COST-EFFECTIVE REHABILITATION OF MINED LAND
IN THE STRIP-COALMINES OF QUEENSLAND

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COMMON ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
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<tr>
<td>ABARE</td>
<td>Australian Bureau of Agricultural and Resource Economics</td>
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<td>ABS</td>
<td>Australian Bureau of Statistics</td>
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<td>ACF</td>
<td>Australian Conservation Foundation</td>
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<td>AMD</td>
<td>Acid mine drainage</td>
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<td>ANZECC</td>
<td>Australia and New Zealand Environment and Conservation Council</td>
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<td>ANZMEC</td>
<td>Australian and New Zealand Minerals and Energy Council</td>
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<tr>
<td>CBA</td>
<td>Cost-benefit analysis cost</td>
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<tr>
<td>CEA</td>
<td>Cost-effectiveness analysis</td>
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<tr>
<td>DME</td>
<td>Department of Mines and Energy, Queensland</td>
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<td>EA</td>
<td>Environmental Authority</td>
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<td>EMOS</td>
<td>Environmental Management Overview Strategy</td>
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<td>EPA</td>
<td>Environmental Protection Agency, Queensland</td>
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<td>ESD</td>
<td>Ecologically Sustainable Development</td>
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<td>NPV</td>
<td>Net Present Value</td>
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<tr>
<td>PoO</td>
<td>Plan of Operation</td>
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<td>QMC</td>
<td>Queensland Mining Council</td>
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ABSTRACT

More than 85% of the 138 million tonnes of coal produced in Queensland in 2000/01 was exported accounting for $6.7 billion or approximately 32% of Queensland's export income. Although making a considerable contribution to the wealth of current Queenslanders, coalmining damages the environment and may be a diseconomy to future generations. The most obvious and immediate impact of strip-coalmining is the destruction of the landscape; however, there may also be both immediate and long-term damage to the watershed. Others may bear the cost of such damage. Following mine closure, the most environmentally damaging impact may not be to the mined land but rather to downstream water quality as a consequence of pollutants originating from the abandoned mine. The market deals poorly with the side effects or externalities of mining and the allocation of resources between present and future generations. Rehabilitating the strip-coalmine spoilpiles in Queensland currently costs around $26,000 per hectare or $90 million per annum. Surrounding land may be purchased for less than $1,000 per hectare. On several occasions, articles in the Courier-Mail have criticised the extent of the strip coalmining industry's backlog of environmental rehabilitation. The cost for completing the backlog was reported to be between $1 billion and $2 billion.

Rehabilitation practices in the strip-coalmines in Queensland's Bowen Basin have in the past been dictated by a potpourri of parliamentary acts, mine lease conditions, and environmental and water quality legislation. The environmental management of mining has been transferred from the Department of Mines and Energy (DME) to the Environmental Protection Agency (EPA) removing a perceived conflict of interest which existed when the DME was both a promoter of mining and the environmental regulator. The lack of a paramount environmental vision, evidenced in previous policy, has been resolved with the Australian and Queensland Governments' acceptance of the vision of ecologically sustainable development (ESD). Under the ESD vision, the EPA has established the objective of protecting or enhancing certain environmental values or various attributes; however, as yet there has been no attempt to place a value on or rank the attributes. The hypothesis of this thesis is that an improved environmental outcome is possible by reallocating the current rehabilitation expenditure amongst the competing environmental attributes. This will require the EPA to rank each of the environmental attributes, in collaboration with mine management, using appropriate risk analysis. The
EPA and the mining companies will then have a defensible decision-making process. On the other hand, overly prescriptive regulations for strip-coal mines in Queensland will not achieve the highest net economic benefit, including environmental benefit, for the mining companies nor for the citizens of Australia.

Relevant welfare economic theory especially in relation to externalities, utility, obligations to future generations and the economic value of the environment is explored. Decision making theory has been incorporated into an environmental decision making hierarchy table for mining projects to show where decision-making responsibility should rest. An initial cost-benefit analysis (CBA) revealed that returning the land to grazing was not economically justifiable; however, the environmental benefits were not identified. In the next phase the relevant environmental attributes were identified and ranked using expert focus groups. The most pertinent findings were that downstream water quality and aesthetics are of more importance than land quality within the mine, whereas most environmental expenditure is focused on land related activities. Furthermore, there is a need for the EPA to clearly enunciate its environmental vision and objectives in relation to mine rehabilitation.

Although it has been possible to place the environmental attributes in ordinal rank, it is not yet possible to place a cardinal value on the attributes. Nor is there an accepted common measure of rehabilitation effectiveness, a prerequisite of cost-effectiveness analysis (CEA). If, however, downstream water quality was to be accepted as the single measure of effectiveness then current expenditure on mined land rehabilitation could be distributed so as to maximise downstream water quality. The data economist need in order to advise on more cost-effective rehabilitation procedures on the strip-coal mines are values for improved water quality in the Fitzroy catchment and values for improving the aesthetics of mined land. The current study indicates that it may be more effective to direct environmental rehabilitation expenditure toward minimising stream pollution rather than the current emphasis on growing vegetation on spoil piles. In the absence of more precise economic data, application of the precautionary principle would suggest that environmental expenditure be directed toward eliminating the risk of any long term regional environmental damage ahead of reducing environmental damage which can be contained within the mine sites.
Shelley's evocative words, said to be inspired by the decaying statue of Ramesses II at the Ramesseum, his mortuary temple at Thebes, questions the belief that we can build structures that will withstand the ravages of time. Just as nature, in time, has destroyed Ramesses's monument to his greatness, so it will destroy all made structures. Often the destruction comes sooner from our own hands as we saw on 11th September 2001. This same naive belief that structures can be designed to last indefinitely is evident in attempts to build engineering structures to protect the environment. An alternative concept is explored in the conclusion.
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Dragline removing overburden. Source: Anglo Coal Australia
INTRODUCTION

Queensland produced 138 million tonnes of coal in 2000/01 of which 108 million tonnes or 78% was derived from opencut coalmines (Qtherm 2001, p. 1). An estimated $26,000 per hectare is spent rehabilitating the mined land. Based on the generic strip-coalmine model developed in Chapter 4, the 2000/01 production of 108 million tonnes of coal would have required the mining of approximately 3,500 hectares of land. In contrast, 588,000 hectares of land were estimated to have been cleared in Queensland in 1999 (ACF 2001, p. 3). The Government's report on the State of the Environment Queensland 1999 shows that permits were issued to clear 425,000 hectares in 1998 (EPA 1999, p. 3.49). Assuming the amount of mined land rehabilitated each year is commensurate with that disturbed by strip-coalmining then the rehabilitation cost for 2000/01 was approximately $90 million. Australia wide mining companies made a provision in their accounts for rehabilitation expenditure of $275 million in 1998/99 and the accumulated balance of provisions for rehabilitation was $1.2 billion (MCA 1999, p. 26).

Environmental assessment, licensing and monitoring of mining is moving toward an environmental risk-based process. This process requires the setting of an overarching vision based on agreed community values. The new paradigm will require mining companies to:

(i) identify the environmental attributes likely to be impacted by mining;
(ii) identify the risk of environmental harm to these attributes;
(iii) mine, within the conditions set out in its environmental authority, so as to mitigate the identified risk of environmental harm; and
(iv) show through performance based outcomes that it is operating within its environmental authority.

Having identified the risks, mining companies will seek the most cost-effective strategies to negate these risks.

Currently rehabilitation guidelines are prescriptive with regard to landform but subjective regarding effectiveness. This places an unrealistic burden on the miner and inevitably the Environmental Protection Agency (EPA) and, given the conservative nature of Government, leads to developers being required to meet objectives and pay security deposits that are not commensurate with the risk involved. Media reporting has left the
public with the perception that achieving the desired environmental outcome is predicated on simply spending a certain amount on rehabilitation. The media directed emphasis on rehabilitation expenditure liability has allowed the detractors of the mining industry to point to the enormous outstanding financial liability and accuse the industry of failing to fulfil its environmental obligations. This simplification is to be expected from media reporting more interested in creating sensational news than achieving a desired environmental outcome. There has been little attempt to inform the public on the environmental issues and thus enable a more considered decision-making process regarding mined land rehabilitation. The expenditure of a certain sum on rehabilitation, or more precisely the amount of assurances or security held, has become the objective rather than a defined environmental objective or goal. Nevertheless, the media cannot be held responsible for the lack of public awareness of the environmental issues relating to mining. Educating the public about environmental issues relating to mining is a task for the mining companies, regulators and especially the politicians.

1.1 THESIS OBJECTIVE

The original intent was to carry out a cost-benefit analysis of mined land rehabilitation. At present, both the regulatory authorities and mine operators, with the responsibility for achieving acceptable rehabilitation, have difficulty defining and quantifying the diverse parameters against which rehabilitation success may be measured. A cost-benefit analysis would have provided a systematic process for selecting and supporting the most environmentally and economically effective strategies for the rehabilitation of mined land. Such a systematic process would have provided an objective method for both miners and the regulatory authorities to assess and justify rehabilitation procedures as opposed to the current subjective process.

Unfortunately, there has been little work done in Queensland to assess the value Queenslanders place on the current level of, or improvements in, environmental attributes. It is impossible to complete a cost-benefit analysis of mined land rehabilitation if the economic value of the resulting environmental improvement is unknown. It is, however, possible to carry out a cost-effectiveness analysis if the environment benefits can be assessed according to a single common measure of success.
From the research undertaken it may be concluded that current rehabilitation practices are unlikely to be cost-effective for two reasons. Firstly there is not a clear understanding as to how rehabilitation will achieve the State Government environmental vision of Ecologically Sustainable Development (ESD). Secondly there are no established economic values for the relevant environmental attributes and hence no established methods for valuing the benefits of rehabilitation in Queensland. The new paradigm proposed by the EPA is progressing toward placing economic value on environmental attributes. Past rehabilitation practices in the strip-coalmines in Queensland's Bowen Basin have been dictated by a potpourri of parliamentary acts, mine lease conditions, and environmental and water quality legislation. The evolution of the rehabilitation practices will be explained and possible interpretations of the current legalisation suggested in the following chapters. The cost-effectiveness of the current practices of rehabilitating mined land in the strip-coalmines located in the Bowen Basin of Queensland is evaluated. Finally, alternative approaches are proposed which may be more cost-effective.

1.2 **Economic Significance of the Australian Coal Industry**

Australia is the sixth wealthiest country per person, according to the World Bank, and the proportion of that wealth derived from minerals and fossil fuels is 2.5 times the average for the 20 wealthiest nations. The value of mining exports, including oil and gas, for the financial year ending June 2000, was $43 billion or 34 per cent of Australia’s total goods and services exports. Twenty per cent of research and development expenditure in Australia is by mining and mining related industries (The Australasian Institute of Mining and Metallurgy 1999). This has helped create a world-class software industry in this country and 60 per cent of the world’s mines use software created by Australian companies. The value of exports of minerals industry related intellectual property in 1998-99 amounted to $1.2 billion, exceeding the value of Australian wine exports in that year (Parbo 2001, p. 7).

Coal is Australia's largest single export earner. In 2000/01 Australia exported 190 million tonnes of coal (Qtherm 2001, p. 2) and the Australian Bureau of Agricultural and Resource Economics (ABARE) estimated coal would earn $10 billion in export revenue (Fisher 2001, p. 4). The estimated value of Australia's major commodity exports for 2000/01 and for 2001/02, as reported by ABARE are listed in Table 1.1 (Fisher 2001, p. 4).
In the 1997/98 financial year, the minerals industry spent $245 million on the rehabilitation of sites on which mining and processing activities have been undertaken. Mining has disturbed less than 0.02 per cent of Australia’s land area and the minerals industry plants over three million trees every year to help rehabilitate that land. (MCA 1998, p. 27). The Australian Bureau of Statistics (ABS) reported that total environmental protection expenditure for metal ore mining, coal mining and oil and gas was $308 million for the year 1996/97 which included $103 million in coal mining. The ABS reported that the environmental expenditure in the agriculture industry over the same period was $192 million of which $28 million was spent in beef cattle farming (ABS 1999, p. 69).
1.3 **COAL MINING IN QUEENSLAND**

1.3.1 **Importance to Queensland’s economy**

Most of the black coal resources in Australia are found in the Bowen-Gunnedah-Sydney Basin, which stretches some 1,750 km from Collinsville in the north to Wollongong in the south (Figure 1.1). The Bowen-Gunnedah-Sydney Basin, which was formed in the Permian period approximately 260 million years ago, is of similar scale to the Carboniferous coal basins of Europe which extend from the coalfields of Scotland to the Soviet border with Poland. It was the coal from the Carboniferous coal basins of Europe that fuelled the Industrial Revolution. The Bowen Basin coalfield (Figure 1.2) is Queensland's most valuable export income earning and energy resource.

**Figure 1.1: The European and eastern Australian coal basins**

Figure 1.2: Bowen Basin coalfield

Source: (Qtherm 2001)
The identified Australian black coal resources were estimated in 1995 to be 70 billion tonnes (Maher et al. 1995, p. 134). Australia's black coal reserves are ranked sixth in the world in terms of mineable tonnes. However, the location of these reserves close to the coast and the high quality of both the coking and the steam coal, have enabled Australia to become the world’s largest exporter of coal. An estimated 25 billion tonnes of coal reserves are contained in the Bowen Basin (Queensland Coal Board 1997, p. 6).

The development of an export coal industry in Queensland is a relatively recent phenomenon, initiated by the dramatic rise of the Japanese steel industry from the early 1960's and sustained by the first and second oil shocks of the seventies. These events stimulated demand for coal in a situation in which major supply sources were confined to the USA, the USSR/Poland, the State of New South Wales and the emerging potential of Queensland, Canada and South Africa. The value of coal exported form Queensland in 2000/01 was $6.7 billion, 32% of the value of State exports (Qtherm 2001, p. 3). The coalmines, export ports and the connecting rail transport system is shown in Figure 1.2.

1.3.2 Surface coal mining practice

The most common surface mining methods used to extract coal in order of importance are:

(i) strip or area mining;
(ii) terrace mining; and
(iii) open-pit mining (Walton and Atkinson 1978, p. A147).

Coal deposits are formed from peat that has been modified by heating as a result of burial. If undisturbed, the tabular coal seams are horizontal or slightly dipping. Such near surface seams are most economically exploited by strip mining. A walking dragline exposes the coal by casting the overburden into the void created by the previous strip (Walton and Atkinson 1978, p. A147). The cost of overburden removal in single-seam strip mining may exceed 60% of the total mining and coal preparation costs (Walton and Atkinson 1978, p. A148) as is the case in the Bowen Basin.
Surface mining in the Bowen Basin is predominantly by strip mining and most commonly overburden is removed by the extended bench method. This method is designed to extend the operating range of draglines in deep overburden (Walton and Atkinson 1978, p. A148). Figure 1.3 shows the sequence of an extended bench strip mine. The dragline digs a key cut along the new high wall of the cut and dumps the spoil from the key cut along the previous high wall to form a platform on which it can later stand and gain increased dumping reach. The disadvantage of the extended bench method is that the spoil platform must be rehandled and stacked on the spoil pile in the following dragline cycle (Chadwick and Seymour 1974, p. 255).

Rehandle in the Bowen Basin is commonly 30% of prime overburden.

The coal is mined in strips parallel to the strike of the coal seam. Strike is defined as the course or bearing of the outcrop of an inclined bed or structure on a horizontal surface (Thrush 1968). For most of the Bowen Basin the inclined coal seam does not outcrop and is overlaid by a more recent geological formation of Tertiary age (65-2 million years old). The width of the excavated strips varies between 50m and 100m. Each mine will have several pits, each pit running parallel to the strike of the coal seam. Each pit should be of sufficient length to enable a complete cycle of extraction in the pit without interrupting the scheduling of overburden removal and coal extraction. A desirable minimum length would be about 3000m (Coleman 1974, p. 267). Coal is hauled out of the pits via haul ramps, which are extended with each successive strip. The desirable haul ramp spacing has been found from experience to be 1200m (Coleman 1974, p. 268).
The strip-coalmines are generally located on the western flank of the Bowen Basin stretching from Collinsville in the north to Moura in the south (Figure 1.2). Typically the seams dip toward the east at about 5 degrees. Coal mining commences at a depth of around 15 metres of overburden and ceases when mining is uneconomical. Seam thickness and quality vary; however, for a 1.5 metre seam the Queensland Coal Board assumes a nominal economic limit, for resource calculation purposes, of 60 metres of overburden for a typical strip-mine (Queensland Coal Board 1997, p. 6).

A cross sectional view of a typical strip-coalmine is shown below (Figure 1.4). The overburden is removed by dragline exposing the coal, which is then loaded onto trucks for treatment by washing or transported directly by rail to ports for export. Pre-stripping, as shown in Figure 1.4, is common in many mines, where the prestripping by more mobile mining equipment allows strip mining to proceed to depths greater than the draglines digging capacity of approximately 45m. For mines which do not prestrip the typical saw tooth pattern remains after mining unless the ridges are flattened as part of rehabilitation.

**Figure 1.4: Typical cross-section through a strip-coalmine**

![Typical cross-section through a strip-coalmine](source)

**1.3.3 Rehabilitation practice**

It costs on average approximately $26,000 per hectare to rehabilitate strip mined land and the Queensland mining industry spends more than $61 million a year on environmental protection and rehabilitation (Department of Mines and Energy 1996, p. 17). The figure of $61 million was for 1995/96 when opencut production was 83 million tonnes and is comparable with the previously stated estimate of $90 million for 2000/01.
Rehabilitation practices are dictated by State Government regulation. Regulators and miners have interpreted these regulations to mean establishing vegetative cover, predominantly grass, over the mined areas. This practice has evolved during a 30-year period and there has been no attempt to establish if the current rehabilitation practices are cost-effective in achieving the Queensland Governments goal of ESD.

When strip-coalmining commenced in Queensland, lease conditions required the land be returned to its original productive state, which was normally grazing land. Current rehabilitation focuses on flattening slopes and planting vegetation predominantly grass. Up to 70% of the expenditure may be spent on contouring the spoil piles in order to create a suitable profile to establish grass when the intention is to create an environment suitable for cattle grazing.

1.4 HYPOThESIS

Rehabilitation practices in Queensland's strip-coalmines have been driven as much by departmental guidelines as by Queensland Government regulation. The popular perception of strip mining appears to be created principally by adverse media coverage regarding previous lack of assurances or security deposits for rehabilitation and the extent of the financial liability to complete the perceived rehabilitation backlog.

The possible environmental impacts of mining, community expectations and the development of mining regulation will be put in their historical context in Chapter two. From the historical base it is possible to show a trend in environmental regulation and predict possible future trends. Based on these predictions, the research and fieldwork, which was carried out for this thesis, were directed toward finding answers to assist decision-makers choose the most cost-effective environmental rehabilitation of strip-coalmines in Queensland.

The impact of mining is placed in the context of classical and modern economic theory in Chapter three. Mining generally has a negative impact on the environment creating externalities. Market failure occurs because of the lack of property rights, especially in
relation to water catchments. The various methods of addressing this market failure are discussed together with the relevant concepts of private and public goods. The Coasian approach of commencing from the current situation and seeking to find a more economically efficient solution has been adopted and presented by way of a cost-effectiveness analysis in Chapter four. Finally conclusions are drawn and recommendations made in Chapter five.

A preliminary cost-benefit analysis indicated that there is no economic value in rehabilitating the spoil piles if grazing of the rehabilitated mined land is the only economic benefit flowing from rehabilitation. The Queensland Government approbates a vision of ESD. Under this vision, the EPA has established certain environmental values or attributes to be protected or enhanced. The strategies developed for each mine under this new paradigm will, I contend, differ from the strategies, which determined rehabilitation practices in the Bowen Basin in the past, of:

(i) achievement of acceptable post-disturbance land use capability;
(ii) stable post-disturbance landform; and
(iii) preservation of downstream water quality.

The hypothesis of this thesis is that under the ESD vision there is a more cost-effective rehabilitation process to protect the environmental attributes and that overly prescriptive regulations for strip-coalmines in Queensland will not achieve the highest net economic benefit to the mining companies nor to the citizens of Australia. The author's intention is to be perspicuous without I hope becoming tedious.
1.5 REFERENCES


Rehabilitation practices in the strip-coalmines in Queensland's Bowen Basin have in the past been dictated by a potpourri of parliamentary acts, mine lease conditions, and environmental guidelines. Regulation of a multi-million dollar industry was reworked over many years without a clear legislative basis. With no stated Government environmental vision, regulation hung like an albatross around the neck of the then regulator the DME.
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2 THE EVOLUTION OF MINED-LAND REHABILITATION OBJECTIVES

The welfare of humans depends on the products of mining. Nevertheless, surface mining destroys the environment immediately above the extracted minerals. Mining also has the potential to cause long-term damage to the wider environment. In Queensland, mining regulators in the past have been required to set standards for mine rehabilitation in the absence of an environmental vision. This task of regulating the mining industry without a clear vision or legislation seriously impacted the ability of the Department of Mines and Energy to fulfil its perceived role as environmental regulator of the mining industry. Governments worldwide and in Queensland have recently committed to the vision of ESD. This vision offers the potential for the new mining environmental regulator to remove the albatross from around the neck of both regulator and miner.

2.1 THE MINERS’ BURDEN - ENVIRONMENTAL DAMAGE

The impact of mining on the environment has long troubled society as evidenced by Georgio Agricola’s sixteenth century text *De Re Metallica*:

“The strongest argument of the detractors is that the fields are devastated by mining operations. Also they argue that the woods and groves are cut down, for there is need for an endless amount of wood for timbers, machines, and the smelting of metals. And when the woods and groves are felled, then are exterminated the beasts and birds, very many of which furnish an agreeable and pleasant food for man. Further, when the ores are washed, the water which has been used poisons the brooks and streams, and either destroys the fish or drives them away. Therefore, the inhabitants of these regions, on account of the devastation of their fields, woods, groves, brooks, and rivers find great difficulty in procuring the necessaries of life, and by reason of the destruction of the timber they are forced to greater expense in erecting buildings. Thus it is said, it is clear to all that there is greater detriment from mining than the value of the metals which the mining produces.” (Agricola 1556, p. 8).

Agricola, in refuting these arguments, first explains the indispensable nature of metals, that no civilised society is possible without them, and; “Moreover, as miners dig almost exclusively in mountains otherwise unproductive, and in valleys invested in gloom, they do
either slight damage to the fields or none at all. Lastly, where woods and glades are cut down, they may be sown with grain after they have been cleared from the roots of shrubs and trees. These new fields soon produce rich crops so that they repair the losses which inhabitants suffer from increased cost of timber. Moreover, with the metals which are melted from the ore, birds without number, edible beasts and fish can be purchased elsewhere and brought to these mountainous regions.” (Agricola 1556, p. 14). Agricola very eloquently presented the first recorded cost-benefit analysis of mining and the environment.

2.2 **THE ENVIRONMENTAL IMPACTS OF MINING**

The most obvious and immediate impact of strip-coalmining is the destruction of the landscape as a consequence of removing the overburden to extract the coal. There may also be other immediate impacts on the airshed and watershed. However, the cost-effectiveness of rehabilitation may only be judged following mine closure. When considering the long-term impacts of mining following mine closure, the most environmentally damaging impact may not be to the mined land but rather to down stream water quality as a consequence of pollutants originating from the abandoned mine.

In examining the impact of pollution from mining it is important to distinguish between stock and fund pollutants. Given a particular flow of a pollutant the stock of the pollutant will either accumulate in the environment if the environment does not have the capacity to absorb the flow of pollutant being produced or dissipate if the environment has the necessary absorptive capacity. A pollutant is defined as a stock pollutant if the environment has little or no capacity to absorb the pollutant and it accumulates over time (Tietenberg 1996, p. 325). Conversely fund or flow pollutants can be absorbed by or flow through the environment. Fund pollutants are completely assimilated by the environment; they may cause contemporaneous damage, but will not cause future harm. The potential for environmental harm is a function of the concentration of the pollutant, the flow of the pollutant into the environment and the environment’s ability to absorb the flow of the pollutant. These concepts are represented diagrammatically in Figure 2.1. The environment can absorb fund pollutants although the immediate impacts may be as severe as the fish kills in the Theiss River in north-west Romania. During February 2000, fish were reported to have died as a consequence of cyanide spills from the mine operated by
the Australian company Esmeralda (MPI 2000); however, there may be little or no long-
term impact from or accumulation of cyanide. Conversely a stock pollutant accumulates in
the environment resulting in long-term impacts on future generations.

