal management systems, investing more resources in engagement with communities and other external stakeholders, and developing mechanisms for regularly reporting on their social and environmental performance. For the most part, the focus of companies has been on managing the performance of their own operations, but cross-company collaboration is also becoming more common. This is occurring not only at the national level, through industry associations such as the Minerals Council of Australia and the Australian Coal Association, but, increasingly, also at the regional level; particularly in areas such as the Upper Hunter Valley, Bowen Basin and Pilbara, where there is a concentration of mining activity.

This project, which is an example of cross-company collaboration, focuses on the challenges involved in dealing with cumulative, or multi-mine, impacts at the local level. The project builds on an earlier Australian Coal Association Research Program (ACARP)-funded project conducted in 2004, undertaken by the Centre for Social Responsibility in Mining (CSRM) that aimed to enhance the capacity of individual mines to monitor and manage their impacts on local communities (Brereton and Moffatt 2005).

Key objectives of the current study, as endorsed by the industry steering committee for the project, were to:

1. Develop a framework for assessing, monitoring and reporting the cumulative social, environmental and economic impacts – both positive and negative – of coal mining on regional areas where multiple mines operated.
2. Undertake a trial of the framework in an area where there were multiple mines.
3. Identify methods and indicators that can be applied to other regions of Australia where multi-site impacts are a salient issue.

The location for the study was Muswellbrook, a town of approximately 10,200 people in the Upper Hunter Valley of New South Wales (ABS 2006). At the time the study was conducted there were five developed coal mines – four open cut (Mt Arthur Coal, Drayton, Bengalla and Muswellbrook Coal) and one underground (Dartbrook) – located on the perimeter of the town. Dartbrook has since been placed on a care and maintenance schedule, but the overall level of mining activity remains high, with major new mines scheduled to be opened in the next few years. Muswellbrook was also the location for the earlier study undertaken by CSRM.

BHP Billiton’s Mt Arthur Coal operation, which is the largest operation in the area, took a lead role in the project. The study also had the active support of Anglo Coal (which operates Drayton and Dartbrook mines), Bengalla Mining Company and Muswellbrook Coal. The Project Steering Committee included representatives from each of these operations, plus
from approved developments yet to commence mining, including the Coal and Allied owned Mt Pleasant mine.

The above-mentioned operations already cooperate with each other in a range of ways; sometimes on a bi-lateral basis (for example, the water sharing arrangement between Mt Arthur Coal and Drayton Coal) and sometimes multilaterally (for example, the Muswellbrook Mine Managers Forum, regular meetings of environmental officers, the Hunter River Salinity Trading Scheme, the joint River Care program supported by Bengalla, Mt Arthur Coal and Coal and Allied, and the annual Mining and Energy EXPO). Support for this research project was an extension of this cooperative approach and was driven by the desire of participating companies to increase their understanding of cumulative impacts and, longer term, to enhance their capacity to manage these impacts.

**Study scope**

Although much of this report focuses on presenting and analysing data specific to Muswellbrook, it is not intended to be a comprehensive study of the cumulative impacts of mining on that community.

Due to time and resource constraints, it was necessary to be selective about what aspects to focus on. The impacts which were selected for investigation by the research team, with the endorsement of the steering committee, related to:

- employment and other economic contributions
- visual amenity
- water quality of the Hunter river
- social impacts.

Because of the need to take a selective approach, the study did not investigate other issues which are potentially salient in the Muswellbrook context, such as whether increased mining has led to changes in background dust levels or ambient noise, is associated with any health impacts, or has impacted – either positively or negatively – on the biodiversity of the Muswellbrook area. Some of these other aspects presented some particularly complex data analysis problems which could not reasonably be resolved within the scope of the study. In addition, the research team was aware that issues relating to the measurement of noise and dust were being addressed in other research studies being funded by ACARP.

A final point is that the project was undertaken primarily to assist coal mining operations better understand and manage cumulative impacts and did not consider in any great detail the roles and responsibilities of local and state governments in relation to the management of these impacts. A more comprehensive study would need to give greater attention to this aspect.
Research Approach

The main research activities undertaken for the project comprised:

- A review of published material, including: academic papers on the definition and measurement of cumulative impacts; the Annual Environmental Management Reports (AEMRs) prepared by each mine; Health, Safety Environment and Community (HSEC) reports (where available); and, environmental and social impact assessments prepared for current and proposed mining projects in Muswellbrook Shire.

- Consultations with community members, industry personnel and other stakeholders (see below for more details).

- Analysis of complaints data provided by the mines.

- Collection and analysis of data relating to the impacts selected for analysis. Some of this information was provided by the mines (for example, employment data), some was obtained from other organisations such as the Australian Bureau of Statistics (ABS) and the New South Wales Government (water quality data), and some was collected directly by the researchers (visual amenity data).

The figure below summarises the research plan that was adopted in consultation with the industry steering committee. At each key decision point thereafter, endorsement was obtained from the committee for the proposed approach.

The initial plan was to engage with community representatives and other external stakeholders to identify what they perceived to be the main cumulative impacts of mining on the Muswellbrook area and then assess whether the available data were consistent with these perceptions. The project broadly followed the plan, although for logistical reasons some tasks were undertaken in a different order. (For example, the project reference group workshop was held later in the process than originally scheduled and analysis of some impacts, such as water quality, commenced before the consultation phase was completed.) Also, as already indicated, due to time and resource constraints only a sub-set of impacts could be examined.
Study Limitations

Like all research projects, this study has several limitations which need to be acknowledged at the outset. These may be summarised as follows:

1. As noted above, in the discussion of study scope, due to time and resource constraints and issues of data availability, it was possible to focus on only some of the cumulative impacts that external stakeholders had identified as potentially significant.

2. Due to scheduling constraints and the fact that this was only intended to be a 12 month project, it was not possible to follow the exact sequence set out in the research plan (particularly in relation to the timing of the project reference group workshop).

3. The consultation component of the study relied largely on qualitative data, rather than quantitative surveys. This reflected the view of the industry that the community was at risk of being over-consulted and that a targeted, rather than broad-ranging, strategy would be more appropriate.

4. In retrospect, the approach taken was arguably too linear, particularly with respect to community engagement. In future studies, a dialogue with the community may be a more effective way of obtaining external input. This would require a more structured approach of information gathering and interpretation followed by presentation and reconsideration of priorities.

5. There was good cooperation from the industry in responding to data requests, but as detailed in the sections of the report dealing with specific impacts, various data
availability and analysis issues were encountered. For example, the researchers were not able to obtain a time series measure of the number of contractors – as distinct from direct employees – employed by the mines, or a comprehensive measure of the industry’s local business spend. Similarly, State government river monitoring of sediment and nutrients was sporadic and not amenable to time series analysis.

A final comment is that, in retrospect, the study was probably overly ambitious in scope, given the complexity of the issues involved, resource constraints, the heavy competing demands on the time of industry steering committee members, and the 12 month timetable set for the completion of the study.

**Definitional Issues**

In the broadest sense, cumulative impacts are the successive, incremental and combined impacts of an activity on society, the economy and the environment. For this study, the term was taken to mean the combined impact of the local coal mining operations on the Muswellbrook community and environment over time.

Cumulative impacts may be either positive or negative. The point in undertaking an analysis of such impacts is not only to identify impacts that may require mitigation, but also to document the contributions that mining is making to a community or region and to identify opportunities to further enhance that contribution.

An important lesson from the study is that there is no one way in which impacts are cumulative and that a more differentiated approach is needed to both the measurement and management of such impacts. The simple typology developed in the course of the study identified six different types of impact.

- **Spatial extent impacts** are those which occur over an area, e.g. the area of vegetation that has been cleared for mining, the amount of land disturbed and rehabilitated.

- **Spatial intensity impacts** result when a location is impacted on by the activities of multiple sites. An example would be where the dust of several upwind mine sites contributes to elevated levels of dust in particular areas.

- **Simple temporal impacts** have a specific time of commencement and a measured form over time. An example would be the amount of land rehabilitated over time as a reflection of the stage of development of the mine life.

- **Offset temporal impacts** occur when multiple simple temporal impacts are superimposed upon one-another over time. Materials moving through rivers are a good example. Assume that the extraction of water for a mine is proportional to its coal production. Initially, little water is extracted; this increases until the mine reaches peak production and plateaus out. As the mine progresses towards the end of its life extraction again declines. If a second mine comes on line half way through the life of the first mine and extracts water in the same fashion, the cumulative impact will be the superposition of the two simple temporal impacts offset in time.

- **Linked triggered impacts** are those that occur when one impact, either by its occurrence or by reaching a threshold level, triggers another impact that would not otherwise have occurred. The second impact is the triggered impact. An example of a triggered impact would be when the economic activity in a town, associated with multiple mines operating, becomes sufficiently large for a new amenity to be financially
viable, e.g. a new shopping outlet. Similarly, as the population of a community grows it is able to support activity networks such as sporting teams.

*Linked associative impacts* occur where multiple impacts occur as a result of a single event or change, e.g. as a result of opening a new mine, expanding a mine or changing operations. An example of this type of impact may be where financial support, or population maintenance, in a town allows a school to remain open or some other form of educational facility to open. A wide range of potential ‘indirect’ benefits can flow to the community as a result of the availability of local education facilities.

**Stakeholder Perspectives on Cumulative Impacts**

A key part of the project involved collecting information on the views of community members and other stakeholders about the growth of mining in Muswellbrook Shire and the associated impacts. The aims here were to help identify which impact areas to focus on in the analysis and to develop a better understanding of what people meant when they used the term ‘cumulative impacts’.

The engagement strategy agreed to with the industry steering committee comprised:

1. Initial informal discussions with some long term Muswellbrook residents who knew the local history, plus key people involved in industry and local government.

2. Nineteen one-to-one interviews with representatives from the tourism industry, the equine industry, the wine industry, the mining industry (including all five General Managers), local youth organisations, local schools, welfare organisations, the Muswellbrook hospital, the Muswellbrook police and local businesses.

3. Four focus groups involving a total of 35 participants. The groups comprised: five members of the Muswellbrook Chamber of Commerce; 15 members of MineWatch (a local NGO that is critical of the mining industry); six employees from three of the five mines in the Shire; and nine representatives of mine community consultative committees (CCCs).

4. A one-day workshop attended by ten representatives of state and local government agencies, regional organisations and the local industry (referred to herein as ‘the project reference group’). Due to scheduling problems the workshop was not held until relatively late in the project, after impact themes had been selected for analysis. The workshop was therefore used to ‘validate’ the outcomes of the community consultations and to enhance the researchers understanding of the impacts in question.

In addition to seeking input directly from community members, project researchers undertook an analysis of complaints data from each of the five mines, to identify what were the most common grounds of complaint and where these complaints were coming from. Social Impact Assessments (SIAs) undertaken for planned new projects and recently approved mining projects in the Shire were also reviewed.
Community consultations: key findings

Key themes to emerge from the community interviews and focus groups were as follows:

- There was a general understanding that the concept of ‘cumulative impact’ related to the collective impact of mines on the town and the Shire, rather than just impacts associated with any one mine.

- There was broad agreement that mining had contributed significantly to the economic development of Muswellbrook, particularly by providing employment and creating opportunities for local businesses. Most people also acknowledged the contribution of the mines in providing substantial monetary donations for local projects and organisations and funding additions to local infrastructure.

- A further positive associated with the increase in mining was the heightened awareness of safety. This was seen as having translated from the work environment on mine-sites to the general community.

- Although the economic and safety contribution of coal mining was acknowledged by most of those consulted, most of the community participants were inclined to interpret the term ‘cumulative impacts’ as referring more to negative than to positive outcomes. The tendency to focus on negatives is characteristic of many studies of community perceptions of impacts, not just of this particular community.

To correct for the tendency of people to focus on negatives, study participants in both the interviews and the focus groups were asked to rank what they perceived to be the four most positive and the four most negative cumulative impacts of mining for the area. The outcomes of this exercise are presented in the table below. In some cases, the ranking task proved to be contentious, with participants in the focus groups arguing their case for different issues. For example, members of the CCC focus group spoke at length about the impact that dust and poor air quality was having on the lives of local people, but eventually the group nominated visual and social impacts as a greater cumulative problem than dust.

Table 1. Main Cumulative Impacts Identified in Community Consultations

<table>
<thead>
<tr>
<th>POSITIVE IMPACTS</th>
<th>NEGATIVE IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing employment – wealth, better lifestyle</td>
<td>Decreasing visual amenity</td>
</tr>
<tr>
<td>Increasing community benefits from mine expenditure</td>
<td>Adverse social changes (loss of community identity, weakened social networks, growing gap between ‘haves’ and ‘have nots’, etc)</td>
</tr>
<tr>
<td>Expanding mine-related businesses</td>
<td>Increasing noise and vibration due to blasting</td>
</tr>
<tr>
<td>Increasing knowledge of safety</td>
<td>Decreasing air quality/dust</td>
</tr>
</tbody>
</table>
Findings from other studies

In addition to undertaking their own consultations, the research team reviewed findings from SIAs conducted as part of the regulatory approval process for new mines in the area. The main source here was the 2006 socio-economic assessment report prepared by Coakes Consulting for the Anvil Hill project: an open cut mine proposed for the Wybong area, about 20 km west of the town of Muswellbrook. As part of this study, interviews were conducted with 112 local landowners/residents, comprising 16 landowners residing in the project area and a further 96 residing within 5km of this area. The study noted that there was a high level of concern in both groups around the proposed development, with the main issues relating to changes in lifestyle (including a decline in sense of community and concerns about possible re-location of households), dust, visual aesthetics, noise, potential reduction in property values, increases in traffic and blasting and changes in water quality. These issues are similar to those raised in the consultations for the present study. ¹

Project reference group workshop

The project reference group workshop was presented with the outcomes of the interviews and focus groups conducted with community stakeholders (see above). In addition, the group was provided with a summary of some of the data that had been collected and analysed for the project, such as visual amenity data and community complaints. The group was then asked:

- Are there other possible cumulative impacts not identified by the community consultations that should be considered?
- Which of these impacts most warrant the attention of the local mining industry?
- What are the reasons for prioritising these particular impacts?

Following discussion, the group was requested to rank all of the issues that had been identified (either by the group or the community stakeholders) on the basis of which issues most warranted attention from the local coal mining industry. Each member of the group was able to cast three votes of equal weight by placing an adhesive ‘dot indicator’ against lists displayed on the walls of the workshop venue.

The reference group was in broad alignment with the community stakeholders about the main issues associated with the increase in mining, but sometimes expressed this in different

¹ The Anvil Hill study also involved a random survey of 400 households in the Muswellbrook LGA (78% of whom were located in Muswellbrook proper). The survey revealed that there was only a limited knowledge of the proposal in the local community. However, after being presented with information about the characteristics and location of the proposed mine, 46 per cent indicated their approval of the project, 24 per cent expressed no opinion either way and 29 per cent expressed their disapproval. The main benefits identified were economic and the main perceived disadvantages were dust, noise and an ‘increase in respiratory conditions’. Given that the proposed mine is located 20km from Muswellbrook, where most survey respondents resided, it is not surprising that the wider community was less concerned than those living locally about possible visual and lifestyle impacts.
language. The group also included loss of vegetation/biodiversity as a significant issue, whereas this aspect did not figure prominently in the community consultations. This may reflect the inclusion of several regulators and representatives of environmental organisations in the group. Another point of divergence is that the group did not rank the visual impacts of increased mining as highly as the community stakeholders.

The rankings for all impacts that received votes from the reference group are shown below.

Table 2. Ranking of priority cumulative impact issues by project reference group

<table>
<thead>
<tr>
<th>PRIORITY CUMULATIVE IMPACT ISSUES</th>
<th>VOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverse social changes – ‘social dislocation’</td>
<td>6</td>
</tr>
<tr>
<td>Vegetation/biodiversity loss</td>
<td>6</td>
</tr>
<tr>
<td>Health – physical and psychological – decreased wellbeing</td>
<td>5</td>
</tr>
<tr>
<td>Air Quality/dust</td>
<td>4</td>
</tr>
<tr>
<td>Increased employment</td>
<td>2</td>
</tr>
<tr>
<td>Changing sense of place</td>
<td>2</td>
</tr>
<tr>
<td>Visual amenity</td>
<td>1</td>
</tr>
<tr>
<td>Improved community infrastructure</td>
<td>1</td>
</tr>
<tr>
<td>Water Quality – post mine</td>
<td>1</td>
</tr>
<tr>
<td>Economic distortion due to over-reliance on mining</td>
<td>1</td>
</tr>
<tr>
<td>Land loss</td>
<td>1</td>
</tr>
</tbody>
</table>

The project reference group agreed that collective action was required to deal effectively with cumulative impacts, rather than these issues just being dealt with on a mine-by-mine basis. It was also agreed by group members that better baseline measurements and ongoing monitoring mechanisms were required.

Complaints analysis

Complaints data from the five mines was aggregated to ascertain whether they provided any insight into the phenomena of cumulative impacts could be gained from the data. Spatial and temporal analyses were undertaken to uncover any trends in time and to determine whether different sub-regions of the study region showed different behaviour. A comparison of the number of complaints and the number of complainants was undertaken to avoid bias in the interpretation as a result of serial complainants. The nature of complaints, i.e. what people complained about the most and least, was presented to help understand whether there was any indication that cumulative impacts should be dealt with differently to near neighbour mine-by-mine responses.

The main findings from this analysis were that:

- The total number of complaints in the study region peaked in 2000 at around 1200, but declined steadily thereafter, even though coal production continued to increase. It is likely that this was mainly because the mines took corrective action to deal with the factors giving rise to ‘near neighbour’ complaints. (Although, some community members who participated in the focus groups indicated that they had “given up” complaining.)

- The town of Muswellbrook, as distinct from adjoining areas, has steadily accounted for a greater proportion of complaints, with the number of complainants rising over time. However, the number of complaints per complainant (~1.5) has remained...
more-or-less steady. These results suggest that the mines may have been less effective in responding to the issues of concern to town residents than to the specific concerns of near neighbours. This provides persuasive evidence of a cumulative impact effect, which can be interpreted as relating to a generalised loss of amenity.

The issues which were most likely to attract complaints related to noise, vibration/blasting and dust/air quality. These were also flagged in the community stakeholder consultations as important impacts. However, other areas of community concern that were identified when people were questioned directly about cumulative impacts (e.g. visual amenity) were rarely the subject of complaints, perhaps because they tend not to be associated with specific events or activities.

Complaints databases provide a potentially useful means of identifying the existence of cumulative impacts, key issues of concern to the local community and of assessing the impact of increased mining activity on community amenity. However, given that they were not designed to record and respond to cumulative impacts per se the information must be interpreted with care. It is also important that the effective response of individual mines to near neighbour complaints is not seen as evidence that cumulative impacts do not occur outside the town. As is evident throughout this report, some cumulative impacts are far more complex than the issues that can be captured through the current codes in the complaints registers.

**Impact analyses: key findings**

**Economic Impacts**

Mining is clearly a very important part of the Muswellbrook economy, as recognised by most stakeholders. However, due to data limitations it was not possible to quantify the full scale of this contribution or to accurately track trends over time. The most reliable data is in relation to direct employment; only rough estimates can be made of the number of additional jobs generated in the form of indirect and induced employment, or of the value of the local business spend. Relevant findings in relation to each of these aspects are summarised below.

**Direct employment**

Coal mining is a major employer in Muswellbrook, directly employing between 13 and 16 per cent of the total Shire workforce between 1996 and 2006. At different times over the past decade there have been additional short to medium term employment opportunities generated in mine-related construction, although the study was not able to quantify the scale of this contribution.

ABS Census data show that the number of Muswellbrook Shire residents working in the coal mining sector has fluctuated considerably in recent years, falling from 1036 in 1996 to 759 in 2001 and then rising again to 1052 in 2006.\(^2\)

---

\(^2\) Not all of the Muswellbrook residents recorded by the census as employed in mining would have been working at mines located within the Shire boundary, but it is reasonable to assume that the great majority were.
These fluctuations have occurred against a continuous upward trend in coal production in the Shire. This indicates that fluctuations in mining industry employment in Muswellbrook have been influenced not only by the level of mining activity, but also by factors such as changing employment practices (e.g. increased outsourcing to contractors) and improvements in production efficiency and output at existing mines.

Over the last decade, there appears to have been a trend towards more employees of local mines living outside of Muswellbrook Shire, mainly in Singleton and Upper Hunter Shires. This may be partly attributable to local factors; for example, perceived quality of services and facilities, and lifestyle choices. Regardless of the explanation, one consequence of this trend has been to contribute to a perception in sections of the community that Muswellbrook has ‘missed out’ on some of the benefits of increased mining activity in the Shire.

Another salient point is that, historically, most of the Muswellbrook mines appear to have had quite stable workforces, with relatively low rates of turnover. For example, in 2004 one mine reported an employee turnover rate of 4% and another one a rate of only 1.2%. Consequently, significant opportunities for local people to find employment in the mines have mainly arisen when a new operation has opened or there has been a major expansion of an existing mine, rather than being available on a continuing basis.

Indirect and induced employment

The number of jobs attributable to mining is significantly greater than the number of people directly employed in the industry, as it includes people who are employed off-site by suppliers and contractors (indirect employment), plus a proportion of those who work in other sectors (such as retail and services) that benefit from the presence of the industry (induced employment).

No reliable estimates of indirect and induced employment are currently available for Muswellbrook, as the multipliers that have been used historically by companies to assess employment impacts of new projects have focused only on the regional level or higher. To remedy this, local mines should consider collectively funding a comprehensive survey of businesses in the Shire, perhaps in conjunction with the Shire and/or Chamber of Commerce, to obtain more accurate data on the amount of indirect and induced employment attributable to mining.

Local business spend

A recent audit by Muswellbrook City Council identified 24 businesses (27% of all of those surveyed) that relied primarily on providing support services for the mining or power industries, although no data were provided on the dollar value of business turnover attributable to mining. Presumably, many other local businesses also derive at least some income from mine expenditure.

A study undertaken for the 1999 Mt Arthur Environmental Impact Assessment by Coakes Consulting estimated that individual mining industry employees contributed approximately $21.2 million in annual household expenditure to Muswellbrook Shire. This amount would

---

3 It is understood that the SIA for the Mt Arthur Underground Project Environmental Assessment has identified estimated flow on employment that will be generated at the township level, i.e. Muswellbrook, Denman, Aberdeen, etc.
most likely have increased considerably since then. There would be value in repeating and expanding this study.

**Local community spend**

According to data published by Muswellbrook Shire, rates paid by the mines exceed $1 million a year and account for 19 per cent of all rates paid to the Shire. Various mines have also made substantial one-off infrastructure payments to the Council, as part of development consent s.94 contributions under the *Environmental, Planning and Assessment Act 1979*. For example, in 2003 Mt Arthur Coal provided $2.5 million towards the construction of a heated swimming pool in Muswellbrook and in 2004 Bengalla contributed $280,000 to the Muswellbrook railway station redevelopment. Local mines also provide on-going monetary and in-kind support to a broad range of community groups, programs and activities. However, as the mines do not use a consistent approach to capturing and reporting this information, it is currently not possible to provide an accurate picture of their total contribution, or trends over time.

**Maximising the local economic benefits of mining**

Building on existing industry good practice, companies operating in Muswellbrook Shire should actively explore opportunities to enhance their contribution to the local economy. This could involve:

- reviewing their purchasing practices and policies to encourage greater utilisation of locally-based businesses
- working with the Muswellbrook Shire Council and organisations such as the Chamber of Commerce to identify practical ways in which more local business opportunities can be created
- ensuring that priority is given to recruiting local residents when starting up or expanding operations, subject to these applicants meeting the required standards (some mines already apply this policy)
- continually reviewing policies and practices regarding local apprenticeships and traineeships, skills training and career mentoring with local schools.

**Visual Amenity**

Visual amenity is a complex issue, the impacts of which are subjective, i.e. they depend on the personal response of individuals. Visual amenity relates to a range of complex and interacting issues. In this study, only one aspect of visual amenity was studied, namely, the extent to which disturbed mined land is visible from the town of Muswellbrook. Quantitative analysis of areas disturbed by mining shows that over the last decade mining has become visible from more locations in the town. Also, those areas of the town from which mining has been visible for some years can now see more mined land.

Mines are required to provide visual assessments as part of the approvals process. There is little evidence that visual assessments are required to be carried out on the basis of cumulative impacts. Most mines have expended significant resources to mitigate the impacts of mine visibility. Visual bund emplacement, construction of additional rehabilitated earth
bunds and native tree planting to provide visual screens have been undertaken. In some cases, this has required changes to the mine designs. Similarly, night lighting impacts have been mitigated with mine design changes, for example day/night dumps, and engineering controls, including louvres and shields. However, there is no attempt overall to mitigate cumulative visual impacts. This could be supported by a single agreed visibility management plan for the town which is based formally on managing cumulative impacts. Individual mines could then deal with near neighbour impacts based on significant vantage points, for example. Measurement of the effect of visual bunds indicates that visibility will be as low as the early 1990s once the bunds are complete and vegetated.

Future research should be conducted to better understand the responses of individuals to different forms of visual impact to ensure that investment is focussed on the most important impacts. The relative importance of cumulative versus individual visual impacts should be clarified as part of this work.

**Water Quality**

Mines in the Muswellbrook area have undertaken considerable effort with on-site water management to minimise their impact on the Hunter River. For example, town effluent is taken to Mt Arthur Coal for re-use, which reduces town discharge to the river and decreases the mine’s draw on river fresh water. Most mines have internal policies that prioritise reuse of water sourced on site (i.e. aquifer inflows, run-off, process and waste water returns) before importing fresh water into the site thereby minimising their draw on regional freshwater supplies. Another example is where mines with water excess to requirements share this with those in deficit, again decreasing the overall draw on regional freshwater. An example of this is the water sharing arrangement in place between Mt Arthur Coal and Drayton that have been in place for over ten years.

Salt concentration, stream flow and salt loads were analysed to test whether the impact of salt water discharge from the mines (under the Hunter River Salinity Trading Scheme, HRSTS) could be discerned. There was no evidence that increased mining activity was having a cumulative impact on Hunter River salt loads. This finding is consistent with what would be expected given that the HRSTS imposes a cumulative cap or limit on the total salt loading possible from all water users in the region (including mines) and that these discharges can only occur under certain high flow conditions in the river (as there would be rainfall in the region) when any discharge would be diluted. This Scheme, in place now for many years, provides an example of industry working collectively and with Government, to reduce the potential for adverse cumulative mine water discharge impacts on the Hunter River.

State government water monitoring in the Hunter River above and below Muswellbrook is not sufficiently comprehensive to permit a temporal analysis of river nutrient or sediment levels. Annual Environmental Reports provide a comprehensive account of mine by mine monitoring of water quality as required by legislation. These data are reported in such a way as to make clear monitoring levels with respect to compliance levels.

Mines could be more effective in communicating their water management policies and activities to ensure that the community is aware of the extent to which effort is put into managing water at the site and cumulative levels.
Social Changes

The population of Muswellbrook Shire rose by 4 per cent between 2001 and 2006, taking it back to roughly 1996 levels. Population fluctuations appear to be linked to the level of employment being generated by the mining industry. Mining has also affected the pattern of income distribution in Muswellbrook, by contributing to the creation of a relatively large group of high income earners.

Data from 2001 and previous censuses indicate that Muswellbrook has been characterised by above average levels of socio-economic disadvantage, but, there is no obvious reason to attribute this to the growth of a large mining industry. Equivalent data for 2006 indicate that there have been no significant changes to Muswellbrook’s average levels of socio-economic disadvantage.

Census data for 1996, 2001 and 2006 show that the unemployment rate in the Muswellbrook LGA has basically reflected the national picture. By contrast, Singleton and Scone have had unemployment rates consistently below the national average. This suggests that, while Muswellbrook has benefited from the recent general upsurge in economic activity, it has not performed as well over time as some other communities in the region.

One of the issues raised in the community consultations concerned the perceived dislocative social impacts of mine-initiated property purchases. However, the available data indicate that the number of people affected by such purchases has been relatively small. Between 1992 and 2005 around 150 properties were purchased by local mines. On a ‘worst case’ scenario, assuming a typical household size, this equates to around 25 people a year who were relocated. Advice from the project steering committee is that:

- In most cases, arrangements were made or offered by the mine to enable the original landowner or occupier to continue to manage and earn income from the land and/or to assist them with their transition to a new location.

While it is probable that some individuals who were re-located had their social networks and sense of place disrupted as a consequence, the numbers involved would have been too small for this to have had a significant impact on social cohesion in the broader Muswellbrook community.

The mines were also criticised in the consultations for introducing rosters that made it more difficult for people to participate in organised community activities. However, while these changes may have made it challenging for some sections of the mining workforce to be involved in organised community activities, there is again no evidence that this has adversely impacted on the broader community. In fact, the 2006 census confirms that Muswellbrook does not have an atypically low rate of volunteer participation.

The local mining industry has made a substantial financial and logistical contribution to supporting community health, education, sporting, heritage, environmental and recreational groups and their related facilities and programs. Some of these contributions have been required under s.94 of the Environmental, Planning and Assessment Act 1979 (NSW), but much of the expenditure has been voluntary.

There are existing examples of local mines jointly sponsoring major community events, such as the Upper Hunter Bursting with Energy Expo. At the same time, there is scope to expand this coordinated approach to other areas (e.g. in relation to managing the community spend of mines).
Further investigation is required to ascertain whether the rapid expansion of mining activity around Muswellbrook has adversely impacted on people’s sense of place, community identity and levels of trust in mining companies and government.

**Managing Cumulative Impacts in Muswellbrook**

Notwithstanding the examples of cooperation provided in this report, mines in the Hunter Valley and elsewhere continue to act predominantly as single entities rather than collectively. This is understandable, given current workloads and the level of issue complexity – plus the fact that coal mining companies are in commercial competition with each other. However, competitiveness and lack of coordination leave mines vulnerable to being played off against each other, and can lead to unnecessary duplication of effort and inefficient use of resources.

To deal with these challenges, mines may need to develop new coordinating structures – or modify existing ones – to ensure that there is an appropriate collective response to the particular challenges presented by cumulative impacts. New models of community engagement may also be required.

**Recommendation 1**

The local mining industry should consider establishing a formal association supported by a secretariat to facilitate coordination amongst mines and with external agencies and other stakeholders.

The functions of such a body would need to be clearly defined, but could potentially include:

- facilitating the exchange of information between operations and with external stakeholders on the management of environmental, social and economic impacts
- representing the local industry in discussions and negotiations with local and state government and other important stakeholders
- initiating and coordinating activities to address identified areas of community concern
- coordinating the ‘social spend’ of local mines, including (potentially) by establishing and administering a common Community Fund\(^4\)
- identifying research needs and taking action to address these needs (either by direct funding or through a body such as ACARP)
- coordinating production of a periodic report from the industry to the local community (see below)
- establishing and maintaining consistent and uniform data collection standards across sites.

\(^4\) This would not prevent individual mines from continuing to operate their own donations programs in addition to a common fund.


Recommendation 2

The local mining industry should discuss with the Muswellbrook Shire the potential for establishing a Muswellbrook-wide consultative forum comprising representatives from the mines and local stakeholder groups, to focus on issues of broader concern and interest to the community.

This could possibly be done by expanding the membership and terms of reference of the Muswellbrook Mine General Managers forum established by the Shire Council. This forum has already identified opportunities for mines to work cooperatively on issues of mutual interest, including water management during the drought.

The proposed forum could be used to:

- inform stakeholders of actions that are being taken by the local industry to manage multi-mine impacts
- provide a forum in which stakeholders can ask questions and raise concerns
- identify opportunities for the local mining industry to further contribute to the economic and social development of Muswellbrook.

Recommendation 3

The local mining industry should consider producing, on a periodic basis, a collective report to the community on the economic, social and environmental performance of the local industry.

Amongst other things, this report could:

- present data on the overall contribution that mining is making to the Muswellbrook Shire in relation to:
  - direct and indirect employment
  - the provision of traineeships, apprenticeships and work experience opportunities
  - local business spend
  - financial contributions to local government in the form of rates and other payments, such as s. 94 contributions
  - financial and in-kind support provided for community programs
- provide an analysis of complaints patterns and trends and indicate what actions have been taken in the reporting period – both collectively and by individual operations - to address factors giving rise to complaints
- provide an overview and update of initiatives that have been taken by local mines to minimise adverse impacts and promote positive environmental outcomes, including in relation to the management of visual impacts, land disturbance, water usage and water quality, and dust and air quality
• summarise the outcomes of any research commissioned by the mines or parent companies that is relevant to the measurement and management of local cumulative impacts.

The work undertaken for this study could serve as the basis for the preparation of an initial report.