**Figure 2.1: The flow and absorption of pollutants**

Most pollutants are capable of being absorbed by the environment given sufficient time.
Nevertheless, Uranium$^{238}$ with a half-life of 4.5 billion years, about the same age as the
earth is a stock pollutant in the time frame of the earth and the universe.

The Rio Tinto (red wine) river of Spain, from which the Rio Tinto Corporation's name
originated, is so named because of pollution from the Iberian Pyrite Belt, one of the largest
sulphide mineral occurrences in the world. The mines were worked from the Chalcolithic
(3000 BC) until the Roman Period, reopened in the 19\textsuperscript{th} century and are still operating on a
small scale. As a consequence of weathering, pyrite reacts with oxygen and water and
with the help of microbial processes, acid water is produced (Gomez et al. 1999, p. 237).
The resulting brown stained water is known as acid mine drainage (AMD). As a result of
the low pH, varying from 1.5 to 2.5, and heavy metal contamination, the Rio Tinto river
died. The quantity of acid mine drainage exceeds the river's absorptive capacity, and as a
consequence of these stock pollutants, the river no longer supports aquatic life.

Pollutants released during the extraction and use of oil and coal are generally relatively
easily absorbed over a matter of months and might be classed as fund pollutants.
Nevertheless, coalmining may produce stock pollutants. The possibility of AMD
emanating from sulphide ore mines is immediately obvious. Not so obvious however, is
the possibility of AMD from mining coal since it is organic in origin. The cause is fine-
grained pyrite in the coal which, although present in small amounts, may be equally as
environmentally damaging as AMD from metalliferous mines. The amount of sulphur in coal is an indicator of potential for a coalmine to be acid producing. Low sulphur coals do not typically produce acid water. The sulphur content of coal in Queensland is generally less than one half of one percent and consequently the coal's potential to produce acid mine drainage is low (Coxhead 1997, p. 6). In the absence of AMD, strip-coalmining produces only ephemeral dust and water borne pollution which can be absorbed by the local environment with no long-term environmental impact. In this context pollutants from coal are fund pollutants.

Burning coal contributes to greenhouse gases. Since greenhouse gases are currently increasing at a rate greater than they dissipate, greenhouse gases may be classified as stock pollutants. The opposing argument is, firstly, that without greenhouse gases the earths surface would be frozen with an average global temperature of $-17^\circ\text{C}$ (McKinney and Schoch 1998, p. 505). Therefore greenhouse gases are not pollutants but a necessary protective blanket. Secondly, even if greenhouse gases are increasing as a consequence of burning fossil fuels, the reserves of fossil fuels will be largely depleted in 200 years and the level of greenhouse gasses will then stabilise and possibly decrease perhaps precipitating the next glacial period. In the time frame of one thousand years, greenhouse gases are fund pollutants; however, in the time frame of one human generation the greenhouse gases are stock pollutants. Thus burning coal may produce fund or stock pollutants depending on the time frame considered. ESD assumes a generational time frame. Planning authorities assume three generations will span 100 years. In a time frame of one generation or 33 years, greenhouse gases produced from burning coal could be classified as stock pollutants.

Even if the mining of coal produces only fund pollutants strip-coalmining requires an unusually large amount of inputs from the environment. The most conspicuous impact of strip-coalmining is the complete, but temporary, removal of the stripped land from non-mining use. "The unsightliness of the stripped land degrades surrounding property values, as well as scenic and recreational qualities. Strip mining may also cause extensive damage to hydrological systems through sedimentation and silting of rivers and streams and the drainage of acidic waste from mine operations may produce stock pollutants. In addition to the adverse effects on water quality, sedimentation can reduce the carrying capacity of waterways and increase the frequency of flooding." (Kalt 1983, p. 894).
2.3 Media reports on coalmine rehabilitation in Queensland

On several occasions over the past decade, articles in The Courier-Mail (Morley and Sanderson 1997) have criticised the extent of the strip-coalmining industry’s backlog of environmental rehabilitation and the low level of financial assurances held by the regulator. The cost for completing the backlog was reported to be between one and two billion dollars. The calculation of the cost of the outstanding rehabilitation of strip coalmines was based on the number of hectares needing rehabilitation and the cost per hectare. Estimates of the cost per hectare, ranging from $21,000 per hectare to $35,000 per hectare, were reported. The then Department of Mines and Energy estimated that the area disturbed by coalmining was close to 65,000 hectares, although a considerable portion of this land is part of the active mining operation and not available for rehabilitation. Multiplying this estimated area to be rehabilitated by an average rehabilitation cost of $25,000 produces an liability for the cost of completing the outstanding rehabilitation of $1.4 billion.

The Mines and Energy Minister and the mining industry spent considerable effort defending their positions on rehabilitation and disputing the amount of the rehabilitation liability. Unfortunately the debate has remained focussed on the extent of the liability with no discussion on the goal of rehabilitation or the most cost-effective way of achieving that goal. Neither the Queensland Department of Mines and Energy nor the mining companies had a defensible process to determine whether the amount either legally required or actually being spent on rehabilitation was being spent cost-effectively. This situation arose because there was no overarching government environmental vision and consequently the objectives or goals of rehabilitation had no foundation and there had been very little scientific or economic work done on the long-term value of rehabilitation.

Mining companies who attempt innovative rehabilitation techniques could be condemned for cutting costs. Reporting on one such technique The Courier-Mail (Williams 1998) stated that the move was the latest in a long battle between mining companies, graziers and conservationists, who have been pressuring the State to force miners to rehabilitate leases. Brian Roberts, of the University of Southern Queensland Land Use Study Centre, said the technique was unproven and did not leave leases close to a pre-mined state. Greens Party spokesman Drew Hutton is reported to have said the technique was cheap and nasty and
that the mine's current Environmental Management Overview Strategy required land to be returned to beneficial usage and there was no case for reducing these requirements. The Greens Party goal or strategy of returning the land to beneficial usage implies a return to grazing or some other revenue generating use which may not deliver the best environmental or economic outcome. A method of establishing the appropriate goals or objectives is explored later in this chapter. Mr Hutton's statements suggest that he expected rehabilitation at any cost regardless of whether the rehabilitation was economically or environmentally efficient.

The role of the Department of Mines and Energy in its capacity as environmental regulator of the mining industry was also criticised. "The Mines Department has not enforced the letter, let alone the spirit of this State's mining laws. It has been the industry's lap dog, not its watch dog." (Morley and Sanderson 1997). This apparent conflict of interest was rectified in May 1999 when the Beattie Labor Government announced that the responsibility for environmental regulation of the mining industry would be transferred to the EPA. This change appears to have been welcomed by both environmentalists and the mining industry as indicated in the following press release.

"Premier Beattie said Cabinet approved interim arrangements which will see environmental management of mining - including assessment, licensing and monitoring - transferred to the State's new Environmental Protection Agency. 'Agreement on this new policy is the realisation of a positive and powerful partnership between the Queensland Government, the mining industry, conservationists, and the general community,' said Mr Beattie." (Queensland Government and Office of the Premier 1999)
2.4 ENVIRONMENTAL LEGISLATION, REGULATION AND GUIDELINES

2.4.1 A brief history of environmental legislation

Over thirty years ago the government of the United States of America (USA) passed the National Environmental Protection Act 1970, which required all federal agencies to prepare an environmental impact statement (EIS) to analyse the effects of any major proposal.

In 1985 the European Commission issued a directive requiring its member States to assess environment impacts of projects likely to have an impact on the environment by virtue of their size, nature or location before giving consent for the project. A directive in March 1997 updated the schedule of projects for which an EIS is compulsory.


The ANZECC Guidelines and Criteria for determining the Need for and Level of Environmental Impact Assessment in Australia (ANZECC 1996) and Basis for a National Agreement on Environmental Impact Assessment (ANZECC 1997) have provided a model for new EIA processes that are being developed by the Australian Commonwealth, States and Territory governments (EPA 2000, p. 6).

The Australian Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) came into effect in July 2000 replacing the EPIP Act. A primary objective of the EPBC Act was to promote ecologically sustainable development through the conservation and ecologically sustainable use of natural resources. The Act requires assessment and approval for any actions having a potentially significant impact on a matter of national environmental significance. These matters, however, relate only to World Heritage properties, Ramsar wetlands, as explained in the following paragraph, threatened species and ecological communities, migratory species, nuclear actions (including uranium mining), marine environment, and matters prescribed by regulation (EPA 2000, p. 7). The
EPBC Act may impact a coalmine if mining had a significant impact on threatened species and ecological communities or migratory species; however, there is no clear definition of a significant impact in the Act.

The Convention on Wetlands, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. There are presently 122 Contracting Parties to the Convention, with 1037 wetland sites, totalling 78 million hectares, designated for inclusion in the Ramsar List of Wetlands of International Importance. Ramsar wetlands refers to those wetlands on the Ramsar List.

2.4.2 The Evolution of mine rehabilitation requirements in Queensland

The first statement of rehabilitation requirements in Queensland was included in the Thiess Peabody Mitsui Agreement Acts 1962 to 1965, which applied to mining at the Moura mine. The Act required:

(i) limited regrading of spoil peaks in areas adjacent to public roads;
(ii) impoundment of water in final voids;
(iii) advising the Minister of the manner of reclamation proposed, based on competent advice, including the extent of regrading to promote revegetation; and
(iv) carrying out of reclamation diligently except in areas for dumping of refuse, for haul roads, or pond areas formed and except where chemical and physical characteristics seriously affect plant growth.

The Central Queensland Coal Associates Agreement Act 1968 applies to the operations at Goonyella, Peak Downs, Saraji and Norwich Park (the CQCA mines). This Act required payment of a bond prior to disturbance of land, refundable if the surface is restored to not less than its former value for purposes connected with grazing (Welsh 1992, p. 33). Additionally any discharges into rivers shall "not render the natural water in the river or stream less fit for human consumption or consumption by stock or for marine life". Since the mines are hundreds of kilometres inland, the reference to marine life would indicate the draftsperson either recognized the potential for riverine quality to impact the marine environment or the draftsperson meant to refer to aquatic or riverine life.
The *Discussion Paper on Environmental Regulation of the Mining Industry in Queensland* (DME 1998a, p. 14) issued by the Department of Mines and Energy, stated that "the environmental objectives are that:

(i) disturbed land will be progressively rehabilitated so that, as far as practicable, pre-disturbance land capability and suitability is reinstated; and

(ii) upon closure of the mining project, wherever feasible and practicable, disturbed land will possess land use capability and suitability similar to that which existed prior to disturbance, unless otherwise agreed."

A policy for Environmental Management of Mining in Queensland was developed in 1991 with the assistance of other Departments and the mining industry. In 1992 the Department of Mines and Energy implemented the guideline *Environmental Management for Mining in Queensland* (EMMQ). This guideline was given a firmer legislative base by amendment of the *Mineral Resources Act* in 1995 (Wilson 1998c, p. 3). This guideline introduced the concept of an Environmental Management Overview Strategy (EMOS) as the essential link between the environmental planning or impact assessment and the actual Plan of Operation (PoO) and the rehabilitation program. As a consequence of these actions the amount of security required from the mining companies increased from $5 million in 1991 to $370 million in 1997. This security may be in the form of cash, bank guarantees, or parent company guarantees. However, recent experiences with company collapses in Australia, where employee superannuation entitlements were not always met would indicate that, in the event of a company collapse, securities may not necessarily be guaranteed. If the funds do not exist they cannot be paid and even bank guarantees need to be maintained. In the unlikely event that they are called in, environmental assurances are most likely to be honoured by large financially secure companies; however, environmental damage is just as likely to be caused by less financially secure smaller companies.

The EMMQ guideline states that "exploration permits, mineral development licences and mining leases should be managed in a responsible manner to achieve the following environmental objectives:

(i) achievement of acceptable post-disturbance land use capability. Mining and rehabilitation should aim to create a landform with land use capability and/or suitability similar to that prior to disturbance, unless other beneficial land uses are pre-determined and agreed;"
(ii) **stable post-disturbance landform.** Mine wastes and disturbed land should be rehabilitated to a condition which is self sustaining, or to a condition where the maintenance requirements are consistent with an agreed post mining land use; and

(iii) **preservation of downstream water quality.** Surface and ground waters that leave the tenure area should not be degraded to a significant extent. Current and future water quality should be maintained at levels that are acceptable for users downstream of the site, and contaminated water shall not unlawfully leave the site. Water discharges from the site are likely to be subject to the provisions of Environmental Protection Policies for water and for mining and petroleum under the Environmental Protection Act 1994.” (DME 1992, p. 2).

The EMMQ guideline was written to assist the mining industry to meet environmental responsibilities under the Mineral Resources Act 1989 when carrying out exploration, mineral development and mining activities. The Department of Mines and Energy considered there were two broad levels of environmental impact assessment (EIA) systems for mining: those which would be handled through an EMOS and those which would require more detailed information from an environmental impact statement (EIS). The long-term goal of the Department of Mines and Energy was a self-regulating mining industry with the Department of Mines and Energy providing technical guidelines, advice and an inspectorate role in overseeing the development and implementation of the policy guideline (DME 1992, p. 2).

The three principal objectives of the EMMQ, listed previously, were reiterated in the draft *Environmental Impact Assessment and Management for Mining in Queensland* issued in 1995, commonly known as the "Green Book" (DME 1995, p. 15). The Green Book gave a comprehensive guide to the EIA process set out in the *Mineral Resources Act 1989* and expanded on the concepts in the EMMQ. This provided three levels of impact assessment for mining lease applications. These were:

(i) **Type 1** A simple EMOS after limited if any consultation;

(ii) **Type 2** An EMOS developed after consulting with advisory bodies; and

(iii) **Type 3** An EIS precedes or accompanies the development of an EMOS.
Mines that opened after the CQCA mines faced more stringent lease conditions similar to the Department of Mines and Energy 1992 EMMQ policy. Conditions varied from mine to mine; however, the general intent was that rehabilitated land should:

(i) achieve post-mining land use capability across the lease area which at least equals that which pre-existed the lease. In judging the pre-mining and post-mining land use capability, factors which may be taken into account will include agricultural productivity, conservation value, ecological utility, and community expectations and values relevant to land use; and

(ii) achieve a minimum standard of surface stability which attenuates the rate of erosion of mining spoil material so that the loss of suspended and soluble material runoff and seepage does not, in the future, preclude the continuation of existing water usage downstream of the mine.

The environmental impact assessment process for mining in Queensland has been subject to a number of reviews since a Criminal Justice Commission Inquiry (CJC) in 1994 (EPA 2000, p. 6). During that inquiry the DME stated that the security liability for coal and metalliferous mining was $480 million and $220 million respectively; however, securities held by the DME amount to $62 million (O'Regan 1994, p. 18). The Report noted that, there was no legislative foundation requiring the miner to produce an EMOS and it is the law that determines the way things have to be performed not governmental policy or departmental practice. R.S. O'Regan QC found it strange that the regulation of a multi-million dollar industry could be reworked over many years without a clear legislative basis for the policy initiatives being taken by the DME and that the officers of the DME relied on departmental policy rather than legislation (O'Regan 1994, p. 25). He concluded that "It is appropriate for this Commission to draw to the attention of the Government, my concerns of issues revealed in the evidence and to press strongly for a further investigation. The investigation should not be limited by the jurisdiction of this Commission but rather examine a range of matters concerning the impact of mining in Queensland, the rehabilitation of mines, the adequacy of securities held by the DME and the departmental policies and oversight exercised by the DME, Department of Heritage, Water Resources Commission and other bodies which may have authority in mining related issues; and finally, to establish appropriate legislation to produce a clear basis for the policies now applied to the mining industry." (O'Regan 1994, p. 26).
Greens spokesperson Drew Hutton said the Goss government initiated the Environmental Protection Policy (EPP) in 1995 largely because the CJC inquiry into toxic dumping called for a broad-ranging inquiry into mining. Neither the Goss nor the Borbidge government wanted such an inquiry but they were willing to support an EPP which established a broad, regulatory framework for mining. In March 1996 a discussion paper on a proposal for an Environmental Protection Policy (EPP) for the Mining and Petroleum Industries was issued by the DME. An EPP is subordinate legislation under the EP Act. The EP Act requires that an EPP must identify the environmental values that are to be protected or enhanced and the segment of the environment to which it applies (Wilson 1998a). The Stakeholder Consultative Committee on the Environmental Protection Policy for the Mining Industry published a draft discussion paper titled *Environmental Management of the Mining Industry in Queensland* in March 1998. The environmental values and objectives were listed under Schedule 6 of the draft discussion paper (DME 1998b, unpaginated). The environmental value for land management was identified as land use capability and suitability, including economic attributes.

The environmental objectives relating to land post-mining are in summary:

1. disturbed land will possess land use capability and suitability similar to that which existed prior to disturbance unless otherwise agreed;
2. disturbed land will possess geotechnical erosion stability consistent with the agreed post-disturbance landform and land capability;
3. upon closure, the mine should not present a danger to public safety; and
4. mitigate any negative socioeconomic impacts of changed land use or land availability on the affected community.

The environmental values relating to water management are:

1. the values identified in the Environmental Protection Policy (Water);
2. surface and groundwater sustainability, including both quality and quantity; and
3. the physical integrity, fluvial processes and morphology of watercourses, including the riparian zone vegetation and form.

The environmental objectives relating to water post-mining are:

1. preserve existing and potential beneficial uses of watercourses, lakes and groundwater;
(ii) rehabilitate any disturbed beds, banks and riparian vegetation to achieve acceptability and integrity; and

(iii) minimise any negative socioeconomic impacts of changed water resource quality or availability (DME 1998b, unpaginated).

With the many changes to legislation the extent of rehabilitation a mine is legally required to carry out is open to interpretation. One possible interpretation is that lease conditions are paramount to legislation and legislation paramount to policy.

The following paragraph summarises evolution of rehabilitation policy presented previously. The first environmental conditions pertaining to Queensland strip coalmines applied to the Moura mine. Only limited regrading of spoil peaks in areas adjacent to public roads was required. By 1968 the CQCA mines were required under the CQCA Act to restore the mined surface to not less than its former value for purposes connected with grazing or forfeit a bond of $50 per acre. By the late 1970's there was a lease requirement to achieve post-mining land use capability across the lease area which at least equals that which pre-existed the lease. The current requirement is that mining and rehabilitation should aim to create a landform with land use capability and/or suitability similar to that prior to disturbance, unless other beneficial land uses are pre-determined and agreed. In addition there are requirements for stability of landform and maintenance of downstream water quality.

Environmental policy has evolved from rehabilitation providing costs did not exceed the perceived benefit of $50 per acre, toward rehabilitation at any cost. The goal of achieving post-mining land use capability across the lease area which at least equals that which pre-existed the lease may in some cases be unachievable at any cost. The cost of recontouring a hectare of mined land and establishing grass cover which may not sustain grazing is at least twenty five times the purchase price of a hectare of undisturbed land adjacent to the mine. The hypothesis of this thesis is that expensive rehabilitation may neither be in the best socioeconomic interest of the State nor deliver the desired environmental objective. Unrealistic community expectations may have been created which, when not met, cause community concerns regarding the value of mining. Discrepancies between legislative rehabilitation requirements and uninformed community expectations have generated
considerable concern regarding the lack of rehabilitation of mined land in the strip coalmines of the Bowen Basin.

Queensland government policy relating to mined land rehabilitation has shown a pattern of evolution similar to that of other developed countries. Wilson, 1998c, also laments that legislation tended to be vague and if a rehabilitation requirement was intended to apply universally, it was expressed in terms that were not conducive to measurement. The original requirement in the Mineral Resources Act 1989 (Qld), for example, stated that the mining company "…shall undertake rehabilitation of the surface area to the satisfaction of the Minister." This trend from the discretion of the minister to more descriptive terms has also occurred in the conditions applicable to mining leases.

2.4.3 Current Queensland legislation

The Environmental Protection and Other Legislation Amendment Act 2000, hereafter referred to as the EPOLA Act, of October 2000 transferred environmental legislation of mining activity from the Mineral Resources Act to the Environmental Protection Act. The EPA now administers the environmental regulation of mining instead of the Department of Minerals and Energy. The overriding legislation governing the environmental issues related to mining is therefore the Environmental Protection Act 1994, hereafter referred to as the EP Act, an act for the protection of Queensland's environment. The EPOLA Act was incorporated into the EP Act in January 2001.

The goal or objective of the EP Act "is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)." (Queensland Government 1994, p. 14). As stated in the explanatory notes to the Environmental Protection Bill 1994, the EP ACT replaced outdated environmental legislation that no longer reflected community expectations for a clean and safe environment. The Act superseded the Clean Air Act 1963, Clean Waters Act 1971, Noise Abatement ACT 1978 and the State Environment Act 1988. The dates of the various Acts may indicate the importance or ranking the community placed on each of the environmental attributes of air, water and noise. Assuming Government action followed the community's growing awareness then clean air may be ranked at the top of
the environmental needs and noise near the bottom. The results from the fieldwork carried out for this thesis indicate that the community may rank water quality most highly.

The object of the EP Act is to be achieved by a cyclical integrated management program with the following phases:
(i) phase 1 - establish the state of the environment and define environmental objectives;
(ii) phase 2 - develop effective environmental strategies to achieve these objectives;
(iii) phase 3 - implement environmental strategies and integrate them into efficient resource management; and
(iv) phase 4 - ensure accountability for implementation of the environmental strategies.

The EP Act states that environmental objectives are determined when the environmental values to be protected are identified by consulting with industry, government departments and the community. The EP Act does not establish any cardinal or universal environmental values such as the need for continual improvement in the aquatic habitat or species protection. The environmental values are to be established by the citizens of Queensland and since protecting these environmental values is the object of the EP Act, by deduction the object of the EP Act is to be determined by the citizens of Queensland. The Act is silent as to when or how these values are to be established or if the values are to apply to the whole state or to regions or specific projects. The EP Act does not attempt to define any performance measures for assessing progress toward achieving any specific objective. For example, how is the state of water quality of the Fitzroy River catchment to be measured? Could water quality be measured by a single environmental indicator such as the number of platypus per kilometer of river? Environmental indicators are still in their infancy in Queensland. In Victoria an Index of Stream Condition has been proposed that includes factors such as hydrology, physical form, streamside zone, water quality and aquatic life (Ladson 2000, p. 291). Nor does the EP Act define any time period in which these environmental goals should be achieved. Section 9 of the EP Act does, however, define an environmental value as:
(i) a quality or physical characteristic of the environment that is conducive to ecological health or public amenity or safety; or
(ii) another quality of the environment identified and declared to be an environmental value under an environmental protection policy or regulation.
The difficult task of articulating the EP Act values into physical environmental values and consequent objectives relevant for the mining industry remains to be completed. The practical definition of environmental values can be found described in subordinate legislation such as the EPP for water. The EP Act, however, does not define actual environmental values or attributes leaving the EPA the task of establishing the attributes and determining the mining industries environmental objectives in relation to these environmental attributes. Likewise the EP Act does not more clearly define the environmental objectives of the State of Queensland. The object of the Act has not been defined any more precisely than that of allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends. This implies that since the ecological processes on which life depends are only to be maintained, the EPA do not have a mandate to improve the existing environment.

Under the EP Act strip-coalmines in Queensland are issued with an Environmental Authority (EA). The conditions of the EA flow from the coalmine's EMOS (Figure 2.2). An EMOS is intended to be an overview strategy for the life of the project, and is a vehicle to ensure that the EA conditions are consistent with this strategy and provide for appropriate levels of environmental protection. The EMOS must demonstrate a clear link with, and be based on, environmental studies or impact assessment undertaken for the mine.

**Figure 2.2: Relationship between the EA, EMOS and PoO**

Source: EPA - Guideline 8 - Preparing an Environmental Management Overview Strategy
The statutory component of the EMOS is presented in section 203 of the EP Act, and
should include amongst other information:

(i) a description of the environmental values likely to be affected by the mining
activities;
(ii) an assessment of the potential impacts on the environmental values;
(iii) environmental protection commitments proposed to protect and enhance the
environmental values in terms of the environmental protection objectives, control
strategies, environmental protection standards; and
(iv) measurable indicators against which progress may be audited.

The potential impact on environmental values may extend beyond the mining lease to
surrounding off-lease areas and include potential impacts of regional extent (for example
the catchment area or airshed).