**Recommendation 4**

*The local mining industry and other key players, such as the Shire Council and relevant government agencies, should collaborate on improving their capacity to monitor and manage cumulative impacts.*

A priority should be to develop some new ‘system-level’ indicators for the area, such as measures for tracking trends in social capital, community wellbeing and environmental conditions.

An opportunity exists to utilise the Hunter Valley Research Foundation’s new ‘wellbeing watch’ survey to develop a profile specifically for Muswellbrook Shire. This could involve provision of supplementary funding to the Foundation to increase the number of Muswellbrook residents surveyed, and then use this to prepare a stand-alone report for the Shire.

**Lessons**

Overall, the prototype framework that was developed to guide the study worked reasonably well, but there were some lessons, which can be summarised as follows:

• The project reference group was difficult to arrange and, ideally, should have been convened earlier, but was an extremely valuable confirmatory tool in the research design.

• There was good cooperation from the industry in responding to data requests. However, often the mine representatives had to take significant amounts of time from their normal areas of responsibility to prepare the information required in an appropriate format. This is an important consideration in planning for comparable studies in the future.

• To achieve significant progress in the understanding of cumulative impacts and their management, there will need to be substantial improvement in the coordination and standardisation of a range of environmental, social and economic performance data. This is a challenge both for the mining sector and regulators.

**Future Applications**

The basic process for assessing and measuring cumulative impacts in an area where there are multiple mine sites should be readily transferable to other sites. However, the scope of the task may vary substantially, depending on where mines are located, their history, the complexity of the community, government regulations, internal business requirements and what work has already been undertaken.

While the level of industry support for this study was laudable, and probably necessary to make the research happen, there may be advantages in having co-funding arrangements in future applications, for example, joint sponsorship by industry and Government of such
projects. If the community and government have money at stake, active participation is easier to achieve and co-ownership of outcomes is more likely.

The overarching conclusion of this study is that a collective approach to the management of cumulative impacts, ideally involving not just mines but government and community as well, has the potential to produce better sustainable development outcomes than individual mines responding predominantly on an individual basis in an uncoordinated way to local concerns. It is recognised this is likely to place an additional impost on the resources at the mine, particularly those personnel within the environment and community teams. In this sense, cumulative impacts assessment and management define a new frontier in the interactions between the mining industry and community. The mines of the Muswellbrook region have already commenced down this pathway and are, therefore, more well prepared than most to move forward.
Recommendations to ACARP

It is recommended that:

1. Further research be commissioned to investigate cumulative impacts in other areas where there is, or is likely to be, a growing concentration of mining activity, such as the Bowen and Gunnedah basins. (Support for this research was provided in the 2006 ACARP funding round, and will be released once the current project has been completed.)

2. The industry seeks out opportunities to engage with regulators and other stakeholders on issues relating to the analysis and management of cumulative impacts.

3. The industry supports work to identify and document good practice in the management of cumulative impacts. (Also addressed in the 2006 funding round).

4. The industry provides resources to assist with the development and delivery of training materials to industry personnel on the measurement and management of cumulative impacts.

5. The industry considers designing and trialling multi-mine engagement mechanisms in regions where there is a concentration of mining activity.
SECTION 1: DEVELOPING THE FRAMEWORK

1.1: Introduction

This chapter provides the background to, and rationale for, the project and discusses why the mining industry is now paying greater attention to the issue of cumulative impacts. The chapter also outlines the aims and scope of the project and provides an overview of the structure of the report.

Project Administration/Project Management

This Project was undertaken jointly by the Centre for Social Responsibility (CSRM) and the Centre for Water in the Minerals Industry (CWiMI), both within the University of Queensland’s Sustainable Minerals Institute (SMI). The study was assisted by a Steering Committee, with representation from each of the five mine sites around the Muswellbrook area – Mt Arthur Coal, Bengalla, Drayton, Dartbrook5, and Muswellbrook Coal – plus Mt Pleasant (a new project). The role of the Steering Committee was to review the progress of the research plan, assist with data collection, and facilitate access to information. The Steering Committee met on a regular basis throughout the Project and was chaired by a mine representative.

The bulk of the research was conducted between March 2005 and June 2006.

Project Background

The Australian mining industry, and the coal mining sector in particular, is required to operate in an increasingly challenging environment of changing community expectations, stricter regulatory controls and greater public scrutiny. In the case of coal, the heightened prominence of climate change has added a further layer of complexity. In line with industry trends generally, Australian coal mining operations are under growing pressure to improve how they monitor, measure, manage and report on the impacts of their operations on surrounding communities. Where communities might once have welcomed mining developments because of the jobs and infrastructure which they provide, there is now more questioning of the value of mining and a greater focus on the potentially negative impacts that mining can have on the local environment and people’s lifestyles. This has been manifested in demands for the industry to be more strictly regulated and, in some areas of the country, strong community opposition to new mining developments (Brereton and Moffatt 2005: 11).

Individual companies have responded to this changing external environment by strengthening their internal management systems, placing more emphasis on engagement with communities and other external stakeholders, and developing mechanisms for reporting regularly on their social and environmental performance. At the broader industry level, companies have also worked together to develop comprehensive codes of practice,

5 In mid 2006, production at Dartbrook mine ceased due to ongoing technical problems and the mine was placed on a ‘care and maintenance’ basis.

For the most part, the focus of companies has been on managing the performance of their own operations, but cross-company collaboration is also becoming more common. This is occurring not only at the national level, through industry associations such as the Minerals Council of Australia and the Australian Coal Association, but also at the regional level; particularly in areas such as the Upper Hunter Valley, Bowen Basin and Pilbara, where there is a concentration of mining activity. In these regions, communities and other external stakeholders are increasingly focusing on the aggregate, or ‘cumulative’, impact of mining on the region, as well as on how individual operations might be performing. For companies operating in these regions, this presents new challenges in terms of how impacts are measured, monitored, reported on and, most importantly, managed.

This project, which is a good example of cross-company collaboration, focuses on the challenges involved in dealing with cumulative, or multi-mine, impacts at the local level. The project builds on an earlier ACARP-funded project conducted in 2004 entitled Monitoring the Impact of Coal Mining on Local Communities (Brereton and Moffatt 2005). That project focused on the impacts associated with a single mine: Anglo Coal’s Drayton open-cut operation, one of several large mining operations in the vicinity of the town of Muswellbrook in the Upper Hunter Valley of New South Wales.

One of the findings of the Drayton study was that community stakeholders had relatively few concerns about how that particular mine was operating. However, there was considerable sensitivity in sections of the community about the impact that further expansion of the coal mining industry could have on land availability, water resources, other land uses (such as wine growing and horse studs), the resilience of the local economy and the general ‘social’ identity of the community. This was often referred to as the ‘cumulative impact’ of increased mining activity, although people understood and used this term in a variety of ways.

Mines in the area were already cooperating with each other in a range of ways; sometimes on a bi-lateral basis (for example, the water sharing arrangement between Mt Arthur Coal and Drayton Coal) and sometimes multilaterally (for example, the Muswellbrook Mine Managers Forum, regular meetings of environmental officers, the Hunter River Salinity Trading Scheme, the joint River Care program supported by Bengalla, Mt Arthur Coal and Coal and Allied, and the annual Bursting with Energy Expo). Support for this research project was an extension of this cooperative approach and was driven by the desire of participating companies to increase their understanding of cumulative impacts and, longer term, to enhance their capacity to manage these impacts. Led by Mt Arthur Coal, local mines collectively agreed to support an application to ACARP in 2004 to fund work on developing tools and methods for assessing and measuring cumulative impacts. It was understood that, while Muswellbrook would provide the case study, the primary focus should be on developing and trialling an approach which would be of more general application to the Australian coal mining industry.

**Project Objectives**

The overall goal of this project was to enhance the capacity of coal mining operations in mining intensive areas within Australia to assess, monitor, manage and report on the cumulative impacts of their activities.
Specific objectives were to:

1. Develop a framework for assessing, monitoring and reporting the cumulative social, environmental and economic impacts – both positive and negative – of coal mining on regional areas where multiple mines operated.

2. Undertake a trial of the framework in an area where there were multiple mines (Muswellbrook).

3. Identify methods and indicators that can be applied to other regions of Australia where multi-site impacts are a salient issue.

As agreed with the local industry and ACARP, this is first and foremost an exploratory study designed to evaluate the efficacy of a particular methodological and theoretical approach and to test and refine some possible measurement tools. The report does not purport to offer a definitive analysis of the cumulative environmental, economic and social impacts of mining on Muswellbrook; nor does it seek to engage in wider debates about the value of mining for Muswellbrook or the Upper Hunter generally. Nonetheless, the case study has generated valuable data about various aspects of the cumulative impact of mining on Muswellbrook and these findings are reported here. The report also contains a range of suggestions to the local industry and government about how these impacts might be better managed.

There are two main outputs from the study:

1. A detailed report to ACARP (this document) describing the development of the framework, its evaluation, and the findings and learnings from the Muswellbrook exploratory study.

2. An information sheet with a summary of key findings and the industry’s response.

The summary report will be distributed to those community members and other external stakeholders who participated in the study. Copies will also be placed in the local library and made available for downloading on the CSRM website (www.csrm.uq.edu.au).

**Project Structure**

The overall structure of the project is illustrated in Figure 2. There were three broad streams of activity which were conducted roughly in parallel.

1. *Conceptual analysis and development.* This entailed reviewing the relevant literature and developing a better understanding of what cumulative impacts are and how they might be characterised.

2. *The Muswellbrook Case Study.* This involved engaging with community members and other stakeholders to ascertain what they saw as the main cumulative impacts of mining on Muswellbrook, and undertaking exploratory analysis of available data for some selected impact areas.

3. *Framework development.* In line with the project objectives, this component focused on developing a framework (comprising a process, a typology and some specific tools) that could be applied in other regions where the management of multi-mine impacts is a significant issue.
Figure 2. Overall project structure.

Structure of the Report

The report is divided into three sections:

This first part (Section 1) provides a general introduction to the project, describes the methodology that was developed to measure and assess cumulative impacts, reviews the relevant literature and develops a typology of cumulative impacts.

Section 2 comprises the Muswellbrook case study, covering aspects such as stakeholders’ perceptions of cumulative impact issues in Muswellbrook, complaint patterns and trends, employment and other economic impacts, visual amenity, water quality, and social changes attributable to increased mining.

Section 3 reviews the efficacy of the framework that was developed and discusses how it might be enhanced for future applications.
1.2: Methodology

Research Plan

Figure 3 summarises the Research Plan that was adopted after initial consultation with the Steering Committee. The agreed approach was to engage with community representatives and other external stakeholders to identify what they perceived to be the main cumulative impacts of mining on the Muswellbrook area and then assess whether the available data was consistent with these perceptions. The project broadly followed the plan, although for logistical reasons some tasks were undertaken in a different order. (For example, the expert workshop was held later in the process than originally scheduled and analysis of some impacts, such as water quality, commenced before the consultation phase was completed.) Also, due to time and resource constraints it proved feasible to focus on only a sub-set of impacts (see below).

Stage 1

The first part of Stage 1 was a scoping phase, involving the following activities:

1. A review was undertaken of the research literature on cumulative impacts and other relevant industry documents and information. This literature is summarised in Chapter 1.3. The report also includes a list of relevant articles, books and research papers.

2. Initial interviews were conducted with some long term Muswellbrook residents who knew the local history, and key people involved in industry and local government. These interviews helped to identify key issues relevant to discussions about potential cumulative impacts in Muswellbrook, and informed the questions asked during the consultation phase.

Figure 3. Diagrammatic representation of the research plan.
3. All the Muswellbrook mine sites were visited and discussions held with relevant management personnel about the issues that they considered most important from their perspective. The researchers also reviewed the Annual Environmental Management Reports (AEMRs) prepared by each mine, plus Health, Safety Environment and Community (HSEC) reports, where they were available.

The second part of Stage 1 was a more structured consultation phase which involved focus groups and face-to-face interviews conducted between May and July 2005. The aim here was to ensure appropriate community representation while avoiding ‘consultation fatigue’, given that a considerable amount of social research had already been carried out in the Hunter Valley generally (and in Muswellbrook specifically) about the effects of mining on communities. Details of who participated in these interviews and group discussions are provided in Chapter 2.2, along with an analysis of the main themes that emerged.

Stage 2

The main activities undertaken in Stage 2 were:

- convening of a project reference group workshop
- analysis of complaints data provided by the mines
- collection and analysis of data for selected impact categories.

Each of these activities is briefly described below.

The Project Reference Group Workshop

The project reference group workshop was conducted in Muswellbrook in February 2006. People were invited to the workshop on the basis that they:

- had extensive knowledge of the social, economic and/or environmental well-being and condition of the Muswellbrook and Hunter Valley area
- were considered specialists in their fields, including mining
- represented regulatory organisations involved in planning, monitoring or assessing the impacts of coal mining on communities.

The ten participants in the workshop reviewed the information collated up to that time, advised on what other information was available, and provided suggestions on how various impacts should be measured and managed (see Chapter 2.2 for further details).

---

6 This workshop had originally been scheduled for November 2005, but had had to be deferred until 2006 because of the unavailability of some key participants.
Complaints Analysis

The complaints databases of the five mines were aggregated and analysed to ascertain if there were any discernible trends and patterns. Complaints are a mechanism for the community to provide feedback to the mines on issues of concern. As such, they are a potentially useful indicator of how a community is being impacted on by mining. Chapter 2.3 presents the key findings from this analysis and discusses the methodological challenges involved in using complaints data.

Analysis of Selected Impact Categories

Given the exploratory nature of the study and the limited time and resources available to the research team, it was not practical to collect data about all of the impact dimensions identified by the expert group and the broader community. Instead, it was decided to focus to four categories: economic impacts (principally employment), visual amenity, social change and water quality.

The rationale for selecting these particular areas was that:

1. They represented examples of different forms of impacts – economic, social and environmental.
2. They had been identified as important issues in the consultations and expert workshop, or had been highlighted by previous studies (as in the case of water quality).
3. A reasonable amount of data was available for analysis.
4. They had not been addressed, or were not being addressed, by other current or recent studies. (For example, dust was excluded as there was another ACARP funded research project underway which was focusing specifically on modelling dust in the region).

To support the analyses, the five mines were requested to provide time series data about coal production, water usage, land rehabilitation and disturbance, staffing profiles and land acquisitions. There was good cooperation from the mines, but for various reasons the data sets were not always complete, or covered only limited time periods. In addition, as discussed in more detail in later sections of the report, the data provided were not always comparable. Data were also sourced from the NSW Department of Infrastructure and Planning (now known as the NSW Department of Planning and the NSW Department of Natural Resources), the Australian Bureau of Statistics (ABS), Muswellbrook Shire and other organisations.

Stage 3

Stage 3 involved the analysis, synthesis and presentation of the information collected in Stages 1 and 2. During this stage, a public report was compiled for the Muswellbrook community, highlighting the key findings of the study.

Draft copies of the Summary report and this ACARP Report were made available to the Steering Committee and ACARP representatives for review and comment before finalisation. All feedback was assessed by the researchers for possible inclusion in reports.
Evaluation

Different evaluation activities were undertaken throughout the project. Aspects considered included participants’ ratings of their experiences, verbal feedback, willingness of industry personnel to be included, meeting attendances, and feedback from the Steering Committee.

All focus group participants completed evaluation forms (Appendix 1) and interviewees were asked if the information they provided could be better incorporated into the outcomes. Similarly, expert participants completed an evaluation of the workshop (Appendix 2). All groups evaluated the process positively.

Also, the data provided by each mine were assessed according to their quality and completeness and the ease with which the information could be combined with data from other mines to provide an overall picture.

Study Limitations

Like all research projects, this study has several limitations which need to be acknowledged at the outset. These may be summarised as follows:

1. Due to time and resource constraints and issues of data availability, it was possible to focus on only some of the cumulative impacts that external stakeholders had identified as potentially significant. Because of the need to take a selective approach, the study did not investigate other issues which are potentially salient in the Muswellbrook context, such as whether increased mining has led to changes in background dust levels or ambient noise, is associated with any health impacts, or has impacted – either positively or negatively – on the biodiversity of the Muswellbrook area. These aspects presented some particularly complex data analysis problems which could not reasonably be resolved within the scope of the study. In addition, the research team was aware that issues relating to the measurement of noise and dust were being addressed in other research studies being funded by ACARP.

2. Due to scheduling constraints and the fact that this was only intended to be a 12 month project, it was not possible to follow the exact sequence set out in the research plan (particularly in relation to the timing of the reference group workshop).

3. The consultation component of the study relied on qualitative data only. This reflected the view of the industry that the community was at risk of being over-consulted and that a targeted, rather than broad-ranging, strategy would be more appropriate. However, inclusion of a quantitative component to this aspect of the research may have strengthened the perceived validity of some of the findings.

4. The approach taken was arguably too linear, particularly with respect to community engagement. In future studies, a dialogue with the community may be a more effective way of obtaining external input. This does not necessarily mean a significantly larger activity but a structured approach of information gathering and interpretation followed by presentation and reconsideration of priorities.

5. As detailed in the sections of the report dealing with specific impacts, various data availability and analysis issues were encountered, notwithstanding that there was good cooperation from the industry in responding to data requests. For example, the researchers were not able to obtain a time series measure of the number of contractors –
as distinct from direct employees – employed by the mines, or a comprehensive measure of the industry’s local business spend. Similarly, State government river monitoring of sediment and nutrients was sporadic and not amenable to time series analysis.

A final comment is that, in retrospect, the study was probably overly ambitious in scope, given the complexity of the issues involved, resource constraints, the heavy competing demands on the time of industry steering committee members, and the 12-month timetable set for the completion of the study.
1.3: Definition, Literature Review and Typology of Cumulative Impacts

Definition

In the broadest sense, cumulative impacts are the successive, incremental and combined impacts, both positive and negative, of an activity on society, the economy and the environment. For this study, the term was taken to mean the combined impact of the local coal mining operations on the Muswellbrook community over time.

Cumulative impacts may be either positive or negative. The point in undertaking an analysis of such impacts is not only to identify impacts that may require mitigation, but also to document the contributions that mining is making to a community or region and to identify opportunities to further enhance that contribution.

Review of Literature

Cumulative impacts are described in much of the literature as being particularly complex, time consuming and costly to address (see problem 5.39 in Burris and Canter 1997; Canter and Kamath 1995; Contant and Wiggins 1991; Smit and Spaling 1995). The constraints lie chiefly in the consideration of an overwhelming number of components to assess, many of which are not environmental, but are also socio-economic, legal, jurisdictional, administrative or policy-related (Cline, Vlachos, and Horak 1983). Nonetheless, there continues to be recognition, internationally and across disciplines, that cumulative impact assessments are critical to protect and enhance the human environment, to adequately evaluate resource sustainability, and to aid in good environmental practice and decision making (Walker and Johnston 1999).

Developing a common set of concepts to describe cumulative impacts has seemingly eluded the courts, regulators, and researchers alike. Many analysts have focused on the forms of development activities that produce cumulative impacts; others have concentrated on the functions of natural systems and the ways that impacts accumulate, interact, or produce systemic changes. Included in many of the typologies of cumulative impacts are:

- the natural systems processes of accumulation (Clark 1986)
- delayed response (Baskerville 1986)
- triggers and thresholds (Preston and Bedford 1988)
- nonlinear functional relationships (Preston and Bedford 1988)
- synergism (Vlachos 1985).

The USA Council on Environmental Quality, 1978 (Contant and Wiggins 1991), specified that connected, similar and cumulative actions should be grouped together in an analysis of environmental impacts. Included were activities that:

- are interdependent parts of a larger actions
• automatically trigger other actions
• have cumulatively significant impacts when viewed with other proposed actions
• are similar enough in time or geography to other reasonably foreseeable or proposed actions.

Contant and Wiggins (1991), considered to be leaders in the attempts to define and operationalise cumulative impacts, argue that when individual projects are assessing cumulative impacts they must consider two categories of contextual issues:

• the relationship between a proposed project and other development activities
• the complex nature and effects of a development activity on a natural system.

The first set of issues documents the presence and influence of past and current development activities, as well as the expectation of future development. These other activities may be similar or different, connected or unconnected, to the proposed action. The interrelationships between, and accumulation of, development activities establish the context for an individual proposed project, and define the cumulative nature of development actions. Effects resulting from this cumulative nature of development actions may be largely ignored or underestimated in most impact assessments of individual projects.

The second broad category of issues included within Contant and Wiggins’ definition of cumulative impacts describes the cumulative nature of the effects of development activities. In particular, these components refer primarily to the natural system context of development activities. Cumulative changes to a natural system include the nibbling away of a resource base by repeated actions; the crowding of a resource base (in time or space); unanticipated (or non-accumulative) responses of a natural system; systemic changes including synergistic responses, structural changes, or cycling; and interactions across natural systems. Taken together, these two general categories yield a much broader and more comprehensive definition of cumulative impacts.

The key problem emerging from the literature is how best to define and identify indirect and cumulative impacts and impact interactions. The definitions of these three overlap and often it is difficult to tease out the individual components because indirect and impact interactions are generally considered parts of cumulative impacts. However, in a study commissioned by the European Commission, Walker and Johnston (1999) proposed the following categorisations:

• Indirect impacts: Impacts on the environment which are not a direct result of the project, often produced away from or as a result of a complex pathway. These are sometimes referred to as second or third level impacts, or secondary impacts.

• Cumulative impacts. Impacts that result from incremental changes caused by the past present or reasonable foreseeable actions of successive projects.

• Impact interactions. The reactions between the impacts of either one project or the impacts of other projects in the areas.

Further, the authors concluded that the assessment of indirect cumulative impacts and impact interactions should be incorporated into all stages of the EIA process, not just as a separate stage, and that a skilled team of personnel undertake these assessments. Most
importantly, the authors noted that there are considerable uncertainties and problems when assessing indirect, cumulative impacts and impact interactions. They proposed that, rather than avoiding the qualitative intuitive and interpretative assumptions made by skilled assessors, these assumptions should be documented for consideration in the EIA.

The measurement of cumulative impacts hinges strongly on the definitions chosen. However, there appear to be a number of commonly agreed guidelines for identifying boundaries, units of measurement and evaluation techniques (Cooper and Canter 1997):

- Spatial boundaries are best defined flexibly to allow adjustments during the assessment process as the nature of linkages become better defined.

- The setting of temporal boundaries will be largely a function of data availability as well as levels of uncertainty and confidence in prediction.

- Determining minimum data requirements that allow defensible and robust impact predictions need to focus particularly on threshold effects and irreversible changes in the use of critical resources.

The use of qualitative measurements in cumulative impact assessments is also recognised by many reports in the literature, due primarily to the complexity of the subject. In particular, the qualitative use of expert knowledge and opinion is acknowledged (Mendoza and Prabhu 2003), as is the effective co-ordination, facilitation and exchange of ideas between project members to reach an integration of the diverse scientific backgrounds. Community consultation is considered an integral part of qualitative measurement of cumulative impacts on human environments (Kohlhuber et al. 2006; Krieg and Faber 2004).

Generally, there is agreement that many of the same methods used for standard impact assessments can be used for cumulative assessments, except that the inherent difficulties in each method will be exacerbated; namely, the subjective weighting of values assigned to indicators and the complexity of relationships that need to be simulated in certain models. Cumulative impacts occurring over a large spatial scale and over considerably longer time frames are extremely difficult to assess. Consequently, much of the successful empirical work has been done on clearly bounded systems such as lakes and watersheds (Brismar 2004; Power 1996; Ziemer et al. 1991), rather than more open systems (Prietzel, Mayer, and Legge 2004; Tran et al. 2004; Trembley and Gariépy 1994). The assessment of cumulative impacts on socio-economic systems has proven to be particularly difficult in isolating cause and effect.

In sum, there is not a clear consensus in literature to date about how cumulative effects should be defined and subsequently measured (Preston and Bedford 1988). However, there is general recognition of the need to carefully define affected resources, identify potential cumulative impacts early in project assessment, and clearly document the information and analysis used to reach conclusions.

**Previous Research on Cumulative Impacts in the Hunter Valley**

The need for a cumulative impact assessment in the Upper Hunter was highlighted by the Commissions of Inquiry into the Bengalla and Bayswater No.3 open cut coal mining projects (Department of Urban Affairs and Planning 1997). The NSW Department of Urban Affairs and Planning (DUAP), in conjunction with various government, industry, environmental and community representatives, released the Upper Hunter Cumulative Impact Study (UHCIS) in June 1997. The aims of the study were to:
• establish the effects of cumulative impacts of various existing and major proposed land uses and activities
• establish a regional framework for the assessment of the environmental impacts of individual development proposals and activities
• provide the basis for coordinated environmental monitoring and enhanced environmental management practices
• assist future strategic land use and development planning at both the local and regional levels.

The scope of the UHCIS was much larger than that of the current project, incorporating the Local Government Areas (LGAs) of Singleton, Muswellbrook, Scone, Murrundi and Merriwa.

The study consisted of three phases:

1) A qualitative review of all potential cumulative relationships between various land uses and activities and the environment, using a set of environmental indicators.

2) Analysis of the more significant potential impacts using quantitative techniques. The most relevant environmental impacts of a cumulative regional nature were examined, including air quality, water quality, catchment conditions and economic and social conditions.

3) Strategic assessment of the findings of phases 1 and 2.

In accordance with the data available at the time, the study found that there were no major cumulative impacts that warranted additional regulatory intervention or major restrictions on development (Department of Urban Affairs and Planning 1997, p. 3).

The UHCIS also highlighted the need for more consideration to be given potential cumulative impacts in future decision making, planning and environmental management. Key proposals were to:

1) Strengthen the planning process – use the outcomes of the study in future EIS and planning activities.

2) Strengthen environmental monitoring and databases – examine the relevance and consistency of data for assessing cumulative impacts.

3) Strengthen environmental management practices – develop and implement best practice guidelines and reconsider existing practices.

4) Improve coordination, liaison and participation – implement initiatives for improved information sharing and consultation.

An action strategy of 39 items was developed to help ensure that greater consideration was given to cumulative impacts over the short-, medium- and long-term.

A number of these action strategy items had particular relevance to the coal industry in the area. These included the recommendation to prepare a Muswellbrook cumulative impact study to examine the specific cumulative environmental impacts of the Kayuga, Mt Pleasant,
Mt Arthur Coal and Sandy Creek mining proposals. It was also recommended that cumulative impact considerations be addressed in EIS preparation, and that a landscape master plan be developed to coordinate landscaping between existing and future mines to lessen the visual impact of construction and mining developments and to ensure appropriate mining rehabilitation.

The study proposed a review of monitoring systems for the Upper Hunter and the development of a consistent and coordinated environmental monitoring approach to enable the detection of long term trends and cumulative impacts. A series of ongoing review reports was also proposed to monitor performance of conditions of consent for coal mining projects with regard to environmental monitoring and independent auditing. Other action items included the development of site-specific blasting guidelines, operational guidelines and a clarification of issues pertaining to community concerns about nuisance dust.

Finally, the study advocated the continued development of best practice guidelines for stabilisation and rehabilitation of areas exposed by mining.

**Cumulative Impacts Typology**

As part of the scoping of this project, the industry representatives requested that the project team deal with the issue of what was encompassed by the term ‘cumulative impacts’ and formulate a working definition. It became clear through the literature review (see above) and discussions with industry and community representatives (including the expert group) that there was no framework or structure for cumulative impacts that the project could simply adopt. Therefore, a simple categorisation of cumulative impacts was devised to meet the project needs.

A significant advantage of this approach is that the working definition for cumulative impacts can remain simple because the details of structure and analysis of impacts are deferred to the typology. An alternative approach is to have a detailed definitional statement for cumulative impacts. The project team concluded that this would not be a particularly helpful way to facilitate industry/community/government discussions on cumulative impacts.

Figure 4 provides a diagrammatic summary representation of the proposed typology. There are three categories of impacts: namely, spatial impacts, temporal impacts and linked impacts.
Figure 4. A summary representation of a typology of cumulative impacts.

Spatial extent impacts are those which occur over an area, e.g. the area over which vegetation has been cleared for mining. An example from the visual amenity component of the Muswellbrook study is shown in Figure 5. A full description of this example is provided in Section 2.6 and Appendix 8).

Figure 5. Example of a spatial extent impact. Image of the Muswellbrook town in which the areas coloured blue are the viewing locations from which disturbed land could be seen in 2004.

Spatial intensity impacts occur in areas where there is overlap between spatial extent impacts from more than one source. An example would be an area where dust deposition occurs and the source of the dust is several upwind mine sites. An example from the visual amenity component of the Muswellbrook study is shown in Figure 6 (see also Appendix 8).

Simple temporal impacts are those which have a specific time of commencement and a measured form over time. An example would be the downstream fine sediment loads following the construction of a stream diversion. These may be accompanied by a short term increase during construction followed by a rapid decrease as the diversion sediment controls become active over time. A second example may be the economic activity in a
nearby town tracing a similar time series to the production of a group of mines. As production starts there is relatively little activity which would peak after some years and then potentially tail off as production decreases.

Figure 6. Example of a spatial intensity impact. Areas marked with blue are the viewing locations from which disturbed land could be seen in 2004. The lighter the blue the more intense the impact, i.e. the more disturbed land can be seen.

Offset temporal impacts occur when multiple simple temporal impacts are superimposed upon one-another over time. The simplest types are where the same simple temporal impact comes from one mine at time \( t \) and from a second mine at time \( t+i \). Materials moving through rivers are a good example. Assume that the extraction of water for a mine is proportional to its coal production. Initially, little water is extracted; this increases until the mine reaches peak production and plateaus out. As the mine progresses towards the end of its life extraction again declines. If a second mine comes on line half way through the life of the first mine and extracts water in the same fashion, the cumulative impact will be the superposition of the two simple temporal impacts offset in time. The resulting combined times series may be very complex and it may be difficult or impossible to ascribe causes to individual parts of the system contributing to the impact. For example, Figure 7 shows a time series of Hunter River water flows above and below the Muswellbrook study region. Water extraction from irrigation, mining and other uses can be seen as there is less flow downstream at Liddell (blue) than upstream at Aberdeen (red) even though there are tributaries entering the Hunter between the two monitoring stations. These data are extracted from a more complete analysis of water quality in the study region presented in Section 2.7 and Appendix 9.
Figure 7. Time series trends in water flow above and below the Muswellbrook study region.

Linked triggered impacts are those that occur when one impact, either by its occurrence or by reaching a threshold level, triggers another impact that would not otherwise have occurred. The second impact is the triggered impact. An example of a triggered impact would be when the economic activity in a town, associated with multiple mines operating, becomes sufficiently large for a new amenity to be financially viable, e.g. a new shopping outlet. Similarly, as the population of a community grows it is able to support activity networks such as sporting teams.

Linked associative impacts occur where multiple impacts occur as a result of a single event or change, e.g. as a result of opening a new mine, expanding a mine or changing operations. An example of this type of impact may be where financial support, or population maintenance, in a town allows a school to remain open or some other form of educational facility to open. A wide range of potential benefits can flow to the community as a result of the availability of local education facilities.

Conclusion

The preceding discussion has highlighted the complex nature of cumulative impacts. While there is general agreement that this is an important area of investigation, the literature to date has been equivocal about how cumulative impacts should be defined and measured. As a way forward, the chapter has presented a simple typology that distinguishes between spatial, temporal and linked impacts. This approach recognises that there is no one way in which impacts are cumulative and that a more differentiated approach is needed to both the measurement and management of such impacts. These points are further developed in following sections.
SECTION 2: THE MUSWELLBROOK CASE STUDY

2.1: Context

This chapter describes the Muswellbrook area and explains why it was chosen as the case study for this project.

The Muswellbrook Local Government Area (Shire)

The Shire of Muswellbrook, is located west of Newcastle in the Upper Hunter Valley of New South Wales (Figure 8), and includes the townships of Muswellbrook, Denman and Aberdeen.

Figure 8. Location of Muswellbrook region within the Hunter Valley.

The shire covers an area of 3046km² and is home to rural industries, horse studs, vineyards, olive groves, light industry and mining operations. The New England Highway, a major arterial road-transport link between the east coast and the western NSW inland areas, runs through the centre of the town of Muswellbrook, linking it with Singleton to the south and Scone to the north. The township is located on the Hunter River, a major source of water for agriculture, viticulture (wine) and mining. Denman is on the Hunter and Goulburn Rivers with the Golden Highway running through it to Dubbo and Newcastle.
The LGA of Muswellbrook (Figure 9) shares boundaries with Singleton LGA, which also contains a number of coal mines.

![Figure 9. LGA of Muswellbrook and surrounding shires](image)

The township of Muswellbrook has a population of just over 10,000 people (see Section 2.8 for details), with the remainder living either in Denman (approx 1,400) or the surrounding rural areas. The LGA population is currently around 16,000. Around 3.6% of the Shire population self identifies as Indigenous, compared to the NSW average of 2% (Hunter Valley Research Foundation 2003, p.33).