The EPA has set as its objective, protecting environmental values or attributes in order to
achieve the ESD vision. Defining these environmental attributes is the next step before
setting in place strategies to protect the environmental values.
Environmental values may include but are not limited to:

(i) air quality and amenity in the local and regional area;
(ii) water quality values, including surface and groundwaters, aquatic ecosystems, both
local and regional and downstream users;
(iii) noise and blasting impacts on the community, including natural communities;
(iv) cultural heritage, historical or socioeconomic values;
(v) ecological process values, such as local or regional impacts on rare or threatened
organisms and their supporting ecosystems; and,
(vi) land management issues especially in relation to post mining land capability and
land use and surrounding land uses (EPA 2001, p. 5).

Agents of the EPA are paid to protect environmental values and by inference it is their
responsibility to define and classify environmental values; however, the values may be
more sensibly classified according to whether they are natural or made as follows:
(i) natural environment
   - ecological
   - water
   - air
   - land use and management

(ii) made environment
   - cultural heritage
   - historical
   - socioeconomic including downstream water use
   - land title
   - noise

Land use and management may be placed in both categories; however, the distinction is made on the basis of those attributes which exist in the absence of humans and those that do not. Land exists with or without humans, whereas those values classified in the made environment can only exist in the presence of humans. Queenslanders would expect that the primary role of its Environmental Protection Agency would be to protect those values in the natural environment category. Some effort is needed to separate values such as water quality from strategies such as the land management needed to maintain certain land values.

The words environmental values in the EP Act appear to have been derived from pre-existing environmental literature. Unfortunately the word values is open to confusion and consequent misinterpretation. The singular form value descends from the Latin valere 'to be strong' and hence have worth. In its singular form it means the property of a thing which makes it desirable and is generally related to economic value. Many famous economists including Smith (1937), Bastiat (1964), Ricardo (1819), Mill (1907) and Marx (Keen 2001, p. 278) went to considerable effort to define the basic elements of value. In its plural form the word values is more generally associated with personal ethics or social ideals such as freedom of speech, love for one another, a clean environment, sanctity of life etc. Examples of the confusion may often be seen in organisations' mission statements and their statement of core values. Mission statements are often supported by core values such as maximising shareholder returns, which although the raison d'etre of most companies, could not be included under the definition of values which relates to ethics. Many
companies confuse their core values with what shareholders value although they could be
the same thing in the case of the newly emerging clean green companies and companies
who adopt the triple bottom line policy. Companies adopting the triple bottom line mantra
consider not only the economic value they add, by way of economic returns they make to
shareholders, but also the social and environmental value they add or destroy. For these
reasons the EPA's choice of the word values may be confusing. An economist might use
the word environmental good instead of values; however, environmental attributes may be
more universally understood than environmental values. The term environmental attribute
is more perspicuous than the EPA chosen term environmental values. The more precise
term environmental attributes will generally be used in preference to the term
environmental values in the remaining text.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000*
prepared by ANZECC also struggled with the concept of environmental values. The
authors defined environmental values as particular values or uses of the environment that
are important for a healthy ecosystem or for public benefit, welfare, safety or health. They
went on to say that such values are often called beneficial uses and for this reason
suggested that the singular form environmental value instead of environmental values
might be more appropriate. These guidelines commence with structurally sound
foundations, a guiding principle or vision and objectives set under this vision. The guiding
principle or vision for the guidelines is ESD and the guidelines' objective, set under this
ESD vision, is to achieve sustainable use of the nation's water resources by protecting and
enhancing their quality while maintaining economic and social development. However,
the objectives are conflicting and this conflict between environmental attributes and the
commercial value of water is evident in the following six environment values identified in
the guidelines (ANZECC 2000, p. 2-6):

(i) aquatic ecosystems;
(ii) primary industries;
(iii) recreation and aesthetics;
(iv) drinking water;
(v) industrial water; and
(vi) cultural and spiritual.
The dilemma faced by the guideline authors is evident in the preceding list. Some of the values listed represent their commercial value in use, whereas aquatic systems and aesthetics are environmental attributes which cannot be bought or sold on the open market. The allocation of water to protect aquatic ecosystems in preference to its use in agriculture is an example of possible conflict. Private use of water for growing cotton precludes its public use to maintain a desired amount of river flow. If value in use were the determining criteria then the water would most likely have greater value if used for growing cotton. These conflicting objectives could have been avoided if the guideline objective was to protect or enhance defined environmental attributes such as aquatic systems and aesthetics. Then, projects wishing to use water would be required to show how these environmental attributes would be protected or enhanced. Unfortunately, the guidelines do not attempt to place a value on aquatic ecosystems or suggest how a conflict between the commercial use of water and the ecology might be resolved.

The EPA has some similar elements of this conflict within its list of environmental values, nevertheless the objective of protecting or enhancing these environmental values is clear. The EPA requires mining project developers wishing to extract minerals to show how the project will protect or enhance the defined environmental attributes, not how the commercial gain from mining might offset the reduction in the quality of environmental attributes. Similarly a cotton farmer, who wishes to use water should be required to show how the environmental attributes will be protected or enhanced, not simply to show that the commercial gain from cotton growing is less than the environmental loss. To its credit, however, the Australian and New Zealand Guidelines for Fresh and Marine Water Quality do acknowledge the need to identify the environmental issues and establish the goals and targets at the catchment level. The guidelines may be more effective if they focused exclusively on ecologically sustainable aquatic systems or simply set water quality standards. The government and society should be left to resolve the conflict between protecting or enhancing aquatic systems or water quality and projects wishing to use or pollute the water.

In respect to mining, the protection of environmental attributes may be divided into three phases and in each of these phases the environmental emphasis changes as follows:
1. prior to mining  
   (i) background monitoring;  
   (ii) risk assessment;  
   (iii) statement of intended release standards; and  
   (iv) final mine topographic and hydrological plans.

2. during mining  
   (i) rehabilitation;  
   (ii) downstream water quality monitoring; and  
   (iii) continual revision of final mine topographic and hydrological plans.

3. after mining  
   (i) mined land rehabilitated to specified conditions;  
   (ii) environmental attributes of the environment outside the mine protected or 
   enhanced against future risk from the rehabilitated mine; and  
   (iii) EPA acceptance of surrendered land.

The mining provisions of the EP Act are currently under review to examine their 
effectiveness and to make improvements especially in relation to rehabilitation. An 
important task of both the mining industry and the EPA will be to establish the relative 
importance of the various environmental attributes and to focus rehabilitation practices on 
the most important attributes. The challenge for the mine owners and the regulators is to 
establish the strategies that will cost-effectively achieve the objective of protecting and 
enhancing the most important environmental attributes. Such a strategy will offer the 
greatest opportunity of achieving the ESD vision.

2.4.4 Defining ecologically sustainable development or ESD

Following a worldwide trend, environmental regulation in Queensland is now founded on 
ESD. The term ESD is used by many with almost religious reverence and an analogy may 
be made with the biblical incident of speaking in tongues (Acts 2: 4-6). There is no 
universally accepted definition of ESD, nevertheless when the word is spoken, the speaker 
and the listener appear to intuitively know what ESD means, even though each may 
attribute a different meaning. Globalisation is a similar universally misunderstood word. 
Like meat pies and vegemite it is not rational to be against ESD. "In fact, the less you 
know about it, the better it sounds."(Solow 1968, p.179). Sustainability, sustainable
growth and ESD are concepts often quoted but not easily understood and there is little support given to the regulators or the regulated in interpreting and then applying the ESD vision to mining (Toman 1999, p. 59).

The United Nations World Commission on Environment and Development report of 1987, *Our Common Future*, otherwise known as the Brundtland report after its editor Gro Harlem Brundtland, proposed sustainable development in order to recognise the needs of future generations. Sustainable development whilst meeting our present needs should not compromise the ability of future generations to meet their own needs (Brundtland 1987, p. 8). The intention of ESD is that we should act out our life on Earth as if we were intending to stay not just visiting for the weekend.

The Australian Government incorporated these ideals in its 1992 publication, *National Strategy for Ecologically Sustainable Development*. This report also drew on the 1990 Commission for the Future report. ESD is defined as using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained. If the definition is considered from an anthropocentric view then quality of life refers to human life. If other species are included then achieving the ESD goal will be a much greater challenge.

### 2.4.5 The mining industry response to ESD

In 1989 James Stevenson of Rio Tinto Corporation (the world's largest mining company) admitted that sustainable growth is an awkward concept for an extractive industry. Since all mines have finite lives, how can any mine be considered sustainable (Evans 1997, p. 27). Resolving the conflict between unsustainable extraction of individual mineral resources and ESD is important if ESD principles are to be accepted by the mining industry. Resolving this perceived conflict between sustainability and extracting minerals and energy from finite reserves may have been the motivating force which lead to establishing the Global Mining Initiative (GMI). Ten of the world's largest mining, minerals and metals companies initiated the GMI in 1999 to provide global leadership for the mining and minerals industry by developing a sustainable development model (GMI 2001, p. 2). Their broader aim is to ensure that the mining industry will be an essential
part of improving the well-being of a changing world and be responsive to global needs and challenges.

A central activity within the GMI is the Mining Minerals and Sustainable Development (MMSD) project which seeks to get an independent analysis of the issues that will determine the future of the industry. MMSD is a two-year project which aims to identify how mining and minerals can best contribute to the global transition to sustainable development. The World Business Council for Sustainable Development (WBCSD) has been commissioned to seek and analyse a wide range of opinions on this question. The analysis will span the three main aspects of sustainable development, namely economic, environmental and social. The project began in April 2000 and a key outcome will be a report to be presented during the proposed global conference on mining, minerals and sustainable development in Toronto in May 2002. This conference will be a significant contribution to the activities that will mark the tenth anniversary of the Rio Earth summit. The 55th General Assembly of the United Nations decided that the Rio + 10 Summit meeting, officially titled "The World Summit on Sustainable Development" will be held in South Africa in September 2002. MMSD is intended to both produce concrete results and to create structures capable of being continued after the project is completed.

Sir Robert Wilson, Chairman of RioTinto, whilst recognising the definitional difficulties, provided an explanation of how the mining industry should embrace ESD:

"While this most indigestible of terms (sustainable development) provokes much definitional debate, there is growing clarity about what it means and about the implications of cooperation between various actors concerned about global environmental and social problems for the future direction of international economic development. At the heart of the term sustainable development is a threefold understanding: firstly that economic activity should be considered together with its social and environmental consequences (the triple bottom line); secondly, that in using resources we have to have regard for the needs and expectations of future generations; and thirdly that government, business and other segments of civil society should act together if they are to act effectively.” (Wilson 2000, p.1).
The MMSD has been promoted by the mining industry as a proactive approach to the issue of sustainability in contrast to the reactive and defensive position which the mining industry has often been forced to adopt in the past.

The Australian activities of MMSD aim to:

(i) identify how the mining and minerals industries can best contribute to sustainable development;
(ii) build understanding and trust between the industry and people affected by its operations;
(iii) develop a common understanding of the industry's contribution, both positive and negative, to society; and
(iv) develop a shared vision for future minerals development in Australia (AMEEF 2001, p. 3).

The MMSD activities planned for Australia will focus on listening, learning and engaging. It will be a lost opportunity to display the stated proactive approach if the MMSD fails to provide creative leadership and define the environmental objectives that the Australian mining industry should pursue in order to achieve the ESD vision.

2.4.6 Relating ESD to mining

We are not required to leave the world as we found it in every detail. This obligation is infeasible and we cannot be morally obligated to do something that is infeasible. ESD does, however, oblige us to leave future generations the option or capacity to be as well off as we are and not to satisfy ourselves by impoverishing our successors. The obligation is to improve rather than reduce the opportunity for future generations to have increasing or at worst non-decreasing well-being over time. Two philosophical questions need to be answered in order for decision-makers to act on these obligations.

The first relates to the substitutability between the endowments to be left for future generations. Some argue for weak sustainability contending that it is the total level of saving provided for the future generations which is important. Supporters of weak sustainability contend that it is possible to substitute human capital and knowledge for natural resources. The second question relates to whose well-being is to be measured. An
anthropocentric view implies that quality of life refers to human life. If all life is included then achieving the ESD goal is a much greater challenge.

Non sustainable activities are not restricted to mining. Agriculture may also be responsible for the steady depletion of soil stocks and water supplies, and herbicides and insecticides can pollute water supplies and contaminate soils. Ploughed fields awaiting seeds are not natural and are easily eroded. Many minor erosions in different places add up to a large loss of topsoil. World wide it is estimated that 25 billion tons of topsoil are lost each year (Hartwick and Olewiler 1998, p. 30).

In Queensland Joy (Joy 1992, p. 44) observed that strip coalmines were often singled out as the land use villains, whilst the impacts of other land use on water quality and quantity were ignored. The annual sediment load of the Fitzroy River passing Rockhampton is shown as 4,330,000 tonnes in Table 3 of (Horn et al. 1998). The maximum possible contribution from all the coalmines in the Bowen Basin is estimated to be 0.4% of the sediment load (Williams 2001, p. 101).

Sustainability means increasing or at worst non-decreasing well-being over time. Even from an anthropocentric perspective, however, well-being has many attributes. For people of an urban nature, another hypermarket or shopping centre may produce a definite improvement in well-being. For such an urban dweller the suggestion of camping in the bush may conjure up fearful visions of snakes, spiders, rampaging fires and flooding streams. Reducing the risk of harm from any of these events would constitute a possible increase in well-being. Obviously for this person human capital and knowledge is very substitutable for the natural environment. Conversely, for those with a deep green persuasion any shopping centre is one too many and having to live surrounded by concrete significantly decreases well-being. Human cultures are similarly different. In some cultures there are few words to describe trees, whilst in others there are hundreds. The value a community places on environmental attributes is strongly influenced by the culture and wealth of that community. The value any individual places on environmental attributes is often endogenous to the cultural context in which they have been raised. Exposure to new ideas and to the natural environment does, however, change the value a society places on environmental attributes and the preferences of its members.
Economists and politicians often assume that degradation of natural resources can be ameliorated by increases in human capital including ideas (Toman 1999, p.60). A high rate of substitutability among the endowments to be provided for future generations focuses activity on expanding opportunities for the current generation.

This leads onto the second question as to whose well-being is to be measured. Economists have always argued the need to focus on the present rather than the long run for as John Maynard Keynes wrote in 1923 "In the long run we’re all dead". Golding argues that it is a natural human instinct to put much greater emphasis on the well-being of those we can identify with most closely (Golding 1972, p. 98). If there is a moral community, does such a society have a contract between those living and those yet to be born? Does this imply an obligation to ensuring a good life for those yet unborn? These questions are explored further in Chapter 3.

2.4.7 Sustainability, energy and the importance of coal

Sustainability concerns are not new. In 1798 Malthus argued that population increases geometrically whilst food supply increases arithmetically and consequently starvation was imminent for many. In 1865 the philosopher-economist W.S. Jevons wrote a book, "The Coal Question" predicting that Britain's coal reserves would be uneconomic within 100 years and that world economic activity would decline because of the exhaustion of coal as an energy source. His advice to the governments was to burn coal because as it became scarcer, the economic system would respond by bidding up its price (Hartwick and Olewiler 1998, p. 41). More currently, reports in 1939 and 1951 predicted that US oil reserves would run out in 13 years (Garrod and Willis 1999, p. 3).

Malthus might be surprised that the world now has a population of six billion compared to the 1 billion when he made his prediction. Nevertheless he would note that 1.3 billion people in the world live below the United Nations defined poverty line of US$1 a day and half the world's people live on less than US$2 per day. Jevons would observe that, although his prediction that coalmining in the United Kingdom would be uneconomic in 100 years was slightly premature, his prediction was correct even if the date was not. In fact the Jevons prediction would have been surprisingly close but for the British Government nationalising the coal industry in 1947 and the subsidisation of coal
production which occurred up until the miners strike of 1984. When the British government nationalised coal in 1947, the industry employed 750,000 people and produced 186 million tonnes a year. Coal production in the United Kingdom decreased from 119 million tonnes in 1986 to 40 million tonnes in 2000. However, until 1995 the UK coal industry was still being subsidised.

In the 1920's Thomas Griffith Taylor, an eminent Australian geographer, estimated the carrying capacity of Australia based on his econographs (Oldroyd 1994, p. 261) which combined rainfall, coal reserves and latitude to determine carrying capacity. His textbook *Australia, in its physiographic and economic* aspects was banned in Western Australia. Continuing antagonism toward his then controversial ideas on the limits to Australia's population capacity led him to leave Australia for America in 1929. Raising the issue of sustainable population has always been fraught with danger. Taylor estimated the population of Australia would reach 20 million by the end of the 20th century and a saturation population of 62 million by 2020. Ironically the latter is now seen by many as being grossly excessive rather than ridiculously conservative.

There is expected to be a 60% increase in demand for energy of all types by 2020. The primary demand drivers are a rapidly rising population and economic development. There are now more than 6 billion people on earth. The UN expects population to grow to more than 9 billion by 2050 and 90% of the population growth will occur in today’s poorest countries. Not surprisingly, more than two-thirds of the increase in primary energy demand over the next 20 years will also come from the developing world. Its share is expected to rise more than 10% to 45% while the OECD share declines by about the same amount to 44%.

Much of the increased requirement for primary energy will be associated with electric power, the provision of which is accepted as one of the keys to providing even a minimum acceptable standard of living. By 2020 the demand for electricity in developing countries is expected to reach 2.5 times present levels. If everyone on earth were to consume a quarter of the per capita energy consumption of the United States in order to lift hundreds of millions out of poverty, energy demand would be many times this figure (O'Riordan and Cameron 1994, p. 4).
Energy prices are yet to show a significant upturn that would be expected with looming scarcity; however, the warning signs are ominous with steep increases in oil prices in the latter part of 2000. Figure 2.3 shows that the price of coal has remained relatively constant due to the development of coalfields throughout the world and improvements in mining and transport technology.

Figure 2.3: Coal prices 1880 to 1999

The data for figure 2.3 were sourced predominantly from Manthy (1978) and Slade (1982). Prices were deflated by the US wholesale price index (1967=1) and are thus in 1967-constant dollars. The data for coal has been extended for 20 years using coal prices in 1965 US dollars for Australian exports reported in Coal 1999 and deflated to match the US data in 1976. The resulting prices were verified by comparing with prices paid for Powder River Basin coal from Wyoming, USA.

Likewise the reports predicting that US oil reserves would run out may also be 100 years premature; however, the prediction is inevitably correct. Ducan (2001) predicts oil
production will peak in 2006 (Figure 2.4) and by 2008 OPEC will produce more than 50% of the world's oil and thereafter control 100% of the world's oil exports.

Figure 2.4: World Oil Production

The invention of the internal combustion engine in 1876 and the diesel engine in 1893 saw oil replace coal as the dominant primary source of energy and today (Table 2.1) the consumption of oil exceeds that of coal.

Table 2.1: World Primary Energy Consumption and Reserves in 1999

<table>
<thead>
<tr>
<th></th>
<th>Million tonnes oil equivalent</th>
<th>Reserves/production years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Oil</td>
<td>3450</td>
<td>60</td>
</tr>
<tr>
<td>Coal</td>
<td>2150</td>
<td>230</td>
</tr>
<tr>
<td>Gas</td>
<td>2050</td>
<td>25</td>
</tr>
<tr>
<td>Nuclear</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>Hydroelectricity</td>
<td>200</td>
<td></td>
</tr>
</tbody>
</table>

Source: BPAMACO Statistical review of world energy June 2000
Technological development which enabled the use of fossil fuels has had some unexpected beneficial environmental outcomes. Many whale species would have been hunted to extinction but for cheaper sources of lighting. The first step, which led to saving the whales, was made by Dr. Abraham Gesner, a Canadian geologist who in 1849, devised a method whereby kerosene could be distilled from petroleum. Edwin Drake's first oil well, drilled in Pennsylvania in 1859, enabled the production of lower cost kerosene. As kerosene became generally available throughout the country, the demand for whale oil dropped precipitously. The 735-ship fleet of 1846 had shrunk to 39 by 1876. The price of sperm whale oil, which had reached its high of $1.77 per gallon in 1856, was selling for 40 cents per gallon in 1896. Yet it could not keep pace with the price of refined petroleum, which dropped from 59 cents per gallon in 1865 to a fraction over seven cents in 1895.

The next important breakthrough was made by Edison who devised the modern light bulb, which produced an even light, burned longer and brighter than oil or kerosene, and was much safer than an open flame. As countries electrified, whale oil and kerosene were both driven from the illumination market. Whaling might have expired then, but for the vagaries of fashion. The peripheral market in baleen and whalebone suddenly exploded as more women began to wear corsets, bustles, and other garments that required a pliant material such as whalebone to keep their shape. From 32 cents per pound in 1870, whalebone rose to $1.12 in 1875, and $3.25 in 1878, reaching $5.00 at the turn of the century. But by 1908, this market had crashed as well. Spring steel replaced whalebone in women's fashions, and as automobiles supplanted horse-drawn carriages, demand for whalebone buggy whips and wagon suspensions collapsed (Robbins 1992).

After World War II, so important was whale oil to the fat rations of Europe that a wave of larger factories and new whaling ships with more powerful diesel engines were built and backed up in their hunt for whales by planes, helicopters, and support shipping. In about 1962, with no more concentrations of large whales, commercial whaling from Europe dwindled, leaving whaling chiefly to the Soviets and Japanese. By the 1980s the international whale trade had virtually ceased. The new technologies of kerosene, electricity and spring steel had saved the whale from extinction. Ominously; however, after war and a subsequent need for fat, Europe had no hesitation in turning back to whale hunting. If the population is hungry or oil scarce then whales will not be safe. The best
guarantee of protection the whale and other animal populations have is a well-fed and environmentally aware human population.

The second law of thermodynamics states that, as energy changes form it degrades into components that have different characteristics from the original matter. When petrol is burnt in cars, the petrol is used up, never to re-appear in its original form. We are left with carbon dioxide, water and other by-products of combustion such as sulphur dioxide (Hartwick and Olewiler 1998, p. 4). As the 21st Century commences, the search is on for a renewable energy that can be made available cheaply to the world's increasing population. Currently available technologies for producing energy based on the renewable flows from the wind, tides or the sun are considerably more expensive than energy produced from fossil fuels. Further more these forms of renewable energy require favourable geographic sites which are often located far from the areas of high population where the energy is needed. Total life cycle costs and benefits must also be included when considering the value of alternate forms of renewable energy. The power source of last resort is the breeder nuclear reactor using $^{238}$U as fuel, which could be seen as providing an energy safety net. World reserves of $^{238}$U are thought to be sufficient to provide energy for over one million years. (Solow 1993, p. 166).

The concept of substitutability between natural capital and artificial or manufactured capital was developed in the last part of the 20th Century in a period when fuel was cheap. Conversion from natural capital to manufactured capital involves a loss of energy. The cost of exploration, development and extraction of oil from reservoirs discovered in the 1940's was equivalent to a ratio of oil energy expended to oil energy recovered of 1-100. By the 1970's the ratio had increased to 1-23 and is now less than 1-8 (Clayton and Radcliffe 1996, p. 103). Despite this increasing cost of discovery and development, oil prices fell in the latter part of the 20th century.

Even those who dispute that oil reserves are limited would have to admit that this trend over the last 60 years would indicate that the cost of extracting oil will make it uneconomic in the first half of the 21st century. This same logic can be applied to the extraction of coal where, although the estimated reserves are sufficient for 230 years, the energy to extract these reserves will continually increase as the depth of the coal being mined increases. It is conceivable that the burning of fossil fuels will, like whaling, be relegated to history within
200 years. In geological time 200 years is minute. Given this very short possible period in which fossil fuels will be available to contribute to greenhouse gasses and possible global warming, the concern regarding the impact of fossil fuel generated greenhouse gasses seems short sighted. The introduction of a regime to reduce the burning of fossil fuel will most likely only extend the time period that fossil fuel gasses are produced. Encouraging the use of a less abundant fossil fuel (oil) over another more abundant fossil fuel (coal) because oil produces less greenhouse gasses would on the basis of intergenerational equity appear to be contrary to the ESD objective. However, the greater concern is that the resources and energy of scientists, industry and governments that are being channelled toward investigating global warming would be much better directed toward finding solutions to the real and imminent problems of decreasing energy reserves and increasing population.