Muswellbrook was traditionally a rural-based economy, but power generation, mining and mining-related businesses are now major industries. According to the 2006 census, 16% of the employed workforce in Muswellbrook Shire worked in black coal mining and another 3% in electricity supply. The rural sector (wine production and horse, beef cattle and dairy farming) accounted for around 10.5% of direct employment (ABS 2006).

The concentration of mining activity in the region – and the close proximity of some mines to the town of Muswellbrook – has resulted in considerable prominence being given to environmental amenity issues (noise, blasting disturbance, dust and visual impacts). When prompted, most of the community participants in this study expressed awareness about the perceived ‘cumulative impacts’ of mining on the environment and the need for data to be collected about the extent and nature of these impacts. Discussions also include implications of mine closure, including the need to develop a post-mining economic base.

The motto of the local Muswellbrook Shire Council is ‘Bursting with Energy’, suggesting that the local area closely aligns itself with mining and energy producing industries, and may even define itself through these industries. The Council reported in (2004) that:

> Over the last twenty years the region has developed into a major industrial area with the increase in coal mining activities and associated support industries.

> Muswellbrook Shire is on the threshold of immense development totalling many millions of dollars; we are now approaching a critical mass which is generating its own momentum.
Throughout this period of regional economic growth it is of vital importance to ensure realistic sustainable development through the diversity of industries, improved education facilities, development of a strong skills base and continued employment opportunities.

The Council concluded that it was ‘determined to see ongoing improvement in the economy and quality of life available to its citizens’ and was also ‘pursuing many other projects to diversify and strengthen the economic viability of the area’ (Muswellbrook Shire Council 2005).

Under NSW legislation, the Council plays a role in assessing development and extensions of mines. The Council has negotiated infrastructure contributions from new mining projects and has worked with the industry to facilitate the purchase of properties that have been adversely affected by new mining developments. A further Council initiative has been the formation of the Muswellbrook General Mine Managers forum. This is a regular meeting between the Council and the General Managers of all the coal mines in the Shire. The forum was established in 2001 with the stated aim of working together for the benefit of the overall community. The forum has worked on a range of projects affecting the Shire, including community consultation committees, coal discussion days, and complaint processes as well as apprenticeships and education in coal mining. Increasingly, discussions are focusing on sustainable development issues post-mining.

**Growth of Mining in Muswellbrook**

The earliest coal mine was opened in Muswellbrook in 1907, indicating that the community of Muswellbrook has had a long exposure to coal mining operations (Figure 10).

![Figure 10. Timeline of coal mining in Muswellbrook](source: Mine supplied data.)
Why Muswellbrook was chosen as a trial site

The Shire of Muswellbrook has five coal mining operations within its boundaries – four open cut and one underground. The General Managers of these mines were all supportive of the research and were willing to be involved in the study and offer their data for analysis.

Figure 11 illustrates the extent of the leases of the mines (blue) in relation to the township of Muswellbrook (yellow stripes). The four open cut operations are within a few kilometres of the township of Muswellbrook, with two – Bengalla (a joint venture of Coal & Allied, Wesfarmers, Mitsui and Taipower) and BHP Billiton’s Mt Arthur Coal operation – being visible from the town. Further expansion is likely in the near future; with Coal and Allied having obtained regulatory approval to establish a new mine at Mt Pleasant, adjoining the current Bengalla operation, and Centennial Coal’s Anvil Hill development planned closer to Denman – some 20 km south east of Muswellbrook. Two coal-fired power stations (Bayswater and Liddell) are also located in the area.

Appendices 3 and 4 describe the five mines that participated in this study as well as providing an outline of the new mining developments likely to occur in the shire the near future. Several other mines are located further south along the New England highway. Although some locals consider these mines to be part of the Muswellbrook regional coal industry, they are not close to the township and are in another shire (Singleton). As such, they were not included in this study.

With several new mining operations planned for the near future, local issues associated with cumulative impacts of mining have been particularly relevant to the local Council. In August 2004, the Mayor of Muswellbrook convened a meeting of the local Coal Mine General Managers Forum to discuss the need for a study to be undertaken of the cumulative impacts of mining on the Shire. That meeting was also attended by the Director General of the New South Wales Department of Infrastructure, Planning and Natural Resources, who indicated that his department was strongly supportive of such a study being undertaken.
Another reason for selecting Muswellbrook as a research trial-site was that the community had past experience of engaging in mine-related research. A previous study of the community impacts of a single mine undertaken in Muswellbrook by the CSRM in 2004 (Brereton and Moffatt 2005) had established positive working relationships with key stakeholders. This study had recognised and identified the need for multi-mine site collaboration to assess cumulative impacts on the community.
2.2: Stakeholders’ Perspectives of Cumulative Impacts

This chapter describes how community input was obtained, presents the findings from the interviews and focus groups, and summarises the outcomes of the expert workshop.

Processes for obtaining community input

The engagement strategy agreed to with the industry steering committee comprised:

1. Initial informal discussions with some long term Muswellbrook residents who knew the local history, plus key people involved in industry and local government.

2. Nineteen one-to-one interviews with representatives from the tourism industry, the equine industry, the wine industry, the mining industry (including all five General Managers), local youth organisations, local schools, welfare organisations, the Muswellbrook hospital, the Muswellbrook police and local businesses.

3. Four focus groups involving a total of 35 participants (see below).

4. A one-day workshop attended by ten representatives of state and local government agencies, regional organisations and the local industry (referred to herein as ‘the reference group’). Due to scheduling problems the workshop was not held until relatively late in the project, after impact themes had been selected for analysis. The workshop was therefore used to ‘validate’ the outcomes of the community consultations and to enhance the researchers understanding of the impacts in question.

In addition to seeking input directly from community members, project researchers undertook an analysis of complaints data from each of the five mines, to identify what were the most common grounds of complaint and where these complaints were coming from. Social Impact Assessments (SIAs) undertaken for planned new projects and recently approved mining projects in the Shire were also reviewed.

All group participants and interviewees were contacted personally by phone and then by letter to confirm their attendance. The purpose of the study was explained and their role in the research outlined. Of the 59 people contacted, 53 participated in either an interview or a focus group (89% response). The remaining six were unavailable at the time the researchers visited Muswellbrook, but agreed to provide some written notes or to be interviewed by phone.

The four focus groups were structured as follows:

- **Muswellbrook Chamber of Commerce (n = 5).** This group consisted of three women and two men, with four of the members owning businesses in the Muswellbrook township. One member was a representative of the Muswellbrook Shire Council and another represented a welfare organisation providing services in the Muswellbrook area.

- **Mine Watch (n = 15).** This focus group comprised eight women and seven men who were involved in Mine Watch, a locally-based environmental organisation. They were mainly property owners who had been directly impacted by mining and who drew from their personal experiences to respond to the researchers’ questions.
- **Mine Operators** \((n = 6)\). This group consisted of six men representing three mine sites. (All mine sites were asked to provide representatives, two did not). A new employee and an experienced mine operator was selected from each of the three participating mines. Some were locals living in Muswellbrook, while others lived out of town and/or out of the Shire.

- **Members of the Community Consultative Committees (CCCs) of the various mines** \((n = 9)\). Every member of the five CCCs was invited to attend this group. Three women and six men attended, two of whom were serving councillors of the Muswellbrook Shire. This group consisted mainly of retirees.

All of the interviewees and focus group participants were asked:

- What do you understand by the term cumulative impacts?

- What do you think are the cumulative impacts of coal mining on Muswellbrook:
  
  - Socially?
  
  - Environmentally?
  
  - Economically?
  
  - Health and safety-wise?

- What are the four most significant positive impacts that mining has had on Muswellbrook? How could these be heightened/increased, and who should take a key role?

- What are the four most significant negative impacts mining has had on Muswellbrook? How could these be lessened and who should take a key role?

The qualitative responses to these questions were recorded by hand, collated and subjected to a thematic and content analysis. A listing of perceived cumulative impacts was generated and ranked according to the frequency with which the impact was mentioned in either an interview or a focus group.

**What stakeholders said**

Study participants expressed a variety of ideas about what was meant by the term `cumulative impacts, as indicated by the following comments:

- `'Cumulative impacts should add other things as well. For example, the cumulative effects of dust plus the impact of the weather as well.'`

- `'Cumulative means everything all of the mines are doing.'`

- `'If you add up the enforcements for so many grams of dust from all the mines circling Muswellbrook, sooner or later the milk bottle will be full. That’s cumulative.'`

- `'Just suck everything in – consume everything – trade workers, skilled workers. Cumulative impact is that we cannot get good workers for our industry.'`
‘Definition? I wouldn’t know. I only know about our impact. But the community asks us these questions. The same with the other mines. We know the rough figures about other mine impacts, the systems they use and what they monitor, but we have no details of “when the rubber hits the road”.’

Although individual participants focused on different aspects, there was a general understanding that the concept of ‘cumulative impact’ related to the collective impact of mines on the town and the shire, rather than just the impacts associated with any one mine.

Specific impacts identified in the consultations are listed in Table 3, though not in any particular priority.

**Table 3. Cumulative impacts perceived by stakeholders**

<table>
<thead>
<tr>
<th>PERCEIVED IMPACT</th>
<th>IDENTIFIED BY</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ENVIRONMENTAL:</strong></td>
<td></td>
</tr>
<tr>
<td>Reduced visual amenity</td>
<td>CCC, Chamber of Commerce and Minewatch focus groups; winegrowers, tourism</td>
</tr>
<tr>
<td>Altered land use</td>
<td>Community – predominantly those in areas close to mines, tourism, winegrowers; Minewatch focus group</td>
</tr>
<tr>
<td>Decreasing air quality; dust</td>
<td>CCC and Minewatch focus groups; education</td>
</tr>
<tr>
<td>Increased noise from blasting</td>
<td>CCC and Minewatch focus groups;</td>
</tr>
<tr>
<td>Decreasing water quality; adverse impact on water table</td>
<td>Wine growers; mine operators and Minewatch focus groups;</td>
</tr>
<tr>
<td>Improved environmental management practices</td>
<td>Mine managers</td>
</tr>
<tr>
<td><strong>SOCIAL:</strong></td>
<td></td>
</tr>
<tr>
<td>Increased ‘social dislocation’ – displacement due to relocation of residents; changed social composition; decreasing friendship networks</td>
<td>CCC and Minewatch focus groups; welfare, youth, police, commerce, tourism, winegrowers, education</td>
</tr>
<tr>
<td>Increased wealth differential</td>
<td>CCC, Chamber of Commerce and mine operators focus groups; education</td>
</tr>
<tr>
<td>Decreasing involvement in social clubs, groups etc due to mine rosters</td>
<td>CCC, Chamber of Commerce, Minewatch and mine operator focus groups; welfare sector, education</td>
</tr>
<tr>
<td>Increasing distance and disengagement between mines and community</td>
<td>CCC focus group, NGOs</td>
</tr>
<tr>
<td>Improved community infrastructure and support – pool, PCYC; donations to community organisations.</td>
<td>CCC and Chamber of Commerce focus groups; police, youth sector; mine managers; tourism</td>
</tr>
<tr>
<td>Increasing social/health problems associated with increased wealth (e.g. gambling, drinking, financial credit/debt)</td>
<td>CCC and Minewatch focus groups; police</td>
</tr>
<tr>
<td>Increased safety awareness</td>
<td>mine managers; health</td>
</tr>
<tr>
<td><strong>ECONOMIC:</strong></td>
<td></td>
</tr>
<tr>
<td>Increased mine-related business opportunities and economic activity</td>
<td>Tourism, other industries, Chamber of Commerce focus group; health; mine operators</td>
</tr>
<tr>
<td>Increased employment and training opportunities</td>
<td>Mine managers; CCC focus group</td>
</tr>
<tr>
<td>Distortion of local economy; loss of skilled workers to mining, increased costs</td>
<td>Wine industry</td>
</tr>
</tbody>
</table>
To correct for the tendency of people to focus on negatives, study participants in both the interviews and the focus groups were asked to rank what they perceived to be the four most positive and the four most negative cumulative impacts of mining for the area. The outcomes of this exercise are presented in the table below. In some cases, the ranking task proved to be contentious, with participants in the focus groups arguing their case for different issues. For example, members of the CCC focus group spoke at length about the impact that dust and poor air quality was having on the lives of local people, but eventually the group nominated visual impact and ‘social dislocation’ as greater cumulative problems than dust.

All rankings from interviews and focus groups were collated. The positive and negative impacts that were most frequently identified as important are shown in Table 4.

**Table 4. Cumulative impacts most frequently identified as important by stakeholders**

<table>
<thead>
<tr>
<th>POSITIVE IMPACTS</th>
<th>NEGATIVE IMPACTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increasing employment – wealth, better lifestyle</td>
<td>Decreasing visual amenity</td>
</tr>
<tr>
<td>Increasing community benefits from mine expenditure</td>
<td>Increasing social dislocation</td>
</tr>
<tr>
<td>Expanding mine-related businesses</td>
<td>Increasing noise-blasting and vibration</td>
</tr>
<tr>
<td>Increasing knowledge of safety</td>
<td>Decreasing air quality</td>
</tr>
</tbody>
</table>

Some key points to note from the focus groups and the interviews are as follows:

- Several community members felt strongly about what they perceived as Muswellbrook’s loss of identity, as a result of it changing from being a predominantly rural community to one that was dominated visually – and economically – by mining. Some focus group participants also referred to what they saw as the increasing number of families and homes being relocated due to mines acquiring land, and of the resulting changes brought about in friendship networks and community interactions.

- There was broad agreement amongst participants that mining had contributed significantly to the economic development of Muswellbrook by providing employment and providing a more diverse economic base than can be found in many rural communities. However, some participants felt that the industry could have done more to provide employment and business opportunities to local people. This was a significant theme in discussions with the Chamber of Commerce focus group, and was also raised in the CCC and Minewatch groups and by a representative of the education sector.

- There was a strong acknowledgement of the contribution of the mines to the community of Muswellbrook in the form of monetary donations and as additions to local infrastructure. For example, most participants in the focus groups and the interviews reported the building of the local swimming pool, improvements to local fitness facilities, the upgrading of local roads and community amenities, as examples of the benefits the town had received from mining in the area. Substantial donations to welfare and charitable organisations were also cited as examples of the mines making a positive contribution.

- Several participants expressed concern that the economic benefits of mining were enjoyed by relatively few people and the high wages paid to mine employees had
created a town of ‘haves and have nots’. This issue was raised in the CCC, Chamber of Commerce and mine operators focus groups and by a representative from the education sector.

- A common theme in the CCC and Minewatch focus groups was that the mining industry was so powerful that local government and regulatory authorities sided with them, and did not take sufficient account of the interests and concerns of the Muswellbrook community. A member of the wine industry expressed a similar view. Some focus group participants reported a general sense of disillusionment, and felt thwarted by technical regulatory benchmarks, and powerless against a state government and local council that they perceived to arbitrate without community in mind, or changed legislation to support mining industry.

- Another criticism voiced was that mine rosters – and the fact that many mine-workers did not live in the local area – meant that employees were often unable to involve themselves in the social networks of Muswellbrook such as community groups and sporting clubs. This issue was raised in the CCC, Chamber of Commerce, Minewatch and mine operator focus groups; and by representatives of the education and welfare sectors. The mine operators group, although acknowledging their lack of involvement in community organisations, put their decreased contribution down to the difficulties in maintaining friendships and balancing the demands of mine work rosters.

- Heightened awareness of safety was seen as a positive that had translated from the work environment on mine-sites, to the general community. Representatives from the health sector, in particular, cited the clear benefit to the community and commented on the increasing number of site-trained employees capable of handling injuries. Additionally, the resources maintained on mines sites to deal with injuries and emergencies were also available to the community if and when there was a need. It was recognised that, as the number of mines were increasing, so too were these resources.

- Mine managers and other industry representatives (apart from the mine operators’ focus group) generally were more inclined than other stakeholders to focus on what they saw as the positive impacts of increased mining. The benefits that they cited included increased employment in mining and supporting industries, improved social and physical infrastructure, greater community awareness of safety and improved environmental management.

**Comparisons with Other Studies**

In addition to undertaking the above consultations, the research team reviewed findings from SIAs conducted as part of the regulatory approval process for new mines in the area. The main source here was the 2006 socio-economic assessment report prepared by Coakes Consulting for the Anvil Hill project: an open cut mine proposed for the Wybong area, about 20km west of the town of Muswellbrook. As part of this study, interviews were conducted with 112 local landowners/residents, comprising 16 landowners residing in the project area and a further 96 residing within 5km of this area. The study noted that there was a high level of concern in both groups around the proposed development, with the main issues relating to changes in lifestyle (including a decline in sense of community and concerns about possible re-location of households), dust, visual aesthetics, noise, potential...
reduction in property values, increases in traffic and blasting and changes in water quality. Specifically, the EIS concluded that:

Amongst landowners in the surrounding area issues such as dust, blasting, visual amenity, lifestyle impacts, including potential for relocation and issues relating to property value figured prominently.

(Coakes Consulting 2006, p.36)

These issues are similar to those raised in the consultations for the present study.

The study also involved a random survey of 400 households in the Muswellbrook LGA (78% of whom were located in Muswellbrook proper). The survey revealed that there was only a limited knowledge of the proposal in the local community. However, after being presented with information about the characteristics and location of the proposed mine, 46 per cent indicated their approval of the project, 24 per cent expressed no opinion either way and 29 per cent expressed their disapproval. The main benefits identified were economic and the main perceived disadvantages were dust, noise and an ‘increase in respiratory conditions’. Given that the proposed mine is located 20km from Muswellbrook, where most survey respondents resided, it is not surprising that the wider community was less concerned than those living locally about possible visual and lifestyle impacts.

The Project Reference Group workshop

Informed opinion is often sought in the fields of sustainable development, particularly to add understanding and value to discussion of environmental and economic issues (Mendoza and Prabhu 2000; 2003). For this project, a one-day workshop was convened in February 2006, towards the end of the data gathering phase of the project. The workshop comprised a group of people who were knowledgeable about the industry and/or the area who were brought together to review the results from community consultation; assess the technical information drawn together to date and to identify information gaps and opportunities for the study. The group included representatives of:

- the NSW Department of Infrastructure, Planning and Natural Resources
- the Muswellbrook community
- the Association of Mining Related Councils
- the NSW Department of Environment and Conservation incorporating the Environment Protection Authority
- the Hunter Central Rivers Catchment Authority
- the Hunter Economic Development Authority
- the Muswellbrook Coal Mine General Managers Forum
- the NSW Department of Energy, Utilities and Sustainability
- the Regional Environmental Management Strategy of the Hunter Councils.
The group was presented with the outcomes of the interviews and focus groups with community stakeholders (see above) and a summary of some of the data that had been collected and analysed for the project, such as visual amenity data and community complaints. The group was then asked:

- Are there other possible cumulative impacts not identified by the community consultations that should be considered?
- Which of these impacts most warrant the attention of the local mining industry?
- What are the reasons for prioritising these particular impacts?

The reference group was in broad alignment with the community stakeholders about the main issues associated with the increase in mining (Table 5), but sometimes expressed this in different language and also included loss of vegetation/biodiversity as a significant issue.

<table>
<thead>
<tr>
<th>CUMULATIVE IMPACTS: Expert group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived decrease in health and wellbeing – physical and psychological</td>
</tr>
<tr>
<td>Decreasing sense of place</td>
</tr>
<tr>
<td>Loss of vegetation/biodiversity</td>
</tr>
<tr>
<td>Increased coal-related transportation and traffic</td>
</tr>
<tr>
<td>Increased noise – operational</td>
</tr>
<tr>
<td>Improved community infrastructure</td>
</tr>
<tr>
<td>Water quality – especially post-mine</td>
</tr>
<tr>
<td>Economic distortion due to over-reliance on mining</td>
</tr>
<tr>
<td>Land loss</td>
</tr>
</tbody>
</table>

The group then ranked all of the issues that had been identified (either by the group or the community stakeholders) on the basis of which ones most warranted attention from the local coal mining industry. Each member of the group was able to cast three votes of equal weight by placing an adhesive ‘dot indicator’ against lists displayed on the walls of the workshop venue.
The allocation of votes from this exercise is shown below:

<table>
<thead>
<tr>
<th>PRIORITY CUMULATIVE IMPACT ISSUES</th>
<th>VOTES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adverse social changes – ‘social dislocation’</td>
<td>6</td>
</tr>
<tr>
<td>Vegetation/biodiversity loss</td>
<td>6</td>
</tr>
<tr>
<td>Health – physical and psychological – decreased wellbeing</td>
<td>5</td>
</tr>
<tr>
<td>Air Quality/dust</td>
<td>4</td>
</tr>
<tr>
<td>Increased employment</td>
<td>2</td>
</tr>
<tr>
<td>Changing sense of place</td>
<td>2</td>
</tr>
<tr>
<td>Visual amenity</td>
<td>1</td>
</tr>
<tr>
<td>Improved community infrastructure</td>
<td>1</td>
</tr>
<tr>
<td>Water Quality – post mine</td>
<td>1</td>
</tr>
<tr>
<td>Economic distortion due to over-reliance on mining</td>
<td>1</td>
</tr>
<tr>
<td>Land loss</td>
<td>1</td>
</tr>
</tbody>
</table>

The high priority given by the reference group to vegetation management and biodiversity was the most significant point of divergence (attracting six votes from members of the expert group, but rarely mentioned by the wider group of stakeholders). This was acknowledged to be partly a reflection of the composition of the group, which included a number of people with an environmental background. Group members also placed less emphasis on visual amenity than did the community stakeholders.

The group was then split into four sub-groups, each of which focused on one of the top for ranked impacts: vegetation/biodiversity loss; health and wellbeing; social change; and air quality.

The sub-groups were asked to consider:

- What is known, and not known, about this impact?
- What factors are contributing to this impact?
- How could we best measure this impact?
- How, if at all, should the impact be managed?

The outcomes of these discussions were then reported back to the whole group (See Appendix 5 for a summary).

There was a broad consensus that the issues around each impact area required some collective action by local mines, rather than simply being addressed on a mine by mine basis. The need to establish baseline measurements and ongoing monitoring of the contributing factors was emphasised. It was also suggested that the socio-economic status of Muswellbrook be compared to other rural towns, to identify whether the perceived changes in the Muswellbrook community could be attributed to mining or to other common issues affecting many NSW or Australian rural economies. Divergent views were expressed about the role of the regulatory authorities in these processes; some workshop participants supported a more proactive and prescriptive stance from the regulators, while others thought the responsibility lay with the industry.
Summary

Key points to be drawn from the above discussion are as follows:

- Although people focused on different aspects, there was a general understanding that the concept of ‘cumulative impact’ related to the collective impact of mines on the town and the shire, rather than just the impacts associated with any one mine.

- The majority of interviewees and focus group participants recognised that there had been some positive outcomes associated with the growth of mining in Muswellbrook and acknowledged the economic contribution of the industry. However, ‘cumulative impacts’ were mostly characterised in negative terms.

- The main negatives associated with the increase in mining related to amenity issues (e.g. visual impact, noise, dust) and unwanted social changes (e.g. a perceived loss of community identity and greater wealth disparity).

The project reference group identified a similar range of issues to the community stakeholders, but assigned greater importance to the potential impact of increased mining on vegetation and biodiversity.

The project reference group agreed that collective action was required to deal effectively with cumulative impacts, rather than these issues just being dealt with on a mine-by-mine basis. It was also agreed that better baseline measurements and ongoing monitoring mechanisms were required.
2.3: Complaints Made to Mines in Muswellbrook

**Background**

Coal mines in the region use feedback from the community as an important part of engagement. One mechanism that is made available for the community to provide mines with feedback is to register complaints. Each mine keeps accounts of the number, timing and nature of complaints. The complaints registers are linked to a comprehensive response approach that incorporates community relations staff from the mines and their activities and environment management and investment in response to complaints. Therefore, complaints databases provide a potentially useful means of identifying key issues of concern to the local community and of assessing the impact of increased mining activity on community amenity. To date, individual mines have dealt with the complaints registered to them. In this section, we examine the potential to use the complaints registers across all the mines to attempt to see if they can be used to separate, understand, and perhaps suggest actions that are more associated with cumulative impacts than individual mine impacts. This was done by first examining the frequency of complaints over time (time series) and then comparing the types of complaints made with the community’s response in this project when they were questioned about priorities regarding cumulative impacts. In short, are the complaints register and the stated cumulative impacts aligned?

**Approach**

The complaints databases from the five mines were aggregated to examine the number of complaints over time, the association this has with coal production, the spatial distribution of complaints and the types of issues that are complained about the most. As a complement to the analysis of the number of complaints, the number of complainants was also checked. Regulations for categorisation of complaints are not very prescriptive. Therefore, over time, each mine has developed a classification system which best meets their needs. This poses challenges for combining the complaints databases. The nature of the limitations and the implications they had for the construction of a combined database for this study, are outlined in Appendix 6. A common set of complaint categories was defined (Table 7) and complaints allocated to them. The process is detailed in Appendix 7.

**Table 7. Classification and coding of complaints made to five mines sites at Muswellbrook**

<table>
<thead>
<tr>
<th>MAIN CATEGORY</th>
<th>SUB-CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>Noise</td>
<td>General plant and operational noise, e.g. noise from the plant operations at mine-site, including washery noise, CHPP, dragline</td>
</tr>
<tr>
<td></td>
<td>Noise–T</td>
<td>Noise – trains and rail, e.g. noise from trains, shunting, loading or related</td>
</tr>
<tr>
<td></td>
<td>Noise–B</td>
<td>Beeping – reversing-alarm noise</td>
</tr>
<tr>
<td></td>
<td>Noise–G</td>
<td>General operational noise, e.g. all noise emanating for the mine-site operation that was not plant specific or traffic or train related</td>
</tr>
<tr>
<td></td>
<td>Noise–P</td>
<td>Positive comments</td>
</tr>
<tr>
<td>Traffic</td>
<td>Traffic–D</td>
<td>Dust, e.g. dust problems caused by traffic, trucks etc, dust that could contribute to dangerous traffic conditions or accidents, incidents</td>
</tr>
<tr>
<td></td>
<td>Traffic–C</td>
<td>Congestion caused by traffic, or likely to contribute to traffic accident or incidences</td>
</tr>
<tr>
<td>Category</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Traffic–N Noise</td>
<td>Noise related to traffic, e.g. excessive operational truck noise, such as braking, acceleration or traffic noise.</td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>General, e.g. traffic related complaints that cannot be attributed to the other three categories, problem driver behaviour</td>
<td></td>
</tr>
<tr>
<td>Visual Amenity/Light</td>
<td>Lighting, e.g. general lighting from mine-site, lights from trains and traffic</td>
<td></td>
</tr>
<tr>
<td>Visual</td>
<td>Visual, e.g. construction or vegetation of bunds, haze, appearance of plant, site, etc.</td>
<td></td>
</tr>
<tr>
<td>Blasting/Vibration</td>
<td>Blast noise, blasting fumes</td>
<td></td>
</tr>
<tr>
<td>Overpressure</td>
<td>Air noise/vibration</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>Ground vibration</td>
<td></td>
</tr>
<tr>
<td>Dust/Air Quality</td>
<td>Dust</td>
<td></td>
</tr>
<tr>
<td>Air Quality</td>
<td>Air quality, e.g. heavy dust clouds</td>
<td></td>
</tr>
<tr>
<td>Spontaneous Combustion</td>
<td>Odours, e.g. usually related to spontaneous combustion and blasting fumes</td>
<td></td>
</tr>
<tr>
<td>Spontaneous Combustion</td>
<td>Combustion and odours</td>
<td></td>
</tr>
<tr>
<td>Communication/CSR</td>
<td>Community consultation, e.g. problems related to meetings with the community, meeting corporate responsibilities</td>
<td></td>
</tr>
<tr>
<td>CF</td>
<td>Cumulative frustration</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communication between mine and non-mine people or organisations</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Any water related complaints</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Development consent, shooting on mine site, kangaroos, rubbish, smoke, neighbours, damage, spoiled washing, potential subsidence, trespassing or intrusion by mine staff, failure of monitoring equipment, safety breaches</td>
<td></td>
</tr>
</tbody>
</table>

**Spatial Distribution**

Given the likelihood that someone is more likely to register a complaint if a mine opens close by, the region was divided into six sectors and complaints were allocated to the sector from which they originated. The allocation was done by the mines to preserve confidentiality of complaint location. Figure 12 shows the sectors overlain on a Landsat scene with major roads included for perspective.

Mapping the spatial distribution of complaints over time (Figure 13) shows that complaints increase in sectors in which mines are opened. There is a tendency for complaints to rise initially and then to decrease (the North West sector shows this effect the least). It is likely that the complaints trend in the outer regions is dominantly due to mines responding effectively to the source of the complaint. Other factors include complainants moving away and a reduction in complaints because of the perception that action will not be taken (see earlier discussion).

The central sector in the region, the Muswellbrook town, is different in that the response to individual mines is less clear and there is not a notable decrease following a peak in numbers. This is an indication that cumulative impacts are gradually becoming noticeable in the township. However, the data for the town for 2005 bear some resemblance to those from earlier years from the outer sectors: that is, an increase in the number of complaints per complainant (see analysis below) and a sharp rise in the number of complaints in a short period.
Figure 12. Spatial units (sectors) of the township and surrounds into which complaints were allocated.
Figure 13. Spatial distribution of complaints through time. Sectors are as illustrated in Figure 12.
Temporal Changes

It is reasonable to expect that as mining increases in the region the number of complaints from the community about mining would also increase. If complaints increases faster than the increase in mining it is possible that this indicates cumulative impacts. That is, if mines do not respond well to complaints, it is reasonable to hypothesise that each mine, as production increases, will receive more complaints. However, if response is effective, the number of complaints may decrease as production increases. In this case, it is likely that response to complaints has been an effective mechanism for avoiding growing discontent with mining, i.e. a broad-based community cumulative impact will have been avoided.

The number of complaints made across the study region over the last decade is shown in Figure 14. The reader is referred to Figure 10 for perspective on significant development events that occurred at various times over the period shown. The figure shows that a significant increase occurred towards the end of the 1990s, when new mines came on line, peaked in 2000, declined steadily until 2003 and then became relatively steady. Prior to 2000 there was a strong linear relationship between coal production and number of complaints ($r^2=0.98$) but this does not continue after 2000. Over the entire period there is no relationship between complaints and saleable coal production ($r^2=0.17$).

Several explanations are possible for the drop off in complaints after 2000. A significant increase in effort by each of the mines to respond to complaints and deal with their impacts as complaints increased is evidence that effective response has resulted in the rapid decline in complaints. Another factor is relocation of complainants either at their own initiative or following the purchase of their property by a mine. Some people who initially were motivated to complain may have adapted to the changed environment. Based on statements made during the community consultation process, some people have stopped complaining because of a perception that complaints are not acted upon. There is some evidence that this

Figure 14. Number of complaints across the study region and saleable coal production.

Source: Mine supplied data.
may also be a contributing factor, but the extent to which people’s propensity to complain may have diminished cannot be quantified.

The data presented and discussed above are the aggregate complaints data from across the whole study region. A somewhat different picture emerges if the complaints from the town of Muswellbrook, which is surrounded by the mines, are examined (Figure 15). First, it is important to note that the vast majority of complaints do not come from the town. Prior to 2005, around 20% of complaints are from the town.

The number of complaints from the town follows a similar pattern to the total complaints from the region (Figure 14) but the decrease between 2000 and 2004 has been less marked and 2005 has shown a significant increase. However, whilst the shape is somewhat similar, the number of complaints from town, as a percentage of the total, has been gradually increasing over time. Unlike the total complaints for the region, there is a linear correlation between saleable coal production and complaints from the town ($r^2=0.66$). This provides some evidence for the interpretation that the reduction in total complaints (described above) has been achieved principally by individual mines responding effectively to near neighbour complaints. By contrast, in the town, results have been less dramatic perhaps indicating that the focus on near neighbours has allowed a slow building of cumulative discontent in the town. It should not be surprising that this has not previously been recognised because this study is the first time these individual mine complaints data have been combined. Therefore, there is no way that the individual mines will have realised that the large decrease in total complaints post 2000 is not reflected in the town. This only becomes apparent by the combination of aggregation of the complaints registers and analysing them from a spatial perspective. Figure 15 also indicates that the hypothesis that people have stopped making complaints because of a lack of response from the mines does not hold up in the town.

![Figure 15. Percentage and number of complaints that come from the town over time. Source: Mine supplied data.](image)

In examining complaints information it is important to take into account that not all complaints come from different people. To shed some light on this effect the number of complaints per complainant can be used. If there are a large number of complaints per
complainant then care must be taken in interpreting complaints as indicators of cumulative impacts. Clearly, a different management response is required to deal with a small number of people making a large number of complaints and a large number of people each making a small number of complaints.

The mines each supplied the number of complainants for each year. This information has been aggregated across mines and separated into the same spatial units as the above analysis. The “number of complainants” information was combined with the “number of complaints” to produce the number of complaints per complainant. Figure 16 shows the aggregated results across the whole region and for the town of Muswellbrook.

These data indicate that there is reason to be cautious in interpreting the number of complaints coming from across this region in terms of cumulative impact because there are so many complaints per complainant (~10 during the periods of highest complaint numbers). This is consistent with near neighbours, who are most strongly and rapidly affected by a new mine, often registering complaints regularly. By contrast, the number of complaints per complainant in the town has not varied very much over time (~1-2). This is evidence that the complaints can be seen as signalling a community response to the existence of cumulative impacts, as distinct from mine-specific impacts, which individual mines are better equipped to deal with.

It is important to note that the same complainant may have registered the same complaint with more than one mine and this would not be detected in the analysis here, as confidentiality of the source of the complaint was maintained by the mines.

![Figure 16. Number of complaints per complainant in the town and region.](source: Mine supplied data.)
Nature of Complaints

An initial analysis of the nature of complaints was undertaken to determine whether complaints registered with individual mines matched the categories that the community indicated were of most concern when asked directly about cumulative impacts.

Figure 17 shows the number of complaints in each of the complaint categories (Table 7) over time. The majority of complaints are for noise, vibration/blasting and dust/air quality. These constitute nearly 90% of all complaints over the reporting period (Figure 18). Blasting and noise account for the higher number of complaints from 1998 to 2001, when mining commenced quite close to the boundary of the Muswellbrook township. Complaints of all types are decreasing except spontaneous combustion and traffic related issues, both of which show slight increases between 2004 and 2005.

![Figure 17. Nature of combined complaints made between 1994 and 2005](source: Mine supplied data)

Complaints about depletion or contamination of water sources and amenities did not feature predominantly. This absence of water-related complaints may have been in response to the efforts taken by the mines towards water quality assurance and more stringent environmental protection control guidelines, in particular through the Hunter River Salinity Trading Scheme.

It should be noted that the contents of the datasets were not always restricted to complaints. Residents would sometimes provide positive feedback in relation to particular conditions (i.e. climatic or operational). For example:

‘Complained of reversing beepers heard at 6:30 am. Commented that dust is not a problem at present and noise is acceptable. Asked that [person] not slam doors when monitoring.’

‘Just letting you know that those trucks are much quieter now.’

Some comments were not expressed as complaints but rather to provide awareness of a situation, for example:
‘Ringing to let you know that we’ve been hearing one of your trucks lately. Quite distinctive and have noticed it the past few nights. Not a complaint but if you could follow this up…’.

Figure 18 shows the distribution of complaints by complaint type for the period 1994-2005 and for the year in which this project sought community, key interviewees’ and reference group opinions as to the main cumulative impacts. Recall that the highest-ranking cumulative impacts perceived by these groups were: social changes (both groups); visual amenity (community stakeholders); and loss of vegetation and biodiversity (expert group).

This demonstrates that when people are questioned about cumulative impacts they do not necessarily respond with all the same issues for which they are most likely to register complaints. This would appear to illustrate a degree of understanding in the community of the concept of cumulative impacts. It is also possible that cumulative impacts raise tensions in a general sense which are expressed though the registration of complaints when specific events, such as blasting, light or noise at night, occur.

![Figure 18. Complaint types made to Muswellbrook Coalmines; (a) 1994-2005; and (b) 2005. Source: Mine supplied data.](image)

Other issues relate to the way in which complaints tend to be recorded and categorised. For example, the Shire Council does not record complaints that cannot be attributed to a specific mine. In addition, there does not appear to be a regulatory ‘category’, or allowance for reporting generalised social or economic changes or impacts. Registering complaints about how the area or scenery appears visually does not have a ‘code’. Of course, it would be difficult for individual mines to respond to these types of complaints, since their mitigation is long term and complex (hence this project). Clearly, strategies to deal with issues arising from cumulative impacts offer an opportunity to design ‘complaint’ and response mechanisms that are better tailored to the complexity of the issues.

**Conclusions**

This analysis is the first time that individual mine complaint registers have been aggregated. Cumulative community impacts in the near neighbour areas surrounding the individual mines are not evident in terms of number of complaints. The processes in place now appear to be managing the issues causing complaints effectively. However, the time series and spatial analyses provide persuasive evidence of the existence of cumulative impacts in the town of Muswellbrook.
An important factor in responding to this new information is to understand whether the nature of the impacts of concern is the same as those of the near neighbour impacts. If they are, then the mines can plan collective actions with the current monitoring and reporting systems used as the basis for action with any necessary tuning to locations, frequencies and communication as appropriate. If, however, different issues arise then the mines may need to take other action. An initial analysis of the nature of complaints indicates that there are areas of consistency but the community also noted areas for concern over cumulative impacts which did not appear in the complaints registers. Action to deal with this would include further engagement with the community to get a comprehensive picture of the issues and possibly introducing other types of monitoring and/or interpretations of the current monitoring.

There would appear to be value in considering the development of a single consistent classification scheme for complaints. This would provide better data for dealing with the complaints and help mines coordinate approaches more effectively. The spatial and temporal analyses here show that there is value in examining the combined complaints information. If the mines did this on a regular basis and coordinated some of the mitigation responses, this might help alleviate some of the perception that action is not taken in response to complaints. To assist with aggregating information for effective action, a consistent spatial locator would be very useful. This would help to understand whether action should be collective or should be dealt with most effectively by a specific mine.

Complaints databases provide a potentially useful means of identifying the existence of cumulative impacts, key issues of concern to the local community and of assessing the impact of increased mining activity on community amenity. However, given that they were not designed to record and respond to cumulative impacts per se the information must be interpreted with care. It is also important that mine-by-mine effective response to near neighbour complaints is not seen of lack of evidence of cumulative impacts outside the town because, as it evident throughout this report, some cumulative impacts are far more complex than the issues that can be raised through the current codes in the complaints registers.
2.4: Prioritising Impact Areas for Investigation

This brief chapter describes how impact areas were prioritised for further investigation.

As discussed in Chapter 1.2, given the exploratory nature of the study and the limited time and resources available to the research team, it was not possible to collect data about all of the impact dimensions identified by the expert group and the broader community. The following selection criteria were therefore developed.

1. Sufficient data were available to enable some quantitative analysis to be undertaken.

2. The impact in question was not the subject of other current, or recent, studies. (This criterion was included to minimise duplication of effort).

3. There should a spread of social, environmental and economic impacts to enable the data issues involved with measuring different types of impacts to be explored.

Within these constraints, priority was given to investigating those impact areas that had been identified as significant by the community stakeholders. (Note that because of scheduling difficulties, the expert workshop could not be held until after it had been decided which impacts to focus on.)

Applying these criteria, the impact areas selected for analysis were:

- the economic contribution on mining to Muswellbrook (principally employment, but including local business spend)
- visual amenity in the town of Muswellbrook
- water quality in the Hunter River
- social impacts (encompassing population growth, income distribution, the issue of ‘social dislocation’, and the community benefits of mine expenditure).

With the exception of the water quality issue, each of these impact areas had been identified as significant by the community stakeholders. The reasons for excluding other significant impacts identified by community stakeholders were as follows:

- community attitudes towards safety – lack of data, apart from anecdotal accounts
- ‘noise, blasting and vibration’ – the subject of other recent work through ACARP
- dust and air quality – also being addressed by another study.

The basis for including water quality in the list, even though it did not score high in the rating process, was to explore some of the issues around the use of ‘hard’ environmental data to measure cumulative impacts. Other relevant considerations were the importance of the Hunter River resource, its proximity to the mines and the high priority that had historically been given to water quality impacts, as evidenced by the formation of the Hunter River Salinity Trading Scheme (HRSTS).
2.5: The Economic Contribution of Mining to Muswellbrook

There was general agreement amongst both the community stakeholders and the expert group that the expansion of mining in Muswellbrook had contributed to increased employment and greater wealth. However, there were diverging views about the magnitude of the economic benefits that could be attributed to mining and about how widely these benefits had been distributed.

The primary focus of the following discussion is on direct employment impacts, partly because this was of particular interest to community stakeholders and partly because more data were available. However, several other aspects are also briefly considered, including indirect and induced employment, employee expenditure patterns and the value of the contribution of the mining sector to local government.

**Employment**

Employment impacts generated by mining may be direct, indirect or induced.

- **Direct employment** refers to the number of people who work in the mining industry and encompasses people employed by mining companies and on-site contractors.

- **Indirect employment** refers to the number of jobs in an economy which are created as a result of a mine purchasing goods and services (such as fuel, transport, maintenance support) from contractors and other businesses.

- **Induced employment** refers to the number of other people in the local economy (such as in the retail and housing sectors) who are employed as a result of local spending from people employed directly or indirectly by the mines.

Data relevant to each of these aspects are reviewed below.

**Direct Employment**

The two sources of information about the number of people directly employed in mining in Muswellbrook are the national census (most recent data available 2006) and employment data collected on an ongoing basis by the individual mines. Data from these two sources are not directly comparable. Census data includes people who live locally but are employed in mines outside Muswellbrook, plus those employed as, or working for, on-site contractors. Conversely, for most years the employment data provided by the mines to the project researchers related only to their own employees (not contractors) and did not distinguish between employees who live locally and those who reside outside of the Shire.

**ABS Data**

In 2006, according to ABS census data, 1,102 people residing in Muswellbrook were employed in the mining industry, representing 16% of the local workforce. This was very close to the level recorded in the 1996 census (1068). The intervening census in 2001, however, showed a significant drop, with the number of local people employed in the

---

7 For example, according to the Environmental Impact Assessment prepared for Mt Owen Operations in 2003, 27 Mt Owen employees lived in Muswellbrook. Mt Owen mine is in Singleton Shire (p. 16.6)
mining industry falling to 789, or 12.7% of the workforce. This reduction was most likely due primarily to significant downsizing in the latter part of the 1990s by two mines with a predominantly Muswellbrook-based workforce – Drayton and Muswellbrook Coal – although changes residential patterns of workers may also have been a factor (Figure 19). Conversely, the increase since 2001 is in line with the recent growth of the industry.8

![Figure 19. Percentage of the total workforce employed in the mining industry in Muswellbrook in 1996, 2001 and 2006. Source: ABS census 2006](image)

**Industry data**

According to industry data, in the period from 1995–96 through to 2000–1 the number of people recorded as employed by the local mines remained more or less stable. However as just noted, the census shows that the number of Muswellbrook residents employed in mining declined over the same period.

A possible explanation for this discrepancy is that there has been a trend towards an increasing number of the jobs available at local mines being filled by people living out of the Shire. A mining industry and employee survey conducted by Coakes Consulting (1999), as part of the Environmental Impact Assessment for the Mt Arthur Coal Project, reported that 56% of employees of Bayswater, Bengalla, Drayton and Muswellbrook Coal lived in Muswellbrook Shire (47.8% in Muswellbrook and 8.6% in Denman).

By contrast (Figure 20), which is based on more recent employment data provided by the mines participating in this study, shows that in 2004, 45% of employees lived in the Shire – 11 percentage points less than recorded by the 1999 survey. Of this number, 40% nominated Muswellbrook as their address and another 5% said that they lived in Denman (Figure 20). This equates to approximately 600 employees living in Muswellbrook Shire.

---

8 Note that the census was conducted after Dartbrook mine had begun to implement significant job reductions as a result of the decision to place Dartbrook Mine on a care and maintenance basis.
Figure 20. Place of residence of mine employees (2004)
Source: Mine supplied data.

Figure 21 compares annual trends in mining employment (based on industry data) with trends in the level of production. This shows that production increased by around 150% between 1995/6 and 2000/01 without any increase in employment.\(^9\) However, since 2000, employment levels in the local industry have increased steadily, broadly in line with the increase in production.

Figure 21. Total number of employees (five study mines) and total coal production (five study mines)
Source: Mine supplied data.

A final point to note is that, historically, most of the Muswellbrook mines appear to have had quite stable workforces, with relatively low rates of turnover. For example, in 2004 one mine reported an employee turnover rate of 4% and another one a rate of only 1.2%. Moreover, typically only a relatively small number of apprenticeships (14 in 2004) and

---

\(^9\) One issue that was raised for consideration was whether the ‘real’ increase in employment over this period was greater than shown, because the mines were now making greater use of contractors. Two mines provided contractor data for the period from 2000-5 and one for 2003-5. In neither of these cases was there any evidence of a shift from direct employment to contract work over the period for which data were available.
traineeships (8 in 2004) have been offered annually by the mines although this figure appears to have increased in the most recent period. Consequently, significant opportunities for local people to find employment in the mines have mainly arisen when a new operation has opened or there has been a major expansion of an existing mine, rather than being available on a continuing basis.

**Direct Employment: Summary**

The data reviewed above confirm that the mining industry has been – and continues to be – a major employer in Muswellbrook. However, the relationship between increased mining activity and employment in the industry has not been linear. As noted, during the 1990s production increased significantly, but overall employment in the local industry remained static and there was a drop-off in the number of Muswellbrook residents working in mining. The more recent upsurge in production has been accompanied by an increase in employment, but the implications for Muswellbrook are difficult to assess, given that there is some evidence to indicate that increasing numbers of industry employees are now living outside the Shire.

**Indirect and Induced Employment**

No reliable data could be obtained on the number of local people employed off-site in firms supplying goods and services to the mines. An unpublished audit of 88 local businesses conducted by the Muswellbrook Shire in 2005 found that 24 businesses (27% of those surveyed) relied primarily on providing support services for the mining or power industries, but the number of jobs this represented was not recorded. There are no empirically-grounded estimates available of the number of jobs in non-mining related businesses (e.g. retail outlets) that have been created as a flow-on from the increased economic activity generated by mining.

Some companies have attempted to estimate induced and indirect employment effects of projects by utilising multipliers of various kinds. Based on work done by the Hunter Valley Research Foundation (1999), the EIS for Mt Arthur Coal used a multiplier of 2.65 to estimate that 860 flow-on jobs would be created as a result of the project (Coakes Consulting 2000). However, this estimate was of jobs generated in Hunter region, rather than in Muswellbrook. The EIS for the Dartbrook Extension asserted that closure of Dartbrook mine within two to three years could result in a total of 438 job losses in Muswellbrook, Scone and Aberdeen Localities, but the basis for this estimate is unclear (HLA Envirosciences Pty Ltd 2000, Section 6.12.3). The recently completed EIS for the proposed Anvil Hill mine uses a multiplier of 2.16, although again this applies to the wider region rather than to Muswellbrook Shire specifically (Gillespie Economics 2006).

---

10 Muswellbrook Shire Skills Audit conducted by the Muswellbrook Shire Council Economic Development Officer, August 2005.

11 The EIS for the Mt Owen expansion contained the claim that the mining industry generates three additional jobs in other industries for every job in mining (citing the New South Wales Minerals Council website as the source) and on this basis concluded that "continued employment of approximately 235 personnel at Mt Owen will result in the continued employment of approximately 750 people in the local community" ((Umwelt Environmental Consultants 2003, p.16.7)
limitation of all of these studies for present purposes is that they focus on broader regional impacts and do not provide estimates specifically for Muswellbrook.\textsuperscript{12}

In summary, while there is no doubt that the total contribution of the mining industry to employment is greater than its direct contribution, there is no reliable estimate available of the scale of indirect and induced employment impacts for Muswellbrook Shire. Moreover, the lack of time series data means that it is not possible to determine whether the balance of direct, indirect and induced impacts has changed over time. Clearly, this is an area where further research would be warranted.

**Expenditure by Employees**

In seeking to assess the full economic impact of mining on Muswellbrook Shire, it is important to take account not only of where employees live, but also where they spend their money. No data were collected on this aspect specifically for this study, but some relevant research was undertaken for the Mt Arthur Environmental Impact Study by Coakes Consulting (‘Mining Industry and Employee Survey’) in 1999. As part of this study, a cross-section of mining industry employees was surveyed about the main towns from which they purchased goods and services. Combining these responses with data from an ABS Household Expenditure Survey undertaken in 1993-94, the Mt Arthur Coal researchers estimated that mining industry employees contributed approximately $21.2 million in annual household expenditure to Muswellbrook Shire, with the balance of expenditure being shared mainly amongst Singleton, Scone, Newcastle, Maitland and Denman. The study did not include people indirectly employed by the mines, so total expenditure attributable to the industry is likely to be considerably higher than this estimate.\textsuperscript{13}

This methodology only measured direct expenditure by employees, and not the indirect flow-on of that expenditure through the community. A number of Upper Hunter Valley coal mines (Nardell, Ravensworth East, Mount Pleasant, Dartbrook Extended and Mt Arthur Coal) have used an income multiplier of 1.66 based on the Hunter Valley Research Foundation’s Input-Output model. Bengalla also used the same multiplier in its EIS, although it gave the Centre for Transport Policy Analysis at the University of Wollongong as the source (Envirosciences Pty Ltd 1993).

**Local Business Spend**

The mines were not able to provide comprehensive and reliable data on the amount of money that they spent purchasing goods and services from Muswellbrook-based businesses. There is no doubt, however, that across the five mines a significant amount of expenditure is involved. For example, as noted above, a recent audit by Muswellbrook City Council identified 24 businesses (27% of those surveyed) that relied primarily on providing support services for the mining or power industries.

\textsuperscript{12} It is understood that the SIA for the Mt Arthur Underground Project Environmental Assessment, which will be on public exhibition early in 2008, has quantified the estimated flow-on employment that will be generated at the township level, i.e. Muswellbrook, Denman, Aberdeen, etc.

\textsuperscript{13} It would be a relatively straightforward matter to update this study, using data from the 2003-04 Household Expenditure Survey, more recent employment and earnings data from the mines and an updated survey of industry employees. However, the resources required to do this were beyond the scope of the current project.
Local and State Government Payments

Collectively, the local mines are substantial ratepayers, having contributed $2.68 million in rates to Muswellbrook Shire in the three years 2004-06 (Table 8). In 2004-5, the mines paid $1,066,805 in rates, which accounted for 19% of all rates paid to the Shire in that year (Muswellbrook Shire Council 2004, p.86)

In addition, various mines have made substantial one-off infrastructure payments to the Council, under s.94 of the Environment, Planning and Assessment Act 1979 (NSW). For example, in 2003 Mt Arthur Coal provided $2.5 million towards the construction of a heated swimming pool in Muswellbrook.

Table 8 also shows the average annual value of royalties paid to the New South Wales Department of Mineral Resources between 2001 and 2006. This amount is many times greater than what is paid by the mines to local government. It is not known what proportion of these royalties flow back to the Shire in the form of Government expenditure.

Table 8. Revenue contribution of Muswellbrook mines to state and regional government

<table>
<thead>
<tr>
<th>Type of Payment</th>
<th>Annual Average ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rates paid to Muswellbrook Shire Council (2004-2006)</td>
<td>893,000*</td>
</tr>
<tr>
<td>Royalties paid to NSW Dept of Mineral Resources (2001 – 2006)</td>
<td>45,386,000**</td>
</tr>
</tbody>
</table>

Source: Mine supplied data.
* Includes five participant mines plus Mt Pleasant
** Excludes data for one mine

Summary

The evidence reviewed in this chapter confirms that mining is a very important part of the Muswellbrook economy. Based on the census data, in 2006 there were 1,102 Muswellbrook Shire residents directly employed in the mining industry, accounting for around 16% of local employment. Total mining-related employment (i.e. including indirect and induced employment) would have been well above this level, although it is impossible to accurately estimate the full employment impacts of mining using available data sources.

In addition, operations and their employees have contributed many millions of dollars annually to the local economy in the form of expenditure on goods and services. The mines are also major ratepayers, providing the Council with close to one fifth of its total rates revenue, and funding some significant improvements in community facilities. Clearly, if there was to be a significant downturn in mining in the Shire, or if it were to cease altogether, this would have major consequences for Muswellbrook, as well as for the wider region.

While the overall economic importance of mining for Muswellbrook is not at issue, there is not a simple linear relationship between increased mining and the scale of economic benefits for the local community. In the case of employment, for example, the latter half of the 1990s saw significant increases in production without a commensurate growth in the number of mining jobs. Factors such as where employees are recruited from and/or choose to live, policies towards the use of contractors, the purchasing policies of local mines, and
the spending patterns of employees can also vary over time, independently of the level of mining activity. Clearly, more work is needed to understand the interactions between these various factors over time and the implications that this may have had for the local economy of Muswellbrook.

Implications

- To enable a more complete picture to be provided of the economic contribution of mining to Muswellbrook Shire, local mines should consider:
- implementing a standard process for capturing and reporting data about their local business and community spends
- collectively funding a comprehensive survey of businesses in the Shire, perhaps in conjunction with the Shire and/or Chamber of Commerce, to obtain more accurate data on the amount of indirect and induced employment attributable to mining
- undertaking an up-to-date industry-wide employee survey, modelled on the work undertaken for the Mt Arthur Coal EIS, to collect up-to-date data about expenditure patterns of mine workers.

Regardless of what any additional research may show, it would be advantageous for the mines to explore ways of increasing direct and indirect employment opportunities for local people and of providing more support for local businesses. This would help to dispel the view held by sections of the community that Muswellbrook has missed out on many of the economic benefits of mining, while bearing a disproportionate amount of the costs. Such an approach would also be consistent with the policy commitments that most major mining companies have made to supporting local communities.

Actions that local mines could take in this regard include:
- reviewing their expenditure practices and policies to ascertain if there is scope for greater utilisation of locally-based businesses
- initiating a dialogue, through the Muswellbrook Mine General Managers Forum, with the Muswellbrook Shire Council and organisations such as the Chamber of Commerce, to identify practical ways in which more local business opportunities can be created
- giving priority to the recruitment of local residents when starting up or expanding operations, subject to these applicants meeting the required standards (some mines already apply this policy)
- reviewing policies and practices around apprenticeships and traineeships (in consultation with TAFE and other education providers) with the aim of creating more employment opportunities for young people from the area.
### 2.6: Visual Amenity (visual exposure to mine lands)

#### The Issues

The community stakeholders and the reference group both recognised the importance of visual amenity when considering cumulative impacts. Visual amenity is a complex issue. It incorporates the direct visual presence of the physical features of the mine and indirect aspects such as dust in the atmosphere and lights at night. It is also complicated by the fact that mitigation measures, in particular land rehabilitation including revegetation, takes several years to come into full effect, and may be delayed by conditions such as drought.

The Annual Environmental Management Reports (AEMR) from each mine often provide information on the activities being undertaken to manage visual amenity. A wide range of mitigation measures are progressively implemented to deal with various issues. For example, conservation of existing vegetation and strategic tree plantings have been undertaken to provide visual barriers from key locations, especially along roads. This has been evident at many of the mine-sites within the Muswellbrook area, including Mt Arthur Coal, Bengalla and Dartbrook mines. Other examples of amenity control measures that have been adopted, in this case at Mt Arthur Coal, include construction of significant earth bunds that are revegetated and use of natural colour tones for new infrastructure, including mine offices and coal processing facilities.

Mines work at night, so lighting can be a source of impact. Careful arrangement and directing of lights, mine design controls, including separate day and night dumps, engineering features including louvres and/or shields and select use of low impact lighting in combination with construction of bunds, are examples of strategies to mitigate potential impacts.

Dust can impact visual amenity when associated with general atmospheric haze or with episodic events. Dust is monitored (with AEMR and other statutory reporting on levels) at locations on- and off-lease in an effort consistent across the mines. Dust can be the source of a range of impacts depending on the distribution and sizes of particles. There is a significant program of dust mitigation measures implemented by sites in an attempt to reduce visible dust levels. In particular, water is used to suppress dust on haul roads and coal stockpile and handling areas. Some mining companies have put significant effort in researching and trialling methods to do this effectively without excessive water consumption. Strategies include consolidating haul routes and operating with sensitivity to ambient environmental conditions (e.g. utilising less exposed areas when windy), operating weather monitoring alarms, completing progressive rehabilitation, optimising truck speeds and wetting rates, establishing dedicated water cart operator teams trained in effective road dust control, applying alternative road dust suppressants (e.g. bituminous-based products), increasing attention to haul road maintenance and developing efficient spray technologies.

It was not possible in this study to deal with all aspects of visual amenity. The issue selected was the extent to which the township of Muswellbrook is visually exposed to mine plant and equipment and land disturbed by mining. The full data analysis for this assessment is contained in Appendix 8. This aspect of visual amenity was chosen for a number of reasons.

1. It demonstrates a number of different types of cumulative impact (see Section 1.3 and Figure 4), namely: simple spatial impacts, spatial intensity impacts and offset temporal impacts.
2. The impact was identified as a cumulative impact by the community and the reference group (albeit the latter rated it of less importance than a number of other issues, see Section 2.2).

3. The analysis could be carried out in the timeframe available.

4. Data were readily available and affordable. The satellite imagery and digital elevation models were purchased from commercial and government sources, respectively. The mines supplied data describing the amount of disturbed and rehabilitated land on a year-by-year basis which could be used to verify estimations of disturbed areas from the satellite imagery. Mines also provided information on the location and elevation of visual bunds\(^{14}\).

5. Direct impacts of dust were not within the capabilities of this research team nor could they have been sourced within the time and budget constraints of the project. As described earlier, a separate ACARP project was dealing with the issue of direct measurement of dust. This is an area requiring considerable specialist expertise. For these reasons, dust was not examined directly for visual amenity assessment.

6. Current EIS and EA information on visual assessment for the mines was not carried out using a quantitative approach. There was a desire to test the use of such methods for potential future applications to various aspects of visual exposure mapping and mitigation planning.

**Method of Measuring Visual Amenity**

As indicated in section 1.3, it is necessary to define the system boundary for assessment of any impact to ensure clarity for interpretation and planning. Figure 22 shows how the boundary (in red outline) of the Muswellbrook town was delineated for this analysis. It was identified in feedback from the mines and review of mine complaint records that additional areas outside of this boundary are impacted from a visual perspective by local mining, however, this boundary was determined by the research team for practical reasons to enable the assessment and given it comprises the majority of the town residential population.

---

\(^{14}\) Unfortunately the information from one mine arrived too late in the project to be included. However, this is not considered to have overly compromised the analysis because the mine in question is relatively visually separated from the town.
Figure 22. Delineation of the Muswellbrook town (impact zone) for visual impact assessment.

The approach adopted was to map the amount of land disturbed by mining that could be viewed from locations in the town. Quantitative assessment permits a large number of viewing locations to be considered. The town area was divided into individual square spatial units (pixels), each of which had a side length of 25m. Each pixel was treated as a viewing location. This allowed continuous spatial mapping across the whole impact zone (Figure 24).

Remotely sensed satellite data scenes (also with pixels of side length 25m) from various years over the period 1989–2004 were used to identify areas of disturbance on all mine leases (Figure 23). Areas of disturbance and rehabilitation supplied by mines (as shown in their AEMR’s) were used to verify the results from the satellite data scenes.
To determine how much disturbed land could be seen from each viewing location in the town, it was necessary to take topography into account. Using a digital elevation model – a topographic map that identifies elevation in pixels – it is possible to calculate which parts of the landscape can be seen from a given location in a given viewing direction. This is termed the ‘viewshed’ (which is an analogue of watershed or airshed) and is an indicator of what people would look out upon if they were at a particular location (although local features such as trees and buildings are not factored in). The viewing direction for each location is determined by computing the aspect using the digital topographic information. The viewshed, because it is computed using digital information, is also made up of a set of pixels.

By overlaying the viewshed from a viewing location on the image of disturbed areas (Figure 23) it is a simple matter to determine which of the pixels that can be seen are disturbed. For each pixel in the town (the impacted region), the number of disturbed pixels that can be seen in the viewshed are added up. Given that the area of each pixel is known, i.e. 25x25=625m², the total area of disturbed land that can be viewed from each location in the town can be computed. This area is termed the impact intensity. Viewing locations in the town from which larger areas of disturbed land can be seen have larger impact intensity. Once the impact intensity of each pixel in the town is computed a map can be produced. The mean...
*impact intensity* is the average of the impact intensities for all pixels in the town, i.e. the sum of total disturbed area that can be seen divided by the number of pixels in the town.

The analysis as described above assumes that the topographic features had not been altered by mining. However, the mines around Muswellbrook are undertaking various activities to mitigate the impact of visual exposure to the township and surrounding areas and so this prompted a review of this analysis approach. The most significant of these is the construction and vegetation of visual bunds. Visual bunds are hill-like structures strategically placed into the landscape, often as determined in consultation with or as directed by Government as part of mining approval, to block the exposure of certain features from particular viewing locations. For example, there are many examples where mine workings and industrial areas cannot be seen from public roads where they would otherwise be visible. A number of the mines in the study have constructed, and continue to construct, bunds of substantial proportions. This necessitates transporting spoil further than it would otherwise have been.

To quantify the effectiveness of bunds, the digital elevation model and analysis was adjusted. Bund location and elevation information was first added to the digital elevation model, the viewsheds were recomputed, and impact intensity re-mapped.

**Findings**

Figure 24 shows the impact intensity maps for Muswellbrook for a set of sample years **assuming that no mitigation measures were put in place**. Interpreting the maps as simple spatial cumulative impact measures, it is clear that the area of Muswellbrook exposed to some disturbed area has increased over time. This can be seen by looking at the amount of black (no disturbed area can be seen from these locations) in each image.

![Impact intensity maps for Muswellbrook](image)

*Figure 24. Impact intensity for the Muswellbrook town from 1989, 1995, 2000 and 2004 (lighter blue indicates greater impact intensity – black indicates no impact).*
The maps in Figure 24 can also be interpreted as spatial intensity impacts – the lighter the colour, the greater the intensity of impact. Overall, the brightness of the blue has increased. Also, by 2004, there are a number of sub-areas within the town which are more exposed than most (light blue-white areas). Again, it should be recognised that this analysis does not recognise rehabilitation areas that would offset these impacts nor controls including tree screens and earth bunds constructed by mines with the specific purpose to reduce visual impacts.

![Graph](image_url)

**Figure 25.** The change in mean impact intensity for the period 1989-2004. The effect of inclusion of visual bunds (with and without completed rehabilitation) is shown for 2004.
Figure 26. Visual impact in the town in 2004 comparing the situations of (a) no visual bunds with (b) bunds treated as disturbed land and (c) bunds that are shaped and vegetated.

The data from the maps can also be interpreted in terms of an offset temporal impact by plotting the change in average impact intensity with time from 1989-2004 (Figure 25). Recall (section 1.3) that an offset temporal impact is one which is displayed as a time series but which includes information that is cumulative in relation to the appearance of different impact sources in time. In this example, the events are related to activities on existing mines changing over time and new mines opening (Figure 24). It can be seen that until 1995, the mean impact changes very little and then it increases, largely due to disturbed land being seen from a greater proportion of the town.

The effectiveness of construction of visual bunds can be seen as simple and intensity spatial impacts in Figure 26. The map at the top (Figure 26a), is the same as that shown in Figure 24 for 2004 in which no controls are represented. If the bunds still under construction in 2004 are considered to be equivalent to disturbed land, the spatial distribution of impact intensity is slightly different than no mitigation. The most exposed areas are reduced but there is a slight increase (generally brighter blue colours) across the town. Also, slightly more of the total area is exposed which is caused by bunds being higher than the original landscape. Figure 25 demonstrates that even when considered 100% un-rehabilitated the bunds reduce the impact intensity. However, the mitigation effect of 100% rehabilitated bunds (Figure 26c) is dramatic – less of the town is exposed (more black) and that which is impacted, is impacted to a greatly reduced degree. Figure 25 shows that the impact intensity under this scenario is reduced to levels of the mid 1990's. It is likely that the time lapse since 2004 (when the most recent data was analysed) has meant that many of the bunds still under construction at that time would have be complete. Consequently impact intensity in Muswellbrook should be less. An example of this is Mt Arthur Coal’s visual bund, a significant feature which took five years to construct and for which the outer face was
completed in 2007. This bund now provides significant screening of the mining operation from residential areas to the north in Muswellbrook and vegetation efforts have benefitted from the rains in June 2007. This improvement in visual amenity is supported by a reduction in lighting complaints received by Mt Arthur Coal from these areas to the north of the mine since the bund construction was completed.

Discussion

The analysis demonstrates, quantitatively, how much could potentially be gained from putting measures in place to limit visual impact. It is important to community and mines that visual controls are effective. The community benefits can be potentially large by having impact intensity reduced to less intrusive levels. Even before the rehabilitation is complete, an advantage of bunds is that mine workings and plant/equipment will be out of view and some shielding from lights at night will occur from the early construction.

For the mines, it is important that bunds are effective because of the substantial cost and effort that goes into their construction and maintenance. In some cases, construction requires transporting materials on-site much longer distances than would normally be required for hauling spoil. The bunds and other visual amenity mitigation actions are part of a response to engaging with the community over actions that can be taken to mitigate the negative impacts of mining. Therefore, they are as interested as the community in achieving the sort of results indicated by this analysis as being possible.