If fossil fuel consumption is to be reduced by reducing energy consumption then this will require individual commitment and social action. Encouraging such a change in human behaviour requires that environmentally responsible actions are rewarded or at least not penalised and that environmentally careless actions are penalised or at least not subsidised. A nation's emissions of CO₂ may be calculated in several ways. Total emissions, emissions per citizen, emissions per area of land mass and emissions per unit of GDP are four possible measures. Each of these measures could be used as a key performance indicator of a nation's contribution to the world's emission of CO₂ as well as the trend in emissions from year to year. The approximate value for each of these performance indicators is shown in Table 2.2.
Table 2.2: CO2 emissions - Australia compared to the major producers.

<table>
<thead>
<tr>
<th>Country</th>
<th>CO2 emissions from fossil-fuel burning, cement production, and gas flaring</th>
<th>Average GDP per citizen $ US</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>total ('000)</td>
<td>tonnes per citizen</td>
</tr>
<tr>
<td>Australia</td>
<td>83,688</td>
<td>4.6</td>
</tr>
<tr>
<td>China</td>
<td>917,997</td>
<td>0.8</td>
</tr>
<tr>
<td>India</td>
<td>272,212</td>
<td>0.3</td>
</tr>
<tr>
<td>Japan</td>
<td>318,686</td>
<td>2.5</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>152,015</td>
<td>2.6</td>
</tr>
<tr>
<td>USA</td>
<td>1,446,777</td>
<td>5.4</td>
</tr>
<tr>
<td>Two highest</td>
<td>USA, China</td>
<td>USA, Aust.</td>
</tr>
<tr>
<td>Two lowest</td>
<td>Aust., UK</td>
<td>China, India</td>
</tr>
</tbody>
</table>

Source: Gregg Marland and Tom Boden (Oak Ridge National Laboratory)

For each of the four performance measures listed in table 2.2, the USA and China, the USA and Australia, Japan and the United Kingdom and China and Australia are the two highest emitters of CO2 respectively. The two lowest emitters are Australia and the United Kingdom, China and India, Australia and India and Japan and the United Kingdom respectfully. Of the six countries listed, India and the USA are the only countries that could not be considered as both a good or bad performer depending on the performance measure chosen. Conversely Australia, China, Japan and the United Kingdom may be considered as good or bad performers depending on the performance measure chosen. This anomaly is created because for those measures which have population as the numerator the numerator of the performance measure is a variable that is contributing to the environmental bad being measured.

The ideal performance indicator is one that unequivocally measures movement toward the desired objective. The assumption is that there is a risk that the current level of CO2 emissions will have an adverse impact on the welfare of future generations and therefore a reduction in total world CO2 emissions is necessary. Nevertheless, from a welfare economics viewpoint, improving the welfare of the world's population is the objective. GDP per head of population is a measure of the welfare of individuals in that nation. For the five countries chosen the correlation coefficient between the level of CO2 emissions and average GDP per citizen is 0.88. Assuming therefore that average GDP per citizen is proportional to the CO2 emissions per person then the challenge is to improve welfare.
whilst reducing emissions. Nations should be encouraged to improve average GDP per person whilst reducing the total national CO$_2$ emissions. Therefore, the two most appropriate performance indicators, which measure these improvements, are total national CO$_2$ emissions and average GDP per citizen. CO$_2$ emissions per square kilometre could also be used and would have the added advantage of linking the damage with a fixed constraining denominator. Improvements in these performance indicators could then be achieved through industrial efficiencies or population reduction. Choosing CO$_2$ emissions per person as a single indicator, however, gives no guarantee that a nation's total emissions will decrease because an increasing population may still increase that nation's overall emissions. Using the variable of population as a denominator will at best conceal and at worst encourage the more serious problem of unsustainable population growth that may have more serious environmental consequences than fossil fuel generated greenhouse gasses. Nations who simultaneously increase average GDP per citizen and reduce total CO$_2$ emissions are likely to simultaneously improve their citizens' welfare and reduce the risk of fossil fuel induced climate change.

Similarities may be drawn between the response to greenhouse gas emissions and mined land rehabilitation in Queensland. Considerable scientific, industry and government effort has been directed at devising ways to grow grass and trees on mined land but is this the right objective to deliver the ESD vision and is vegetation cover the right measure of success?

2.5 ENVIRONMENTAL CODES OF CONDUCT


VISION

A valued Australian minerals industry achieving outstanding environmental, social and economic performance.

MISSION

To achieve continual improvement in the environmental performance and accountability of the Australian minerals industry.
SIGNATORY VALUES
Amongst others the signatories to the Code commit to the integration of environmental, social and economic considerations into decision-making and management, consistent with the objectives of sustainable development. Sustainable development being defined as "development that meets the needs of present generations without compromising the ability of future generations to meet their own needs." (Brundtland 1987).

PRINCIPLES
There are seven principles, the fourth being to minimise the immediate and long-term environmental impacts of activities by:

(i) adopting a proactive and cautious approach to environmental risks throughout the life of each operation;
(ii) applying ecological principles that recognise the importance of biodiversity conservation; and
(iii) planning for closure during the feasibility and design phases of a project and regularly reviewing plans to consider changes in site conditions, technology and community expectations (MCA 2000, p.2 ).

The vision purports outstanding environmental performance and the mission proposes a commitment to continually improving environmental performance. Unfortunately these terms have not been defined and gauging performance is difficult. Commitment by signatory mines to actions such as producing and continually updating mine final topographic and hydrological plans would be more quantifiable and substantive than commitments to unquantifiable policies such as achieving outstanding environmental performance.

The Queensland Mining Council (QMC), the peak representative organisation of the Queensland minerals industry, published Guidelines for Mine Closure Planning in Queensland in 2001. These guidelines stated that the objectives of mine closure planning are to:

(i) reduce or eliminate adverse environmental effects once the mine ceases operations;
(ii) establish physical and biological conditions which meet regulatory requirements; and
(iii) ensure the closed mine does not pose an unacceptable risk to public health and safety.
This guideline by stating the objective of reducing or eliminating environmental effects from mining is much more precise than the Minerals Industry Code which merely commits to an outstanding environmental performance.

The QMC guidelines having stated the environmental objective then sets out a strategy to achieve this objective by listing the suggested contents of the closure plan, a summary of which follows:

- Introduction
- Background information
- Regulatory requirements
- Stakeholder involvement
- Risk assessment
- Completion criteria
- Closure costs
- Timeline
- Resource and activity database
- Rehabilitation plan
- Decommissioning plan
- Post-closure plan (QMC 2001, p. 8)

The guidelines suggest that the rehabilitation plan should include:

(i) maps detailing planned topography, hydrology and biological information at closure;
(ii) maps detailing the topography, hydrology and biological data for works completed each year; and
(iii) a monitoring program to evaluate success against the rehabilitation acceptance criteria e.g. stability, resistance to erosion, species density and diversity, and water quality.

The QMC guidelines are more quantifiable than those produced by other industry bodies in that there is a defined environmental objective and suggested strategies for achieving the objective. Nevertheless, there is not a stated link to the EP Act and the suggested environmental objective of protecting or enhancing environmental values or attributes.
There remains a gap between the EPA environmental objective and an agreed mining industry strategy for best achieving the EPA objective.

2.6 THE REHABILITATION OBJECTIVE

Prior to the transfer of environmental management of mining to the EPA, the Department of Mines and Energy (DME) was both the promoter of mining and the environmental regulator. The transfer has removed this perceived conflict of interest. Nevertheless, the EPA has yet to be complete the task of defining the environmental objectives and strategies. The nature of this problem is best explained by questioning the objectives of the DME's policy guideline *Environmental Management for Mining in Queensland*. These objectives in summary are:

(i) achievement of acceptable post-disturbance land use capability;
(ii) stable post-disturbance landform; and
(iii) preservation of downstream water quality.

Why did the Department of Mines and Energy set these goals? There are many possible reasons. Placing the current objectives in an historical context gives a helpful insight. Land use capability was one of the earliest environmental lease conditions for coalmining. These conditions were set when Queensland's economic base was predominantly rural and country votes and political representation significantly influenced government policy. Two possible reasons for setting the previously listed objectives are, firstly, to ensure the ongoing productivity of the mined land and secondly, to reduce off-site impacts. Since mining occupies approximately 0.02% of the less agriculturally productive land of the State, reducing off-site impacts is probably of more economic importance to the State.

In the policy guideline, the first objective is stated as: "Achievement of acceptable post-disturbance land use capability." While it is correct that land capability is typically related to agricultural land use, it does not necessarily imply that this is required under the legislation. The DME has allowed mines to propose a post-mining land use rather than presupposing its pre-mining land use. The post-mining or final landform and ecological conditions had to be capable of sustaining the proposed post-mining land use. This may be agriculture, wildlife habitat, or other options such as recreation, landfills, aquaculture etc.
The DME gave each mine the opportunity to negotiate the acceptable post-mining land uses.

However, it may be assumed that the State's unstated goal is to have no liability for maintenance after the mine lease is surrendered. The company's goal is also to surrender leases with no ongoing liability. Presupposing that a productive land use such as grazing is the most effective way of attaining this goal may have been responsible for directing research and rehabilitation effort in a different direction than if the goal had been to ensure that the closed mine did not cause offsite environmental damage.

The EPA are in a better position to define environmental goals and strategies than was the Department of Mines and Energy which was forced to develop rehabilitation strategies in the absence of an overriding vision. Distinguishing between vision, goals and strategies is not merely an academic curiosity. No universally accepted lexicon appears to exist to describe this hierarchy of decision making; however, a good deal of current literature on the topic is to be found in management philosophy both in business and in the church. The following explanation will clarify why the distinction is important. The word strategy is based on the combination of two Greek words "stratos" meaning the army and "agein" to lead. Tactic is derived from the Greek "tassein" meaning to arrange in battle formation. The need for the distinction becomes clear in the original military use of the words. "As the word has been handed down from the military, 'strategy' refers to the important things, 'tactics' to the details." (Costin 1998, p. 35). Myrick Freeman III in his review of Reagan's executive order 12291, which required cost-benefit analysis of new legislation, states that tactics refers to how to employ a given set of weapons or tools to implement some larger strategic design (Smith 1984, p. 167). Since both tactics and strategy have a Greek origin relating to armies, World War II will be used as an analogy.

The peoples of the democratic nations shared the values of fairness, honesty, and respect for human dignity, freedom and liberty. These shared values helped form their Governments' vision of peaceful coexistence with freedom and liberty under democratically elected legislatures. In the context of World War II, the immediate goal to make the vision a reality was to win the war. The war cabinet determined the strategy to win the war. The tactics to win each battle were determined by military commanders. The hierarchy of decision making commences with establishing the vision, next agreeing on the
goal or objective and then developing the strategy to achieve that goal and finally devising tactics to achieve the strategy.

A good example of an attempt to define the hierarchy may be found on the World Wide Web at [http://www.tc.umn.edu/~icf/presentation/Vision/TurningVisionIntoAction.htm](http://www.tc.umn.edu/~icf/presentation/Vision/TurningVisionIntoAction.htm) where the hierarchy is explained in a religious framework as follows:

(i) **Values** are the non-negotiable ethical perspectives on life. Values are the ethical personal or institutional beliefs. Values direct individual or institutional behaviour when making decisions or when judging the importance of opportunities and alternatives. Values are not on the decision making tree, rather values can be likened to the water that keeps the tree alive. Any decision at any point on the tree must accord with these values. A biblical example is to "Love one another" (John 13:34).

(ii) **Vision** is a clear mental portrait of a preferable future. The concepts are captured in the following proverbs:

"If your vision is for a year, plant wheat. If your vision is for a decade, plant trees. If your vision is for a lifetime, plant people." – Chinese Proverb.

"When there is no vision, the people perish" (Proverbs 29:18)

(iii) **Goals or Objectives** are the ends we wish to accomplish flowing from our vision. Goals identify what is to be accomplished in some quantifiable form and by when.

(iv) **Strategy** is a particular approach to reach the goals you wish to accomplish.

(v) **Tactics** are the implementation phase. A tactic is what you do in a strategic fashion to meet your goal.

A similar hierarchy may be applied to mined land rehabilitation. Continually asking the question ‘why?’ will determine where an action lies in the hierarchy. Referring to Figure 2.5, we commence by one asking: Why is one of our tactics to develop a mine closure hydrology plan? It is because in developing our strategy, downstream water quality was identified as the most important environmental attribute to be protected or enhanced both during but more importantly after mine closure. This strategy will in part achieve the goal
of protecting or enhancing the identified environmental attributes. The goal of protecting or enhancing the identified environmental attributes will in turn deliver the Government’s ESD vision. By continually asking why each action is taken, hopefully we will arrive at the top of the hierarchy. The action of developing, maintaining and implementing a mine closure hydrology plan is thus an important tactic in achieving the ESD vision. Having established the decision-making hierarchy each action lower down the hierarchy can be evaluated to see how effectively the action achieves the vision.

Figure 2.5: Decision making hierarchy for mining projects

Although the DME spent considerable effort establishing the tactics and standards such as recommended spoil pile slope angles, this effort was made difficult if not impossible by the lack of an overarching vision. Fortunately the EPA have an agreed vision. The ESD vision is stated in the EP Act. The EMOS guidelines established the goal of protecting and enhancing certain environmental values. Those values associated with the natural environment are; air ecology, land and water. The EPA’s choice of the term values is confusing in the context of the decision making process as previously explained. The author’s preferred term is environmental attribute; however, both environmental attributes and environmental values have been used through this thesis and may be considered as
synonymous. The immediate task ahead of the EPA and the mining companies is to develop the strategies to achieve the goal of protecting and enhancing certain environmental values. This will require identifying the risk to each identified environmental attribute and then giving priority to protecting those attributes considered most important and need of protection. The strategies that were previously developed by the DME in the absence of a vision were:

(i) achievement of acceptable post-disturbance land use capability;
(ii) stable post-disturbance landform; and
(iii) preservation of down stream water quality.

The DME then went on to develop tactics and standards for achieving these strategies by developing a comprehensive manual *Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland* which proposed standards for the mining industry. For example the landform design criteria suggested the maximum height for a slope of angle 20% was to be 10m and for a 10% slope 22m (DME 1995, p. 5). Although a commendable effort, by continuing to develop standards in the absence of an agreed vision, the DME were never in a position to be able to say why these standards were necessary. To quote Seneca "If one does not know to which port one is sailing no wind is favourable." (Seneca 4BC-AD65).

The EPA has the opportunity to reassess the DME strategies. The first step is to identify the environmental attributes to be protected, the potential risk to these environmental attributes and then to rank the attributes in order of environmental importance. This is a critical process, which must precede the next task of determining tactics, and would be most effective if carried out cooperatively with each mine. It would then be up to the mine staff to develop tactics to cost-effectively achieve the agreed strategy. The EPA may be better guided by Sun Tzu who considered the best strategy was winning the war without fighting (Tzu 1971). Although the EPA has a vision there appears to be a lack of decisiveness in defining which environmental attributes are of most importance. It has taken the important first step in stating that there are environmental attributes which the mining companies should protect or enhance; nevertheless, this is no more than a restatement of the vision of protecting Queensland's environment and maintaining the ecological processes on which life depends. To be effective the EPA must offer leadership in ranking the importance of the various attributes to be protected. Their role in relation to
the mining industry is to differentiate the most important environmental attributes from those which are less important and then to determine the potential of mining to cause significant long-term damage to the important environmental attributes. The EPA must be able to establish the relative importance of the attributes to be protected and to determine how to measure whether these attributes have been successfully protected or enhanced. Failure to establish an agreed strategy will result in the EPA continuing the guerilla war with environmentalists and miners. Developing and testing a method of ranking the relative importance of each environmental attribute was an important component of the fieldwork undertaken for this thesis.

Expenditure on rehabilitation in strip coalmines is currently about $26,000 per hectare. Surrounding grazing land may be purchased for under $1,000 per hectare. The dilemma for both the mining industry and the EPA is how to assess whether an acceptable outcome can be achieved by expending $1,000, $25,000 or $100,000 per hectare on rehabilitation. The DME have noted that other countries, and especially the United States, recognise the importance of goal setting. "The US EPA is moving away from command and control to processes that achieve measurable results. This places greater importance on value-based management goals and defining what to measure. The recent Guidelines for Ecological Risk Assessment provides a framework for risk assessment." (Wilson 1998b).

ESD may be considered as a vision or a light on the hill to guide the policy makers. Strategies, which move us toward that light, should be established for each particular mine or mining field and take account of the environmental attributes in the context of their regional setting. For example, in the Bowen Basin that strategy could be to protect or enhance the ecological sustainability of the Fitzroy River system. The tactics to achieve that objective should be developed by the staff at the mine taking into account the particular characteristics of that mine.

Mining improves the welfare of the current generation. There is a limit to the amount of money that can be spent on rehabilitation. Leaving the next generation an environmental mess to clean up does not accord with the ESD vision; however, neither does wasteful expenditure on rehabilitation. There is always uncertainty as to the environmental impacts of mining following mine closure. Therefore, the environmental strategy for each site needs to be based on a risk analysis of the possible environmental impacts. A risk
assessment in combination with cost-effectiveness analysis will give decision-makers a defensible structure for developing environmental strategies which will be based on the best information available at the time. This approach also requires continuing environmental research and monitoring and application of the precautionary principle in the absence of complete knowledge.

The precautionary principle evolved out of the German socio-legal tradition of the 1930's. It encompasses notions of risk prevention, cost-effectiveness and ethical responsibility for maintaining the integrity of natural systems whilst recognising the fallibility of human understanding. Throughout the 1970's and 1980's these notions were extended to six basic concepts:

(i) preventative anticipation: taking action in advance of scientific proof if delaying is likely to be more costly to society and nature;
(ii) safeguarding of ecological space: leaving environmental room to manoeuvre by recognising that margins of tolerance should not be approached;
(iii) cost-effectiveness of margins of error: cost-benefit analyses to include a weighting function for ignorance and possible danger to future generations;
(iv) duty of care: the onus of proof rests with those who propose change;
(v) intrinsic natural rights: the need to allow natural processes to function so as to maintain the essential support for all life on earth; and
(vi) paying for past ecological debt: penalties for not being cautious or precautionary in the past (O'Riordan and Cameron 1994, p. 16)

In summary the Queensland Government has adopted the ESD vision and the EPA have established the objective of protecting or enhancing environmental attributes to achieve this vision. The EPA and the mines are now in a position to rank the relative importance of each environmental attribute within each regional setting. Tactics to protect and enhance those attributes selected may then be developed based on risk and cost-effectiveness analyses. How does this process accord with the relevant economic theory? Chapter 3 attempts to answer this question.
2.7 REFERENCES


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Chapter 3

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That after many wanderings, many years
Of absence, these steep woods and lofty cliffs,
And this pastoral landscape, were to me
More dear, both for themselves and for thy sake!

-William Wordsworth (1770 - 1850):

Lines Composed a Few Miles above Tintern Abbey, 1798

As previously noted many famous economist including Adam Smith, Frederic Bastiat,
David Ricardo, John Stuart Mill and Karl Marx grappled with the concept of economic
value, attempting to define its basic elements. Economics is now struggling with the
concept of environmental value even though it has been recognised from the time of our
earliest ancestors and was venerated by the Romantic poets including Wordsworth.
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3 ENVIRONMENTAL VALUE AND OTHER RELEVANT ECONOMIC THEORY

3.1 THE WELFARE OF NATIONS AND ITS PEOPLE

Cost-benefit analysis (CBA) and its sibling cost-effectiveness analysis (CEA) draw on the language of welfare economics, the sub-discipline of economics that gives CBA and CEA their intellectual foundation. Welfare economics is founded on the premise that the well-being of society can be measured by the single social welfare metric. Social welfare is a yardstick that enables us to examine alternate states of our society and choose the state with the greatest welfare. The moral architects of the 18th and 19th Century including Bentham, Mill and Kant and latterly John Rawls developed methods to define and measure welfare and suggested political economies, which would increase welfare.

3.1.1 The value of things

The challenge for environmental economics is placing a value on the non-marketed benefits that the environment provides. Environmental values cannot be included in any economic analysis unless an economic value can be placed on the non-marketed aspects of the environment. Only then can the changes in welfare caused by moving from one state of the environment to another be compared. Adam Smith (1723 - 1790) observed in *The Wealth of Nations*, published in 1776, that value has two different meanings. The first referred to the utility of some object and is a measure of the object's "value in use". The second refers to the power of purchasing other goods and is a measure of the object's "value in exchange". Things having great value in use may have little value in exchange and vice versa. "Nothing is more useful than water: but it will purchase scarce anything…A diamond, on the contrary, has scarce any value in use; but a very great quantity of other goods may frequently be had in exchange for it." (Smith 1937, p. 32).

Adam Smith died before the industrial revolution; however, John Harrison had produced H-4, the clock which eventually won the longitude prize, in 1760 and inside this five inch diameter 'pocket' watch Harrison had littered the joints of the counterbalances with diamonds and rubies to reduce friction (Sobel 1996, p. 107). Nevertheless, Smith could not have foreseen the significant value in use of industrial diamonds in the 20th Century. Ironically, as an increasing human population requires more water, the world's fresh water supplies are failing to keep up with demand and the price of water is increasing. Nevertheless, Smith succinctly shows the dilemma economists face when attempting to
place a value on one of our most precious environmental resources, water. Two hundred years on, this task is still proving a challenge for economists.

Utility is one of the pillars on which welfare economics is constructed. It is an important staging post on the journey toward establishing the value of an environmental good. This chapter begins that journey with the moral architects of the 18th Century and their efforts to value individual pleasure and pain, which lead onto the concept of utility. The journey continues to the present with our efforts to assess our obligations to future generations and ecologically sustainable development (ESD). Frances Hutcheson (1694 - 1746), a seminal figure in the Scottish Enlightenment, said in *An inquiry Concerning Moral Good and Evil* (1725) that an "action is best, which produces the greatest happiness for the greatest number". His intellectual influence extended to such major figures as Adam Smith, Immanuel Kant, Jeremy Bentham and John Stuart Mill. His phrase, the greatest good for the greatest number, became the motto of the Utilitarians.

### 3.1.2 The Utilitarians

*An Introduction to the Principles of Morals and Legislation*, one of the basic texts of Utilitarianism, was first published in 1789. Its author Jeremy Bentham (1748 - 1832) believed that mankind was governed by two sovereign masters, pain and pleasure. According to Bentham people acted so as to improve their utility. By the principle of utility he meant that principle which approves or disapproves of every action according to whether that action promotes or diminishes happiness. By utility he meant "that property in any object, whereby it tends to produce benefit, advantage, pleasure, good, or happiness... or... tends to prevent the happening of mischief, pain, evil or unhappiness." (Bentham 1961, p. 17). Bentham proposed that the impact of any act affecting a community could be assessed by summing the pleasure and pain felt by the individual members of that community. (Bentham 1961, p. 38).

Bentham was at the forefront of the Utilitarianism movement whose mission statement is now considered to be "the greatest good for the greatest number", however he is best remembered for developing the concept of utility. Bentham said that the principle of utility was fully and explicitly defined by Catherine the Great of Russia when she said; "an act ought to be forbidden: where the tendency of it is pernicious to such and such
individuals in particular, and where it is pernicious to the community in general. For the end, the only proper end and object of the law is the greatest happiness of those who live under its protection." (Everett 1966, p. 34).

Bentham proposed that utility could be measured and he gave a detailed account of the elements of pleasure and pain. Pleasure and pain could be measured on a scale starting at zero and with units and, although Bentham did not use the term, this can be referred to as a cardinal scale. The concept of utility as a measure of individual and society welfare is the cornerstone of economics and the proposition that welfare change can be measured is the foundation of cost-benefit analysis.

For Bentham, welfare consisted only in individual experiences. Anything that happens outside an individual's conscious awareness and does not effect that awareness cannot effect that individual's welfare (Crisp 1997, p. 21). Assuming this position leads to the proposition that polluting a pristine but uninhabited river system would lead to no loss of utility then *a fortiori* the action would be acceptable.