An important aspect of leading practice development of bunds is progressive rehabilitation. This means that bunds are vegetated as soon as possible during their construction. This is practiced by the mines around Muswellbrook. Limits to how rapidly this can be achieved are imposed by construction schedules (such features take some time to build), which includes ensuring that final design levels are reached and so reshaping and revegetation can commence. Also, climatic conditions can slow establishment of vegetation. For example, the drought over the five years preceding the study made it challenging, led to the loss of some previously established vegetation and slowed planting programs. Recent rain (once flooding impacts are managed) should help. The regional Synoptic Plan is a collective industry revegetation and rehabilitation plan which includes strategies for bunds. Given that rehabilitation takes several years to establish, the industry strategy of designing and constructing bunds that can be progressively vegetated, whilst expensive, is likely to provide the best outcomes. This is an example of a temporal simple, positive cumulative impact where the time series indicates the progressive improvement in visual amenity over time. However, there is an inevitable period at construction where the bunds will appear little more appealing than other disturbed land.

Analysis of complaints data from the five mines showed that complaints from the town have been an increasing percentage of total complaints over the last decade (Figure 15). That analysis also showed that the events that triggered that majority of complaints (noise and blasting) were different from what stakeholders saw as the most significant cumulative impacts. Dust/air quality (ranked third in complaint numbers and scored high by both the community stakeholders and expert group) and visual amenity (ranked by the community stakeholders as a key cumulative impact) were the closest matches. A relationship emerges between the average visual impact intensity and the proportion of total complaints that come from town (Figure 27). It might be argued that this relationship could be the result of a small number of people making a large number of complaints from areas of extreme exposure. However, this is not supported by the data on number of complaints per complainant in town (Figure 16) nor by the visual impact maps, i.e. it is not until 2004 that there are regions in the town that would be significantly more exposed than others (Figure
and even this is unclear because it is not known how those people consider the effectiveness of visual bunds (Figure 26). Therefore, it is reasonable to interpret the relationship as a meaningful indicator of cumulative impact generally across the town.

![Graph showing the relationship between mean impact intensity and total complaints from the township through time.](image)

**Figure 27. Relationship between mean impact intensity and total complaints from the township through time.**

There are a number of interpretations of this relationship. It is possible that the complaints are not related to the visual exposure and the relationship is coincidental. Alternatively, it may be that bunds under construction are a reminder of the proximity of mining. This reminder makes it more likely that when an event occurs for which a complaint category exists, e.g. blasting and noise, there is a greater chance that a complaint will be lodged. If this is a reasonable interpretation, then mines taking action on the basis of the complaint will not, over time, reduce the number of complaints. This cumulative impact effect is in contrast to the successful management of complaints on a mine-by-mine basis (see section on analysis of complaint data) where action on the basis of the complaint has led to a significant reduction in the number of complaints. In contrast, the proportion of complaints from the town is continuing to increase.

**Summary**

Analysis of remotely sensed data indicated that there has been an increase in the amount of disturbed land in the Muswellbrook area over the last decade. Using maps of the disturbed areas and topography, the intensity of direct visual impact on the township was quantified. Without mitigation, it was evident that visual impact would also have increased over the last decade. The construction of visual bunds and other measures, including tree screens, has reduced the visual impact. To fully capitalise on the cost and effort of constructing the bunds it will be necessary to wait until reshaping and revegetation is complete. At that point, the impact intensity may return to levels of the mid 1990’s although this is not promoted as a realistic objective given the expansion in residential areas and other factors not directly attributable to mining during this time.

The strong correlation of the percentage of complaints coming from town with mean visual intensity indicates that the relationship between complaints and the cumulative impact of mining is different in the town than for the neighbours of individual mines. Further, the information provided by the visual impact analysis is potentially a high level indicator that can be used as part of a constructive dialogue between the community and group of mines.
More work is required on assessing visual impact to include the effects of local features in the town, for example, trees and buildings, and to understand how different views are perceived, for example, mines, pastures, residential areas, sporting grounds, industrial areas, vineyards and highways.

**Implications for Policy and Practice**

Future research should include verifying, in a more spatially-disaggregated way, the community relationship with impact intensity. More elaborate techniques, for example, visual sensitivity, could be used to assess the degree of perceptual difference between the visual experiences of certain types of land use. This could be useful in better understanding relationships such as that between proportion of complaints and visual intensity.

The mines in the region are currently complying with landscape plans and are generally operating to increased regulatory stringency for light and dust management. It is common practice in EIS and EA documents to take photographic montages from selected viewing locations. In many cases, these also have qualitative “artists impressions/renditions” of changes to the view. Whilst these provide a qualitative feel for the visual impact of mines, they are not easily used to conduct a quantitative survey of visual impact. It is the view of the researchers that current EIS and EA documents do not provide sufficient information for the town to develop an appreciation for the final (or progressive) visual quality over time except from the set of viewing locations presented in those documents, albeit that these locations are meant to represent the most impacted areas. Therefore, there is a possibility that the entire community are not aware of the progressive development and eventual endpoint expectation of visual bunds. Consequently, they do not necessarily consider the current state as a temporary visual feature.

The most integrated source of information on the final visual impact is the Synoptic Plan: *Integrated landscapes for coal mine rehabilitation in the Hunter Valley of NSW* (Neil, 1999). The document identifies Muswellbrook and surrounds as a mining area of regional visual sensitivity (see their Figure 17). However, the Synoptic Plan acknowledges that it was not able to provide a comprehensive viewshed and visual analysis and instead gave an overview of the expectations for Muswellbrook (p.30). The analysis carried out here, and the certainty with which mine activity is now known (for example the Synoptic Plan did not include Mt Arthur Coal) indicates that it is now plausible to develop a more complete and integrated visual assessment for the town. Such an assessment, including forecasts of expected final visual outlooks, could form the basis of a collective action and communication between all the mines and the town. Today’s technologies make it possible to consider having available in the town a tool to view the final visual outcomes from any location rendered at high quality in 3D. The matching of community expectation with progressive development of bunds and other visual amenity mitigation strategies could provide a productive area for ongoing dialogue between the mines, the community and the local government. Such a dialogue, based on quality information and progressive assessment, could, in and of itself, be considered a positive cumulative impact.

An additional development that would be consistent with an integrated approach to communicating final visual outlooks is integrated planning. It is expected that an update to the Synoptic Plan will be produced. Perhaps that document, in concert with mine-by-mine visual planning could be used to develop a more integrated approach to the visual endpoints for the region including the township of Muswellbrook. It is possible that quantitative visual assessment and modelling may deliver more cost-effective bunds.
2.7: Water Quality in Muswellbrook

The Issues

Water quality was raised as an issue by the community and expert group but it was not given as high a priority as the other issues covered in this report. However, the project team and industry steering committee agreed to include investigation into water quality for the following reasons:

- Water is a critical resource for the community and the range of industries in the study region – mining, viticulture, horse studs, tourism and agriculture. As such, it is fundamental to the character and viability of the region. Water links these users spatially because the hydrological systems (groundwater, surface water run-off and the river) are variously connected physically and because it can be stored, reused and potentially shared. In this region, the Hunter River is where many of the implications of water use become integrated and measurable. For individual mines, water management needs to consider the sources of water (upstream dams, the river and other water users) and the interaction between the mine and its surrounds across the lease boundary. On-site water management planning and innovation are crucial to achieving good outcomes in the other two domains. Mines in the Muswellbrook area have undertaken considerable effort with on-site water management to minimise impact on the Hunter River. Most mines have internal policies that prioritise reuse of water sourced on site, i.e. aquifer inflows, run-off, process and waste water returns before importing fresh water into the site thereby minimising their draw on regional freshwater supplies. Town effluent is taken Mt Arthur Coal for re-use, which reduces town discharge to the river and decreases the mine’s draw on river fresh water. In some cases, mines with water excess to requirements, share this with those in deficit again decreasing the overall draw on regional freshwater. An example of this is the water sharing arrangement in place between Mt Arthur Coal and Drayton that have been in place for over ten years.

- Perhaps the clearest example of recognition and management of cumulative impacts in the study region surrounds management of water quality (salinity) in the Hunter River. The study region is part of a larger scheme of cooperation between government, industry and community to manage salinity in the Hunter River. This scheme is known as the Hunter River Salinity Trading Scheme (HRSTS)\textsuperscript{15}. Under this scheme, salinity credits are allocated to a range of users up to a predefined cap. Credits can be traded amongst users and salty water can be discharged into the river under defined conditions relating to the level of flow. Essentially this is a capped dilution scheme. The scheme provides an accurate and up-to-date source of data on salty mine water releases to the river. Also, historical State Government river volume discharge (quantity of water flow) and salt concentration (via the conventional electrical conductivity analogue measurement) monitoring data are available which pre-date the introduction of the HRSTS.

- The project team included expertise in quantitative assessment of water quality.

\textsuperscript{15} A comprehensive explanation of the HRSTS and its operating conditions and methods can be found at: http://www.environment.nsw.gov.au/licensing/hrsts/index.htm (last accessed 16 January 2008).
• Water quality provides a good example of temporal cumulative impacts.

• It was necessary to commence some quantitative analysis of cumulative impacts before the community consultation and reference group assessments were complete. Given the availability of data, the expertise in the research team, the importance of water to the region and the effort individual mines have placed on water management and security, it was decided to commence work on water quality. It was understood that there was a possibility that water quality may not be an issue raised by the subsequent consultation.

Method

Daily water flow and water quality information was sourced from the state government databases. Monitoring stations in the study region are shown in Figure 28. Aberdeen is upstream of the mines in the Muswellbrook region. Liddell is downstream of the mines. Between these two stations is Muswellbrook bridge and then Denman on the Hunter. Between Denman and Liddell a tributary, the Goulburn River, joins the Hunter. The confluence of Wybong Creek occurs before the Goulburn meets the Hunter.

![Figure 28. State government water quality monitoring locations and mine site lease boundaries in the study region.](image)

Water flows were compared at all the monitoring stations down the river, with a focus on comparing Aberdeen and Liddell (as this stretch of the Hunter River includes all the study region mines). First, the statistical differences in flows across all times were tested, to establish whether or not the flows and salinities at the stations are different. Statistical
comparisons were made by aggregating all measurements at each station and forming the probability distributions of flow, i.e. how often (in terms of proportion of time) at which flows of different size occur. Modes (peaks) in the probability distribution functions were compared. To test for significant differences in these distributions, normalised cumulative probability density functions were compared using a Kolmogorov-Smirnov test. This test is sensitive to differences in any part of the distribution, i.e. low, medium or high flows.

Salt concentration (as monitored by measuring electrical conductivity, EC) was treated in the same way.

Salt loads were calculated by converting electrical conductivity to salt concentration and multiplying by flow volume, i.e. salt load (tonnes/day) = EC (μS/cm) x 0.64 x volume (Ml/day)) / 1000. Statistical analysis of differences in salt loads was carried out in the same way as for flow and salt concentration.

Changes over time were examined by smoothing the daily data using cubic splines. This technique is superior to moving averages, clarifies trends, is more informative than annual averages and is robust to the gaps in monitoring. The method is described in Appendix 9.

Having determined which monitoring locations were different and whether there were any differences in time trends, the next step was to test whether the discharges of salty water from mines under the HRSTS produced a significant impact downstream. It was necessary to exclude salt entering the river at Aberdeen. The travel times of water from Aberdeen to each of the downstream stations was estimated. It was assumed that water and salt travel times were the same. Therefore, it was a simple matter of subtracting the salt from the appropriate day at each downstream location from that upstream. It was then possible to see whether salt was gained, lost or did not change between stations. The main tributaries which enter the Hunter between Aberdeen and Liddell (Goulburn River joined earlier by Wybong Creek) were similarly taken into account.

After subtracting upstream and tributary salt sources from Liddell, a ‘residual’ salt signal remained. This represents possible influences of irrigation off-takes (and return flows) and groundwater which may flow into the river or take water from the river at different places and times (see David et al. 2004). It also includes the regulated mine discharges under the HRSTS. As no data are available for irrigation return salt flows or groundwater salt inflows only the HRSTS data was studied. These data were subtracted from the residual signal at Liddell and the normalised cumulative probability distributions compared using the Kolmogorov-Smirnov test. If the mine discharges were of sufficient magnitude the frequency of certain salt loads would be statistically significantly different before and after subtracting the discharges.

An attempt was made to analyse aspects of water quality other than salinity, namely, nutrients and turbidity. Unfortunately, the quantity, quality and continuity of State Government monitoring of these attributes was insufficient to support analysis of the impacts of the mines (see Appendix 9). It is important to note that this does not relate to the information available from individual mines with regard to water quality monitoring in accordance with their environmental management regulations. Each mine reports as required on their water quality monitoring results in the Annual Environmental Management reports. The reader is referred to these documents for assessment of individual mine performance in this regard. All mines supplied this information to the project team. However, license requirements do not mandate that quality measures (generally based on concentration monitoring) are complemented with water quantity measurements. This is because license conditions in this region (consistent with the Australian Water Quality
Management Guidelines) – as in most regions around the world – are based on concentration thresholds not on loads. It is not possible, therefore, to analyse the cumulative impacts on the river because it is necessary to know the quantity of the material, e.g. sediment, that enters the river and the river flows at the same time, to estimate the combined concentration and load impacts on the river (see analysis of salinity below).

**Findings**

No findings on Hunter River turbidity or nutrients were possible because of the limited data available.

![Stream Flow distribution at Liddell and Aberdeen](image)

**Figure 29. Non-parametric cumulative probability density functions for Aberdeen and Liddell monitoring stations (daily water flow is shown).**

**How to read cumulative probability density functions:**

A cumulative probability density function relates the size/magnitude of something (e.g. river water flows) to the regularity (frequency) with which it occurs. Frequency is expressed in terms of the percentage (or proportion) of the time of the whole record. For example, in Figure 29 half the time (which is the same as saying half of the flows that were measured) (cumulative density of 0.5) the flow at Liddell is less then 200 Megalitres per day; whereas at Aberdeen it is less than ~400 Ml/day. So half the time, the flow at Aberdeen is twice that at Liddell. As another example, ~83% of the time both stations are below ~700 Ml/day.

The flow at Liddell was less than that at Aberdeen for nearly all frequencies reflecting either water extractions (for irrigation and mining) and/or possibly leakage into groundwater systems.
In contrast to water flow, salt concentration at Liddell was greater than Aberdeen (Figure 30). The largest peak for Aberdeen is \( \sim 350 \text{ uS/cm} \) and for Liddell \( \sim 500 \text{ uS/cm} \)\(^{16}\). Also, the largest peak at Aberdeen is clearer than that at Liddell which shows a broad distribution with a number of peaks (most of which are higher than any at Aberdeen. Therefore, it is likely that the sources of salt at Aberdeen are more consistent than those at Liddell which appear to me more variable. Higher concentrations at Liddell indicate that there is a source of salt between Aberdeen and Liddell. A number of possibilities exist: mine discharge, irrigation return flows, groundwater or tributary flows. As most of these possibilities are variable in nature and timing, i.e. salt is made available in an intermittent fashion associated with the water use activities and/or rainfall in the source areas, none can easily be eliminated based on the difference in the variability of the distributions.

![Image of probability density functions of EC for Aberdeen (red) and Liddell; Liddell has higher salt concentrations](image)

**Figure 30. Probability density functions of EC for Aberdeen (red) and Liddell; Liddell has higher salt concentrations**

There is some evidence that salt concentrations at Aberdeen and Liddell have been decreasing over the last few years (Figure 31). The concentrations at Liddell are more variable than Aberdeen (the visual scatter in Figure 31 is consistent with the broader distribution of salt concentration described above (Figure 30). In spite of the variation, the decrease at Liddell appears to be more pronounced than that at Aberdeen raising the prospect that management controls on salinity (landscape and industry interventions) between the stations are effective. Towards the end of 2005 (the last data in Figure 32) concentration appears higher than for some time prior to that.

\(^{16}\) It is important to note that in most communications the effectiveness of the HRSTS is assessed with respect to salinity levels at Singleton, which is downstream of Liddell. The HRSTS target for Singleton is 900uS/cm.
Figure 31. Salt concentration time trends at Aberdeen (red) and Liddell (blue).

Figure 32. Salt load (tonnes per day) time trends at Aberdeen (red) and Liddell (blue).
Figure 32 shows the time series of salt loads (the combination of salt concentrations and water flows) at the two monitoring stations since 1991. Historically, Liddell salt loads have been greater than Aberdeen. Since around the turn of the century this has reversed (see arrow on plot) until very recently where again Liddell became greater. This coincides with the recent increase in salt concentration mentioned above. For the period over which Aberdeen has greater salt loads than Liddell, the loss of salt between the stations is more likely related to water extractions from the river than to mine discharge control because of the relatively small quantities of salt involved (see below). There have been a number of significant peaks at Liddell. The biggest peak at Liddell for which records are available for both stations also appears at Aberdeen. Therefore, the current situation of low salt loads (in terms of historical averages) at both stations should be interpreted with caution in terms of it being indicative of a permanent shift in the River’s condition recalling that load is a combination of discharge and salt concentration.

Salt flowing into the Hunter River from the Goulburn tributary (which includes Wybong Creek) was subtracted from the Liddell salt flows. This showed that the tributary accounts for the additional concentrations of salt at Liddell. Some anomalies in the residual data are evident (negative and positive). These may be a result from differences in monitoring calibration or effects of irrigation and groundwater as mentioned above. Finally, the mine discharges were subtracted from the residual Liddell signal (Figure 33). The cumulative probability density functions with and without salt loads from the mines are not significantly different to a high degree of statistical confidence.

![Figure 33. Residual salt loads at Liddell after removal of upstream, tributary and mine discharge salt influences.](image)

A more detailed description of all the analyses presented this chapter can be found in Appendix 9.
Summary

Daily stream flow and water quality data were sourced from state government databases (PINEENA v.8, more recent water flow data available from the DIPNR web site and another data set known as Discrete Water Quality data for the monitoring sites in the region). The monitoring station upstream of the study region is Aberdeen and Liddell is downstream with Muswellbrook town and Denman in between. Unfortunately, there were insufficient data for any of the monitoring locations to support analysis of river turbidity (fine sediment) or nutrient levels. For example, data were sporadic and suffered from changes in measurement methods at different periods associated with different projects. However, significantly more data were available for flow and salt concentration.

Salt concentration, stream flow and salt loads were analysed to test whether the impact of salt water discharge from the mines (under the HRSTS) could be discerned. There is less water flow with higher salt concentrations (lower salt loads) at the bottom of the study region than at the top. To a high degree of statistical significance no impact of mine discharges of salty water on salt loads can be discerned. System differences are explained by salt input to Liddell from Goulburn River and Wybong Creek, which join and enter the Hunter between Denman and Liddell. Some anomalies exist which may be from monitoring calibrations and/or dynamics of irrigation, groundwater and climate. This study did not demonstrate evidence of cumulative impact of the mines on Hunter River salt loads.

Implications for Policy and Practice

Given that no analysis of turbidity or nutrients was possible because of lack of data, it would be necessary to commence monitoring if impacts of any land use in the region are to be understood. Similarly, there is little information on the influence of irrigation return flows and groundwater on the river. Anomalies in salt loads at Liddell indicate that these influences may be important and are likely to be more significant in the river than regulated mine site discharges of surface water.

In practice, individual mines are constantly working to improve water management practices. For example, the General Managers of mines in the region meet regularly and water is seen as a priority to this influential group. A number of examples of collective and collaborative water management activities exist. The industry could, perhaps, make more effort to communicate these activities to the community so that there is a greater comprehension and appreciation of the water management credentials of the industry. Such communication may also raise opportunities for more effective total water resources productivity because of the mine’s capacity to use sources other than fresh water as is currently evidenced by the use of town effluent.

Water extractions between Aberdeen and Liddell can be detected in the river flow data. Given the importance of Goulburn River (and Wybong Creek) on the salt loads at Liddell it may be important to take these flows into consideration below Liddell if analysing the impacts of mine salt water discharges further downstream in the Singleton region.

The lack of salt discharge to the river raises the issue of long term management of salt on sites. ACARP Project C11050 has recently examined, in some detail, post-mining salt management (David et al. 2004). An important consideration is the interaction of on-site salt storage, particularly in tailing facilities, and groundwater systems. Similarly, the salts held in spoil need to be managed with a long term view.
The analysis conducted here indicates that the HRSTS in this region appears to be an effective control strategy for salty surface water discharges from mines.

A possible policy opportunity for the General Managers would be to commence a process of strategic assessment of the potential for sharing of non-fresh water which would include all sources, climate variation and infrastructure implications. Significant mine-to-mine activity already occurs in this region and elsewhere in the Hunter Valley which could be boosted with a strategic investigation and implementation plan. The importance and potential for harnessing irrigation return flows, for example, could be included in such an investigation.
2.8: Social Changes in Muswellbrook

Introduction

A wide range of stakeholders observed that the increase in mining in Muswellbrook had contributed to some significant social changes, although there was a divergence of viewpoints about the extent to which these changes should be regarded as positive or negative.

This chapter first presents a brief socio-demographic profile of Muswellbrook and considers whether – and how – the expansion of mining has shaped the current make-up of the community. Subsequent sections focus on some specific issues that were identified in the consultations:

- the scale and impact of household relocations due to mine property purchases
- the effect of changed working time arrangements in the mining industry on levels of community participation
- the community’s changing sense of place
- trust in institutions.

The chapter also presents some data on the industry’s financial and in-kind contribution to improving facilities and supporting community organisations.

Measurement Issues

As is the case also for environmental impacts, measuring social change and testing possible explanations for these changes is hampered by the limited availability of relevant time series data and the difficulty of controlling for the multiplicity of factors (many of which may be unrelated to mining) that contribute to change. Nonetheless, it is important to explore the available data relating to the potential socio-economic impacts of mining, in order to better understand these impacts and identify where future research effort should be concentrated.

The analysis presented in this section draws on two main sources:

- data provided by the participating mines (e.g. on employment and community spend)
- data from the five-yearly national census for 1991, 1996, 2001 and 2006 (e.g. such as employment, income levels and measures of social disadvantage).

Where relevant, reference is made to other research conducted in the region, such as social impact studies undertaken as part of the regulatory approval process for new mining developments.

As indicated, the analysis includes some comparisons between Muswellbrook and other communities, using the statistical Local Government Area (LGA) as the unit of analysis. The comparison LGAs were:
• Singleton: A nearby town in the Hunter Valley which, like Muswellbrook, has a strong association with the coal mining industry

• Scone: A rural town situated in a non-mining area 26 km north of Muswellbrook along the New England highway.

• Goulbourn: A town without large-scale mining in the vicinity, but with some similarities to Muswellbrook, including: having a jail in close vicinity; being a rural centre on a main transport highway; and a history of pasturing and stocking of the land.

A Socio-Demographic Profile of Muswellbrook

Population trends

Muswellbrook Shire has been characterised by fluctuating population levels over the last decade or so. Between 1996 and 2001, the population fell by 5 per cent, from 15,562 to 14,796. By contrast, it rose by 4 per cent between 2001 and 2006, taking it back to roughly 1996 levels. It has been predicted that the population of Muswellbrook will fall over the next decade (Hunter Valley Research Foundation 2006, p.46), Singleton, on the other hand, held its population between 1996 and 2001 and experienced an 8 per cent increase between 2001 and 2006.

The lack of consistent population growth in Muswellbrook since the mid 1990s may be partly attributable to the ‘downsizing’ that occurred in the mining industry in the latter part of the 1990s, plus the trend towards more mine employees living outside of the Shire. This does not mean that the employment practices of the industry are responsible for Muswellbrook’s failure to keep pace with Singleton, but it does indicate that the Shire has struggled to find alternative drivers of growth.

Income distribution

As shown by Figure 34, in most respects the pattern of income distribution in Muswellbrook in 2006 mirrored that for the Hunter Valley and New South Wales as a whole. However, it is noteworthy that the proportion of high-income earners in the Muswellbrook LGA (defined as those earning more than $1600/week) was above both the State and Hunter Valley average. It is highly likely that this was due to the presence of a substantial mining workforce in the town, given that mining industry employees have the highest incomes of an industry grouping and there is no other large-scale high income industry in the area.
Figure 34. Distribution of income earners in Muswellbrook, Hunter Valley and NSW – 2001

Figure 35. Percentage of employed people across Muswellbrook, Hunter Valley and NSW earning $1500/week or more in 1996 and 2001.
Source: ABS Census 1996 and 2001

Figure 33 shows that the proportion of high income earners in Muswellbrook who earned $1500/week or more roughly doubled between 1996 and 2001, in line with the state trend. This occurred despite a decline of around 20% over the same period in the number of residents employed in mining (see earlier discussion). The most likely explanation for this
apparent anomaly is that those who remained working in the industry received substantial pay increases, which had the effect of pushing many of them into the top income bracket.\textsuperscript{17}

**Wealth Levels**

Consistent with the presence of a sizeable group of high income earners, expenditure in the Muswellbrook LGA in 2001\textsuperscript{18} on highly visible consumer items such as cars, boats, extensions to homes and entertainment systems was above the NSW average (National Institute of Economic and Industry Research 2003). However, this high level of expenditure does not appear to have translated into increased wealth creation in the community generally.

The ABS Wealth Indicators measure – which captures the total wealth of households in terms of financial assets (excluding superannuation), housing values, and the value of unincorporated business assets owned by the household – shows that in 2001 Muswellbrook was performing less well than the rest of the Hunter Valley and the comparison LGAs of Singleton and Goulbourn, and was below the state average (Table 9). Muswellbrook and Scone had very similar scores in 2001, but whereas Scone was on an upward trajectory, Muswellbrook had been largely static since 1991. Given other indicators of growth in the local economy between 2001 and 2006, it is possible that Muswellbrook’s relative position may have improved since 2001. However, the ABS data required to make this assessment are not yet available.

**Table 9. Relative Wealth Indicator Values (100 – 0) for Muswellbrook and comparison LGAs**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Muswellbrook\textsuperscript{19}</td>
<td>45.7</td>
<td>45.5</td>
<td>46.9</td>
<td>45.4</td>
</tr>
<tr>
<td>Goulburn</td>
<td>57.4</td>
<td>59.7</td>
<td>61.7</td>
<td>57.7</td>
</tr>
<tr>
<td>Singleton</td>
<td>65.5</td>
<td>69.6</td>
<td>70.1</td>
<td>68.7</td>
</tr>
<tr>
<td>Scone</td>
<td>29.9</td>
<td>31.8</td>
<td>33.4</td>
<td>45.3</td>
</tr>
<tr>
<td>Hunter Statistical District</td>
<td>57.5</td>
<td>55.9</td>
<td>57.4</td>
<td>55.9</td>
</tr>
<tr>
<td>New South Wales &amp; ACT Average</td>
<td>72.8</td>
<td>73.4</td>
<td>74.2</td>
<td>73.5</td>
</tr>
</tbody>
</table>

Source: (National Institute of Economic and Industry Research 2003)

**Unemployment**

Census data for 1996, 2001 and 2006 indicate that the unemployment rate in the Muswellbrook LGA has basically reflected the national picture\textsuperscript{20} (Table 10). By contrast, Singleton and Scone LGA’s have had unemployment rates consistently below the national

\textsuperscript{17} It is not possible to show comparable data for 2006, as the ABS categories have changed.

\textsuperscript{18} Note that relevant data from the 2006 census are not yet available.

\textsuperscript{19} The higher the score (100 to 0), the better the performance in that area. Of the 629 Local Government Areas in Australia, a wealth indicator score of 100 ranks a region 1\textsuperscript{st} in Australia while a score of 0 ranks the region as 629\textsuperscript{th} in Australia. In other words, a higher wealth indicator equates with a higher ranking.

\textsuperscript{20} Muswellbrook township has had a consistently higher unemployment rate than the LGA (in the vicinity of one percentage point). However, the trend has been the same.
average. This suggests that, while Muswellbrook has benefitted from the recent general upsurge in economic activity, it has not performed as well as some other communities in the region.

**Table 10. Unemployment Rates (%) for Muswellbrook and comparative areas**

<table>
<thead>
<tr>
<th>Region</th>
<th>1996</th>
<th>2001</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Muswellbrook LGA</td>
<td>9.2</td>
<td>7.9</td>
<td>5.4</td>
</tr>
<tr>
<td>Singleton LGA</td>
<td>6.8</td>
<td>5.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Scone LGA</td>
<td>7.7</td>
<td>6.6</td>
<td>4.2</td>
</tr>
<tr>
<td>Australia</td>
<td>9.2</td>
<td>7.4</td>
<td>5.2</td>
</tr>
</tbody>
</table>

**Other measures of socio-economic disadvantage**

The 2001 census shows that, on a range of measures, the level of socio-economic disadvantage in Muswellbrook was higher than the state and national average Table 11. This was especially apparent in education and occupation structure, where Muswellbrook was placed in the bottom 25% of the state. Muswellbrook also had the highest level of socio-economic disadvantage of all Hunter Valley LGAs other than Cessnock (Hunter Valley Research Foundation 2006:45). Equivalent data for 2006 indicate that there have been no significant changes to Muswellbrook’s SEIFA scores.

**Table 11. Socio-Economic Indexes for Areas (SEIFA) for Muswellbrook and comparative areas**

<table>
<thead>
<tr>
<th>Indexes for 2001 (ABS)</th>
<th>M’brook</th>
<th>Scone</th>
<th>Singleton</th>
<th>Goulburn</th>
<th>NSW</th>
<th>Aust</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic Resources21</td>
<td>995.12</td>
<td>976.80</td>
<td>1029.60</td>
<td>963.52</td>
<td>1000</td>
<td>973</td>
</tr>
<tr>
<td>Education and Occupation22</td>
<td>910.00</td>
<td>932.72</td>
<td>937.60</td>
<td>952.32</td>
<td>993</td>
<td>979</td>
</tr>
<tr>
<td>Relative Socio-economic Disadvantage23</td>
<td>949.20</td>
<td>955.12</td>
<td>984.56</td>
<td>956.00</td>
<td>996</td>
<td>998</td>
</tr>
<tr>
<td>Relative Socio-economic Advantage/Disadvantage24</td>
<td>945.44</td>
<td>976.16</td>
<td>986.40</td>
<td>953.04</td>
<td>994</td>
<td>978</td>
</tr>
</tbody>
</table>


---

21 The Index of Economic Resources reflects the income and expenditure of families, mortgages and rent, dwelling size, and family structure. For NSW postal areas, the scores ranged between 889 and 1170.

22 The Index of Education and Occupation is designed to reflect the educational and occupational structure of communities. This index does not include any income variables. For NSW, the scores ranged from 903 to 147.

23 The Index of Relative Socio-economic Disadvantage is derived from attributes such as low income, low educational attainment, high unemployment, jobs in relatively unskilled occupations and variables that reflect disadvantage rather than measure specific aspects of disadvantage (e.g., Indigenous and Separated/Divorced). For NSW, the scores ranged between 916 and 1103.

24 The Index of Relative Socio-economic Advantage/Disadvantage is a continuum of advantage to disadvantage. Low values indicate areas of disadvantage; and high values indicate areas of advantage.
Summary and Discussion

In summary, the available socio-demographic data (some of which is now several years out of date) indicates that:

- Muswellbrook’s population has fluctuated over the last decade, although there was a modest increase between 2001 and 2006. Singleton, by contrast, has experienced more consistent growth.

- Muswellbrook has an above-average number of high income earners, but is below the state and regional average on broader indicators of wealth.

- Muswellbrook has above-average levels of socio-economic disadvantage (based on 2001 census data).

- The unemployment rate for the Shire has been close to the national average, but has been consistently higher than in Singleton and Scone. In line with national trends, there was a significant decline in unemployment between 2001 and 2006.

It is not easy to disentangle the impact of the mining industry from the many other factors that can influence how a community develops. However, the evidence reviewed here supports the following conclusions:

1. Population trends in Muswellbrook appear to be linked to the amount of employment generated by the mining industry. This is probably also the case for Singleton, but it has benefitted from being seen as a more attractive residential location.

2. The presence of a mining industry is the most obvious explanation for why there are a comparatively large number of high income earners in the community.

3. To the extent to which Muswellbrook has under-performed on broader measures of wealth and socio-economic disadvantage, this is most likely due to factors unrelated to the mining industry, such as the national decline in rural populations, Muswellbrook’s geographical location, and the local presence of the jail.

4. The release of additional data from the 2006 census in the first half of 2008 will provide the opportunity to determine whether there has been any more general reduction in the level of relative socio-economic disadvantage and ‘social distress’, apart from the reduction in unemployment.