John Stuart Mill (1806-1873) developed Bentham's utility principle in his seminal work *Utilitarianism*, published in 1863. Mill defined Utilitarianism as a creed that accepted maximising utility, or the Greatest Happiness Principle as the foundation of morals. The Greatest Happiness Principle, holds that actions are right if they tend to promote happiness, wrong if they tend to produce unhappiness. Mill, however, believed that humans had natural sympathies toward one another and fulfilling obligation to others was a vital constituent of human happiness. Mill thus distanced himself from Bentham's view that human actions were dominated by self interest (Crisp 1997, p. 12). Mill doubted Bentham's proposal that pleasure and pain could be measured according to duration and intensity and placed on a cardinal scale (Crisp 1997, p. 23). Mill drops full cardinality in favour of an ordinal scale of pleasure or pain. A higher pleasure is more valuable than a lower pleasure but how much more cannot be determined (Crisp 1997, p. 31).

The Italian-born, Swiss economist Vilfredo Pareto (1848-1923) considered that the relationship between the individual and a particular good determined its utility rather than the characteristics of a particular good. He suggested the term ophe limity be used in preference to the often-misconstrued term of economic utility. Pareto defined the
ophelimity (utility) of a particular good for an individual to be the pleasure that the
particular good affords the individual. Pareto developed this concept by showing how an
individual selects a certain combination or bundle of goods. According to Pareto, when an
individual chooses quantities of good $x$ and $y$, it is possible to construct an indifference
curve of differing combination of the goods $x$ and $y$ such that the individuals utility is equal
along the curve. At any point along such an indifference curve the individual's utility is the
same (Mitchener 2000, p. 25).

The Utilitarians did not attempt to establish a right distribution of utility. Their emphasis
was on maximising utility and they did not venture into the rights, justice, or fairness of a
distribution of utility. Nevertheless, Mill did believe humans had an innate moral
obligation to fellow humans and this instinct when incorporated into a Utilitarian socio-
economic structure would deliver the greatest good for all. Philosophers and lawyers
closer to the human condition were not convinced and considered Utilitarianism lacked a
framework for delivering equity in society.

3.1.3 Justice and equitable utility

The German philosopher, Immanuel Kant (1724 - 1804) another moral architect of the
period took a more legalistic approach, proposing that the first principle of moral
obligation was to "so act, that the rule on which thou actest would admit of being adopted
as a law by all rational beings." (Mill 1907, p. 5). The Judaeo-Christian influence in these
principles can be seen in Jesus of Nazareth's commandment to "Love one another as I have
loved you" and "To do unto others as you would have them do unto you." Mill indeed
made this connection and suggested that "in the golden rule of Jesus of Nazareth, we read,
the complete spirit of the ethics of utility. To do as one would be done by and to love one's
neighbour as oneself, constitute the ideal perfection of utilitarian morality." (Mill 1907, p.
25).

It was not until the latter half of the 20th century, in the writings of John Rawls, that the
possibility of injustice flowing from Utilitarianism was posed in all their starkness (Crisp,
p. 13). John Borden Rawls was born in Baltimore USA in 1921. His seminal work A
Theory of Justice was published in 1971 after 20 years in the writing. According to Rawls
the striking feature of the Utilitarian view of justice is that it does not matter how the total
sum of satisfaction is distributed among individuals, only that the correct distribution is that which yields the maximum utility (Rawls 1971, p. 26).

He explained that the principle of efficiency or Pareto optimality held that a configuration was efficient whenever it is impossible to change it so as to make some persons better off without at the same time making other persons worse off (Rawls 1971, p. 67). This concept is illustrated graphically in Figure 3.1

**Figure 3.1: Pareto optimality**

![Figure 3.1: Pareto optimality](image)

Consider there is a fixed stock of commodities distributed between two persons x and y. Curve AB represents the points such that for a given distribution to x there is no way to distribute the commodities so as to make y better off.

The points on curve AB are efficient and can be seen to satisfy Pareto's criterion. It is clear there are many efficient points on the line AB. The principle of efficiency does not by itself select one particular distribution of the commodities to be the most efficient. To select one position among the efficient distributions Rawls contended that a principle of justice was necessary (Rawls 1971, p. 68). The fact that the Pareto principle of efficiency cannot serve as a conception of justice is generally recognised in welfare economics (Scitovsky 1952, pp. 60-69, Little 1957, pp. 112-116).

Rawls considered Utilitarianism to be a teleological theory focussing on the outcome rather than the means of achieving the outcome. His focus was on justice as fairness which he considered to be a deontological theory focusing on the moral obligations toward other individuals (Rawls 1971, p. 30). He considered that a classical Utilitarian was indifferent
to how a constant sum of benefits (utility) was distributed and he attempts to solve the issue of distributional fairness with his second principle (Rawls 1971, p. 77).

Rawls invites us to enter the world via his now famous "original position". We enter behind a "veil of ignorance", and are denied knowledge of everything that makes us who we are: our class, skills, age, gender, sexuality, health, religious views and conception of the good life. Rawls argues that in this position the principles, which we choose to regulate our relations with one another, would be just.

Rawls' first principle holds that each person should have a right to the most extensive basic liberties (the right to vote, freedom of thought, and so on) compatible with a like liberty for others. Rawls contends that the state should remain neutral between different conceptions of how to live, simply safeguarding the freedoms that allow us to live according to our own conception of what liberties are valuable. Rawls' second principle; the "difference principle", states that social and economic inequalities are acceptable only in so far as they benefit the least advantaged.

Combining these two principles overcomes the indeterminateness of the single efficiency principle of Pareto utilitarianism. For any proposed increase in welfare, the higher expectations of those better situated are constrained by Rawls' second principle which requires that their expected improved utility is just if and only if they work to improve the expectations of the least advantaged members of society (Rawls 1971, p. 75).

Distributive justice is commonly defined in economics by two end state objectives. Jeremy Bentham (1748 - 1832) proposed the hedonistic goal of the greatest happiness for the greatest number or maximum utility (Byrns and Stone 1981, p. 426). When this mantra is interpreted in its simplest form, everyone's utility is weighted equally. Rawls proposed that distributing resources equally would reduce the incentive of the most productive people to work hard. The Rawls view allows an unequal distribution of resources providing these inequalities make the least-well-off in society better off (Pindyck and Rubinfeld 1998, p. 594). The final version of Rawls' second principle stated that the most equitable allocation maximises the utility of the least-well-off in society.
Distributive justice is achieved under Utilitarian theory when the utility of the total society to maximised. Redistribution should take place until the marginal utility of the last dollar spent by every individual whether rich or poor is the same. Maximin theory requires the maximum possible income for the person on the minimum income. The theories differ in that the first maximises the utility of the society and the latter it is the utility of the least well-off individual that counts (McTaggart et al. 1996).

The views on distributive justice or equity so far presented can be summarized as follows:
(a) free market - the market will deliver the most equitable outcome;
(b) Pareto utilitarianism - maximise total utility of society. Change is justified providing the total utility of society is increased;
(c) Rawlsian - Change is justified only if the utility of the least-well-off increases; and
(d) maximin - maximise the income for the person on the minimum income.

There has been a distinct evolution of thought from Adam Smith to Rawls as the democratic nations have become more egalitarian and society has recognised the rights of all members of that society to both freedom and equity. This appreciation of the rights of fellow human beings is now being extended to other animals and to nature in general. In Australian society this change was starkly shown by the public's reaction to three fatal attacks by white pointer sharks in a two month period toward the end of 2000. A national survey of talkback radio showed 59% of callers did not want the sharks killed (Brook 2000, p. 1). Society is becoming more aware of the need for equity even for sharks. Likewise there is a growing awareness and expectation of the need for equitable distribution of wealth and psychologists are exploring the human psyche in order to understand the nature of human well-being or utility.

The Utilitarians believed that welfare of the individual and society was the sum of each individual's utility. Utility was a function of the absolute levels of consumption and was cardinal rather than ordinal. However, modern research into psychology, sociology and social anthropology suggests that people measure their utility relative to others in society, and relative to expectations. An individual's utility for levels of consumption above the level necessary for survival depends on that individual's consumption relative to others in the society and is ordinal rather than cardinal (Clayton and Radcliffe 1996, p. 181).
Economic principles for determining a just distribution of wealth are rare and devising such principles is a challenge that few economists embrace. Marx and Engels came closest with: from each according to his ability, to each according to his needs (Rawls 1971, p. 305). There is no universally accepted economic principle for sharing wealth amongst the current generation. Attempting to devise a principle for allocating wealth and resources between generations might be considered a challenging academic endeavour at best and an exercise in futility at worst. Rawls thinks likewise that the solution as to how the burdens of capital accumulation and raising the standard of civilization and culture are to be shared between generations admits no definite answer (Rawls 1971, p. 286). He considered that a moral theory by which policies could be assessed was preferable to the classical theory of utility. Since from a moral point of view there is no reason for discounting future well-being then the Utilitarian doctrine may direct us to demand heavy sacrifices of poorer generations for later generations that are far better off. Conversely, if a high discount rate is applied, we are effectively adjusting the rate to achieve an outcome in line with our intuitive judgements (Rawls 1971, p. 298). Rawls contends that the Utilitarian approach was an incorrect conception to examine intergenerational equity. There has always been a more selfish reason for ensuring the welfare of future generations other than a moral obligation. There is a natural human pleasure gained from children and grandchildren and an instinct to protect them that might be simply seen as increasing pleasure as suggested by Bentham. Even more relevant to the current generation is the need to be looked after in old age and so each generation perceives a welfare benefit in protecting future generations. Do these two selfish reasons, akin to Smiths invisible hand, provide sufficient incentive to protect future generations or do we have a greater obligation to future generations?
3.2 THE ENVIRONMENT'S ROLE IN OUR OBLIGATIONS TO FUTURE GENERATIONS

If we believe we have an obligation to future generations to preserve the existing ecology and culture then the premise is that our current ecology and culture is a social ideal that embodies a conception of the good life for humans as well as all other creatures (Golding 1972, p. 89). However, the concept of what constitutes a good life varies both between and within cultures. The concept of a good life for an urban person may be different from that of a person who loves the outdoors, just as it may be very different between a person living on Hong Kong Island to one living on Lord Howe Island. Nor are the social ideals static. The expectations of the average resident of Brisbane as to cleanliness and health and life expectancy would probably exceed that of any Pharaoh in ancient Egypt. Given that there is no universally accepted definition of what constitutes a good life currently, and that any definition would certainly have changed over the past 5000 years, we cannot assume that what constitutes the good life now is relevant to future generations. How will future generations measure their well-being and is our conception of the good life for humans relevant to future generations? The answer is unknowable; however, if we do have obligations to future generations then the extent of such obligation is much clearer for the current generations. Likewise, if we have obligations to future generations then we have obligations to our children and grandchildren and those generations to be born in the immediate future (Golding 1972).

The concern about the welfare and equity of future generations seems anachronistic since we do not have equity in the current generation. The logic of sustainability says, "You ought to be thinking about the poor people today." (Solow 1968, p. 185). In his analysis of intergenerational equity Solow concluded that, although the maximin criterion seemed reasonable, it required the original capital stock to be large enough to support a decent standard of living, else it perpetuates poverty (Solow 1974). "The nearer the generations are to us, the more likely it is that our conception of the good life is relevant to them. There is certainly enough work for us to do in discharging our responsibility to promote the good life for them. But it would be unwise, both from an ethical and practical perspective, to seek to promote the good life of the very distant." (Golding 1972). We would be ethically well-advised to confine ourselves largely to removing the obstacles that stand in the way of the current generation of children realising their social ideal.
Parents judge how much they should spend on the rearing of their children and how much to set aside for their children's inheritance. This parental generosity alone defines a just saving principle between generations (Rawls 1971, p. 290). This parental generosity should, however, be extended to the socioeconomic structure of nations. The greatest anthropogenic causes of human sufferings have occurred during the expansion of or the collapse of empires. During these periods the environment has also suffered. Perhaps the greatest contribution each generation can make toward ESD is not in the amount of untapped resources set aside for the next generation, but a strong social and economic system. In this regard, an international cooperative structure which emulates the structure of the Internet may be the most robust. The great strength of the capitalist system is its ability for individual badly managed companies to fail without causing failure of the system. Similarly, an interwoven cooperative of many democratic nations based on Rawls' principles would allow for failure of individual nations from time to time without causing the failure of the whole system.

3.2.1 Obligations to our children

It is natural instinct for a parent to wish for their children and grandchildren lives at least as bountiful if not more bountiful than their own. This requirement bounds the actions of the current generation and is sufficient to determine the actions of the current generation. Ethically, therefore, we can confine ourselves to removing the obstacles that stand in the way of realising the current social ideal of well-being. This requires not only cleaning up the environment and making our cities more habitable, but also implies certain restraints on waste of resources (Golding 1972).

The desire for clean air and clean water and fertile soils are considered fundamental to the current generation and therefore current generations have an obligation to leave the land as productive and the air and water as pure and unpolluted as that which they inherited from their ancestors (Solow 1968, p. 180). For mineral resource development and consumption this requires efficient use of resources, whilst ensuring that future generations do not bear the cost of cleaning up the environmental damage caused by past generations. However, if we are required to leave the world as we found it in every detail, this obligation is infeasible and you cannot be morally obligated to do something than is infeasible. Solow believes the obligation is to conduct ourselves so that we leave future generations the
option or capacity to be as well off as we are. The obligation is not to satisfy ourselves by impoverishing our successors. However, to some extent all parts of the endowment are substitutable (Solow 1968, p. 181). Resources are to some extent fungible with consumers substituting one good for another. For many people different amenities and particular species are substitutable. If this were universally the case then there is no specific good which the goal of sustainability requires us to leave in place.

One solution studied by Hartwick was to invest the revenues attributed to non-renewable resources (Hartwick 1978, p. 350). When we consume irreplaceable reserves of minerals we should provide a substitute of equal value. Solow compares Great Britain’s use of North Sea oil revenue with that of Norway. Great Britain spent its revenue as it was received, whereas Norway has converted its revenue into investments. This same comparison can be made in Australia with the partial sale of Telstra. $1.5 billion of the proceeds is being made available from 1996 to 2002 to prevent the decline in the quality of Australia’s natural environment. The _Natural Heritage Trust Act 1997_ established the Natural Heritage Trust (NHT) to manage the Trust’s funds. $673 million of the NHT funds has been dedicated to the Bushcare and Landcare programs. In comparison $196 million is dedicated to the rehabilitation of the Murray-Darling Basin. For Bushcare the 1998/99 NHT report lists 10,000 hectares revegetated. An estimated 400,000 hectares of native vegetation was destroyed by land clearing in the same period (ACF 2000, p. 3). Similarly, in the case of the Murray Darling, there is little indication that water quality is improving. Although there has some investment in establishing allocation priorities and efficient use of water there has been little success in reducing over use of the resource or identifying and quarantining salt producing areas. It will take decades to correct the environmental damage and will require long term research followed by even longer term political will and commitment. By 2002 the NHT funds will be spent. The amount spent on tree planting will be of little long-term benefit if the amount of water taken from the river continues to increase and the mount of land clearing exceeds the amount of tree planting. Unfortunately, the NHT funds have been spent rapidly and randomly rather than investing the funds and using the interest to first identify the sources of the problem and then to set a long-term strategy for restoring the quality of the catchment. The evidence of and opportunities for a lack of cost-effectiveness evident in the NHT are replicated in the management of mine site rehabilitation. In both cases there has been a lack of overarching vision and the initial focus has been on growing vegetation rather than addressing water
quality. Similarly, if environmental budgets are not spent cost-effectively during the project, there is little chance of additional funds being available at the end of the project.

We are entitled to please ourselves as long as it is not at the expense of future generations. The endowment we leave includes both the natural and built environment, the developed and undeveloped natural resources, infrastructure, the economic and social systems as well as the knowledge and skills to survive. We could be equally condemned in Queensland for squandering valuable resources on building brick veneer houses, which are uncomfortable without air conditioning and environmentally inefficient in the Queensland climate, as we could for polluting rivers or degrading land. Likewise, we do future generations a disservice if we fail to pass on our skills and knowledge and, more importantly, provide them with the opportunity and education necessary to gain the new skills to adapt to a changing world. The triumph of capitalism over socialism has placed capitalism on a pedestal. All social systems have strengths and weaknesses and capitalism's greatest weakness is its myopia. It has a short time horizon and immediate gratification has a greater value than future benefit. (Thurow 1996, p. 286). For example, Commonwealth Government expenditure on Tertiary education in Australia per equivalent full-time student unit (EFTSU) decreased between 1983 and 1999 (Vice-Chancellors 2000, Table 3). At the same time the burden for education is being increasingly borne by the student. The education bill for an average medical student is over $38,000. How can the elderly expect care from the current generation when they failed to provide for their education and training?

Capitalism is a triumph for individuality; however, it has come at the expense of the concept of full time employment with one company. Through two decades of downsizing, rationalising and business failures workers are learning from experience that they ought to be a short-run earnings maximiser, moving to a new employer whenever wage offers are higher. Individual success in the future will go to those who continue to invest in lifetime career skills. "Lifetime employment is replaced by lifetime employability."(Thurow 1996). Nothing should be more important to the old than the economic success of the young and this success will be dependent on their initial education level. Support for this education is being reduced by today's decision-makers just at the time the support is needed more than ever. We have met the financial enemy and he is the soon to be retired politician and policy maker of today (Thurow 1996, p. 114).
3.3 ENVIRONMENT VALUE AND HUMAN NEED

The community's perception of the environment may depend on the current well-being of the community as much as any cultural appreciation of the environment. When Europeans first arrived in Australia they saw a savage land that had to be tamed. It was necessary to first cut the trees in order to have land for crops. The eucalypts and acacias of the Australian forests were a formidable challenge to the axe when compared to an English oak. Rain was infrequent and dams a necessity. The battle has raged for over 200 years and still for many the only good tree is a dead and burning one. When Dorothea Mackellar first published her poem *My Country* in 1908 our image of the bush was changing. After over one hundred years of European settlement many native born Australians shared her preference for a sunburnt country in contrast to the green and shaded lanes and ordered woods and gardens of Britain. She paints a vivid image of "the stark white ring-barked forests, all tragic to the moon." Dorothea and the Australian nation were beginning to look on the Australian bush as a friend that "pays us back threefold" rather than a foe. By 1900 Australia's standard of living was comparable with any place in the western world and whilst still seeing the need to tame the land there was developing an appreciation of the landscape and its beauty. Our first National Park, Royal National Park in New South Wales was established in 1879, and is the world's second oldest national park - after Yellowstone in the USA. Australia is now in a third phase where, as a nation, we have achieved a high standard of living and developed sufficient understanding of the importance of the ecosystems to propose and hopefully attain ecologically sustainable development.

A nation is more likely to embrace nature when most of its people have reached a comfortable standard of living. For much of white Australian history, leisure had been a luxury. Likewise, until recently, a sound clean environment had also been seen as an expensive luxury (Blainey 2001). Maslow proposed a hierarchy of human needs. That hierarchy is shown in Figure 3.2 with an inverted pyramid indicating that whilst the physiological needs, food, shelter etc are physically limited the higher needs are limitless (Davis 1994, p. 103).
Figure 3.2: Maslow's hierarchy of human needs

Maslow uses this hierarchy of human needs to show in Table 3.1 how a community's perception of the environment depends on the current well-being of that community.

Table 3.1: Environmental appreciation and community well-being

<table>
<thead>
<tr>
<th>Maslow category</th>
<th>Role of environment</th>
<th>Example</th>
<th>Demands on environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transcendence</td>
<td>temple</td>
<td>spiritual persons</td>
<td>harmony, beauty</td>
</tr>
<tr>
<td>Self-fulfilment</td>
<td>museum</td>
<td>intellectuals</td>
<td>rarity, exoticness, antiquity</td>
</tr>
<tr>
<td></td>
<td>refuge</td>
<td>solitary walkers</td>
<td>space, limited isolation</td>
</tr>
<tr>
<td>Self-respect</td>
<td>sportsground</td>
<td>climbers</td>
<td>wilderness obstacles</td>
</tr>
<tr>
<td></td>
<td>health &amp; recreation</td>
<td>tourism</td>
<td>limited comfort, beauty</td>
</tr>
<tr>
<td>Belonging</td>
<td>productive partner</td>
<td>organic farming</td>
<td>biological processes</td>
</tr>
<tr>
<td>Security</td>
<td>warehouse</td>
<td>conventional farming</td>
<td>raw materials</td>
</tr>
<tr>
<td></td>
<td></td>
<td>mining</td>
<td></td>
</tr>
<tr>
<td>Physiological</td>
<td>waste tip</td>
<td>polluters, consumers</td>
<td>absorptive capacity</td>
</tr>
</tbody>
</table>

Self preservation and expediency will dictate that for a community lacking fuel the forest will act as a source of timber. If a community can easily obtain sufficient food and energy
from the environment it will have sufficient leisure time to be able to appreciate the beauty of the environment. The value of the environment to a community is dictated by the current well-being of that community (Jenkins and Midmore 1999, p. 277).

In 1955 Simon Kuznets attempted to answer the question "does inequality in the distribution of income increase or decrease in the course of a country's economic growth?" In his own words the paper was 5% empirical information and 95% conjecture (Kuznets 1955, p. 26); however, this seminal paper established the use of what has become known as Kuznets curves to examine changes in, for example, environmental quality against per capita income. Evidence presented by Shafik suggests that it is possible to grow out of environmental problems with deforestation and ambient sulphur dioxide decreasing and the availability of safe drinking water increasing as income approaches US$10,000 per annum (Shafik 1994, p. 764). Grossman and Krueger also concluded that most environmental indicators first deteriorate then improve with the turning point of the curve occurring before per capita income reaches US$8,000 (Grossman and Krueger 1995, p. 370). Nevertheless Hettige et al found that their evidence did not support the Kuznets hypothesis for industrial water pollution (Hettige et al. 1999, p. 78) and Shafik found a similar relationship both for faecal coliform in rivers and carbon emissions. On the basis of evidence so far presented it cannot be assumed that rising income levels will ensure improved river water quality.

Aldo Leopold attributed a moral status and intrinsic value to nature independent of human use (Jenkins and Midmore 1999, p. 269). Is the concept of ESD to be interpreted only from an anthropogenic perspective or does ESD embrace a broader objective of managing nature for nature's sake? Is ESD a value in use concept or does the concept place humans as custodians of the earth rather than masters? These issues may be more easily understood by considering the challenges in valuing the non-marketed values of a river catchment.

3.3.1 The non-marketed value of a river catchment

There is general acceptance amongst economists that there is a current willingness to pay for the preservation of the quality of the non-marketed aspects of the natural environment
in general, and rivers in particular. These preservation benefits are distinct and additional to the consumer surplus benefit from using the natural environment.

Preservation benefits include option, bequest and existence value. Some citizens may wish to keep open the option to choose between competing alternative uses of the environment. In one of the first published attempts to measure option value respondents were asked if they were willing to pay for the option of preserving the river quality for recreational use as opposed to mining in the river catchment with the likelihood of irreversible water quality damage (Greenley et al. 1981). This non-use value is distinct from the actual recreational use value. It is distinct from the amount people are willing to pay for the knowledge that the natural environment is preserved and will continue to exist. Bequest value is the satisfaction of endowing future generations with the preserved environment (Greenley et al. 1981, p. 657).

Greenley et al. asked 220 residents of the South Platte River Basin in Colorado what they would be willing to pay for water quality preservation. There were four categories of value: option, bequest, existence and recreational. Using a $6^{\frac{3}{8}}$ percent discount rate ad infinitum, the present value of the annual benefits from water quality preservation was almost one billion $US dollars. The option value was $US 165 million and the recreational use value $US 414 million.

The South Platte River Basin has a catchment area in the order of 70,000 square kilometres. In comparison the Fitzroy Basin which has comparable rainfall rates has a catchment area of 140,000 square kilometres. It is tempting to use a simple benefit transfer and assume that the value of preserving the quality of the Fitzroy catchment is two billion $US. However, in order for such an approach to be remotely valid adjustments would have to be made to take account of:

(i) population sizes;
(ii) the people of the South Platte Basin may value the water quality differently from those in the Fitzroy Basin; and
(iii) the different ecological characteristics of the two basins.

The obvious question is what is the common denominator in attempting benefit transfer. In the case of rivers it may simply be the quality of a cubic metre of water. Skinner
postulated that, contrary to the Club of Rome's concerns regarding diminishing mineral resources, water will be the first factor to constrain economic growth (Skinner 1993, p. 6).