Relocation of Households

Another set of ‘social change’ issues raised in the consultations concerned the impact on household units and the wider community of relocations arising from property purchases by the mines.
• Figure 36 indicates that between 1992 and 2005 various mines purchased 149 properties\textsuperscript{25}, with the largest number of purchases occurring between 1992 and 1998. In an indeterminate number of cases, this resulted in the occupants moving or being relocated. Advice from the project steering committee is that:

• In most cases, arrangements were made or offered by the mine to enable the original landowner or occupier to continue to manage and earn income from the land and/or to assist them with their transition to a new location.

Assuming, for the sake of argument, that 80% of properties were occupied and that everyone moved, the ‘worst case’ scenario is that around 320 people, or an average of 25 a year, may have moved from their immediate local area over this 13-year period, directly as a result of mine acquisitions. This assumes that the average household size was 2.7 people (based on estimates from the 1996 and 2001 ABS census).

![Figure 36. Number of properties purchased in Muswellbrook 1992–2005 (including properties purchased by Mt Pleasant Mine)](source: Mine supplied data.)

Relocations can have impacts at two levels: on the well being of those individuals and neighbourhoods that are directly impacted, and on the social cohesion and ‘social capital’ of the wider community.

Apart from some anecdotal evidence from the community consultations, no data were available about the direct impacts of relocations. Some participants in the study spoke in strong terms about the disruptive effect of relocation on their social networks and sense of community belonging. For example:

‘Everyone else decided to move out, so our local community is gone. We had a social life that revolved around barbecues and friends getting together and our children did things together. All of that’s gone

\textsuperscript{25} This data includes properties purchased by Mt Pleasant, a company that has not yet commenced mining, but will do so in the near future.
now because everyone else has moved out. Tenants moved into the house next door and we’ve had all sorts of problems with them. Your whole life changes.’

However, it cannot be assumed that all, or even most, of those who were relocated would have been affected in the same way. While some people may have found the process traumatic, others may have shifted to elsewhere in the town and experienced little or no loss of connectivity. Individuals also vary in their acceptance of change.

A further salient point is that social networks are complex and often extend well beyond the immediate area in which people live (for example, to include family members, friends, workmates and people who share common interests). Without more information about the networks of those households that were relocated, it is not possible to accurately assess the scale, or duration, of the disruption to these networks or people’s sense of wellbeing.

Regardless of the impact on individuals, the implications of these relocations for the broader Muswellbrook community would appear to be quite limited. Assuming, for example, that up to 40 people may have been relocated in 2002, this represented 0.3% of the town of Muswellbrook. It is also probable that many of those who were relocated would have moved to another part of Muswellbrook, rather than exiting the community altogether.

A final observation is that social networks in many rural communities that are ‘mining-free’ are also being disrupted, as populations decline and people seek employment and urban lifestyles elsewhere. This raises the broader question – which was not canvassed in the present study – of whether the overall level of mobility in Muswellbrook (whether ‘forced’ or voluntary) is significantly different from that of other communities.

Levels of Community Participation

Various community stakeholders observed that Muswellbrook has experienced a decline in recent years in formal community participation, as measured by such things as participation in organised support and involvement in service clubs and other voluntary organisations. Some attributed this, at least in part, to increased working hours and the move in the mining industry towards continuous operation and 12 hour shifts. Specifically, it was argued that the shift to 12 hour shifts and continuous rosters had made it more difficult for employees to be involved in organised sporting and social activities and had disrupted involvement in social networks more generally. Participants in the mine employees’ focus group agreed that the difficulties of balancing the demands of mine work rosters hindered involvement in community activities. Some mentioned that they had not seen friends for months because they worked at the same times but in different mines or sites, while others reported that seeing their children was difficult because of the 12-hour shifts.

‘Your circle of friends changes. Sport is your social life, if your shifts don’t match with your friends’ you lose touch and aren’t available. Your friends become your roster mates.’

At the same time, it should be acknowledged that this change in working hours may create advantages for some families and individuals and that not everyone will have been impacted in the same way.

While changes in working time arrangements may have made it more difficult for some individuals to be engaged in organised community activities, there is no evidence that this has had a significant impact on the Muswellbrook community as a whole. As indicated, only around 13% of the local workforce is directly employed in the mining industry and not
everyone in the industry works shift work and weekend rosters. (For example, at one mine 40% of the workforce worked a standard Monday-Friday day shift). Moreover, it is likely that many of the people working shifts would not be involved in organised community activities even if their working time arrangements were changed.

The 2006 census included, for the first time, a question which asked people if they had undertaken any unpaid voluntary work for an organisation or group in the previous 12 months. The figure below shows the volunteer participation rate (expressed as a percentage of the population aged 15 years or over) for Muswellbrook, the comparison communities of Singleton, Scone and Goulburn, and Australia and New South Wales as a whole. It indicates that the rate of volunteering in Muswellbrook was above the state and national averages, comparable to Singleton, slightly below Scone, but above Goulburn. Based on these data, there is no evidence to indicate that Muswellbrook has an atypically low rate of volunteer participation.

![Figure 37. Percentage of population aged 15 years and over engaging in voluntary work in the previous 12 months.](image)

Based on trends elsewhere in Australia and the Western World, it is likely that involvement in organised community activities in Muswellbrook has declined over time. However, this is almost certainly due primarily to broader social changes such as demographic shifts, changes in lifestyles, the emergence of new forms of media, and reduced leisure time, rather than locally specifically factors such as changes in mining industry working practices.

**The Community Contribution of Companies**

In considering the community impacts of increased mining activity, it is important to focus not just on potentially negative impacts, but also on areas where the impacts may have been positive. As emphasised by mine representatives and as acknowledged by many of the stakeholders who participated in the study, the mines have collectively made a substantial
contribution over the years to the local community, in the form of funding and in-kind support for community organisations and improved community sporting and recreational facilities. It is unlikely that this support would have been forthcoming from other sources had there not been a large mining industry in the Shire.

In the three-year period between 2001 and 2004, the five local mines collectively contributed a total of $5,185,051 (excluding rates and other payments) to the Muswellbrook community (insufficient data are available to provide an equivalent figure for more recent years). Approximately half of this amount was in the form of infrastructure contributions made in compliance with Section 94 of the *Environmental, Planning and Assessment Act 1979* (NSW) relating to improved facilities such as gymnasiums, a velodrome, construction of a heated swimming pool and redevelopment of the railway station. The balance was in the form of donations to support a wide range of community organisations. In addition, mines provided various forms of in-kind support, such as staff time and use of equipment. Table 12 provides examples of the various ways in which local mines have contributed to the community of Muswellbrook.

**Table 12. Types of support given by local coal mines to the community and environment of Muswellbrook**

<table>
<thead>
<tr>
<th>TYPE OF SUPPORT GIVEN BY MUSWELLBROOK MINES</th>
<th>RECIPIENTS OF SUPPORT FROM MUSWELLBROOK COAL MINES</th>
</tr>
</thead>
</table>
| Various school resources and equipment (books, projectors, resources, outdoor seating, sports equipment, excursions) | Dunmore Lang Christian School, Muswellbrook  
St Joseph's High School, Aberdeen  
St Joseph’s Primary School, Denman  
St James’ Primary School, Muswellbrook  
Muswellbrook Primary School  
Muswellbrook South Public school  
Muswellbrook Public School  
Muswellbrook High School  
Scone Grammar School |
| Infrastructure assistance | Upper Hunter Show Association  
Muswellbrook Hospital |
| Research partnerships | Hunter Medical Research Institute |
| Financial donations | St Vincent de Paul Christmas Appeal  
Muswellbrook Art Show  
Muswellbrook Lions Club  
Broke Village Fair  
Junior football teams in Muswellbrook  
Cancer Council of NSW  
Westpac Rescue Helicopter  
Camp Quality  
Muswellbrook Race Club events |
| Muswellbrook Swimming Pool* | Muswellbrook community |
| Cycling velodrome* | Muswellbrook community |
| Road upgrades | Muswellbrook community |
| Income from mine rental properties to provide infrastructure and machinery for improved farm and pasture management | Muswellbrook and local area farming community |
| Drayton Youth Café | Muswellbrook youth |
| House and property: ‘Youth off the Streets’ | Homeless youth of Muswellbrook |
Land donation under lease agreement

Community trust partnership program to assist and support joint-venture projects and community action, improve social and educational opportunities, and support programmes that promote long-term sustainability and improve the quality of the Upper Hunter environment

Establishment of PCYC Drop-In Centre

First Aid training

Donation of 75 hectares of land and annual management fee for a NSW State Forestry-managed and resourced plantation that could contribute to a future local timber industry

Historical restoration of local cemetery

Park in the Muswellbrook township ($500,000)

Environmental stewardship through the Upper Hunter River Rehabilitation Initiative (UHRRI) to redress the decline in river health and to reinstate the natural vegetation and woody debris in the river, replicating conditions 200 years ago that controlled erosion and sediment loads and increased the availability of fish habitat

Undergraduate scholarship schemes

Funds allocated for redevelopment and upgrades to the Muswellbrook Rail Heritage Centre, the railway precinct, including a visitors centre and facilities*

Student traineeships and training programs

Arts and music

Muswellbrook Pistol Club

Hunter Valley communities – Muswellbrook, Cessnock, Maitland, Singleton and the Upper Hunter

Muswellbrook youth and families

Muswellbrook community

Muswellbrook environment and future generations of Muswellbrook community

Muswellbrook community

Muswellbrook community

Muswellbrook environment and community

Muswellbrook High School students. Students from mine employees’ families

Visitors, tourists and local Muswellbrook community

Secondary school students

Muswellbrook community

* indicates s.94 contribution.

- While these contributions, in aggregate are substantial, there is scope for this spending to be better coordinated across companies. There are examples already of a cooperative approach, such as the Upper Hunter Bursting with Energy Expo, where the local mines collectively work together to jointly sponsor major community events; the challenge and opportunity for the local industry is to build on these relationships (e.g. by pooling contributions to create a ‘critical mass’ to support some key community programs).

- There also does not appear to be consistency across mines in terms of the scale of their community contribution. For example, in one year one mine’s cash contribution was in excess of $400,000, whereas another, relatively large, operation spent only $24,000. Moreover, mines differ in what they count as community contributions.
Changing Sense of Place

‘Changing sense of place’ and ‘community ownership’ were identified by both the expert group and the focus groups as being related to the increasing changes in the local physical environment due to mining. There is evidence from international research that as the visual amenity of an area decreases, this can impact on people’s attachment to their environment, and their concern about its upkeep (Kohlbuecher et al. 2006; Shriver and Kennedy 2005). As discussed earlier in this report, the visual impact of mining has increased in recent years and this has been correlated with a steady increase in complaints from the township of Muswellbrook. This aspect of social change – sense of place – is much harder to quantify and is usually measured by qualitative information, and sometimes by indicators such as house ownership compared to house rentals. A study being conducted by the University of Newcastle may give an indication of the current state of these community indicators (Conner et al. 2004; Higginbotham et al. 2007). Either way, it is an important issue to explore further.

Trust Towards Institutions

Several CCC members described lessening involvement and a decreasing sense of confidence amongst the residents they represented that their concerns or input were valued by the mines. Further, at the time of the writing of this report, some mines were having difficulty in attracting sufficient community representation to their committees. There was a strong perception amongst CCC members and other community stakeholders that the collective influence of the local mining industry was growing stronger, with the community losing influence at both the state and local level. Regulatory authorities were also seen as ‘siding’ with the mining industry and not with the interests or concerns of the Muswellbrook community. Similar issues were identified in the EIS prepared in the late 1990s for the Mt Arthur Coal project. This study noted that ‘one of the most prominent themes that emerged related to the Environmental Impact Assessment process and community participation in this process’ (Coakes Consulting 2000, p.221). More recently, the Anvil Hill EIS observed that while many landowners were appreciative of the opportunity to have their individual issues heard and recorded:

There was also a general sense of weariness among many residents due to the history of the project in the community. Given the presence of other mining projects, there was a sense that the project was ‘a done deal, and that the development would go ahead despite community concerns.

(Coakes Consulting 2006, p.41)

These perceptions appear to be having an adverse impact on the relationship between the community, mines and regulators. It could be beneficial to examine this issue further, especially given that, as noted, other recent studies have commented on the problematic relationship between the community and the mines. In particular, it may be time to consider a refreshed approach to engaging the community and the mines; for example, by creating a higher-level engagement mechanism for the Shire, with representation from all the mines, local agencies and key community stakeholders.

Summary

Assessing the extent to which the increase in mining had contributed to social change in Muswellbrook was a challenging exercise, due to the limited availability of data and the
difficulty of attributing social changes to any particular factor, such as the expansion of the mining industry. However, the available data support the following conclusions:

- The population of Muswellbrook has fluctuated in recent years. This appears to be primarily linked to the level of employment and other economic activity being generated by the mining industry, although other factors, such as the trend to more employees living outside of the Shire, may also have had some impact.

- Mining has affected the pattern of income distribution in Muswellbrook, by creating a relatively large group of high income earners.

- In recent years, Muswellbrook has been characterized by above average levels of socio-economic disadvantage. However, there is no obvious reason to attribute this to the growth of a large mining industry.

- Relocation of households due to property purchases by the mines is likely to have adversely affected the social networks and sense of well-being of some individuals and possibly some local neighbourhoods, but this has been on too small a scale to have had a significant impact on social networks and social capital in the community more generally.

- Changed working practices in the mining industry, such as rosters and 12-hour shifts, have made it challenging for sections of the mining workforce to be involved in organized community activities. However, there is no persuasive evidence that this has had a negative impact on the broader community.

- Over the years, the local mining industry has contributed to improve community sporting and recreational facilities and has provided substantial support to community and sporting groups. However, there is scope for greater coordination of this spending.

- The impact of the rapid expansion of mining on community members’ ‘sense of place’ and their trust in mining companies and regulators is a significant issue which warrants further investigation.

**Implications for Policy and Practice**

In the case of Muswellbrook, community engagement has mainly been conducted at an individual mine level with multiple Community Consultative Committees. To minimise the demand on the community as mining increases, a single collaborative committee with representatives from those in affected areas as well as those who are not, might be better placed to address the issues that have been identified in this discussion. Representation from various groups such as youth and aged organizations, local business, tourism, health, welfare, policing and education, would help to ensure that a broader range of issues are considered.

Currently, the mines spend substantial amounts of time and resources on community engagement. Unlike a one-mine town or a purpose-built mining town, multiple mines have been established in Muswellbrook after the town developed a tradition of pastoral farming and other land uses. Therefore, assessments of environmental and social impacts are repeated every time a new mine is at exploration stage, or an established mine expands. Monthly community newsletters are produced by the five mines, in addition to annual HSEC reports, open days, and regular meetings with disaffected local residents and
complainants. This is a lot of information for community members to read and digest. It is possible that a combined approach by the mines on some issues may be more effective, although there will clearly remain issues that are best addressed on an operation-specific basis.

There would be value in the industry and local stakeholders collaborating on defining some key social indicators for Muswellbrook and a common set of social performance measures for the local mines. This would provide a common reference point with which to monitor the social impacts of mining on the community and assist in developing strategies for managing these impacts into the future, and assist in addressing the perception – real or otherwise – that there has been a decrease in social amenity and social capital in Muswellbrook and that the mining industry has contributed to this. Release of the 2006 census data would provide a good opportunity to initiate this process.

A recent study of the link between strong mutual community associations and strong social capital by McQueen and Lyons (2001) found that lack of civic participation was a result of the loss of state/civic linkages. The authors concluded that among communities where there is a strong sense of civic and associational participation, measured in terms of social engagement and commitment, levels of confidence in civic leadership will be higher. This is reflected in a more optimistic outlook for the community’s future and a more favorable perspective on the current socio-economic climate. There are usually higher levels of cooperative collaboration that result in mutually beneficial community outcomes. Civic leadership that promotes this kind of social engagement will enhance the ability of the community to cope with negative external influence.

The challenge for the local authorities, government and NGOs, together with the mines and the community, is to address ways in which they can collectively increase Muswellbrook’s amenity, its sense of community ownership and, thereby, its social capital. There are models around the world where this has been achieved and given the potential Muswellbrook has for economic prosperity, there is ample scope to develop these opportunities.
This case study has identified a number of ways – some positive, some negative, some mixed – in which the growth of mining has impacted on Muswellbrook Shire, and the town of Muswellbrook in particular. The study has also highlighted some significant data gaps and pointed to areas where further research is required to understand the extent, nature and determinants of the cumulative impacts that have been attributed to mining.

There is likely be a further substantial increase in mining activity in Muswellbrook over the next few years, as new mines come on-line and some established operations expand production. For this reason, it is very important that the local mining industry and other key players, such as the Shire Council and government regulatory agencies, collaborate on improving their capacity to monitor and manage cumulative impacts.

The industry and regulators should investigate ways in which data collected by individual mining operations can be combined to provide a clearer picture of the environmental and social performance of the industry as a whole. Specific areas where there is a need to develop clear and consistent data standards include:

- recording and classification of complaints
- employment measures (including contractors)
- local business spend
- community expenditure by mines.

There is also a strong case to be made for developing some new ‘system-level’ indicators for the area, such as measures for tracking trends in social capital, community well-being and environmental conditions. These indicators would be ‘owned’ and maintained by external agencies, rather than the industry itself, but would need to be readily accessible to the industry.

Existing community engagement structures and processes should be reviewed, with the aim of facilitating a more collaborative approach to managing issues associated with community impacts. To date, community engagement has been conducted mainly at an individual mine level with multiple community consultative committees, in part to meet regulatory requirements. While there may be a case for retaining these committees to deal with operation-specific issues, consideration should also be given to creating a higher-level engagement mechanism for the Shire, with representation from the mines, local agencies and key community stakeholders, to focus on the bigger picture. The terms of reference, composition and resourcing of such a mechanism would need to be worked out between the mines and relevant stakeholders but, ideally, it would play a coordinating and planning role, rather than just being a forum for exchanging information.

The following recommendations are put forward for consideration by the local industry:

**Recommendation 1**

The local mining industry should consider establishing a formal association supported by a secretariat to facilitate coordination amongst mines and with external agencies and other stakeholders.

The functions of such a body could include:
• facilitating the exchange of information between operations and with external stakeholders on the management of environmental, social and economic impacts

• representing the local industry in discussions and negotiations with local and state government and other important stakeholders

• initiating and coordinating activities to address identified areas of community concern

• coordinating the ‘social spend’ of local mines, including (potentially) by establishing and administering a common Community Fund

• identifying research needs and taking action to address these needs (either by direct funding or through a body such as ACARP)

• coordinating production of a periodic report from the industry to the local community (see below)

• establishing and maintaining consistent and uniform data collection standards across sites.

Recommendation 2

*The local mining industry should discuss with the Muswellbrook Shire the potential for establishing a Muswellbrook-wide consultative forum comprising representatives from the mines and local stakeholder groups, to focus on issues of broader concern and interest to the community.*

This could possibly be done by expanding the membership and terms of reference of the Muswellbrook Mine General Managers forum established by Council. This forum has already identified opportunities for mines to work cooperatively on issues of mutual interest, including water management during the drought.

The proposed forum could be used to:

• inform stakeholders of actions that are being taken by the local industry to manage multi-mine impacts

• provide a forum in which stakeholders can ask questions and raise concerns

• identify opportunities for the local mining industry to further contribute to the economic and social development of Muswellbrook.

Recommendation 3

*The local mining industry should consider producing, on a periodic basis, a collective report to the community on the economic, social and environmental performance of the local industry.*

Amongst other things, this report could:

• present data on the overall contribution that mining is making to the Muswellbrook Shire in relation to:
  • direct and indirect employment
• the provision of traineeships, apprenticeships and work experience opportunities

• local business spend

• financial contributions to local government in the form of rates and other payments, such as s. 94 contributions

• financial and in-kind support provided for community programs

• provide an analysis of complaints patterns and trends and indicate what actions have been taken in the reporting period – both collectively and by individual operations - to address factors giving rise to complaints

• provide an overview and update of initiatives that have been taken by local mines to minimise adverse impacts and promote positive environmental outcomes, including in relation to the management of visual impacts, land disturbance, water usage and water quality, and dust and air quality

• summarise the outcomes of any research commissioned by the mines or parent companies that is relevant to the measurement and management of local cumulative impacts.

The work undertaken for this study could serve as the basis for the preparation of an initial report.

**Recommendation 4**

*The local mining industry and other key players, such as the Shire Council and relevant government agencies, should collaborate on improving their capacity to monitor and manage cumulative impacts.*

A priority should be to develop some new ‘system-level’ indicators for the area, such as measures for tracking trends in social capital, community wellbeing and environmental conditions.

An opportunity exists to utilise the Hunter Valley Research Foundation’s new ‘wellbeing watch’ survey to develop a profile specifically for Muswellbrook Shire\(^{26}\) (2006). This could involve provision of supplementary funding to the Foundation to increase the number of Muswellbrook residents surveyed, and then use this to prepare a stand-alone report for the Shire.

---

\(^{26}\) *Wellbeing watch* is will be an annual publication by the Hunter Valley Research Foundation which “aims to assess the quality of life in the Hunter, explain trends in how people live and provide an understanding of the influences on wellbeing and how regional wellbeing can be improved”.
SECTION 3: IMPLICATIONS

3.1: Learnings and Future Applications

Learnings from the Muswellbrook Study

Overall, the prototype framework that was used to guide the process used in the Muswellbrook Study (Figure 3) proved to be a reasonable approach. This section describes the strengths of the process and discusses where improvements might be made for future studies. The following section proposes a process flow chart as a guide for other regions considering studying cumulative impacts.

Community Engagement Processes

The engagement of the community went smoothly, due in part to the familiarity of the Muswellbrook community with social research, and with an earlier study done in 2004 with Drayton. Of equal importance was the willingness of stakeholders, both within the community and the industry, to assist and direct the researchers to the most relevant areas for scoping and initial meetings.

In retrospect, the framework as applied in the Muswellbrook Study was arguably too linear, particularly with respect to community engagement. In future studies, a dialogue with the community may be more effective. This does not necessarily mean a significantly larger activity, but a structured approach of information gathering and interpretation followed by presentation and reconsideration of priorities. A major advantage of such an approach would be a gradual improvement in the quality of interactions between the interested parties based on successive information sessions. It is recommended that a subgroup of the stakeholders be used for the majority of this interaction to minimise community consultation burn-out.

Industry Involvement

Assessment of the cumulative impacts of mining on regional communities could not be undertaken successfully without active involvement of the industry. This study was initiated and resourced by the coal mining industry (including all of the five participating mines) without any efforts to share the cost with the community or government. The General Managers of each of the participating sites were also positive, with this group actively supporting the research throughout. Industry steering committee meetings and the industry representation on this body were integral to the success of this study.

While the level of industry support was laudable, and probably necessary to make the research happen, there may be advantages in having co-funding arrangements in future ‘operational’ studies. If the community and government have money at stake, active participation is facilitated and co-ownership of outcomes is more likely. Consequently, successful implementation of strategies to mitigate negative impacts and capitalise on positive impacts is also more likely.

The Reference Group Workshop

In the Muswellbrook study, a reference group was brought together for a workshop to review the priority community issues and the initial quantification and description by the research team. This workshop worked well and added significant value to the project. The high calibre of the participants meant that a substantial amount of information was covered in one day, and that valuable outputs were achieved. Nonetheless, there would have been some benefit in utilising their expertise earlier in the project. There would also have been value in holding a second workshop, later in the process. While there would likely be strong overlap in attendance at the two workshops, some different expertise may be used in the second iteration if important additional issues have arisen during the intensive community engagement and analysis phases.
Project Management

The Project Steering Committee had the role of oversight of all three streams of the project, i.e. cumulative impacts conceptual development, Muswellbrook study and framework development (Figure 2). In operational studies the first and third of these tasks would not be required. Therefore, it may be beneficial for the Steering Committee to include members from outside the industry. This is consistent with the discussion above which proposes that there would be advantages in having the studies co-funded by the interested parties (funding would not necessarily have to be on equal terms).

Important early tasks for the research team and Project Steering Committee were to draft a Communication Plan and develop a Project Risk Register. These two documents were invaluable. Given that cumulative impacts of mining are often newsworthy, it is critical that media be considered in the Communication Plan. This is an important part of managing expectations of what the project does or does not expect to deliver and/or affect in the region.

Data Issues

There was good cooperation from the industry in responding to data requests. However, often the mine representatives had to take significant amounts of time from their normal areas of responsibility to prepare raw data and to ensure its compatibility with release policy. Other communities wishing to investigate the cumulative impacts of multiple mine sites may need to look at how they might help ‘share the load’ in this regard.

Some data proved to be easier to collect than others. For example, gathering technical data about visual amenity, dust, noise abatement and blasting was relatively straightforward. Technical information is readily available from regulatory authorities and from the mine operations. Indeed, there are strict regulatory frameworks surrounding the operations of coalmines, and the five mines in this study, like others in the industry, report substantial amounts of data and information to authorities and for the public record. They comply with strict monitoring standards, which are increasingly reflecting the public demand for a cleaner and renewable environment, and they are regularly monitored. Their databases and numerous reports, where confidentiality allowed, were made readily available.

In other cases, however, it proved to be extremely difficult to source specific data. Even if the data was available it was sometimes very complex and open to various interpretations, or too old. Such was the case with social issues and community impacts. Very few social and welfare organisations collect social statistics at a local town level. Some ABS data, which does evaluate socio-economic indicators, is restricted to 1996, and 2001, making some information over four years old. In addition, although the mines willingly provided any data requested for the study around employment, HR and complaints, sometimes their methods of collection or storage differed because of the individual regulatory requirements. This made aggregating or merging the data difficult or, in some instances, impossible.

In some cases, data may not be available to enable analysis at the local scale. In this project, the multipliers associated with economic impacts are an example. It is advisable that the scale over which the analysis is conducted is appropriately matched to the data available for the issues of priority. In some cases it may be necessary either to change the scale or omit analysis of some priorities.

It is very likely that all studies of this nature will entail considerable data management complexity. There are many sources of data and it comes in many formats. This project did not develop a Data Management Plan; consequently, data management was more difficult than it might have been. Earlier involvement of a project reference group and initial regional data analysis would have helped considerably in determining the necessary content and structure of such a plan. It should include the likely sources of data, the types of data, the likely size of holdings, a confidentiality rating scheme and identify which software, electronic and hardcopy filing systems are needed. Requests for data, from all
sources, should be accompanied by a brief explanation of the project owners, goals and delivery expectations. Data should only be requested when a clear need for its use in the project has been identified, although this may be easier than it sounds as the project team will not always know whether certain data exist unless it asks.

The impost on sites can be reduced if there is a standard procedure by which a survey of data holdings is carried out. This should include a request for the existence of certain data, its type, size, confidentiality and an estimate of how difficult it would be to access and how long such access might take. This would allow the data providers to contribute valuable information and to be prepared to respond should particular data sets be requested. This is also a good way to introduce the project to an important group of people who will not necessarily have any other direct project involvement.

**Proposed Future Process**

Figure 38 is a diagrammatic representation of the framework proposed for future studies.

![Figure 38. Proposed framework for assessing cumulative impacts of mining in regional communities.](image)

The key differences between this framework and the one used in this study are as follows:

- In the revised framework, community engagement does not commence until later in the process, after background data analysis has been undertaken and there has been an initial meeting of the project reference group. This is designed to facilitate a more structured approach to engagement, in which information is provided to community stakeholders – as well as being received from them – with a view to promoting a more informed dialogue about cumulative impacts.
• In the initial framework, the research method was to discern community/stakeholder perceptions about cumulative impacts and then attempt to verify these by testing them against the available data. It is proposed that in future applications a more general overview of the community is used as a backdrop to parallel investigations of community perceptions and data analysis. Synthesis of the two lines of investigation would still be undertaken, however, the attempts at validation would be more circumspect.

• In the revised framework, provision is made for a second expert workshop, after data collection and analysis have been completed, to review findings and assist with the formulation of an action plan.

• The revised framework also builds in feedback loops, whereas the initial model was very linear in orientation.

This basic process should be readily transferable to any area where there are multiple mines operating, or planned, although the scope of the task may vary substantially, depending on the mines’ locations and histories, the complexity of the community, what work has already been undertaken, and internal company requirements.

To achieve significant progress in the understanding of cumulative impacts and their management, there will need to be substantial improvement in the coordination and standardisation of a range of environmental, social and economic performance data. This is a challenge both for the mining sector and regulators.

As discussed in the context of Muswellbrook, new models of community engagement may be needed to meet these challenges. In most instances, mines continue to act as single entities. This competitiveness leaves them open and vulnerable to communities to play them off against each other, and can lead to unnecessary duplication of effort and inefficient use of resources. Mines may also need to develop new coordinating structures to ensure that there is an appropriate collective response to the particular challenges presented by cumulative impacts.

The overarching conclusion of this study is that a collective approach to the management of cumulative impacts, ideally involving not just mines but government and community as well, has the potential to produce better sustainable development outcomes than individual mines responding in an uncoordinated way to local concerns. In this sense, cumulative impacts assessment and management define a new frontier in the interactions between the mining industry and community.
References


Envirosciences Pty Ltd. 1993. Environmental Impact Statement for Bengalla Coal mine: Prepared for Bengalla Mining Company Pty Ltd.,


McQueen, M, and M Lyons. 2001. The missing link: mutual forms of organisation, social capital and community regeneration in regional Australia. In ACCORD Paper No.5. Sydney: University of Technology.


### Appendix 1: Focus group Evaluation Form

<table>
<thead>
<tr>
<th>A) I felt I was able to put my opinion forward</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B) I felt that my opinion was listened to:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>C) The focus group was well run:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>D) Other participants contributed well to the focus group</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>E) The project was clearly explained:</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F) The focus group achieved its aims</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Not at all</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sometimes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mostly</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completely</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 2: Expert Workshop Evaluation Form

<table>
<thead>
<tr>
<th>Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I felt I was able to put my opinion forward</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. I felt my opinion was listened to</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The Workshop was well run</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Other participants contributed well to the Workshop</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. The Project was clearly explained</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The Workshop achieved its aims</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. This type of workshop is a valuable tool for other communities to assess their impacts of mining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix 3: The Coal Mines of Muswellbrook

Bengalla

Bengalla is an open-cut coal mine is a joint venture between Coal and Allied (40%), Wesfarmers (40%), Taipower (10%) and Mitsui (10%). The mine is a dragline and truck/excavator operation covering a 10 km² mining lease and is located 4km west of Muswellbrook. Development consent was granted in 1996 and production commenced in 1999. Bengalla achieved sales of 5.6 Mt of thermal coal in 2004, of which 4.3 Mt was exported. The mine utilises a 4.5 km conveyor system to transport ROM coal to the CHPP. Confirmed reserves total over 200 million tonnes. Bengalla’s environmental management system has been certified to the ISO14001 Standard for Environmental Management Systems since March 1997.

Dartbrook

A joint venture between Anglo Coal (Dartbrook) (77.5%), Marubeni Thermal Coal (15.5%) and Ssang Yong Resources (7%), Dartbrook is the only underground mine participating in the study. The mine, located 8 km north of Muswellbrook, employed around 458 people in 2003-04, including 49 at the CHPP. Dartbrook is an underground longwall mine producing low sulphur bituminous thermal coal exported for power generation and industrial applications. The mine comprises the Wynn seam (mining completed mid-2004) and the Kayuga seam, where mining commenced in June 2004. Dartbrook has approval to extract up to 6 Mt p.a. of ROM coal and produced 3.88 Mt of ROM coal in 2003-04. Coal is conveyed 4km underground to the CHPP before being exported. Extensions to Dartbrook Coal were granted in 2003 with further development of the eastern site involving storage of waste material and loading facilities being undertaken during 2004. Dartbrook achieved certification to the ISO14001 Standard for Environmental Management Systems in September 2004.

Drayton

Anglo Coal’s Drayton open-cut coal mine is located 10 km south of Muswellbrook. The mine is a joint venture between Anglo Coal (Drayton) (74.5%), Anglo Coal (Drayton) No. 2 (13.42%), Mitsui Drayton Investment (3.83%), Mitsui Mining Australia (3%) Hyundai Australia (2.5%) and Daesung Australia (2.5%). It utilises both dragline and truck-and-shovel operation to produce bituminous thermal coal for domestic and international markets. Original development consent for the mine was given in September 1980. In 2002, Drayton renewed its development consent conditions to expand to the east of existing operations. Drayton achieved certification to the ISO14001 in 2003. A new wash plant was approved by Council and came into production in the later part of 2004. Drayton produced 5.12 Mt of saleable coal in 2004 and employs around 284 people (2003-04).