Greenley's original research may, however, be flawed and the economic values may be indefensible. Mitchell and Carson raised two possible problems. Firstly that there may have been confusion in the minds of the respondents on the difference between recreation and option values. The Greenley et al. article does not provide a clear definition of the distinction between these two values. Secondly, there was no specification of budget constraint (Mitchell and Carson 1985, p. 292). This may have been partially solved by asking the question "In addition to the amount you were willing to spend on recreation what additional amount would you be willing to pay for the categories of option, existence or bequest values. These, however, would not have bounded the respondents' overall budget constraints including all other environmental preservation objectives in Colorado, the USA and the World.

Nevertheless the research indicates that when measuring the value of river basins there are significant non-marketed values to account for when assessing the preservation of water quality. Unfortunately, these values have not yet been fully identified and the methods of measuring the values are in their infancy. Perhaps it is more important to resolve some of the broader philosophical problems first. Is it just current commercial man who has the right to decide or should we take account of current non-commercial man or even generations as yet unborn? Should all sentient and non-sentient life be included?

3.3.2 Valuing nature for nature’s sake

Adopting an anthropocentric viewpoint, then only the value humans placed on the catchment would be included, but which humans? If a willingness to pay criterion is adopted then it is only those who can pay that are relevant to the decision and children and the as yet unborn generations are excluded. In their evaluation of the distance effect on the willingness to pay for the preservation of water quality in the Flathead River Drainage system in Montana, Sutherland and Walsh included option, existence and bequest value (Sutherland and Walsh 1985). They found that the aggregate of these three values which households were willing to pay approached zero at 650 miles from the study area. Extending their findings, if an ore deposit were to be found in an as yet unpopulated or
lightly populated area, for example the Fly river in New Guinea in 1970, then the value of preserving the water quality of the river would be low especially given the low average income of the local residents. This approach assumes that the population remains constant and is immobile. An economic analysis done prior to human migration out of Africa 100,000 years ago would value all catchments outside Africa as zero. Any of the current methods of assessing values whether they are revealed preference methods or other methods seem only to be appropriate where there is a dense and steady state population with incomes approaching those of the first world.

Many of the environmental consequences of development projects are completely irreversible or reversible only over a long time scale. Species extinction or other irreversible environmental losses are ones for which future generations are least likely to forgive this generation (Goodland and Ledec 1987, p.30). Nevertheless, if the impact is not physically obvious will future generations care? How many people yearn to see the Cape lion symbolically represented on Britain's Royal Coat of Arms or the Mauritian dodo, or the American carrier pigeon or the Tasmanian tiger? Humans caused the extinction of each of these animals and now their live presence is outside the frame of human awareness or expectation. If much that once was is now lost and no one left who can remember, how can we that are left place a value on things we have never known. Perhaps the words "you don't know what you've got till it's gone" apply to the immediate past, but within a human generation or even sooner there is little yearning for what's gone. The fact of the extinction of these animals may sadden some humans but for the majority even the fact is outside their consciousness. For those fighting starvation a carrier pigeon even if it were the last one on earth would be of more value as food than as a rare thing of beauty warranting preservation.

### 3.3.3 Valuing landscapes and biodiversity

Landscape is perhaps the most complex environmental good to value. Methods which attempt to value the individual attributes of a landscape, such as choice experiments, contingent ranking and utility scaling offer most promise. During the 20th Century there was a trend toward preserving the natural and man-made landscapes as against the command and control approach of the 19th Century (Garrod and Willis 1999, p. 259). Fashions change, and it is impossible to predict how future generations will perceive
landscape. Attempting to rank landscape preference for the current generation is acknowledged to be difficult, attempting to predict future generation's preferences would seem to be futile.

Preserving biodiversity of flora and fauna may result in the total number of individuals in some species being reduced. An optimal biodiversity policy may be the one which results in the highest present discounted expected value of diversity. The major challenge for any policy maker enacting such a policy is measuring the benefits of biodiversity (Garrod and Willis 1999, p. 263). The objectivity of biodiversity preservation is often overshadowed by a bias toward the charismatic megafauna, especially those higher forms of life with perceived humanoid characteristics. For example, we preserve whales whilst simultaneously exterminating the orange roughy fish. The orange roughy fish, which are exploited at depths ranging from 700 to 1,400 metres in southern Australian and New Zealand waters, reach maturity at age 20 to 25 years and may live over one hundred years. Even complete property rights would not preserve the species because its rate of growth is so slow that it is bound to yield a return below the ruling rate of interest in any economy (Baland and Platteau 1966, p. 19). In Australia we have a preference for preserving cuddly marsupials whilst destroying our native fish habitat.

Regulations protecting a species may not ensure a species' preservation because many species are threatened by habitat destruction and by introduced predators (Tisdell 1991, p. 117). Many species are of no particular interest or value to humans but are associated with a particular habitat or ecosystem such as the Brigalow forests of Queensland and are destroyed as a consequence of the destruction of their habitat. The major cause of flora and fauna loss are its consumption by man or introduced species or the destruction of habitat by man or most commonly a combination of all three. The Bridal Nail Tailed wallaby was once the eastern seaboard's most common wallaby, until the fox was introduced. Europeans cleared the wallaby's natural habitat, the Brigalow belts of inland Australia west of the Great Divide, and by 1930 it was declared extinct in that region. The Bridal Nail Tailed wallaby is now being reintroduced at some sites in Queensland and its beauty which admits it into the classification of charismatic megafauna, albeit a small one, may ensure its survival. Other less charismatic animals are not so fortunate.
3.3.4 Discount rate applicable to the value of environmental attributes.

Having agreed on the value of the environmental attributes, the next challenge is to account for these attributes in present day terms. Cost-benefit analysis enables the costs and benefits for all impacted individuals to be compared over specific time periods. The net present value (NPV) is calculated using the following formula:

\[
NPV = \frac{(B_1-C_1)}{(1+r)} + \frac{(B_2-C_2)}{(1+r)^2} + \frac{(B_i-C_i)}{(1+r)^i} + \cdots + \frac{(B_n-C_n)}{(1+r)^n}
\]

Where Bi and Ci are the benefits and costs in period i. In cost-benefit analysis the discount rate r is called the social discount rate.

In practice, monetised estimations of the environmental costs and benefits of any policy change or project often amount to little more than guesswork (Goodland and Ledec 1987, p. 24). It is ironic that, at a time when there is an increasing number of humans whose basic physiological needs are not being met, there is an increasing belief among the more well off, that human beings should take care to avoid the extinction of other living species. Similarly, many people appreciate the mere existence of free-flowing rivers and other undeveloped natural wonders even when these people have no immediate plans to visit or directly use them. Efforts to measure such environmental values, which are ethical or spiritual in nature using techniques such as willingness to pay are not yet satisfactory (Goodland and Ledec 1987, p. 26).

The NPV technique discounts the value of future benefits. Some economists including Ramsey, Pigou, Allias and Solow have voiced discomfort at discounting future benefits and argue that a benevolent social planner will place a greater weight on future consumption (Caplin and Leahy 2001, p. 2), whilst others argue that environmental future values should be discounted at a lower rate or even a negative rate to reflect their increasing value to future generations. Other economists see an "intergenerational invisible hand" (Barnett and Morse 1963) and propose that by devoting itself to improving the lot of the living, each generation transmits a more productive world to those who follow. It is logical, therefore, to discount the future at a high rate assuming future generations will be much wealthier in material terms. This assumption of an improving living standard may have been valid in the United States in 1963; however, the picture was very different at the end of 1992. In the United States, over the 20-year period ending 1992, real male wages have fallen. At no other time since data have been collected have
real male wages consistently fallen for a two-decade period of time (Thurow 1996, p. 24). A similar trend is apparent in Australia where the estimated net average wealth for people in the 15 to 44 year age bracket fell in the years between 1986 and 1998 (Harding et al. 2001, p. 4). At the end of the 20th century parents were not so optimistic that their children would be wealthier in material terms. As well, increases in material wealth have in large proportion been made possible by the consumption and depletion of cheap energy (Goodland and Ledec 1987, p. 35).

3.4 A POSITION ON ENVIRONMENTAL VALUE AND THE NEEDS OF FUTURE GENERATIONS

The philosophers, economists and lawyers previously mentioned are considered the pre-eminent voices in the field of welfare economics and justice. The conclusions they reached will form the foundation for considering the implications of ESD for mined land rehabilitation in this thesis. This analysis of the cost-effectiveness of rehabilitating mined land will take account of the following factors, which are discussed in their order of importance.

It is impossible to guess how future generations will measure their well-being. Maslow's hierarchy of human needs proposes that as human welfare increases so does appreciation of the natural environment and that the preservation of nature for nature's sake will be a higher priority for future generations. Increasing human welfare leads to recognition of nature as a sanctuary rather than a source of fuel. Maslow's hierarchy of human needs indicates that our desire to care for the environment is influenced by the level of welfare in that society. Therefore any suggested change in rehabilitation policy should have the ability to improve human welfare because this improved welfare will, most probably, lead to and increase in the desire for an improved environment.

Pareto optimality will be chosen to assess welfare change; however, this will be tempered by the Rawls' veil of ignorance and Kant's just law principle. Any policy change by this generation should be considered just by any future generation. Rawls, Golding and Solow have each concluded that since we care for our children's welfare, each succeeding generation will do the best it can for the needs of its children. This intergenerational link, providing there is knowledge of the impact of current actions on the environment, will achieve the ESD objective. The focus will be on improving the welfare of the humans
living today. The well-being of the next generation will depend on the strength of the social and economic structures and education of the young as well as the ability to develop resources. Education and knowledge of ecosystems will be considered to be equally important as attempting to repair environmental damage. Irreversible damage to rivers and large ecosystems will be considered unjust even if the areas are currently unpopulated by humans. Rivers and large ecosystems should be maintained in at least their current state with a policy of continual improvement.

The debate regarding valuing nature for nature's sake and whether the welfare of other forms of life should be included in any analysis is important; however, from observation improvement in human welfare generally leads to increases awareness of and ability to improve the welfare of other forms of life. Therefore, only the welfare of the current generation of human and their unborn children will be considered when examining whether there is a more cost-effective allocation of the current expenditure on rehabilitation

This set of values will form the reference framework upon which the cost-effectiveness of mine site rehabilitation will be judged. The Coasian economic analysis approach of examining if there is more cost-effective allocation of expenditure on rehabilitation than the current allocation has been chosen. Cost-effectiveness will be judged in terms of economic efficiency using the Kaldor-Hicks criteria.

3.5 ECONOMIC INEFFICIENCY AND ITS CAUSES

Pareto optimality holds that an economic configuration is efficient whenever it is impossible to change it so as to make some persons better off without at the same time making other persons worse off. In 1939 Hicks and Kaldor extended the original concept proposed by the Italian engineer-economist-sociologist Vilfredo Pareto, who is also credited with devising the law of the trivial many and the critical few, known as the 80:20 rule or Pareto principle. The Kaldor-Hicks concept of the potential Pareto welfare improvement, or compensation principle is at the heart of welfare economics. This criterion states that a given change in social welfare will be desirable if those who gain from it could completely compensate those who lose and still be better off themselves. Pareto optimal allocation is, in economic terms, considered efficient. Inefficient allocations indicate market failure (Perkins 1994).
The Pareto optimal allocation does not, however, guarantee the Utilitarians' goal of the greatest happiness for the greatest number and failure to achieve the latter is not considered to be a symptom of market failure under the Pareto definition of economic efficiency. In a two person economy the Pareto definition of a more efficient economy infers an outward shift of the utility curve shown in figure 3.1. The Utilitarians were seeking to maximise utility and this may be achieved by moving along the utility curve and increasing one person's utility at the expense of the other providing a higher total utility was achieved. Most commonly a market will fail to deliver economic efficiency when there is either imperfect competition in a market or when markets fail to develop. In the former situation economists from Adam Smith to Friedrich Engels have suggested that only a perfectly competitive market can deliver just the variety and quantities consumers desire (Baumol and Blinder 1997, p. 211). However, perfect competition requires:

(i) numerous small firms and customers;
(ii) freedom of entry and exit; and
(iii) perfect information.

Although consumers may desire to have perfect competition, in the expectation of lower prices, the producer aims to monopolise the market and hence maximises profits. Thus the objective of perfect competition is always under constant attack in a capitalist economy. The United States of America, often considered the paragon of the free market, has a long history of regulating or breaking up monopolies. Federal regulation of America's railroads began when the Interstate Commerce Act of 1887 created the Interstate Commerce Commission (ICC) which had broad powers to regulate railway rates and various business practices of the railroads. The legislation represented the choice of "enforced competition" over government ownership and operation. The ICC continued to regulate rail haulage rates for almost one hundred years until the Staggers Rail Act of 1980, effectively deregulated the railways (Ekelund and Herbert 1988, P. 3). The most notable recent attempt to break up a monopoly is the US government's attempt to divide Microsoft, the company who supplied the software that made it possible for the author to type this thesis.

The market deals poorly with:

(i) the provision of, and protection of public goods;
(ii) the side effects or externalities of many economic activities; and
(iii) the allocation of resources between present and future generations.

In these instances markets are often absent. Each of the previously listed issues are present when considering the environmental impacts of mining. The approach to future generations has already been discussed. Public goods and externalities are now considered. Public goods are commodities which are valuable socially but which the market cannot or does not provide to the optimal level. National defence and national parks are two examples.

3.5.1 The attributes of a public good

The economic theories relating to public goods and externalities are considered relevant to mined land rehabilitation and are now considered in more detail. The most expedient way to explain a public good is to contrast it to the attributes of a private good. Privately goods are characterised by excludability and rivalness.

3.5.1.1 Excludability and public goods

A commodity has the characteristic of excludability if someone who does not pay for it can be kept from enjoying it (Baumol and Blinder 1997, p. 310). The degree of excludability is dependent on the degree of property rights and the ability to enforce those rights. A full theoretical set of property rights does not necessarily bring with it the ability to enforce exclusion of others. Countries have expanded the exclusive economic sea zones out from their shores from 12 miles in the nineteenth century to 200 nautical miles today. Expansion of the sea boundaries only became practical with longer range technical surveillance ability. Likewise agreements are possible to protect natural resources which have less than full private ownership. Open access is often considered to be synonymous with common property and the opposite of exclusive private ownership. Neither of these concepts accurately portrays the true nature of open access. Nor does it show the connection between open access and private and public goods or explain the often temporal nature of open access.

Scott and Johnson rate the degree of property right according to the extent the owner has the right to:

(i) exclude others;
(ii) the continued use over time or to transfer the right to others; and
(iii) use and receive the full benefit from all the resources of the property.

The more the property right has of each of these characteristics the more complete is the property right (Scott and Johnson 1985, p. 379) (Campbell 1999, p. 15).

The extent to which property rights will develop; however, depends on the nature of the good, with private and public goods being at opposite ends of the spectrum. A private good is generally characterised by both rivalness in consumption and exclusion in the market place. A public good can be consumed or enjoyed without the available supply being reduced, and once supplied, it is impossible to exclude individuals from using it (Kuronuma and Tisdell 1993, p. 247). The rivalness characteristic is now considered.

3.5.1.2 Rivalness and public goods

The impacts on two individuals' consumption of private and public goods are shown diagrammatically in Figure 3.3.

**Figure 3.3: Private, public and mixed goods -**

![Diagram of Private, Public and Mixed Goods](source: Kuronuma and Tisdell 1993, p. 248)
Assume the maximum amount of the good consumers A and B would wish to consume is represented by A and B in Figure 3.3. Line AB represents the limits of consumption for a private good. For a private good if consumer A consumes $a_1$ then consumer B can only consume $b_1$. However for the public good both consumers may consume to their desired maximum amount of A and B respectively.

Figure 3.3 can also be used to explain a mixed good. Consumption of the same good as a public good does not decrease the amount available for consumption of a mixed good as a private good, whereas the consumption of the same mixed good as a private good reduces the amount available for consumption as a public good (Kuronuma and Tisdell 1993). If Consumer A was consuming A as a public good, such as a river for swimming or recreational fishing, there is nothing to exclude consumer B consuming say $b_1$ of the water for irrigation or for that matter polluting the river as a private good. However, once B has consumed $b_1$ consumer A can no longer consume an amount A as a public good. That is A's use does not exclude B's use; however, B's use does exclude A's use.

3.5.1.3 Commons and public goods

Open access has often been assumed to be synonymous with communal land or commons. Open access is, however, more accurately described as a temporal condition occurring when there is an absence of enforceable property rights. Garrett Hardin in his article *The Tragedy of the Commons* rebutted Smith's invisible hand theory by making use of an 1833 pamphlet by William Forster Lloyd. First assume that the common is carrying the maximum sustainable yield of cattle. A herdsman by adding one more cow to the common makes a personal gain whilst there is a loss to the collective as a result of over grazing. A "rational herdsman concludes that the only sensible course for him to pursue is to add another animal to his herd. Therein is the tragedy. Freedom in a commons brings ruin to all." (Hardin 1968, p. 9).

Although *The Tragedy of the Commons* has become synonymous with the failure of communal property management, Hardin like Malthus was primarily concerned with overpopulation of the earth by one species, Homo sapiens, and the lack of resources to support the human population which would result in ruin for all.
Hardin elegantly proved that an open access common would fail; however, he either intentionally or unintentionally commenced with the premise that open access was synonymous with commons. This incorrect conclusion had been drawn previously by colonising nations in earlier centuries and this was perhaps the greater tragedy of the commons.

This misconception may have been as a result of the lack of commons in the 20th century and the consequent misunderstanding that common property was synonymous with open access. The commons of Britain were largely subsumed by the government by Acts of Enclosure in the early 18th century culminating in the General Enclosure Act of 1845. By 1876, 0.6 percent of the population owned 98.5 percent of the agricultural land in England and Wales (Goldsmith et al. 1992, p. 133). There were many peasant revolts against enclosure and these commons were not given up without resistance. The sentiments of the peasants are well expressed in the following traditional rhyme from that era:

They hang the man and flog the woman
That steal the Goose from off the Common
but let the greater villain loose
who steals the Common from the Goose.

(Hartwick and Olewiler 1998) and many others have proposed three classes of property based on exclusivity:

(i.) private property granting the holder exclusive use of the resource;
(ii.) common property right held by a group of individuals that excludes those not in the group; and
(iii.) open access where there is a lack of property rights (Hartwick and Olewiler 1998, p. 8).

Berkes, however, considers open access is a temporary condition created often by particular forces during a relatively short historical period. Some of the pressures that led to open access included colonisation, the rise of capitalism, population growth, and the development of exploitive technology (Berkes 1985).
Conservation problems arising from open access occur most commonly in two situations. The first situation occurs when a private good exists with open access conditions. This situation is unusual since one would expect property rights to have developed. Scott contends that property rights are spontaneous social inventions. He notes the existence of well developed property rights amongst the Eskimo and cites a story about an Alaskan cannery. The cannery was closing after the summer season and the half-Eskimo winter watchmen was removing the locks from various items. When asked why, he replied that "the locks were not needed now that the Christians were gone." (Scott and Johnson 1985, p. 407). This story explains the difficulty of transient or free rider populations who do not comprehend or reject the existing tradition of communal ownership. When these situations occur property rights may not develop. In frontier situations transients or free riders are in effect plundering a resource. Current day examples include fisheries in international waters, migratory game and forests made available in remote areas where modern technology and new infrastructure has made access possible.

The second situation arises where open access exists for a mixed good. This is typically the case for water catchments where one group, farmers use water as a private good and others use the catchment for recreation.

As shown in Figure 3.4, in both the situations previously described, there is an increasing need for government intervention as property rights decrease and this especially applies to pollution of a public good under open access.

**Figure 3.4: Increasing need for government control to protect public goods**
Berkes (1985) explains that privatisation is only one solution to the commons dilemma. "A second, more common solution, is communal ownership. Here a common property resource is not ownerless (res nullius) but owned in common (res communes) by a well-defined social group, the local community. In such common property situation, exploitation is restrained and access is not free." Thus open access may be defined as a temporal condition where there is a lack of enforceable property rights which may apply to any of the three forms of property ownership, private, communal or government. Feeny et al. (1990) considered that it was necessary to amend Hardin's heuristic fable as follows: "providing the herdsman using the common could control access to the common then they would control access, and agree on rules" which would achieve the maximum sustainable yield. Commons may be considered res nullius, res publices, or res communes depending on how the commons are controlled.

Open access may occur on private property, communal property or government property if exclusion is impossible or uneconomic. Success in the regulation of uses and users is not universally associated with any particular type of property rights regime. Communal property, private property and government property have all been associated with both success and failure to achieve ESD (Feeny et al. 1990). Open access is a state of anarchy often as a result of a temporary hiatus of law and order, regulation and ownership. In a situation of open access "Individuals face a situation of the prisoners-dilemma type…each individual has a selfish interest not to contribute even though he desires the collective goal. State interference may be necessary to achieve the desired collective goal." (Tisdell 1972).

Common ownership as opposed to open access has and can deliver sustainability. Some modern commons work well and are often taken for granted. The footpath outside the suburban house is tenderly nurtured for the benefit of the whole community; however, free riders such as overhead cable TV operators have taken advantage of the airspace to the chagrin of the community. There is increasing involvement in the rehabilitation of commons in Australia exemplified by the growth of neighbourhood groups rehabilitating council parks and river catchments and the community involvement in Landcare. The extent of community care of common land is perhaps a social barometer of the well-being of a community.
Public goods have been categorised by the extent that the market fails to provide them in adequate quantities. This form of categorisation groups national defence, police forces, and government in with national parks, air and water quality and ecosystem diversity. A clear distinction can be made between a made public good such as national defence and a natural public good such as ecosystem diversity. One has to be created and the other protected from destruction. These types will be referred to as created and natural public goods as shown diagrammatically in Figure 3.5.

**Figure 3.5: Created and Natural Public Goods**

<table>
<thead>
<tr>
<th>Created Public Goods</th>
<th>Created Natural Public Goods</th>
<th>Natural Public Goods</th>
</tr>
</thead>
<tbody>
<tr>
<td>National defence</td>
<td>National parks</td>
<td>Air quality</td>
</tr>
<tr>
<td>Government</td>
<td>Marine reserves</td>
<td>Water quality</td>
</tr>
<tr>
<td>Police force</td>
<td></td>
<td>Ecosystem diversity</td>
</tr>
</tbody>
</table>

Natural public goods are most vulnerable to free rider abuse and detrimental externalities may often be present.

### 3.5.2 Externalities

An activity generates a detrimental or beneficial externality if that activity causes incidental damages (diseconomies) or benefits to others, and no compensation is provided by or paid to those who generate the externality (Baumol and Blinder 1997, p. 305). When markets fail to develop, externalities are likely to persist where exchange occurs through markets governed only by the private interest of individuals (Hartwick and Oleviler 1998, p. 182). Externalities are likely to exist in the presence of natural public goods for which property rights are weak and this is often the situation for mining. These natural public goods are often geographically large in area and available to all; nevertheless, a single individual or company can impact on the quality for a disparate group of individuals. Such disparate groups often lack information on the extent of impact and lack the ability to unite and fight for their cause as a group. This is the free rider problem where a few individuals gain at the expense of the amenity of the many.
Strip mining creates externalities. As a result of strip mining private and social costs are unequal (Randall and Grunewald 1978). It may not be possible to resolve these externalities by private negotiation. The most likely externality is river pollution. Queensland rivers have attributes of both public and private goods. Kuronuma and Tisdell define a good having both private and public attributes as a mixed good as explained by Figure 3.3 (Kuronuma and Tisdell 1993, p. 248). There is open access to Queensland rivers for recreation and the water is consumed for both potable and non potable purposes. River pollution from strip coal mining may be considered as an externality or spillover resulting from market failure. The market failure in this instance is a consequence of the public nature of the rivers and weak property rights related to water quality.

The Fitzroy catchment of central Queensland may be regarded as a mixed good that to some extent is under open access albeit with substantial barriers to entry. Although the aboriginals based their borders on the basis of communal water rights, Europeans are yet to establish a concept of communal ownership of water. With one exception all the Bowen Basin Strip coalmines are in the Fitzroy catchment. What institutional changes are required in order to protect the catchment? One solution might be to create property rights or at the very least to create communal property From the preceding analyses the river can be characterised as a mixed good and there is little likelihood of establishing communal property rights in the near future. Nevertheless one way of recognising the rights of the community in the catchment would be to create a Fitzroy catchment common with the cooperative having legal ownership and responsibility for regulating and enforcing all aspects of the river and sharing the benefits with the catchment community.

When there are possible externalities such as long-term river pollution from mining, economic theory suggests several approaches to obtain a potential Pareto improvement. Choosing a method of correcting market failure and realising potential Pareto improvements is at the core of the neo-classical debate in welfare economics. Mishan (1971) suggested the following methods:

(i) the tax-subsidy method proposed by Pigou to encourage the firm or industry to produce at the optimal level; and

(ii) creating property rights and negotiation by mutual bargaining, supported by Coase, including selling pollution permits as suggested by Dales;
(iii) government regulation of volumes of production or prohibition of spillover effects such as pollution or both as suggested by Baumol (Tisdell 1993).

Economists have been, and are still divided on the need for intervention in the economy. Classical economists such as Adam Smith were strong believers in the ability of the invisible hand to deliver economic efficiency without intervention. In contrast Robert Malthus saw a need for intervention. Adam Smith contended that an individual who intends only his own gain is led by an invisible hand to promote the public interest (Smith 1937, p. 335). Adam Smith made this particular point, however, to show that capital would be naturally and efficiently directed to the most beneficial domestic industry and hence free trade between nations should not be feared. He considered restrictive trade practices between nations to be detrimental to economic efficiency and the wealth of nations. Unfortunately, the invisible hand may not deliver either economically efficient levels of created public goods or maintain the quality of natural public goods when externalities are present.

Consider the hypothetical case of a mine which releases polluted water into the river causing fish kills and as a result reduces the catch of a downstream fisherman. The loss to the fisherman can be calculated. The fisherman may pay the mine operator to reduce pollution to a level, which will not kill fish. Providing this payment and the negotiating costs are less than the loss resulting from fish kills, there is a potential Pareto improvement. The Hicks-Kaldor principle does not, however, address the ethical issue of welfare distribution. It does not dictate that a rich mine owner should compensate the poor fisherman for the fisherman's loss of production, only that a more economically efficient state potentially exists and in the example above the mine owner may continue to pollute the river to the detriment of the poor fisherman.

Coase (1960) and the Chicago School of Economics would argue that if property rights for the stream existed then the mine or the fisherman would be able to negotiate the most efficient solution, providing the transaction cost of negotiation are not prohibitive. This school of economic thought also contends that the extent of market failure is exaggerated and that in many cases market failure can be overcome by creating conditions more favourable to market operations. They advocate the creation of private property rights rather than permitting common or open access to a resource (Tisdell 1993, p. 7). Coase
proposed that with the creation of a full set of property rights economic inefficiencies relating to externalities could be eliminated most effectively through the legal system (Coase 1960). The Coase Theorem proposes that if property rights exist and transaction costs are low, private transactions are efficient (McTaggart et al. 1996). On the other hand neoclassical economists such as Pigou and Pareto argued the need for intervention to correct externalities.

3.6 POLICY MEASURES TO IMPROVE ECONOMIC EFFICIENCY

3.6.1 Pigouvian taxes

Pigou explained that externalities create a difference between the marginal private cost to the firm and marginal social cost as a consequence of the social loss. Pigou further suggested that a tax, equivalent to the difference between the marginal private cost and the marginal social cost, at the socially optimal level of output, would internalise the externality and produce an improved economic outcome.

The Pigouvian tax is demonstrated in Figure 3.6. The industry's combined marginal production cost of good X is represented by line BT. However, the pollution externality increases the marginal social cost above BT and is represented by line BS. If AD is the marginal value of the production of good X to society then it is optimal to produce \( X_1 \) of good X instead of \( X_2 \), which is the level of production achieved by the private market. Pigou proposed that a tax equivalent to $MN would internalise the externality.

Figure 3.6: Pigouvian pollution tax (Tisdell 1993)
The weakness of the pure Pigouvian tax on product output is that a tax on industry implies that all polluters pollute equally. A tax on coal production in Queensland to reduce example acid mine drainage, for example, would impact all mines when the potential for acid mine drainage only exists at a few mine sites.

3.6.2 Property rights - the Coase approach

Coase acknowledges that the divergence between social and private cost is at the fountainhead of modern welfare economic analysis; however, he disputes the need for the taxes proposed by Pigou. As Pigou explained in *Economics of Welfare* this divergence occurs when; "one person A, in the course of rendering some service, for which payment is made, to a second person B, incidentally also renders services or disservices to other persons (not producers of like services), of such a sort that payment cannot be exacted from benefited parties or compensation enforced on behalf of the injured parties." (Coase 1960).

Pigou used the example of a real situation in Britain where a railway did not normally compensate damage by fire caused by sparks from an engine. Coase believed Pigou was recommending state intervention to correct the situation. Coase rebutted Pigou's recommendation. "Suppose that the railway is liable for damage from fires caused by sparks from the engine. A farmer on lands adjoining the railway is then in the position that, if his crop is destroyed by fires caused by the railway, he will receive the market price from the railway; but if his crop is not damaged, he will receive the market price by sale. It therefore becomes a matter of indifference to him whether his crop is damaged by fire or not." (Coase 1960). The farmer will have no incentive to protect his crop and will plant land adjoining the railway even though there is a high risk of fire. Coase contends that in the absence of negotiation, the outcome is a Pareto sub-optimal. Now the railway will be forced to negotiate an efficient outcome with the farmer, whereas previously the situation was reversed. Government intervention has not produced a more efficient outcome only changed the negotiating positions. Coase argued that, given established property rights, an efficient outcome will be achieved by negotiation irrespective of which party has the property rights. In this instance an optimal solution is reached when the maximum crop is obtained at the minimum overall cost of reducing the risk of fire. Planting fire resistant
crops adjacent to the line or reducing the production of sparks or a combination of both can reduce risk of fire damage to the crop. The most efficient outcome is achieved when both parties have sufficient rights to stimulate a negotiated outcome.

Coase was cautionary on government regulation. “It is my belief that economists and policy-makers generally, have tended to over-estimate the advantages which come from governmental regulation.” (Coase 1960). He cautioned against faulty economic analysis and commencing with the assumption of the ideal world. “A better approach would seem to be to start our analysis with a situation approximating that which actually exists, to examine the effects of a proposed policy change and to attempt to decide whether the new situation would be, in total, better or worse than the original situation…In devising and choosing between social arrangements we should have regard for the total effect.” He was seeking a solution that would maximise the value of production. Coase considered that the factors of production should be considered as rights and that “The cost of exercising this right is always the loss that is suffered elsewhere in consequence of exercise of that right, for example, the inability to cross land.” (Coase 1960).

Unfortunately the cost of negotiation may preclude the most economically efficient outcome. If large and disparate groups of people are affected over an extensive geographic area then negotiation may not eventuate and a potential Pareto improvement may not be realised.

### 3.6.3 Pollution rights

Dales advocates creating a market for pollution by issuing pollution rights to achieve an efficient outcome (Tisdell 1993). Pollution rights may be considered as a form of property right. This method overcomes the shortcomings of a Pigouvian tax on production because the pollutant is controlled rather than the output of goods which society demands. The amount of available pollution rights, as shown graphically in Figure 3.7 controls the level of pollution.
Assume the current level of pollution is E and a reduction in pollution of R is desired. Then the desired level of pollution (E-R) is achieved by issuing a quantity of pollutant rights equal to (E-R) which trade in a competitive market at price P. Thus the optimal level of pollution is achieved at the minimum cost. Since producers are likely to have differing marginal costs of abatement, each producer will decide how much to pollute and the total cost of abatement is minimised. Baumol, however, contends that a tax on the pollutant is more efficient (Tisdell 1993), because a tax can be varied until the desired level of the pollutant is achieved. Nevertheless, there first needs to be agreement on what is an acceptable level of pollution and this level may vary geographically and with density of the polluters and whether the pollutant is a fund or a stock pollutant.

If none of the options previously canvassed will deliver the potential Pareto improvement then the less desirable options of regulation or standards or banning the offending pollutant may be considered.

3.6.4 Regulation and standards

International regulation has been successful in reducing the production of chlorofluorocarbons (CFC's); however, there was alternative technology available at almost the same cost. In situations where pollution is ubiquitous and the impact crosses national boundaries and there is a significant cost penalty to be less polluting, it may prove impossible for nations to either agree on pollutant levels or enforce pollutant taxes at a reasonable cost. This situation is likely to occur in the domain of the pure public good.
with open access conditions. In these situations it may be easier to reach agreement on
regulation, especially if the externality is a threat to life. The total ban on the use of CFC's
is an example where it was easier for countries to agree on banning than Pigouvian taxes or
pollutant rights.

3.7 POLICIES APPLICABLE TO STRIP-COALMINING

The physical and psychic environmental impacts of strip coal mining result in external
costs and perhaps benefits. If these costs are not internalised by surface mine owners, then
economic inefficiencies as defined by Kaldor-Hicks will result. Economic efficiency can
be increased providing market or non-marketed methods of internalisation have costs of
administration (i.e. transaction costs in the generic sense) that are less than the otherwise
external costs (Kalt 1983).

The strip-coalmines of Queensland are large scale with individual mines typically
producing in excess of three million tonnes of coal per annum. There are less than thirty
mines in the Fitzroy River catchment and any externality may have an impact on many
thousand disparate individuals located over a large geographic area. A Coasian solution is
unlikely because there is a lack of property rights relating to river water quality and it is
difficult for the disparate group of impacted individuals to unite. In addition the impacts
from mining often occur after mining ceases and the mining company no longer has
responsibility for the surrendered mine site.

The only likely major long term impact of strip coal mining in Queensland is to the Fitzroy
River system where the current state of the water quality is low as a result of continual
degradation since European occupation. Any contingent valuation method is likely to
yield a relatively low willingness to pay to improve water quality, given the past open
access to the river system and the perception that rivers are sewers provided by nature for
disposal of any unwanted material or at best a water storage facility. On the other hand
there is an increasing awareness of the importance of river water quality and assuming this
trend continues, future generations will have an increasing desire for pristine river systems.
Placing a value on the utility of a river system for future generations is difficult and beyond
the scope of this thesis. Obtaining a value for the river system to the current generation
requires an estimate of option and bequest value and the techniques of obtaining such a value are still in their infancy in other countries and almost non-existent in Australia. Likewise attempts to measure existence value have not been successful in Australia. For these reasons cost-effectiveness analysis is considered the current pragmatic choice for economic analysis of strip-coalmine rehabilitation.

Generally the mining companies purchased the pastoral properties on which the strip coalmines of the Bowen Basin are located. Private transactions have from a Coasian viewpoint, internalised any on-site externalities. Nevertheless many of the off-site environmental costs of strip mining are not internalised by mine owners in an unregulated market. "Organization costs and free rider problems appear to be sufficient, for example, to prevent the typically large number of neighbours suffering property devaluation and aesthetic losses from effectively organizing to make Coasian payments to would-be mine operators. The infeasibility of such transactions is, of course, even more pronounced in the case of distant individuals who attach existence value to unstripped land areas. In the case of water pollution, the absence of a market in water and the prevalence of governmental allocation of water supplies often leave polluting mine operators free of the costs they impose on downstream water consumers. Similarly, many recreational amenities, game animals, and fish on both public and private lands are communally owned and are not permitted to be marketed, thus precluding or inhibiting the use of Coasian transactions by hunters, fishers, campers, and hikers. In short externalities are likely to be present to a significant degree when a land area is strip-mined." (Kalt 1983).

Whilst the private transactions between the mine owner and the previous pastoral property owner internalise externalities on the mine-site it is apparent that the invisible hand is absent off the mine-site. There is no automatic mechanism, however, which makes the control of the State perfect (Tisdell 1972). We should in an open-minded manner weigh up the evidence in each case and take account of the type of analysis and the issues (Tisdell 1991, p. 120). The choice of economic instruments for improving the management of the off-site impacts of strip coal mining should be considered on a case by case basis.
3.8 VALUING THE ENVIRONMENT

The strip-coalmines of Queensland spend an estimated $90 million each year rehabilitating the environment. Placing a monetary value on the environmental benefits of rehabilitation will enable the regulator and the miner to evaluate alternative policies. Unfortunately, in most cases environmental goods are not marketed and it is the economist's task to place a monetary value on these non-marketed environmental benefits.

The techniques used to value these non-marketed environmental benefits can be subdivided into two categories according to how the preference of the consumer is estimated. The value a consumer places on a non-marketed environmental good can sometimes be revealed by examining how much a consumer spends in order to consume the good. The cost of travel to and from National Parks reveals the value of the National Park to the consumer. The change in value of a product, for example housing impacted by an industry externality such as smoke, can reveal the cost of the externality. The former travel cost method and the latter hedonic pricing method are two of the revealed preference techniques used to establish environmental values.

If environmental values cannot be derived from revealed preferences then it is necessary to ask the consumer to state their preference in order to establish the value the consumer places on the environmental good or bad. The stated preference technique establishes the consumer's willingness to pay using techniques such as contingent valuation and random utility modelling. The value can also be estimating by transferring the value of a good that has already been estimated in a similar environment. This benefit transfer technique requires a high degree of correlation between the sites.

The various methods that have been developed for valuing the environment are listed in Table 3.2
The environmental evaluation methods listed in Table 3.2 have been used worldwide; however, the use of the stated preference techniques has been received with some scepticism in Australia as will be explained in the following section.

### 3.9 ENVIRONMENTAL VALUATION IN PRACTICE

#### 3.9.1 Environmental valuation in the United States

Techniques for measuring environmental values have been extensively used in the United States of America; however, there is not universal acceptance of the methods as illustrated in the 1985 case of the Idarado Mine in Colorado. Hexavalent chromium was discovered in two new municipal water supply wells in Telluride. The plaintiff, the State of Colorado claimed that the tailings blown from the mine had polluted the Uncompahgre River that charged the aquifer which the wells intersected.

A summary estimate of damages provided by the plaintiffs and the Idarado Mine (the defendant) follows in Table 3.3

---

<table>
<thead>
<tr>
<th>VALUING PREFERENCE</th>
<th>USE VALUE</th>
<th>USE VALUE &amp; NON-USE VALUE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Revealed preference</td>
<td>Stated preference</td>
</tr>
<tr>
<td>METHOD In order of preference VALUE</td>
<td>Market value</td>
<td>Hedonic pricing</td>
</tr>
<tr>
<td>ACTIVITY MARKET</td>
<td>Agriculture</td>
<td>Commercial Fishing</td>
</tr>
</tbody>
</table>
The defendant did not accept the use of contingent valuation and argued that there were a large number of almost perfect substitutes for recreational fishing. The plaintiff estimate of impact was as high as $150 million and the defendant estimated an impact of $0.5 million (Garrod and Willis 1999, p. 54). The largest part of this three hundred fold difference is explained by the contingent valuation of non-use values. Although Garrod and Willis claim that the differences in the plaintiff’s and defendant’s estimates relate to a difference in assumptions rather than the benefit estimating techniques Table 3.3 would indicate otherwise. The defendant in this case and the general public in Australia remain unconvinced as to the validity of contingent valuation of non-use values or even use values for that matter.

Table 3.3: Valuation methods used for the Idarado mine

**Idarado Mine case**
(Values in $US Million)

<table>
<thead>
<tr>
<th>Contingent valuation</th>
<th>Plaintiff Colorado State</th>
<th>Defendant Idarado mine</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Future Damages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Use values</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County residents</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>State residents</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td><em>Non-use values</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County residents</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>State residents</td>
<td>28</td>
<td></td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td><strong>42</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Past Damages</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Use values</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td>County residents</td>
<td>1.9</td>
<td></td>
</tr>
<tr>
<td>State residents</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td><strong>106</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>147</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Other evaluation techniques**

<table>
<thead>
<tr>
<th>Aquifer contamination</th>
<th>4</th>
<th>0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Service replacement technique</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soil contamination</td>
<td>2</td>
<td>0.3</td>
</tr>
<tr>
<td>Property value (hedonic)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recreational fishing</td>
<td>1.15</td>
<td>0.005</td>
</tr>
<tr>
<td><strong>Unit day rate</strong></td>
<td><strong>7.2</strong></td>
<td><strong>0.5</strong></td>
</tr>
</tbody>
</table>
3.9.2 *Australian experience in dealing with the externalities of mining.*

The externalities created by strip mining may be classified into those that have a direct financial impact and those that impact amenity. Externalities that have a direct financial impact include:

(i) water damage due to pollutants including sediment;
(ii) land damage to adjacent land by detrimental flora and fauna migrating from mined land and a reduction in adjacent land values because of mined land aesthetics; and
(iii) flooding as a consequence of changed hydrology and siltation.

Amenity may be decreased as a result of:

(i) reduced recreation, including swimming and fishing;
(ii) reduced aesthetics both for locals and visitors;
(iii) loss of existence for those who prefer unmined land;
(iv) loss of options; and
(v) loss of bequest value.

The last three above listed factors proved to be very significant in the case of Coronation Hill where the aboriginal claimants to the land considered mining to be a desecration of the land.

A contingent valuation survey was conducted for the Kakadu National Park Conservation Zone in 1990. The Conservation Zone was considered highly prospective for minerals and included Coronation Hill. The previously mined area of Coronation Hill had been reassessed by the current Joint Venture leaseholders to be a financially viable mining project. Those commissioned to carry out the contingent valuation study reported that Australians would be willing to pay $647 million annually for 10 years to have the Kakadu Conservation Zone included in the Kakadu National Park. This value was 55 times the annual benefit to Australia of the proposed mine (Australia Bureau of Agricultural and Resource Economics 1991). The large contingent valuation was ridiculed by protagonists of the mine and both the survey method and the interpretation of results found little acceptance (Australia Bureau of Agricultural and Resource Economics 1991). Critics felt that if the Australian adult population was considered the relevant market then, using the contingent valuation to gauge existence value requires the question to be presented in the
context of all the available options. If each adult Australian has some surplus they would be willing to spend on conservation, what percentage would they direct to the Kakadu National Park Conservation Zone? The survey’s failure to take this approach resulted in an unbelievably large contingent value. The result reflected badly on both economists in general and the contingent valuation method in particular. Many environmental valuations are commissioned by parties with a vested interest in the outcome. Researchers may be pressured into establishing values favourable to the organisation commissioning the research. Succumbing to this pressure to produce biased valuations bring into question the environmental valuation techniques as well as the environmental economics discipline (Garrod and Willis 1999, p. 367). In an attempt to reduce the possibility of bias, the World Bank and other organisations have produced guidelines for the application of cost-benefit analysis and cost-effectiveness analysis.

There have been many proposals to dam the Dawson River, a major tributary of the Fitzroy, at Taroom. The Queensland Government engaged Hyder Environmental to carry out an Impact Assessment Study for the proposed Dawson River dam and their 1997 economics report made no attempt to value the impacted environmental attributes. The 1998 supplementary report acknowledges that only primary benefits and costs, which could be valued in monetary terms, were included (Thistlethwaite 1998, p. 11). Even for such a major dam, the Government and the consultant did not attempt to place a value on the environmental attributes.

3.10 EVALUATING ENVIRONMENTAL POLICY

3.10.1 Cost-benefit analysis and cost-effectiveness analysis

Cost-benefit analysis (CBA) and cost-effectiveness analysis (CEA) are economic techniques that may be used to assist public decision-makers. CEA is a particular form of CBA. CEA assumes a certain desired outcome is required and CEA is applied to establish which action achieves the outcome with the smallest loss in well-being in the form of cost. (Kopp et al. 1997, p. 791). CEA might assume that all policies are beneficial and rank the policies on the basis of the detrimental effect the cost will have on social welfare (Kopp et al. 1997, p. 793). CBA and CEA can be either primal or dual in approach. These terms may best explained by examining two aspects of mined land rehabilitation, for example, expenditure on vegetation cover versus expenditure on catchment protection.
Figure 3.8: Budget constrained environmental expenditure

Assuming that total expenditure is constrained to an amount $E$, then how is utility maximised? The budget constraint curve for the two goods is a straight line as shown in Figure 3.8.

There are two possible ways in which CBA and CEA can be used. Firstly in the primal application, utility is maximised subject to a budget constraint as shown in Figure 3.9

Figure 3.9: Primal approach to CBA and CEA

Primal

Maximise $U(V,C)$ s.t. $E=Pv^*V + Pc^*C$
The second approach is to minimise expenditure given a chosen utility level as shown in Figure 3.10. This is known as the dual (Nicholson 1998, p. 161). The term reflects the mathematical principal of duality: any constrained maximisation problem has associated with it a dual problem in constrained minimisation. Thus assuming a consumer wishes to maximise utility given a budget restraint then the dual problem for the consumer is to minimise expenditure subject to a given level of utility (Nicholson 1998, p. 49).

Figure 3.10: Dual approach to CBA and CEA

Either method is applicable for a CBA or CEA of mined land rehabilitation; however, the question this thesis is attempting to answer is, given the current expenditure on rehabilitation, is there a better allocation of expenditure? Therefore the primal approach has been chosen.

The following review refers predominantly to the more broadly used and understood CBA; however, the comments may equally apply to CEA since it is a particular form of CBA, although CEA will only yield the same result as CBA if the benefits can be quantified. The reason for using CEA, usually, is that the benefit cannot be measured.
The critics of CBA question whether:

(i) individual well-being can be characterised in terms of satisfaction;
(ii) individual well-being can be summed to obtain aggregate well-being; and whether
(iii) it is possible to quantify the economic value of individual well-being.

The validity of preference satisfaction has been debated since Bentham. The concept of preference satisfaction and utility is fundamental to microeconomics in general and welfare economics in particular and their legitimacy is not questioned in this thesis. The second criticism is also not particular to CBA but a fundamental principle of welfare economics. The first two principles will therefore be considered as axiomatic in their application to CBA. The third criticism of placing economic values on the preference index is particular to CBA and considerable economic research has been directed at improving valuation techniques. Nevertheless, there is an acceptance of techniques designed to evaluate willingness to pay as well as an acceptance of the need for improvement in such techniques (Kopp et al. 1997, p. 788).

The conceptual challenges in calculating the economic value of individual well-being include:

(i) evaluating environmental goods which, in the main, are public goods;
(ii) quantifying the social, spiritual and psychological environmental values;
(iii) including the rights of future generations; and
(iv) determining discount rates applicable to environmental goods.

Economic valuation of use and non use environmental values is explicitly and systematically employed by the US EPA under The Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), and various other Acts. The Environmental Act, 1995 in the UK states that the Environmental Agency will take into account the likely costs and benefits of the exercise or non exercise of any power; however, this may not be a formal or rigorous CBA analysis. There is an increasing awareness and use of environmental valuation techniques in Norway, Netherlands, Germany and Switzerland; however, although providing support for environmental decision making, they do not play a crucial role in the process (Garrod and Willis 1999, p. 359). Much research is needed into the use of methods such as multi-attribute utility
theory to estimate the value of non-marketed goods in CBA. Nevertheless, there is a
danger that research in environmental valuation will seek to improve the accuracy and
robustness in explanations of non-marketed values only by making existing methodologies
more mathematically sophisticated and esoteric (Garrod and Willis 1999, p. 370).

CBA, or benefit-cost analysis as it is better known in the United States, is a well
established process for evaluating public projects. In the United States the US Flood
Control Act, 1936 initiated the practice by the US federal government. This Act required
that "the federal government should improve or participate in the improvement of
navigable waters or their tributaries, including watersheds thereof, for flood control
purposes if the benefits, to whomsoever they may accrue, are in excess of the estimated
costs." (Smith 1984). A set of guidelines, essentially for the implementation of this Act
was issued in 1950 and covered amongst other things the measurement of benefits and
costs, and interest and discount rates.

The World Bank, the Organisation for Economic Cooperation and Development (OECD)
and the United Nations Industrial Development Organisation (UNIDO) have all sponsored
cost-benefit manuals for evaluating projects in third world countries.