Mt Arthur Coal

Mt Arthur Coal is owned and operated by Hunter Valley Energy Coal, a wholly-owned subsidiary of BHP Billiton. Mt Arthur is currently the largest single site in the Hunter Valley, totalling around 41 km². The mine is located around 4 km southwest of the township of Muswellbrook and employs around 476 people (2003-04), including 41 at Bayswater CHPP. The Bayswater colliery commenced open-cut mining in 1968 and was purchased by BHP Billiton in 1996. The mining lease for Mt Arthur North was granted in 2001 and the first coal was mined in April of 2002. In 2002, Mt Arthur North, Bayswater No. 2, Bayswater...
No. 3 and the rail loading facility were merged to form Mt Arthur Coal. The combined operations have a combined development consent of 20 Mt of saleable product per annum. In 2004, Mt Arthur Coal produced around 9.7 Mt of saleable coal for domestic and export power generation. Since then, the mine has continued with its major expansion and is on target to produce approximately 12 Mt p.a. of saleable coal by 2006.

**Muswellbrook Coal**

Muswellbrook Coal Company Ltd (MCC) has a long association with coal mining in Muswellbrook, commencing underground mining in 1907 and open cut mining in 1944. MCC currently operates the Muswellbrook No. 2 open-cut coal mine (100% owned by Idemitsu Kosan Co Ltd), located 6 km to the northeast of Muswellbrook. Mining at No. 2 Open-cut commenced in 1965 and it currently produces around 1.5 Mt of thermal coal for export and domestic consumption. The mine currently employs around 67 people and mining is undertaken with truck-and-shovel and hydraulic excavator. Approvals have been obtained to extend the former No. 1 open cut mine and prolong the life of the open cut operations by another seven years.

In total these five mines account for the majority of the coal production in the Muswellbrook local government area, and a significant proportion of total New South Wales production (Figure 39).

---

**Figure 39. Raw production comparisons**

---

96
Appendix 4: Possible Future Developments in the Project Area

Anvil Hill (Centennial Hunter Pty Ltd)

The Anvil Hill proposal (Centennial Hunter Pty Ltd) is located 7km northwest of Denman. It holds 126.4 Mt of proved reserves and a further 31 Mt of probable reserves. It is listed as an open-cut mine to produce thermal coal with potential markets still to be determined. The project is currently being assessed for both domestic and export supply.

Mt Ogilvie (Mt Arthur Coal)

Mount Arthur Coal is currently exploring contiguous coal resources for possible future underground development (EL 5965). In 2004, coal exploration was undertaken in the Mt Ogilvie region. As part of its continuing exploration program, Mt Arthur has submitted a proposal to undertake an exploration audit in the Woodlands Hill coal seam. This is to provide detailed information regarding the underground coal resource which will assist in the planning for a potential future underground mining operation.

Mt Pleasant Project

The Mount Pleasant lease is located adjacent to Coal & Allied's Bengalla mine three kilometres west of Muswellbrook. Mount Pleasant is 100 per cent owned by Coal & Allied Industries Limited. Coal & Allied obtained an authority over the Mount Pleasant resource in April 1992. Exploration, mining studies and an environmental impact statement (EIS) were completed in 1997. After a 26 month process involving extensive community consultation and a Commission of Inquiry, development consent was granted in 1999 allowing an open cut operation of up to 10.5 million tonnes per annum (Mtpa) of run of mine (ROM) coal over a 21 year life. The Mining Lease Application area (MLA 100) covers 3,985 hectares and contains approximately 450 million tonnes of coal recoverable by open cut mining.

In 2006, Coal and Allied commenced a feasibility study on the Mount Pleasant Project. If developed, the Mount Pleasant Project would be a long life operation, with employment expected to peak at 700 during construction and approximately 300 people during operation.

Saddler’s Creek (Anglo Coal)

Exploration works have been undertaken at Saddlers Creek (close to Drayton) with an emphasis on underground reserves. This mine would be capable of producing both thermal and coking coal products. This preliminary exploration is expected to be finished in late 2006.

Sandy Creek Proposal (MCC)

Development consent for the Sandy Creek underground (board and pillar) mine was granted to Muswellbrook Coal Company in April 1999. The mine has 18 Mt of proved reserves and will produce around 0.50 Mt p.a. The development plans to re-enter the former No. 2 underground mine and its development is subject to market conditions. Mining will not commence until extraction at the company's No. 2 mine is completed.
Coal Loader – Antienne

Construction of a $60m coal loader at Antienne (near Muswellbrook) to supply the Bayswater and Liddell power stations is expected to start early in 2006 following development application approval. The project will provide full-time jobs for 70 construction workers and 18 permanent new employees. It also ensures the on-going viability of both power stations and the existing 550 workers (Department of Planning 2005).
### Appendix 5: Reference Group: Summary of Opinion About The Contributing Factors, Measurement and Management Of Cumulative Impacts

<table>
<thead>
<tr>
<th>Identified Cumulative Impact</th>
<th>Question</th>
<th>Response by Expert Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Change</td>
<td>What is KNOWN and NOT KNOWN about this cumulative impact?</td>
<td><strong>Two community elements</strong>&lt;br&gt;• existing Muswellbrook community (with same identity)&lt;br&gt;• incoming itinerant worker community (without local identity)&lt;br&gt;<strong>Known...</strong>&lt;br&gt;• Anecdotal sense of social fabric of local family/citizens&lt;br&gt;• There is recognised worker turnover and transience (through school children turnover)&lt;br&gt;• Other influences:&lt;br&gt;  • Army&lt;br&gt;  • St Heliers Correctional Facility&lt;br&gt;• School class number record and fluctuations&lt;br&gt;• ABS on rates of rental/house ownership&lt;br&gt;• Earlier some resentment locally to transient workers removing wealth/income from town&lt;br&gt;• Social divide – much talked about&lt;br&gt;• Income&lt;br&gt;• Leisure time&lt;br&gt;• Loss of sporting groups/outlets because of shifts at mines&lt;br&gt;• Internal family unit dislocation&lt;br&gt;• Time at home&lt;br&gt;• Divorce rates&lt;br&gt;• Child supervision&lt;br&gt;• $$$ community enhancement allocations of local Govt&lt;br&gt;<strong>Unknown...</strong>&lt;br&gt;• Community doesn’t know about community enhancement contributions&lt;br&gt;  • Adequacy&lt;br&gt;  • What outcome&lt;br&gt;  • What process&lt;br&gt;• Contribution of non-mining factors to haves/have nots&lt;br&gt;• Is Muswellbrook any different to any other rural community?&lt;br&gt;• Anecdotal not quantitative</td>
</tr>
</tbody>
</table>
| What are the contributing factors to this cumulative impact? | - Shift rostering – time away from home/fatigue/stress  
- Pay/incomes differential – mining jobs retail/services jobs in township  
- Mine workers who do not live in the shire  
- Losing trust in regulatory authorities  
- Local Govt responsiveness  
- S94 community enhancement  
- Non-local mine employees  
- People moving into community  
- Another mine will impact heavily (environmentally, land use, new location)  
- Relocation of community members/neighbors  
- State legislation/policy (lack of technology – political engagement) |
|---|---|
| How can this cumulative impact be measured? | - The 'rural' profile/demographic may indicate if Muswellbrook is any different to other rural communities  
- Benchmark against other similar communities without mining (Junee, Goulburn)  
- ABS Stats on horse/wine industry for context |
| How might this cumulative impact be managed? | - More management can provide community awareness on contributions  
- Council can account and also report on those contributions  
- Increased information about:  
  - Social fabric of Muswellbrook town/LGA  
  - $$ contribution  
- Better engagement of community  
- Dialogue on town planning  
- Targeted programs to community groups  
- Through new LEP as a focus  
- Understanding regulation/process  
- Focus through youth/school  
- Traineeships  
- Mentoring on mining industry and mine related industry  
- Focus on sporting outlets/facilities |
<table>
<thead>
<tr>
<th>Biodiversity and Vegetation</th>
<th>Known...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>• Complex</td>
</tr>
<tr>
<td></td>
<td>• Valley floor largely cleared pre-mining BUT moving into remnant vegetation area now/future contains threatened species (T.S)</td>
</tr>
<tr>
<td></td>
<td>• Increasing knowledge of T.S – process for rare and endangered grouping</td>
</tr>
<tr>
<td></td>
<td>• Mines have an understanding of what is on site</td>
</tr>
<tr>
<td></td>
<td>• Biodiversity targets in Catchment Action plan</td>
</tr>
<tr>
<td></td>
<td>• Mining is a major threat to Biodiversity</td>
</tr>
<tr>
<td></td>
<td>• Replacement’ (to some extent) can be achieved</td>
</tr>
<tr>
<td></td>
<td>• Full replacement cannot be achieved</td>
</tr>
<tr>
<td></td>
<td>• Values of corridors</td>
</tr>
<tr>
<td></td>
<td>• Mining companies are in a good position to help ‘manage/improve’ biodiversity</td>
</tr>
<tr>
<td></td>
<td>Unknown...</td>
</tr>
<tr>
<td></td>
<td>• Impacts of removing vegetation/Biodiversity</td>
</tr>
<tr>
<td></td>
<td>• Consequences of losing Biodiversity</td>
</tr>
<tr>
<td></td>
<td>• Intergenerational equity</td>
</tr>
<tr>
<td></td>
<td>• Non-mining factor of clearing</td>
</tr>
<tr>
<td></td>
<td>• Are we restoring or replacing? Enhancing or improving? (terminology is important)</td>
</tr>
<tr>
<td></td>
<td>• Carbon Accounting, Biobanking Accounting – early days</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>What is KNOWN and NOT KNOWN about this cumulative impact?</th>
</tr>
</thead>
<tbody>
<tr>
<td>What are the contributing factors to this cumulative impact?</td>
</tr>
<tr>
<td>• Land clearing</td>
</tr>
<tr>
<td>• Fragmentation via transport corridors</td>
</tr>
<tr>
<td>• Planning for vegetative screens in landscape – off mining footprint</td>
</tr>
<tr>
<td>• Social goodwill recognised by mining companies – time sequencing</td>
</tr>
<tr>
<td>• Carbon sequestration – bio banking, carbon emission accounting</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>How can this cumulative impact be measured?</th>
</tr>
</thead>
<tbody>
<tr>
<td>• CMA targets – measure</td>
</tr>
<tr>
<td>• REMS survey – measure</td>
</tr>
<tr>
<td>• Carbon accounting</td>
</tr>
<tr>
<td>• Social accounting</td>
</tr>
<tr>
<td>• On amenity levels</td>
</tr>
<tr>
<td>• Of visual catchment</td>
</tr>
<tr>
<td>• Measure of effectiveness on dust propagation/mitigation</td>
</tr>
<tr>
<td>Health and Wellbeing</td>
</tr>
<tr>
<td>----------------------</td>
</tr>
<tr>
<td><strong>How might this cumulative impact be managed?</strong></td>
</tr>
<tr>
<td>- Post mining - land use requirements/liability/tenure</td>
</tr>
<tr>
<td>- Targeting areas for specific attention – landscape mosaic</td>
</tr>
<tr>
<td>- Zoning – in perpetuity for biodiversity/ env zones/VCA (voluntary conservation agreements)</td>
</tr>
<tr>
<td>- Bio banking</td>
</tr>
<tr>
<td>- Bio offsets – off lease site</td>
</tr>
<tr>
<td>- Use of carbon credits to coal sites – generated by mining companies</td>
</tr>
<tr>
<td>- Ecosystem valued</td>
</tr>
<tr>
<td>- Upfront planning to undertake land use/strategic/constraint planning to limit coal mine sites</td>
</tr>
<tr>
<td>- Noted that Biodiversity is not a ‘local’ issue – needs to be managed on a catchment/regional scale</td>
</tr>
<tr>
<td>- Aesthetics – change visual attributes of dumps to enhance biodiversity and model to look like natural landscapes</td>
</tr>
<tr>
<td>- Localised ‘town view’ of mine dumps be reduced by increasing vegetation in town</td>
</tr>
<tr>
<td>- Guidelines – Mine Closure Completion Criteria</td>
</tr>
</tbody>
</table>

| **What is KNOWN about this cumulative impact?** |
| **Known...** |
| - Hunter Area Population Health Survey (Dr. Craig Dalton) some studies on ‘Health Issues’ Hunter Valley. |
| - ‘Mental Health’ impacts/stress. |

| **Unknown...** |
| - Not known if Muswellbrook community different to other communities similar size. |
| - What mines are ‘doing’ that influence health and wellbeing e.g. drug programs, OHS program, shift work. |

| **What are the contributing factors to this cumulative impact?** |
| - Non-mining related demographic population shift. |
| - Shift work/recreational facilities. |
| - Dust/Asthma. |
| - Background noise (increased). |

<p>| <strong>How can this cumulative impact be measured?</strong> |
| - Review HIC data indicators of ‘illness’ in community. |
| - Compare health incidents to other towns (possible problem population size). |
| - Mine employee assistance program data. |
| - Community surveys (Newcastle Uni survey). |
| - Hospital data on cases of lung/other? Asthma. |</p>
<table>
<thead>
<tr>
<th>Air Quality</th>
<th>What is KNOWN and NOT KNOWN about this cumulative impact?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Known…</strong></td>
<td>- Dust is an amenity issue.</td>
</tr>
<tr>
<td></td>
<td>- Highly visible/key issues for community.</td>
</tr>
<tr>
<td></td>
<td>- Already large number monitoring sites/data.</td>
</tr>
<tr>
<td><strong>Unknown…</strong></td>
<td>- Link between coal mining (open cut) and dust.</td>
</tr>
<tr>
<td></td>
<td>- Not clear if dust is a health issue i.e. mining dust not the same as ‘other’ dust sources.</td>
</tr>
<tr>
<td></td>
<td>- Lack of base line data pre mining.</td>
</tr>
<tr>
<td></td>
<td>- No central database/analysis.</td>
</tr>
</tbody>
</table>

| How might this cumulative impact be managed? | Consider options to reduce the ‘contributing factors’ e.g. dust, noise, improve visual amenity. Financial ‘planning’ support services. |

<table>
<thead>
<tr>
<th>What are the contributing factors to this cumulative impact?</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Particulates (dust). [TSP and PM10]</td>
</tr>
<tr>
<td>- Fine particulates [PM10 to PM 2.5] 30% approx</td>
</tr>
<tr>
<td>- ‘Chemical’ NOx, SOx, spontaneous combustion.</td>
</tr>
<tr>
<td>- Meteorology (temperature inversion) (wind speed/direction, prevailing wind)</td>
</tr>
<tr>
<td>- Other land uses (power stations, agriculture)</td>
</tr>
<tr>
<td>- Highway traffic – particulates diesel emissions.</td>
</tr>
<tr>
<td>- Bush fires. Dust drought</td>
</tr>
<tr>
<td>- Proximity to the source of dust/emissions.</td>
</tr>
<tr>
<td>How can this cumulative impact be measured?</td>
</tr>
<tr>
<td>-------------------------------------------</td>
</tr>
</tbody>
</table>
| ▪ Can be accurately measured, air emissions, dust NOx, SOx.  
| ▪ Difficult to obtain representative sample or attribute to specific sources.  
| ▪ Need network of monitoring sites.  
| ▪ Used to validate air shed/dispersion models.  
<p>| ▪ Lack of comparative data (before and during mining). |</p>
<table>
<thead>
<tr>
<th>How might this cumulative impact be managed?</th>
</tr>
</thead>
</table>
| ▪ Need to establish well co-ordinated ambient monitoring network/data analysis.  
| ▪ Better statistical reporting to community/understanding of what the data means.  
| ▪ Consideration of alternative standards.  
| ▪ Develop new ways of reducing dust.  
| ▪ Adaptive management (best practise). |
Appendix 6: Issues in Managing and Analysing Multi-Mine Complaints Data

The initial intention was to spatially represent the distribution of results depicting a visual representation of the correlation of data between the three variables of time, location and nature of the complaint. In order to complete this assessment, the three variables were required to be arranged in a format that was conducive to spatial mapping. The following section details the methods of database management, enquiry and analysis that were undertaken to process the data and achieve the results of the investigation.

An initial audit was conducted to assess the quality and extent of the complaints data. This audit served to confirm what data had been obtained, still required collection or was awaiting submission from the data sources. This process also enabled the identification of commonalities between different data sets especially in regards to the type of data recorded (e.g. narrative vs raw score) and the nature of the recording process (e.g. daily, weekly, monthly).

The audit involved the compilation of a temporal matrix that identified what months of the year over an eleven-year time period (1993-2005) there was a record of complaints. The detail and extent of information was also investigated in relation to street addresses, specific complainant locations (house or property number). The nature of the complaint was also audited with regard to the initial goal of spatially mapping the frequency and distribution of complaints over time.

Some complainants complained more frequently and intensely than others, leading to an observation that serial and seasonal complainants did exist. A complainant of this nature was identified as someone that consistently and continually registered a complaint over an extended period or throughout the time series of data. Some narratives reflected that certain complainants were pestering, or vexatious. These were noted, and their complaints recorded as one complaint per day, if multiple and of the same nature.

**Temporal Analysis:**
The time series analysis of all the data was limited by an incomplete time series, heterogeneous data formats and missing dates. For example, some dates were recorded in a monthly format only. To overcome this and the other temporal limitations, the AEMRs were revisited and the mining companies were approached to ascertain if any additional data could be retrieved. With the additional information provided, larger sections of the desired time series became continuous to the extent that considerable periods of the time series could be analysed.

**Spatial Analysis**
The spatial analysis of all the data remained incomplete due to the lack of uniformity in reporting styles and information gathered. To achieve some degree of similarity between datasets, information regarding location/address had to become generalised, and the spatial representation of complaints at a specific place had to be altered resulting in an area-proximate representation of complaints. This improvement did allow for some spatial representation but minimised subtle dynamics such as shifts in complaints across areas over time. The absence of spatial detail and specificity also contributed to the limited extent of spatial analysis, as it was difficult to find the exact location or address. This was evident in the recordings that involved a RMB, ‘Property Name’ and street name only. This was particularly problematic if the road was a considerable distance in length and passed through...
several towns (e.g. New England Highway, Thomas Mitchell Drive). This particular type of non-uniformity also influenced the decision to make an area-proximate representation of data.

The restrictions prescribed by various privacy laws and policies also affected the extent of data released by the mines for the purposes of this study. Until three years ago, the names (and therefore arguably, the addresses) of complainants were recorded and published in annual reports. With the change in legislation surrounding privacy of complainants, this data could no longer be released, which restricted the success of determining the relationship between complaint types and the complainant (for serial complainant analysis).

These limitations were largely overcome with the decision to spatially map the data based on area-proximate locations. This involved re-coding the location/address information into a set of codes of more generalised areas. Although this option was not necessarily perfect, it did provide an indication of the distribution of results across time and space that would have not previously been possible.

**Nature of Complaints:**
Analysis of the nature of the complaints was limited by the non-uniformity of complaints narrative. Some mining companies gave thick description narrative whereas others did not. In the case of the latter, the complaint was often recorded only as raw score or had been manipulated for other reporting exercises (e.g. AEMR’s). To overcome this limitation, the complaints were coded using categories that already existed in the dataset, and additional sub-categories where possible. Some original coding was disregarded due to the presence of narrative that was descriptive enough to provide a more precise indication of the nature of the complaint. In a few cases, the coding was altered to more appropriately reflect that nature of the complaint. For example: ‘fumes’, ‘odours’ and ‘spon com’ were coded under a subset of ‘Spontaneous Combustion’ given the likelihood that they were all related events.

Another limitation was that data was stored and recorded in different software formats, and databases. To more effectively and efficiently manage the data provided for the purposes of this study, a combined complaints database was constructed, which also assisted in process of analysis.
Appendix 7: Constructing a Combined Complaints Database

Why do complaints databases exist?

Mining companies in New South Wales are under statutory obligations in accordance with their operating license conditions to fulfil certain reporting requirements. This legal requirement is expressed under the Protection of the Environment Operations Amendment Act 2005 (previously the Protection of the Environment Operations Act 1997). It is important to note however that although each mine has specific operating conditions, the conditions of reporting may be completely different and hence account for the different approaches undertaken to environmental and complaints data recording and management.

The existence of mining company complaints databases is to serve obligations under legislative and policy requirements, to facilitate community engagement and consultation, and to also assist in the disclosure of events that would not usually have drawn attention. The general policy context charges all mining companies with a degree of responsibility that requires the recording of complaints. Although this policy allows for some level of discretion, it is generally non-prescriptive of specific data recordings and methodologies that could assist in industry investigations and operations analyses. A complaints database can also assist in understanding the concerns and dynamics of the community, and can inform the response to follow events disclosures (incidents and accidents) apart from raising awareness of formerly unknown issues, also provides for environmental checks on the performance of mitigation measures.

Contents of the Complaints Datasets:

The datasets provided by the five mines generally included:

- nature of complaints
- location/address
- date of the complaint
- names of the complainants.

A description of each of these components is contained below. In some instances, they also included the mine’s response to the complaint, however, due to time constraints this component was not analysed.

Each of the databases varied because of the methods and techniques implemented by staff to collect, process and code data. The five mining companies each commenced operations at various times and at different intervals from the previous mining establishment. The quality of the narrative within the databases subsequently improved over time although each database remained inherently different from the others displaying divergent depths of narrative, as evidenced in the following two entries about noise:

'Noise is better, can you do anything to lower further?'

'Complained of reversing beeper heard at 6:30 am. Commented that dust is not a problem at present and noise is acceptable. Asked that [person] not slam doors when monitoring.'
**Nature of Complaint (Type of complaint):** The nature of the complaint was recorded in either descriptive narrative or raw score data. It provided an indication of the event/s that contributed to the complaint in terms of the type of activity, the duration of the activity and the extent of the activity (singular or multiple occasions). The nature of the complaint also indicated the extent of discomfort experienced by the complainant often revealed through specific comments and detailed narrative. Each of the complaints databases received from the respective mining companies had different complaint recording formats that varied in form from their own codes, details of the complaint and response to the complaint.

**Location/Addresses:** These terms were generally used synonymously with one another despite the possibility that complainants could register a complaint from a location entirely different to their residential address. What was most problematic however, was the different ways in which each mine site recorded the address/location of the complainant. In some cases it was recorded as a town (e.g. Muswellbrook, McCullys Gap, Denman etc), a main road (e.g. the New England Highway, Thomas Mitchell Drive), or a road and the town (e.g. New England Highway, Aberdeen). In others, records included only a property name (e.g. ‘Malara’) or a Roadside Mailbox (RMB) and, sometimes, the precise address with or without a postcode (e.g. XX Shannon Close, Aberdeen 2336). Still other entries included a road with directions (e.g. Skellatar Road, middle near school) and others merely featured an estate (e.g. Antiene Estate).

**Date:** The date was recorded for most complaints within the database. Date recordings were typically on a daily or monthly basis, and were recorded against an annual time scale within a financial or calendar year. Some complaints were recorded against the time of the complaint being received.

**Names:** The names of the complainants were removed from some of the databases received due to the requirements of various privacy laws. Additional nominal data was removed in the later stages of analysis with respect to continued confidentiality. Therefore, assumptions could not be made in relation to the contents of a complaint and the presence and influence of serial complainants.

**Cleaning and Coding Complaints Datasets**

Complaints datasets from each mine site were collated in an Excel worksheet. Each year of the time series that proved viable (1994-2005) was allocated a separate spreadsheet in the database. If it appeared that a mining company was unable to provide data for a particular year, it was annotated to pursue at a later stage. Although some complaints data had been received from the Muswellbrook Shire Council, the decision was made not to include this data in the analysis due to time constraints and the information that could be derived from the mining company data alone. This became the first of three stages in the management of the combined complaints database.

The second stage involved re-coding of the data. Coding of the nature of complaints information was largely dependent upon the classification scheme used by the mining companies in their reporting. It also became more descriptive as time passed. Initially, a manually created list of 19 different categories (codes) was compiled. As code processing continued, the number of categories increased to the point at which it became more appropriate to create sub-categories of the codes. In the instances where particular complaints did not match a specific code (e.g. ‘rubbish’, ‘kangaroos’) these complaints were collectively categorized as ‘other’. Table 13. Classification and coding of complaints made to five mines sites at Muswellbrook below describes the types of complaints and the associated description for each category and sub-category. If a recorded complaint from a mine’s data
set had separate components or various types of complaints mentioned in one entry or narrative, each was regarded as a separate complaint. This explains why the total number of complaints in the combined database was larger than the aggregation of all complaints from the five mine sites’ individual datasets.

Table 13. Classification and coding of complaints made to five mines sites at Muswellbrook

<table>
<thead>
<tr>
<th>MAIN CATEGORY</th>
<th>SUB-CATEGORY</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noise</td>
<td>General plant and operational noise, e.g. noise from the plant operations at mine-site, including washery noise, CHPP, dragline</td>
<td></td>
</tr>
<tr>
<td>Noise–T</td>
<td>Noise – trains and rail, e.g. noise from trains, shunting, loading or related</td>
<td></td>
</tr>
<tr>
<td>Noise–B</td>
<td>Beeping – reversing-alarm noise</td>
<td></td>
</tr>
<tr>
<td>Noise–G</td>
<td>General operational noise, e.g. all noise emanating for the mine-site operation that was not plant specific or traffic or train related</td>
<td></td>
</tr>
<tr>
<td>Noise–P</td>
<td>Positive comments</td>
<td></td>
</tr>
<tr>
<td>Traffic–D</td>
<td>Dust, e.g. dust problems caused by traffic, trucks etc, dust that could contribute to dangerous traffic conditions or accidents, incidents</td>
<td></td>
</tr>
<tr>
<td>Traffic–C</td>
<td>Congestion caused by traffic, or likely to contribute to traffic accident or incidences</td>
<td></td>
</tr>
<tr>
<td>Traffic–N</td>
<td>Noise related to traffic, e.g. excessive operational truck noise such as braking, acceleration or traffic noise.</td>
<td></td>
</tr>
<tr>
<td>Traffic</td>
<td>General, e.g. traffic related complaints that can not be attributed to the other three categories, problem driver behaviour</td>
<td></td>
</tr>
<tr>
<td>Lighting</td>
<td>Lighting, e.g. general lighting from mine-site, lights from trains and traffic</td>
<td></td>
</tr>
<tr>
<td>Visual</td>
<td>Visual, e.g. construction or vegetation of bunds, haze, appearance of plant, site, etc.</td>
<td></td>
</tr>
<tr>
<td>Blasting</td>
<td>Blast noise, blasting fumes</td>
<td></td>
</tr>
<tr>
<td>Overpressure</td>
<td>Air noise/vibration</td>
<td></td>
</tr>
<tr>
<td>Vibration</td>
<td>Ground vibration</td>
<td></td>
</tr>
<tr>
<td>Dust/Air Quality</td>
<td>Dust</td>
<td></td>
</tr>
<tr>
<td>Air Quality</td>
<td>Air quality, e.g. heavy dust clouds</td>
<td></td>
</tr>
<tr>
<td>Odour</td>
<td>Odours, e.g. usually related to spontaneous combustion and blasting fumes</td>
<td></td>
</tr>
<tr>
<td>Spontaneous Combustion</td>
<td>Combustion and odours</td>
<td></td>
</tr>
<tr>
<td>Communication/C SR</td>
<td>Community consultation, e.g. problems related to meetings with the community, meeting corporate responsibilities</td>
<td></td>
</tr>
<tr>
<td>CF</td>
<td>Cumulative frustration</td>
<td></td>
</tr>
<tr>
<td>Communication</td>
<td>Communication between mine and non-mine people or organisations</td>
<td></td>
</tr>
<tr>
<td>Water</td>
<td>Any water related complaints</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Development consent, shooting on mine site, kangaroos, rubbish, smoke, neighbours, damage, spoiled washing, potential subsidence, trespassing or intrusion by mine staff, failure of monitoring equipment, safety breaches</td>
<td></td>
</tr>
</tbody>
</table>
Appendix 8: Visual Amenity Analysis

Introduction

The community stakeholders and the expert group both recognised the importance of visual amenity when considering cumulative impacts. Visual amenity is a complex issue. It incorporates the direct visual presence of the physical features of the mines and indirect aspects such as dust in the atmosphere and lights at night. It is also complicated by the fact that mitigation measures, in particular land rehabilitation including revegetation, takes several years to come into full effect, which may be delayed by conditions such as drought. This analysis deals with the direct visual impact and focuses on land disturbance as its indicator. An important aspect of visual amenity is how individuals respond psychologically and/or emotionally to particular landscape elements. People do not, in general, feel that a car park and a forest are equally different to pasture land, for example. This analysis does not deal with this aspect of visual amenity. Only two classes of visual experience are included, namely, areas disturbed by mining and areas not disturbed.

Visual amenity was assessed by first breaking the landscape up into small square areas of land each with side length of 25m. Each square element of land thus defined is termed a pixel.

The assessment of the cumulative impacts on visual amenity consists of three components:

1. **Visual Exposure Analysis.** This analysis consists of computing the extent to which each pixel of the landscape that is disturbed by mining is able to be viewed from the Muswellbrook town, i.e. is exposed to the town (impacted area). The greater the number of town pixels that can ‘see’ a given pixel of disturbed landscape, the greater the visual exposure of that disturbed pixel.

2. **Impact Intensity Analysis.** This analysis computes the extent to which each pixel of the Muswellbrook town can see landscape that has been disturbed by mining. The more disturbed area that can be seen from a given pixel that greater the impact intensity on that pixel.

3. **Effects of Bunding (disturbed and undisturbed).** Visual bunds have been put in place by a number of mines to screen the view of the mine from the town. The extent to which bunds change the visual exposure and impact intensity is measured. The measurement is done twice; once where the bund pixels are considered the same as disturbed pixels and once where the bund pixels are considered equivalent to undisturbed landscape pixels. This simulates the difference between earth bunds and rehabilitated/vegetated bunds. Bund shape is not analysed.
Data Acquisition

Table 14. Summary of data acquired for the visual amenity analysis, its source and any specific pre-processing required.

<table>
<thead>
<tr>
<th>Data set</th>
<th>Source</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>25m Digital Elevation Model (DEM) of the project area.</td>
<td>DIPNR</td>
<td>Hydrologically corrected (sink filled) to ensure surface water flow ‘clearance’.</td>
</tr>
<tr>
<td>ARCGIS shape files of boundary leases of the project mines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contour maps of some project mines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disturbed area and progressive rehabilitated area measurements</td>
<td>Project -region mines</td>
<td></td>
</tr>
</tbody>
</table>

Definition of Impacted Area

Due to the focus on cumulative impacts, it was necessary to restrict the demarcation of the impacted area to an area that felt the impacts of more than one mine. Given its centrality to the project mines and the community population, the impact area was defined by drawing a border around the township of Muswellbrook. Following discussions with the Project Steering Committee, the vicinity of the racecourse was included. The western boundary was set on the Hunter River (Figure 40). The total coverage of the impacted area measured 9.38 km².
To compute both visual exposure and impact intensity it was necessary to delineate the areas disturbed by mining and thereby identify the set of pixels that would be categorised as disturbed.

Remotely sensed imagery at 25 m resolution was obtained for the epochs 1989, 1992, 1995, 1998, 2000, 2002 and 2004, providing a 15-year timeframe over which cumulative impacts could be observed. Areas of disturbed area on each of the project mines are readily discernible on each of the Landsat scenes. The method used to map disturbed area was to trace the land that appeared to be disturbed on the Landsat images for each epoch. Figure 40 gives an illustration of the changes in disturbed area of the 15-year time period.

**Figure 40. Outline of the impacted area overlain on the remotely sensed imagery.**

**Mapping disturbed area**

To compute both visual exposure and impact intensity it was necessary to delineate the areas disturbed by mining and thereby identify the set of pixels that would be categorised as disturbed.

Remotely sensed imagery at 25 m resolution was obtained for the epochs 1989, 1992, 1995, 1998, 2000, 2002 and 2004, providing a 15-year timeframe over which cumulative impacts could be observed. Areas of disturbed area on each of the project mines are readily discernible on each of the Landsat scenes. The method used to map disturbed area was to trace the land that appeared to be disturbed on the Landsat images for each epoch. Figure 40 gives an illustration of the changes in disturbed area of the 15-year time period.
Figure 41. Disturbed areas as mapped (shown in blue) for four time periods – 1989, 1995, 2000 and 2004 overlain on the remotely sensed image of that epoch.

It was necessary to test whether the visual mapping of disturbed areas was accurate. This was achieved by comparing the visual mapping with land disturbance and rehabilitation data provided by the mines in annual rehabilitation reports. Comparisons were made between visual disturbance maps and reported data for:

- disturbed land only
- disturbed land and all rehabilitation
- disturbed land and the last year of rehabilitation.

Taking rehabilitation into account is important, because it may be difficult to distinguish rehabilitated land in the first year or so after rehabilitation either because the planting was undertaken close to the end of the recording year and/or because vegetation may take a number of years to establish to the extent that it is clearly visible in the remotely sensed imagery.
Figure 42 shows that the correlation between mapped and measured disturbed area is slightly better when all rehabilitation is taken into account than when only land disturbed is compared. However, maps of disturbance overestimate the area measured in mine site reports of disturbed land only. This is indicated by the slope of the linear fit being greater than 1. Mapped areas underestimate the area compared to measured mine site reports of disturbed area and total rehabilitated area (slope < 1). Therefore, the visual mapping is between total disturbed area and total disturbed area less total rehabilitated area.

A comparison was then carried out between the visual mapping and reported figures of disturbed area and area rehabilitated in the reported year. Figure 43 shows that these measurements correlate acceptably with the visual mapping and that the slope of the linear correlation is close to one (1.0968). This comparison suggests that mapping disturbance using Landsat images is similar to mapping areas of disturbance and recent rehabilitation which may still look disturbed from above.

**Figure 42. Mapped disturbance and mine site reported disturbed area**

A comparison was then carried out between the visual mapping and reported figures of disturbed area and area rehabilitated in the reported year. Figure 43 shows that these measurements correlate acceptably with the visual mapping and that the slope of the linear correlation is close to one (1.0968). This comparison suggests that mapping disturbance using Landsat images is similar to mapping areas of disturbance and recent rehabilitation which may still look disturbed from above.
Other factors affected the precision of disturbance mapping, for example, time constraints did not permit the exclusion of small vegetated features situated within apparently disturbed areas. Also, a slight variance in figures may be derived from temporal variability in Landsat image capture (flight paths for each scene have a duration of up to 12 months), which makes cross comparisons difficult. That is, the comparison is not made at the same time of the year for each scene. Given the exploratory nature of this analysis, the accuracy attained in the approximate visual delineation of disturbed area using Landsat imagery was considered to be acceptable.

### Visual Exposure

Visual exposure is a measure that focuses on the landscape. The analysis consists of computing the extent to which each pixel of the landscape that is disturbed by mining is able to be viewed from the Muswellbrook town, i.e. is exposed to the town (impacted area). The greater the number of town pixels that can see a given pixel of disturbed landscape the greater the visual exposure of that disturbed pixel.

### Method

1. **Calculate the total viewshed of the impacted area.**

To determine visual exposure of disturbed area, it was necessary to perform a viewshed analysis for each pixel of the impacted area. The impacted area was divided into 25m x 25m pixels (a total of 15,005 pixels), which were then converted into individual ArcGIS points. The viewshed algorithm utilises the digital elevation model (DEM) to calculate a binary exposure map for each pixel (which can be thought of as a viewing location/point). In the viewshed, every pixel that can be seen from this point is given a value of 1 whilst pixels that cannot be seen are given the value zero (Figure 44).
The process is then repeated for each of the 15,005 points in the impacted area. The sum of the binary maps gives the composite viewshed map for the impacted area (Figure 45). Each pixel in the composite viewshed will have a value ranging, in this case, from zero (unexposed) to 13,503 (can be seen by 13,503 of the 15,005 viewing points — highly exposed). These values indicate the number of 25m² units in the impacted area that can see each corresponding unit of land.

Figure 45. Total viewshed of impacted area
2. Extract the total viewshed through the maps of disturbed area for each epoch.

The composite viewshed produced a visual exposure map for the whole region. To analyse the visual exposure of disturbed area it was necessary to extract the exposure map through the ArcGIS shapefiles of disturbed area. This was done for each of the Landsat epochs (1989, 1992, 1995, 1998, 2000, 2002, 2004). Figure 46 provides an example of the visual exposure map of disturbed area in 2004.

![Figure 46. Visual exposure map extracted through the mask of 2004 disturbed area.](image)

**Results**

**Disturbed Area:** Mapping of disturbed areas using remotely sensed data shows that there has been a significant increase in disturbed land over the last 15 years (Figure 47, Table 15). While there has been a steady increase in exposed disturbed area, for most of the relevant timeframe it has been in proportion to disturbed area, sitting under 20% of the total. There appears to have been an increase since 2000, however, with the proportion of exposed disturbed area rising from ~18% to ~25% of total disturbed area.
Figure 47. Visual exposure, area of land disturbed and area not exposed over the period 1989-2004.

Table 15. Disturbed area

<table>
<thead>
<tr>
<th>Year</th>
<th>Disturbed Area (km²)</th>
<th>Area with No Exposure (km²)</th>
<th>Disturbed Area Exposed (km²)</th>
<th>Exposed Disturbed Area (% of total)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>15.99</td>
<td>12.94</td>
<td>3.05</td>
<td>19.06</td>
</tr>
<tr>
<td>1992</td>
<td>15.40</td>
<td>12.71</td>
<td>2.69</td>
<td>17.44</td>
</tr>
<tr>
<td>1995</td>
<td>19.52</td>
<td>16.25</td>
<td>3.28</td>
<td>16.79</td>
</tr>
<tr>
<td>1998</td>
<td>29.03</td>
<td>24.21</td>
<td>4.82</td>
<td>16.60</td>
</tr>
<tr>
<td>2000</td>
<td>32.26</td>
<td>26.53</td>
<td>5.73</td>
<td>17.75</td>
</tr>
<tr>
<td>2002</td>
<td>39.87</td>
<td>31.10</td>
<td>8.77</td>
<td>21.99</td>
</tr>
<tr>
<td>2004</td>
<td>47.57</td>
<td>35.85</td>
<td>11.72</td>
<td>24.64</td>
</tr>
</tbody>
</table>

Visual exposure: Mean visual exposure is the average area (number of pixels) that can see each pixel of disturbed land. Total visual exposure is the sum of the visual exposure across all exposed pixels. Mean visual exposure and total visual exposure of disturbed area increase over the study period. Mean visual exposure increased from 0.04 km² in 1989 to 0.20 km² in 2004 (Figure 48). Over the same period, the total visual exposure grew from 930 km² to 15,392 km² in 2004 (Figure 49).

The change in visual exposure can be described as three stages of increase over the 15 year time period. The first stage, – between 1989 and 1995, - shows very little change in visual exposure. The second stage occurs between 1995 and 2000 and is identified by a steady increase in visual exposure. The third stage, from the year 2000 onwards, shows a marked increase in visual exposure.
Figure 48. Mean visual exposure.

Figure 49. Total visual exposure.
Impact Intensity

Method

This analysis computes the extent to which each pixel of the Muswellbrook town (impacted area) can see landscape that has been disturbed by mining. The more disturbed area (pixels) that can be seen from a given town pixel that greater the impact intensity on that pixel.

Impact intensity assessment is similar in nature to visual exposure analysis but is undertaken in the opposite direction (i.e. towards the impacted area).

1. Convert the exposure maps of disturbed area to ArcGIS points

The first stage of the impact intensity analysis is to utilise the exposure maps of disturbed area created in the visual exposure analysis. Exposure maps for each epoch are converted to ArcGIS points 25 metres apart, ready for viewshed analysis. All unexposed points can be omitted from the analysis to reduce time for computation.

2. Perform a viewshed from each of the disturbed area points

The viewshed is calculated for each of the disturbed area points and summed to give a composite exposure map (Figure 50). Unlike the visual exposure analysis, the viewshed operation must be repeated for each Landsat scene (1989, 1992, 1995, 1998, 2000, 2002, 2004) as the viewshed will change as areas of disturbed land shift and grow.

Figure 50. Viewshed from disturbed points in 2004
3. Extract the total viewshed for each epoch through the mask of the impacted area

After the viewsheds have been undertaken for each epoch, they are extracted through the mask of the impacted area (Figure 51). The series of viewsheds provides a 15-year time period over which to study the changes in impact intensity within the Muswellbrook township.

*Figure 51. 2004 Viewshed extracted through impacted area. Brighter areas indicate greater visual impact (more disturbed areas can be seen).*
Results

Binary Impact: Figure 52 shows the binary impact maps for each of the epochs computed. The racecourse area and ridges in the northern part of the town become exposed early in the series. There is a significant increase in the 1998 scene followed by a gradual filling-in. The region in the south-east remains unexposed.

Figure 52. Binary impact time series (excessive decimal places seem to be inherent in the mapping software).
Binary impact (as a term for an indicator variable) refers to the area of the town that is impacted – it could equally be expressed as a proportion or percentage of the impacted area that is impacted at a given time. Binary impact is calculated by summing the pixels that can see at least one disturbed pixel. There appears to be three distinct stages of development of binary impact (Figure 53, Table 16). From 1989 through to 1995 the exposure of the impacted area remains steady at around 35% of the total impacted area. In 1998 there is close to a doubling of exposure with an additional 2.93 km² exposed. There is a further jump of 1.35 km² in 2000 before exposure levels off at around 80% in 2004.

![Figure 53. Binary impact time series](image)

**Table 16. Visual impact intensity as indicated by binary maps.**

<table>
<thead>
<tr>
<th>Year</th>
<th>Area Exposed (km²)</th>
<th>Percentage of Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1989</td>
<td>3.4</td>
<td>37</td>
</tr>
<tr>
<td>1992</td>
<td>3.3</td>
<td>35</td>
</tr>
<tr>
<td>1995</td>
<td>3.2</td>
<td>34</td>
</tr>
<tr>
<td>1998</td>
<td>6.1</td>
<td>65</td>
</tr>
<tr>
<td>2000</td>
<td>7.4</td>
<td>79</td>
</tr>
<tr>
<td>2002</td>
<td>7.3</td>
<td>78</td>
</tr>
<tr>
<td>2004</td>
<td>7.5</td>
<td>80</td>
</tr>
</tbody>
</table>
**Impact Intensity:** The maps of impact intensity over time are shown in Figure 54. These maps contain additional information compared to the binary maps (Figure 52) – not only is it possible to determine which areas are impacted but the magnitude of the impact is visible (lighter blue tones in the figure). Whilst there is a general increase across most impacted areas, there is significantly more impact on the ridges and at the town periphery in the south west and, to a lesser extent, the racecourse.

*Figure 54. Impact intensity (km²) time series (excessive decimal places seem to be inherent in the mapping software).*
Mean impact intensity is the average amount of disturbed area that can be seen by each pixel of impacted area. It is computed by taking the average of each map in Figure 54. Mean impact intensity remains steady for the first 6 years of the measurement period. Between 1995 and 2000 it rises steadily from 0.05 km² to 0.40 km². After 2000, mean impact intensity increases at a higher rate until it reaches 0.97 km² in 2004 (Figure 55). The shape of the curve mirrors the three stages described above in the binary impact analysis.

![Figure 55. Mean impact intensity over time.](image)

**Analysis of visual bunds**

Visual bunds have been put in place by a number of mines to screen the view of the mine from the town. The extent to which bunds change the visual exposure and impact intensity is measured. The measurement is done twice; once where the bund pixels are considered the same as disturbed pixels and once where the bund pixels are considered equivalent to undisturbed landscape pixels. These two cases are compared to the results above which do not consider bunds (this is referred to as the plain analysis). This simulates the difference between earth bunds and rehabilitated/vegetated bunds. Bund shape is not analysed.

**Method**

1. **Make maps of disturbed area to incorporate disturbed and undisturbed bunds**

Due to the simplified nature of this analysis, disturbed bunds are considered to be no different from other areas of disturbed land and are mapped accordingly. Undisturbed bunds are treated the same as undisturbed landscape and, as such, are excluded from maps of surrounding disturbed areas. Mapping was performed for the 2004 Landsat epoch to ensure consistency with the bunding information received from the project mines.

2. **Modification of DEM to incorporate relevant bund information**

Two metre (2m) contour models were obtained from 2 project mines and converted into 25m by 25m raster datasets. These datasets were then merged with the existing DEM to create a modified DEM with bunding elevations represented.
3. Perform visual exposure and impact intensity analyses using the modified DEM

The modified DEM was utilised to calculate the viewshed of all of the points in the impacted area. The resulting exposure map was then extracted through the mask of disturbed area with bunds treated as disturbed, and disturbed area with bunds considered undisturbed. Viewshed analyses for each of the disturbed points in both bunding scenarios are then undertaken. These were then extracted through the mask of the impacted area.

**Results**

*Visual Exposure:* Both forms of bunding reduce the amount of exposed disturbed area (Figure 56). With disturbed bunds, 6.8 km² of disturbed area is exposed – around 14% of total disturbed area. Undisturbed bunds decrease the amount of exposed disturbed land to less than 10% of the total. With the original analysis, 11.7 km² of disturbed area is exposed, amounting to almost 25% of total disturbed area.

<table>
<thead>
<tr>
<th>Bunding Scenario</th>
<th>Area km²</th>
<th>Exposed Area</th>
<th>% of Total</th>
<th>Total Exp. km²</th>
<th>Mean Exp. km²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disturbed Bunds</td>
<td>49</td>
<td>6.8</td>
<td>13.8</td>
<td>13360</td>
<td>0.17</td>
</tr>
<tr>
<td>Undisturbed Bunds</td>
<td>45</td>
<td>4.4</td>
<td>9.8</td>
<td>2498</td>
<td>0.03</td>
</tr>
<tr>
<td>Plain Analysis</td>
<td>48</td>
<td>11.7</td>
<td>24.6</td>
<td>15392</td>
<td>0.20</td>
</tr>
</tbody>
</table>

*Figure 56. Exposed disturbed area under different bunding scenarios*

*Figure 57. Mean visual exposure comparison*
Visual Analysis Limitations

- Limitations regarding frequency of Landsat scenes – only every 2-3 years.
- Lack of precise timing for Landsat images (flight paths up to 12 months in duration) – makes cross comparisons with other time specific data difficult (e.g. yearly rehab data)
- Only an approximation of disturbed area (no demarcation of individual vegetation features on mine sites)
- Viewshed does not take into account obstacles, such as trees, houses and buildings, which do not show up on the Digital Elevation Model
- Only one analysis incorporated contemporary bunding scenarios. Viewsheds for other years did not incorporate bunding into analysis. Not all mines supplied bund information.
- No consideration of the potential perceptual and psychological differences between different landscape elements.

Conclusions

The analysis of visual amenity indicated that the direct visual impact of land disturbance from mining is a cumulative impact in the Muswellbrook town. Remotely sensed data showed that there has been an increase in the amount of disturbed land in the Muswellbrook area over the last decade. Impact intensity and visual exposure have also increased over the period. Visual bunds can largely mitigate this impact if the appearance of the bunds is similar to undisturbed land. If not, the large cost incurred in building them is likely to return relatively marginal benefit. With good quality bunds, the visual impact intensity to the township of Muswellbrook could be as low as it was in 1995 – prior to the major expansions in mining. More work is required to include the effects of local features in the town, for example, trees and buildings, and to understand how different views are perceived, for example, mines, pastures, vineyards and highways.
Appendix 9: Detailed Water Quality Analysis

Data acquisition

Two data sources have been accessed. First, the so-called Pinneena data set (purchased as a DVD with code 14001) and second, more recent water flow data available from the DIPNR web site (code 15001). Unfortunately, these two data sets are not entirely compatible. Interactions with DIPNR staff to try to sort out the differences did not prove successful. A second data set, known as ‘Discrete Water Quality’ data, are available for the monitoring sites mentioned above. Data has been taken from various datasets ranging back as far as 1979. Sampling is sporadic and often inconsistent between datasets. These water quality (electrical conductivity) and flow data have been acquired for the period 1991 – 2005 for Water Quality Monitoring Stations at (see Figure 58 for map of monitoring locations)

- Hunter River at Aberdeen
- Hunter River at Muswellbrook Bridge
- Hunter River at Denman
- Hunter River at Liddell

![Map of Hunter River monitoring sites](image)

Figure 58. Locations of State water monitoring sites on the Hunter River.

Nutrients and turbidity

First, turbidity has been examined. Such an analysis should try to compare upstream levels with those downstream of the study area. Unfortunately, the turbidity records for Aberdeen and Liddell do not support such an analysis because of the paucity of data. The Muswellbrook station has a ‘reasonable’ turbidity record (Figure 59). There is some indication that background turbidity has increased slightly since the mid-1990s.
As the turbidity data is equivocal, an attempt was made to see if total phosphorus data (total P) showed a consistent pattern. Use of total P as a proxy for fine sediment is considered reasonable if loads can be estimated, because in many systems the majority of total P is attached to fine sediment rather than in solution. It is apparent that there are significant gaps in the monitoring data which are unexplained (Figure 60).

A second issue relates to the coding of projects or particular reasons why specific samples have been taken. For example, the apparent dramatic increase in total P indicated in Figure 60 is explained by studying the project codes (colour-coded in Figure 61), i.e. there is a separate code for all the high recent values. This code relates to a specific study of algae and may represent the use of a different method for estimating total P.
It is disconcerting that an attribute with apparently the same units and description is so different. Coding of all the historical sampling for phosphorous indicates considerable such potential for misinterpretation and renders analysis of total P as an indicator of fine sediment in the Hunter River challenging (if not impossible). No further analysis was considered worthwhile, given the data quality and time available.

**Comparison of salt concentrations (EC) upstream and downstream of Muswellbrook**

**Overall comparison**

Our aim here is to establish whether there is any difference between the concentration of salt at Aberdeen (upstream of Muswellbrook) and Liddell (downstream of Muswellbrook). We implement one of the most popular nonparametric density estimation techniques (Marron, Jones, and Sheather 1996). The results are given in Figure 62. The mode of the density corresponding to the highest peak for Aberdeen is located at 363.5. The mode of the density corresponding to the highest peak for Liddell is located at 570. Note that the other smaller peaks for Liddell are located at 680 and 860. Finally on Figure 63, the two densities are plotted on the same graph using data from 1998 to 2005.
Figure 63. EC distribution at Liddell and Aberdeen from 21/03/98 to 14/10/05

An assessment, using the bootstrap method, was made as to whether the difference in the modes is significant or simply due to sampling variability. Data from both densities over the 98-05 period was re-sampled many times and the modes recalculated thus providing an estimate of the distribution of the difference in the modes (see Figure 64). From the graph we conclude that there is strong evidence to suggest that the salt concentration at Liddell (downstream) is larger than the concentration at Aberdeen (upstream). Since the EC measurements upstream and downstream of the Hunter River are not independent, it may be more appropriate to consider the bivariate density of the Aberdeen and Liddell EC measurements. Figure 65 (left) is the contour plot of the estimated bivariate density using a Gaussian kernel. Figure 65 (left) suggests that the Liddell EC values are more spread out (the blotch of high density is vertical) and generally higher (the centre of the blotch is about [380, 500]). Figure 65 (right) represents the surface plot of the bivariate density. It confirms the impression that Liddell EC values are more spread out.
Figure 64. Distribution of the difference of the modes of the Liddell and Aberdeen EC data.

Figure 65. Contour plot (left) and surface plot (right) of the estimated joint density of Aberdeen and Liddell EC data

Trend comparison

Figure 66 shows the trends in the Aberdeen and Liddell time series over the period 91-05 using cubic splines. The data points on which the smoothing is based are also displayed on the graph. Many of the EC measurements between 1991 and 2005 are missing making it impossible to use wavelet or Fourier analysis on the time series except for periods for which there are recorded values at regular daily intervals. Cubic spline smoothing or a low order digital low pass filtering (see Smoothing methods, p143) are not affected by intervals with missing data to the extent that other methods are. Digital filtering or splines are used in the exploratory data analysis for this reason. The density analysis of the previous section is confirmed by Figure 66 (left). The Liddell trend is more variable, but is always above the Aberdeen trend. This suggests that salt is added between the two monitoring stations. Figure 66 (right) shows the trends across all sites. There are several things to note from the trends:

1. Liddell has fluctuations not present in Muswellbrook and Aberdeen.
2. The trend at Liddell is much higher than the trend for all other sites.
3. There is a general increase in the salt concentration from Aberdeen to Muswellbrook, little increase from Muswellbrook to Denman and a substantial increase of salt concentration from Denman to Liddell.

![Aberdeen and Liddell EC trends](image1)

![Trends in EC data across sites](image2)

**Figure 66. Trends in Aberdeen and Liddell EC data using smoothing splines (left) and trends in EC data across all stations (right).**

This suggests that there may be two different sources of salt between Aberdeen and Liddell. One of these sources could be the tributary stream (c.f. the Goulburn/Wybong tributary on Figure 58) located between Denman and Liddell that flows into Hunter River.

**Comparison of the stream flow at Aberdeen and Liddell**

**Overall comparison**

We now compare the stream flows (daily time step data) at Aberdeen and Liddell. To make the presentation of the data easier we transform the data by taking the logarithm of all stream flow observations. Figure 67 shows the cumulative distribution functions of the data on a logarithmic scale for both Liddell and Aberdeen.

![Stream Flow distribution at Liddell and Aberdeen](image3)

![Stream flow comparison](image4)

**Figure 67. Stream flow cumulative distribution functions (left) and stream flow densities on a logarithmic scale (right) at Aberdeen and Liddell.**
It is clear from the graph that the two flows follow different distributions. This is confirmed using the non-parametric Kolmogorov-Smirnov test. The output of the test is:

\[
\text{Test statistic } = T(data) = 0.29289 \\
\text{p-value } = p = 6.0945 \times 10^{-127}
\]

The p-value is extremely small, hence there is strong evidence to accept the alternative hypotheses, namely, that the stream flows at Liddell and Aberdeen follow different distributions.

\[\text{Figure 68. Joint density of the Aberdeen and Liddell stream flow data on a logarithmic scale.}\]

Figure 67 also suggests that about 80% of the time Liddell flow is smaller than 80% of the Aberdeen flow. Note that we have used all of the available data for each of the two sites, i.e. the Aberdeen data runs from 1998 to 2005 and the Liddell data runs from 1991 to 2005. (The results would not be significantly different had we used data from 1998 to 2005 only.) This impression is also confirmed from Figure 67 where the corresponding density functions are plotted. The Aberdeen flow density has three major modes, all of them larger than the main mode of the Liddell density. We can thus conclude that there is evidence to support the hypotheses that the stream flow at Aberdeen is larger than the stream flow at Liddell. See Figure 68 for a visualization of the joint density of the Aberdeen and Liddell stream flow measurements.

**Trend comparison**

Figure 69 (left) shows the trends at Liddell and Aberdeen with the actual data on a logarithmic scale. Figure 69 (right) shows the flow trends across the monitoring sites of the Hunter River. Somewhere about the end of 2000 and beginning of 2001 the flow at Liddell becomes smaller than the flow at Aberdeen and the other sites (see Figure 69). This may be due to water extraction or loss of water to
the surrounding ground water system. Figure 69 further suggests that the major loss of water is between Denman and Liddell.

![Trends in the flow at Aberdeen and Liddell](image1)

![Trends in stream flow across sites](image2)

**Figure 69. Trends in Aberdeen and Liddell flow data (left) and trends in flow across all monitoring sites (right).**

**Comparison of salt load trends**

Salt loads were calculated using the formula:

\[
\text{salt load} = \frac{\text{EC} \times 0.64 \times \text{Flow}}{1000}.
\]

Figure 70 shows the trends in salt loads at Liddell and Aberdeen over the 1991-2005 period. Broken line segments denote periods with missing data. Note that sometime during early 2002 the salt loads at Liddell decrease relative to Aberdeen. Figure 70 also shows the trends in salt loads across all the sites. Note how from 2002 onwards Aberdeen, Muswellbrook and Denman seem to follow a similar trend and that the major reduction of salt occurs between Denman and Liddell.

![Trends in salt loads at Aberdeen and Liddell](image3)

![Trends in stream flow across sites](image4)

**Figure 70. Salt trends at Aberdeen and Liddell (left) and across all sites (right).**
In this section we try to establish the effect of the mine discharges on the Liddell salt load signal. Figure 71 shows the salt discharge events (under the Hunter River Salinity Trading Scheme) superimposed on the stream flow trends. The graph shows that the mines discharge salt at periods with high flow as required by regulation. We compare the Liddell salt load distribution before and after subtracting the mine discharges. To accomplish the removal of the mine discharges correctly we need to take into account the time it takes for the salt discharged from the mine sites to travel down to the Liddell monitoring station. We use the stream flow data to assess how long it takes for salt to travel downstream. If, for example, it takes a pulse of water one day to travel from Aberdeen to Liddell, any salt released today at discharge locations close to Aberdeen will be likely to appear in the Liddell salt load signal approximately 24 hours later.

Figure 72 shows the correlation between the Liddell and Aberdeen stream flow time series computed using the normalized version of:

\[
\text{CrossCorrelation}_{xy}(m) = \begin{cases} 
\sum_{n=0}^{N-m-1} x_{n+m} y_n & m \geq 0 \\
\text{CrossCorrelation}_{yx}(-m) & m > 0
\end{cases}
\]

where \( y \) is Liddell, \( x \) is Aberdeen and \( m \) is the lag. The maximum cross correlation between the Aberdeen and Liddell stream flow time series is achieved at lag 1 with the next highest being at lag 0. A pulse of water takes roughly about a day to reach the Liddell monitoring station.
Figure 72. Correlation between the Liddell and Aberdeen stream flow time.

Figure 73 shows the Liddell versus Aberdeen data at different lags with the line of best fit in each case. The fit is not strong for any lag, but a linear association seems to be strongest for lag 1.

Figure 73. Correlation between the Liddell and Aberdeen stream flow time series.
Similarly, Figure 74 shows the cross-correlation between the stream flow time series of Liddell and the Denman and Muswellbrook monitoring stations. This time the maximum correlation is attained at lag 0 with the next highest cross-correlation at lag 1. Thus it takes roughly less than a day for a pulse of water to reach Liddell. Once we have estimated the time it takes for water/salt from the upstream stations to reach Liddell we can then subtract the mine discharges from the salt load time series of Liddell at the appropriate dates (i.e. taking into account the lags associated with the arrival of the mine discharges at the Liddell monitoring station).

In Figure 75 we compare the Liddell salt load distribution with and without the discharges from the mines. The two curves are not distinguishable and a Kolmogorov-Smirnov test decidedly rejects the hypotheses that the curves are any different. Thus at this stage of the analysis we can conclude that the mine discharges do not appear to affect the natural salt load trends at Liddell. In the next section we try to establish whether, after removing the salt contributions of any tributaries to the Liddell salt load signal, the mine discharges will appear to be significant.

**Figure 74. Correlation between the Liddell and Muswellbrook (left) and Denman (right) stream flow time series.**

**Figure 75. Empirical distribution of salt loads at Liddell with and without the discharges.**
The Goulburn River and Wybong Creek tributaries

Some of the trends in the Liddell signal may be due to the tributaries of Hunter River in the region of the mines. We consider Goulburn River and Wybong Creek as contributors to the Liddell trends. Figure 58 shows that Wybong Creek and Goulburn River merge into a single tributary which has its confluence upstream of Liddell and downstream of Denman. We make the following observations:

1. Figure 76 (left) suggests (by visual inspection) strong association between the Goulburn River flow and the Liddell flow (daily data). The Wybong Creek flow is weak compared to the Liddell flow yet it seems to follow a similar trend. This impression is confirmed by Figure 76 (right) which compares the sum of the Goulburn River and Wybong Creek flows with the Liddell trend.

2. Figure 77 (left) does not suggest an obvious association between the Liddell EC trend and the EC trends of Wybong Creek and Goulburn River. There seems to be, however, a slight positive correlation between the Liddell EC measurements data and the Goulburn EC measurements as seen on Figure 77 (right) which shows a scatter plot of the Goulburn versus Liddell EC data with the contours of the estimated joint density. Figure 78, which is a scatter plot diagram with the contour map of the joint density of Goulburn and Wybong shows that there is no correlation between the Goulburn and Wybong EC data.
Figure 78. Scatterplot of EC data of Wybong Creek and Goulburn River.

Figure 79. EC trends for all monitoring sites (left) and distribution of EC data at Liddell, Wybong and Goulburn (right).

3. Inspection of Figure 79 (left) shows that Wybong Creek has the greatest overall concentration of salt amongst all monitoring sites. Aberdeen on the other hand has the least overall salt concentration of all sites. This impression is confirmed by Figure 79 (right) which shows the EC data probability distribution at Wybong creek, Goulburn River and Liddell. It is clear from the picture that Wybong creek has the highest overall salt concentration followed by Goulburn and Liddell. Note the region of the Goulburn density with low EC values. All of these observations, however, should be considered with great caution as there are many periods of missing data for Goulburn River and Wybong Creek.

4. Figure 80 shows the stream flow trends across all sites. There is a substantial change in the stream flow from Denman to Liddell at some time in the early 2002. As noted previously this suggests the possibility of water extraction or loss to the underground water system somewhere after Denman.

27 Again missing line segments correspond to periods for which no monitoring data is available.
Figure 80. Stream flow trends for all monitoring stations.

5. From Figure 81 we can see that the Liddell stream flow is comparable to the flows at the monitoring stations upstream after taking the Wybong creek and Goulburn river contribution into account. After removing the Wybong and Goulburn contribution from the Liddell signal we obtained some negative stream flow values. One possibility may be that extraction of water for irrigation purposes has occurred downstream of the confluence of Goulburn river with the Hunter river. Another possibility is that the negative values are due to calibration discrepancies between the measurements of the Hunter River and the Goulburn River.

Figure 81. Liddell stream flows with and without the Goulburn and Wybong contribution.

6. Figure 82 shows that Wybong creek has the lowest salt loads and that Liddell, with the exception of the two annotated periods, has the largest amount of salt.
7. Figure 83 (left) shows a low-pass filtered signal, not the Liddell salt loads, after removal of the Goulburn and Wybong salt loads contribution. For comparison we display the Liddell signal as it is. Note the two lobes where the salt loads are negative. The negative salt loads do not seem to be strongly associated with low stream flow values as seen on Figure 83 (right), which shows the ‘Liddell minus Wybong/Goulburn’ stream flow values versus the ‘Liddell minus Aberdeen minus Wybong/Goulburn minus Mine Discharges’ salt load values.

8. Finally, Figure 84 shows the residual salt at Liddell after the Wybong/Goulburn, Aberdeen and mine site salt discharges are accounted for. Although the overall trend is centred around zero, there are many outliers which are not accounted for.

We have tried to establish the significance of the mine discharges after removal of the effects of the Hunter River tributaries. The crucial question is whether the mine discharges are manifest in the Liddell signal after removal of the effects of the Goulburn contribution? A Kolmogorov-Smirnov test was performed and the null hypothesis (i.e. that the two underlying distributions are the same) was accepted, with p value close to one. Thus the effect of the mine discharges is still not seen in the Liddell signal even after taking the tributaries into account.
Smoothing methods

Spline method

The smoothing spline which was used in the report is the function $f(x)$ which is the solution of the variational problem:

$$\min_f \lambda \sum_{i=1}^{N} (y_i - f(x_i))^2 + (1 - \lambda) \int_{x_1}^{x_N} |f''(x)|^2 \, dx,$$

where $\{(x_i, y_i)\}_{i=1}^{N}$ represents the data and $0 \leq \lambda \leq 1$ is the smoothing parameter. Values of the order of $\lambda = 10^{-3}$ gave satisfactory smoothing.

Digital Filter specification

The digital filter used in the report is the $M$-th order low pass filter defined through the linear discrete time-invariant recursive system:

$$y_n = (1 - \lambda) x_n - \sum_{k=1}^{M} \binom{M}{k} (-\lambda)^k y_{n-k}, \quad 0 \leq \lambda \leq 1.$$
The input signal is given by \( \{x_n \}_{n=1}^{N} \) and the output of the filter is \( \{y_n \}_{n=0}^{N} \). Thus the system/transfer function is given by

\[
H(z) = \frac{(1-\lambda)^M z^M}{(z-\lambda)^M}, \quad 0 \leq \lambda \leq 1, \quad n \geq 0.
\]

and the magnitude of the frequency response is:

\[
|H(e^{j\omega})| = \frac{(1-\lambda)^M}{[1 + \lambda^2 - 2\lambda \cos(\omega)]^{M/2}}.
\]

The unit impulse response is:

\[
h_n = (1-\lambda)^M \frac{(M=1+n)!}{(M-1)!n!} \lambda^n, \quad n \leq 0.
\]

It is clear that the filter is causal and stable. Values used were \( M = 3 \) and \( \lambda = 0.95 \).

For these values the magnitude of amplitude response and the impulse response is given by Figure 85. The phase response of the filter is not linear. To correct this problem we perform a zero-phase digital filtering by processing the input data in both the forward and reverse directions (see problem 5.39 in Oppenheim and Schafer 1989). After filtering in the forward direction, we reverse the filtered sequence and run it back through the filter. The resulting sequence has precisely zero-phase distortion and double the original filter order.

**Figure 85.** Magnitude of the frequency response (left) and unit impulse response of the filter (right).
We chose this particular filter because its output is always positive to a given positive input (e.g. stream flows). This is not true for a general linear low pass filter. Figure 86 shows the various levels of smoothing achieved with the low-pass digital filter. The data points on which the smoothing is performed are also displayed. Note that the smoothed time series has troughs and peaks which fall in a smaller range of values than the actual data.

**Figure 86. Various levels of smoothing of Liddell salt loads.**