Executive orders relating to the consideration of the economic consequences of regulations
have been issued by every president of the United States since Jimmy Carter. *Executive
order* (EO) 12291, signed by President Reagan in 1981 was the first to codify requirements
for agencies, under the oversight of the Office of Management and Budget (OMB), to
evaluate the benefits of a proposed regulation and to show that the benefits of the proposed
regulation outweigh its costs (Kopp et al. 1997, p. 826). EO 12291 established the
dominance of CBA for evaluating regulations in the United States. This order was a
natural extension from the acceptance and application of cost-benefit analysis for
government infrastructure projects to its application for evaluating government regulation.
The order required that "Regulatory action shall not be undertaken unless the potential
benefits to society for the regulation outweigh the potential costs to society." (Smith 1984).
This clause makes a link between the use of cost-benefit analysis and the Kaldor-Hicks
criterion for judging the economic efficiency of a proposed change.
Executive Order (EO) 12866 issued by the Clinton administration in 1993 requires that benefits are to justify costs rather than outweigh them, which was a departure from the earlier EO 12291 which mandated cost-benefit analysis. The list of impacts to be considered include environmental protection, distribution and equity that can transcend economic considerations. (Toman 1999, p. 67). Nevertheless, the Clinton order still endorses CBA as a tool for helping to choose among alternative regulatory options and the 104th Congress has continually sought to legislate requirements for CBA and risk assessments (Kopp et al. 1997, p. 827). EO 12866 established the process by which the Office of Management and Budget (OMB) objectively and dispassionately reviews agency proposals to ensure they are consistent with the president's philosophy. This philosophy included:

(i) Developing alternative approaches to the traditional command-and-control regulation such as performance standards; and  
(ii) Developing rules, that according to sound analysis, are cost-effective and have benefits that justify the cost.

The OMB favours performance measures rather than command and control standards. Telling people what goals or objectives to meet, instead of how to meet them, gives both regulated entities and competitive industries the flexibility to meet the regulatory objective most cost-effectively (OMB 1996, p. 8). The OMB report went on to acknowledge that using sound economic analysis to improve regulations, such as cost-benefit analysis and cost-effectiveness analysis called for in EO 12866, is vital to generating maximum health, safety, environmental and other benefits to society from the limited resources available.

The executive order requires agencies to:

(i) assess the cost and benefits, both quantifiable and no quantifiable, of a regulation and its alternatives;  
(ii) use the best available scientific, technical and economic data when making decisions; and  
(iii) meet the regulatory objective in the most cost-effective manner possible (OMB 1996, p. 12).

In response to EO 12291, the US Environmental Protection Agency (US-EPA) with some reluctance, adopted the cost-benefit approach of evaluating regulation and developed a twenty page cost-benefit manual with numerous appendices; however, the manual is not as
comprehensive as the UNIDO manual. The US-EPA main criticism was not so much of the CBA technique itself but the lack of guidelines for using the technique and the lack of scientific data on which to assess the benefits of regulation.

3.10.2 Application of CBA in the coalfields of Britain

Whilst the coalmines in the Bowen Basin are continuing to expand and new mines being opened, many of the coalmines in the Carboniferous Basin of Europe, which fuelled the Industrial Revolution, are now abandoned or contemplating closure. British coalmines were and are dominantly underground and the coal mined has a relatively high sulphur content. "In 1950 the UK had 1,800 working coalmines; now the figure is 30! The frightening lesson from the coalfields is that although the waters from the working coalmines are but moderately saline…and typically contain only 2mg/l total dissolved iron and therefore deposit little or no ochre, after closure the water table rebound may produce very acid, polluting waters with high iron content." (Evans 1997). Evans calls this phenomenon nature's revenge, for as Britain kills its coalfields, their corpses bleed brown iron oxides into the surrounding streams. These mines have generally been deep underground mines of which the collieries of Durham in England are a typical example.

"During the last three centuries, the natural ground water flow regime within the coal measures in County Durham has been extensively modified to expedite deep mining. The current dewatering scheme involves pumping about 105ML/day from mine pumping stations in the exposed coalfield. Recharge into this area of the coalfield is approximately equal to the combined pumping rate of these nine stations…Recent closures of these collieries has removed the need for continued dewatering. However, abandonment of the established pumping network will lead to the development of high acidity and high heavy metal loadings in the groundwater as the water table rises and oxidised remnants of pyrite are dissolved." (Younger and Harbourne 1995).

As the mines flood the groundwater will emerge into the River Wear, reaching its maximum flow in 30 to 40 years. Once the mine-water begins to discharge it is expected to be many decades before water quality improves to an acceptable level. The conclusion is that the water emanating from the mine following flooding is at its worst immediately after the water first begins to flow. For mined systems of all sizes, it is safe to assume that, after the water begins to flow it is at its worst quality and there follows an approximately
exponential improvement until an asymptote (of around 10 mg/l of iron) is reached after approximately 40 years. It should be noted that the asymptotic value of around 10 mg/l of iron is still high enough to cause significant staining in receiving waters for all but the largest streams (Younger 1997). Younger carried out a cost-benefit analysis comparing the options of pumping or not pumping and concluded, "the cheaper option over a 100 years would be to maintain the current dewatering scheme." (Younger and Harbourne 1995). In this instance generations past have created a debt which has to be paid by future generations. As stated earlier in this chapter irreversible damage to rivers and large ecosystems will be considered unjust and not in accord with the ESD vision. Nevertheless, these same coalfields fuelled the industrial revolution that in time produced a significant increase in the well-being of all Britons.

3.10.3 Application of CBA in the coalmines of the USA

In examining the *Costs and Benefits of Federal Regulation of Coal Strip Mining*, Kalt valued the external costs of strip coal mining in three regions in the United States. The results presented in Table 3.4, although they may not be directly transferable to the Queensland strip coalmines, help serve as a guide to the possible range of impacts.

Table 3.4: Comparison of the cost of externalities in US mining regions

<table>
<thead>
<tr>
<th>Externality</th>
<th>Appalachia $US</th>
<th>Midwest $US</th>
<th>West $US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water damage</td>
<td>0.1</td>
<td>0.06</td>
<td>0.01</td>
</tr>
<tr>
<td>Land Damage</td>
<td>1.42</td>
<td>0.75</td>
<td>0.01</td>
</tr>
<tr>
<td>Flooding</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reduced recreation</td>
<td>0.53</td>
<td>0.22</td>
<td>0.04</td>
</tr>
<tr>
<td>Reduced aesthetics (local)</td>
<td>1.08</td>
<td>0.31</td>
<td>0.04</td>
</tr>
<tr>
<td>Reduced aesthetics (non-user)</td>
<td>1.26</td>
<td>2</td>
<td>0.93</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4.49</strong></td>
<td><strong>3.34</strong></td>
<td><strong>1.03</strong></td>
</tr>
</tbody>
</table>

Of significance is the percentage impact of aesthetics, which is shown in Table 3.5 (Kalt 1983).
Table 3.5: percentage contribution of externalities in US mining regions

<table>
<thead>
<tr>
<th>Externality</th>
<th>Appalachia $US</th>
<th>Midwest $US</th>
<th>West $US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water &amp; flood damage</td>
<td>4%</td>
<td>2%</td>
<td>1%</td>
</tr>
<tr>
<td>Land Damage</td>
<td>32%</td>
<td>22%</td>
<td>1%</td>
</tr>
<tr>
<td>Reduced recreation</td>
<td>12%</td>
<td>7%</td>
<td>4%</td>
</tr>
<tr>
<td>Reduced aesthetics</td>
<td>52%</td>
<td>69%</td>
<td>94%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Aesthetic value exceeds 50% of the total value in all sites. In both this example and for Coronation Hill the largest costs relate to a non-material value. The strip mines in the Powder River Basin of Wyoming are located in areas no dissimilar topographically to Queensland's Bowen Basin, however the ratio of overburden to coal is less in the Wyoming mines.

The introduction of the *Surface Mining Control and Reclamation Act of 1977* (SMCRA) in the United States increased the price of coal by approximately 2%. The cross elasticity of oil demand with respect to coal prices is 1.0 in the United States and therefore oil demand was expected to increase by 2%, (Kalt 1983). Consequently imported oil was expected to replace domestically produced coal; however, the reduction in mining costs in the Powder River Basin and the reduction in rail freight rates resulted in coal being shipped across America from west to east. The intent of the SMCRA is that strip-mined land be returned to its pre-mining state. This was less of a cost for the newly opening mines in the Powder River Basin of Wyoming because overburden ratios were lower than for the Appalachian mines, where the terrain was more undulating and overburden ratios higher. In his analysis of the costs and benefits of the Federal regulation of coal strip mining, Kalt concluded that the SMCRA worsened the allocation of resources nationally and that the impact of the was regressive. This was because the consumption of outdoor recreational amenities is positively correlated with income and more importantly because electricity consumption is strongly income inelastic. "As individuals move down the income scale, they generally want to fill their consumption baskets with more of the commodities produced from natural resources and less of the amenities produced from a clean environment" (Kalt 1983) and the converse applies. The proposition (Kalt 1983) that the poor generally want to fill their
consumption baskets with more of the commodities produced from natural resources and less of the amenities produced from a clean environment accords with Pigou who contended that an individual's preference for a particular good will depend on their marginal utility of income. "Pigou's law of diminishing utility of income states that as a person's income increases absolute wants are more nearly satisfied, leaving only the relative and less important remaining. Thus while absolute utility continues to increase it will do so less proportionally and hence marginal utility will begin to fall." (Vinnicombe 1990).

3.10.4 The environmental value of rehabilitation in Queensland's strip coalmines

Environmental protection is now a primary consideration when evaluating the feasibility of any mining project in Australia or when considering the purchase of a new mine. Environmental objectives; however, are not clearly defined and the method selected for protecting the environment will often depend on the disciplinary area of those carrying out the environmental protection (Mulligan 1996). Environmental regulation in Queensland has focussed environmental protection efforts in strip coalmines on rehabilitating spoil dumps for grazing purposes and media and environmental lobby groups have reinforced this agricultural focus. Regulators have had little option but to continue on this path whilst attempting to direct regulation toward managing environmental risk. Recommendations for a holistic, ecological approach, with integrated legislation dealing with drainage catchments and land management are gaining support (Mulligan 1996); however, this is not reflected in current legislation.

International evidence indicates that one of the most significant values of rehabilitating strip-coalmines flows from improved water quality and stream hydrology. River water quality is therefore important in any cost-benefit analysis. The Bowen Basin coalmines are located almost exclusively within the catchment of the Fitzroy River as shown in Figure 3.11. The Fitzroy river system, with a catchment of nearly 150,000 km², is the second largest in Australia and the largest of the easterly flowing catchments. The five major sub-basins that make up the catchment are the Connors/Isaac, Nogoa, Comet, Dawson, and Mackenzie River system (Noble et al. 1996). The dominant primary industries within the catchment are coalmining, magnesite, nickel and historically gold and copper mining, grazing, dryland cropping, irrigated cotton and horticulture.
Figure 3.11: Fitzroy catchment

Source: (Department of Natural Resources 1998)
International studies previously discussed show a public willingness to pay for clean rivers. There is a probability that strip coal mining will impact on the river catchment but what is the risk of environmental damage to the catchment?

3.11 INCORPORATING RISK

CBA compares the distribution of net benefits. Where the benefits and costs are subject to the risk of certain events occurring and these events have a know probability of occurrence the utility of these net benefits might be weighted by their likelihood of occurrence and summed. The structure of this utility function is dependent on the reference groups perception of risk. Critics argue that individuals often have a poor perception of risk and often underestimate low-probability, high consequence events in particular (Kopp et al. 1997, p. 821).

Proper assessment of risk is best made by persons with full information regarding the probability and consequence of the risk event occurring. There is a reasonable argument that informed experts should carry out such risk assessments. Such informed experts are better positioned to differentiate between individual and population risk (Kopp et al. 1997, p. 822). In the particular case of strip coalmining an expert would be in a better position to judge the impact of all mines on the total river catchment as opposed to an individual resident who would be more concerned about individual nearby mines impact on a local stream.

Damage to water courses may occur after mining ceases. Risk analyses are required to determine the risk of such potential. In the past regulation has focussed on land rehabilitation. Future legislation needs to take a risk based approach to mining; however, this task is difficult if environmental legislation does not clearly define the environmental attributes to be protected. Kopp et al. argue that risk assessment is a subset of benefit analysis and is needed to quantify the relationship between pollution exposure and population or ecological response. Economists and expert risk assessors together are needed to address how to give appropriate attention to lay perceptions of risk (Kopp et al. 1997, p. 843). The issue of risk is more fully explored in Chapter 5 and introduced here, along with the concept of expert focus groups, as an insight into the fieldwork presented in Chapter 4.
3.12 **FOCUS GROUPS**

Contingent valuation surveys may often be preceded by discussions with focus groups of approximately 8 people for a period of up to two hours. These groups can provide insights into the likely understanding of and attitude towards the environmental issue being investigated and provide valuable information in framing the questionnaire for the contingent valuation survey (Garrod and Willis 1999, p. 133). To overcome the lack of cardinal values of non-marketed environmental goods, focus groups have been used to produce an ordinal index of the environmental attributes. This approach may have met favour with the economist Frederic Bastiat who considered that economics was the study of human action and should be explained that way. He may not have been so impressed with attempts to place a value on the environment as he believed that the desires of market participants could not be weighed or measured and that exchange was necessary in order to determine value. (Bastiat 1964, p. 35). He did, however, consider that a good economist must take into account not only those effects, which are immediately obvious, but also those effects that must be foreseen and environmental value can be classed in the category that must be foreseen. In Chapter 4 methods which attempt to foresee the value of environmental attributes are presented.

3.13 **THE PATH THAT LED TO CBA AND EVENTUALLY CEA**

Critics argue that CBA is limited by the empirical problems encountered in quantifying economic value. Whilst recognising these limitations adherents argue it offers the advantages of transparency and accountability and a constant framework for identifying gaps and uncertainty of knowledge. The use of the money metric makes it possible to aggregate dissimilar effects such as aesthetics into one measure of net benefits (Kopp et al. 1997, p. 788). The latter advantage, along with the knowledge that there are few plausible alternatives, explains its international acceptance. Nevertheless, CBA is difficult to apply to mine rehabilitation because of the lack of know money values for protecting and enhancing the environmental attributes.

A cost-benefit analysis attempts to identify all the effects of a project on the individual welfare of all members of the community. All these effects must be measured in some common unit so that aggregate benefits can be compared with aggregate costs. "There are various ways in which one might set about identifying, measuring and comparing changes
in people's welfare. One particular system of dealing with welfare changes lies at the heart of cost-benefit analysis. This is the potential Pareto improvement criterion. In the language of welfare economics, a change that makes one member of a community better off and makes none worse off is a Pareto improvement." (Sugden and Williams 1978). The potential Pareto welfare improvement, or compensation principle, or Hicks-Kaldor compensation principle is central to cost-benefit analysis. It is the justification for choosing projects whose benefits outweigh their costs. The excess of benefits over costs is called the project's net benefit (Perkins 1994). Cost-benefit analysis is a universally accepted tool for measuring the potential Pareto improvement.

A summary of the chain of events which lead to cost-benefit analysis can be represented by the face of a clock are as shown in Figure 3.12. The most market orientated and least cost institutional changes are earliest on the clock

**Figure 3.12: Preferred economic approaches to correct market failure**

Unfortunately the nature of the externalities created by strip coalmines in the Bowen Basin of Queensland preclude the options which economists consider most efficient. Alternative economic options, which might be considered for the most likely off-site impact, stream pollution, are limited because of a lack of property rights and scientific data. Taxing
production impacts possible polluters and non polluters equally without necessarily reducing pollution. Taxing pollution if it were feasible would be costly to administer and does not address the main concern of possible pollution after mining ceases.

Aesthetic value was shown to be the largest cost externality in the United States; however, no attempt appears to have been made to survey residents in the vicinity of the Bowen Basin strip-coalmines in order to place a value on the aesthetics of strip-mined land. There is a probability that the mined land may cause damage to the Fitzroy catchment and if this were to occur then this may result in far greater environmental damage than the localised damage of the mined land which is relatively small in area. Unfortunately the available data is insufficient data to place a value on either the aesthetics of mined land in the Bowen Basin or water quality in the Fitzroy catchment. It was beyond the resources of this thesis to establish the value of these environmental attributes. For this reason CEA, a form of CBA, will be used to justify the thesis that coalmine rehabilitation and environmental protection expenditure should have as its primary objective the long-term protection of the associated river system.
ACF. 2000. ACF's Assessment of the Natural Heritage Trust, Melbourne.


Vice-Chancellors. 2000. Key Statistics - University Funding and Expenditure on Australian Universities. Committee of Australian Vice-Chancellors, Canberra.


The task of developing environmental standards in the absence of an agreed Government vision was akin to the albatros which was hung about the the ancient mariner's neck. Accepting the Government vision of ESD and setting goals to achieve this vision may free the new regulator, the EPA, from the albatros. However, there is an important next step before that albatros falls. The regulator has to inform the miner of the relative value of the environmental attributes to be protected or enhanced. The miner, in turn, has an obligation to work with the regulator to develop strategies to achieve the then clearly defined goals. The miner should then be free to develop cost-effective tactics in line with the agreed strategies. The fieldwork described in Chapter 4 outlines a way of progressing from the
ideal of protecting or enhancing environmental attributes generally, to making the practical
decision as to what attributes are most important and in most need of protection.

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4 FIELDWORK AND ANALYSIS

4.1 RESEARCH METHODOLOGY

The social science of economics, like other sciences, distinguishes between positive and normative statements. Positive economics examines the real world to discover how it works, whereas normative economics makes value judgements as to how the world should work. The distinction between a positive and a normative statement may be explained by referring to the debate on greenhouse gasses. Burning of fossil fuels increases the amount of the greenhouse gas CO$_2$ in the atmosphere. This is both a scientific fact and a positive statement. That we ought to reduce our use of fossil fuels is a normative statement (McTaggart et al. 1996, p. 9). Positive arguments make no value judgments and conclusions reached through positive analysis are either right or wrong. Normative arguments are based on judgement. It is impossible to say which of the normative arguments is right (Holcombe 1996, p. 39). In this thesis cost-benefit analysis is used to compare the current rehabilitation process against alternative proposed approaches of rehabilitation of strip-coalmines in Queensland. The positive economic approach aligns with the philosophical approach proposed by Coase (McTaggart et al. 1996, p. 487) of commencing with what is in preference to what ought to be. This thesis commences by taking a positive economic standpoint and examines the existing situation as the starting point rather than presupposing there is an ideal state with an ideal economic solution. Nevertheless, because of a lack of economic data, it may be necessary to base environmental decisions on value judgements. This was found to be the case in this analysis and consequently both positive and normative arguments are presented.

There were two phases in the research, which may be classified into the categories of positive and normative economics. The first phase included a cost-benefit analysis, which was carried out as partial fulfilment of a Postgraduate Diploma in Applied Economics at the University of Queensland. Extracts of that work are included in this thesis; however, ideas and concepts have been extended with the additional knowledge gained. This first phase will be defined as the cost-benefit phase. In the second phase the normative arguments are presented and this will be defined as the cost-effectiveness phase. Finally alternative economic and institutional arrangements that may produce a more efficient economic outcome are considered and actions necessary to achieve a more efficient outcome recommended.
4.2 COST-BENEFIT ANALYSIS PHASE

A cost-benefit analysis of mined land rehabilitation of strip-coalmines in Queensland is used to *predict* the pattern of resource use by the private market, to *evaluate* the economic efficiency of that pattern, and to *prescribe* public policies which will result in a pattern of resource use which leads to a higher level of economic welfare.* (Campbell 1999, p. 20).

This thesis focuses on the strip-coalmine spoil piles and immediate environs. Other features of the mines, such as tailings dams and mine buildings, which may require rehabilitation or removal, have been excluded from the scope of the thesis. The greatest percentage of rehabilitation expenditure on the strip-coalmines relates to the rehabilitation of spoil piles and the exclusion of these other features does not alter the economic argument. Conversely the approach, which is about to be explained, could equally be applied to these other features.

In order to avoid the dilemma of using confidential information, a typical or generic Bowen Basin strip-coalmine and grazing property are described. Economic models are then developed for the generic strip-coalmine and the generic grazing property for the cost-benefit analysis. The economic models were run using discount rates ranging from zero to 20 percent in five percent increments. The possible environmental impacts are reviewed qualitatively, taking account of the current debate regarding the rehabilitation of strip-coalmines. The possible environmental benefits are listed and ranked; however, there has been no attempt to quantify the economic benefits of rehabilitation. Nor has any attempt been made to quantify the value of the environment or to address the vexing question of the appropriate discount rate for recreational areas. The cost-benefit analysis examines the financial impact of changes in environmental spending on the citizens of Queensland who are defined as the referent group. The other related parties are the Australian Commonwealth Government, a generic Bowen Basin mining company and a generic Bowen Basin pastoral company.

The quantifiable transaction flows between these groups are shown diagrammatically in Figure 4.1; however, except for sales, private commercial transactions have not been shown and nor have government regulatory costs been shown.
4.2.1 Data collection

In the initial phase of data collection five strip-coalmines, Blackwater, Curragh, Gregory, Oakey Creek and South Blackwater were visited and selected personnel surveyed by personal interview in order to gain an understanding of mining and rehabilitation methods and costs. The mines are located in the southern half of the Bowen Basin as shown in Figure 1.2. The purpose of these initial visits was to identify the stakeholder groups, understand the environmental issues and actions necessary to address these issues and to obtain an estimate of the cost of the various elements of rehabilitation. The intention was to interview separately the Mine Manager, the Technical Services Manager and the Environmental Officer. Individual interviews reduce the risk of responses being unduly influenced by those in more senior positions within the company. This approach also allowed more senior people to respond frankly. An extensive questionnaire was developed and a sample of the questions is shown in Table 4.1
Table 4.1: Selected questions from the Mine Visit Questionnaire

MINE VISIT QUESTIONNAIRE

MINE SITE DESCRIPTION:
MINE DESIGN:
CLIMATE:
WATER QUALITY REQUIREMENTS:
MINE WATER QUALITY RANGE:
TOPOGRAPHIC SETTING OF MINE SITE:
ECO-SYSTEM SETTING OF MINE SITE:
WHAT DO YOU PERCEIVE ARE THE KEY ISSUES OF STAKEHOLDERS?
NATURE AND COMPOSITION OF SPOIL:
LAND USE (PRE-MINING, SURROUNDING AND POST-MINING):
CURRENT SPOIL REHABILITATION STATUS:
REHABILITATION STRATEGY:
WHAT ARE YOU DOING TO PREPARE FOR CLOSURE?
MAINTENANCE OF REHABILITATION:
HOW WELL IS THE SPOIL REHABILITATION WORKING?
HOW WELL IS THE SURFACE WATER DIVERSION WORKING?
ONSITE IMPACTS:
OFFSITE IMPACTS:
How would you rank the following potential causes of offsite impacts from spoil areas on the logarithmic scale 1 = 1 in 1,000 (unlikely during the operating lifetime of the mine), 2 = 1 in 100 (possible), 3 = 1 in 10 (likely)?

1. Aesthetics: ______________________________
2. Slope instability: __________________________
3. Piping failure: ___________________________
4. Excessive erosion: ________________________
5. Excessive settlement: _____________________
6. Mobilisation of solids in runoff: ___________
7. Mobilisation of dust: _____________________
8. Mobilisation of salts: ____________________
9. Acid mine drainage: _____________________
10. Dissolved heavy metals: __________________

REHABILITATION COSTS:

There was a subset of questions for each of the major topics listed in Table 4.1. Some topics required the respondent to make a judgement, an example of which is shown in the penultimate question on off-site impacts.
4.2.2 The generic mine

Although mining and rehabilitation cost estimates were received from individual mines, these costs are considered confidential for commercial reasons. Nevertheless, strip-coalmines in the Bowen Basin are sufficiently similar that a generic mine, encompassing the features most typical to the Bowen Basin mines, would be more representative than considering any particular mine. The advantages of creating a generic mine model are two fold; firstly it enables the pertinent features of all mines to be included, whilst excluding mine specific features which are not so relevant to the cost-benefit analysis, and, secondly, it overcomes the problem of releasing mine specific confidential information.

The rehabilitation cost estimates used in the model were derived from costing data supplied during the mine visits and from (Williams 2001, p. 112), (Goh 1998, p. 6-15). A composite of the information from these sources is shown in Table 4.2.

Table 4.2: Rehabilitation cost as used in the mine model

<table>
<thead>
<tr>
<th>Item</th>
<th>Unit rate $/hectare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recontouring box-cut spoil - 15% slope</td>
<td>19,000</td>
</tr>
<tr>
<td>Recontouring dragline spoil - 17% slope</td>
<td>15,000</td>
</tr>
<tr>
<td>Recontouring haul-ramps - 27% max</td>
<td>30,000</td>
</tr>
<tr>
<td>Drainage trenches</td>
<td>3,000</td>
</tr>
<tr>
<td>Topsoil placing</td>
<td>4,500</td>
</tr>
<tr>
<td>Seeding &amp; fertilising</td>
<td>1,500</td>
</tr>
<tr>
<td>Maintenance - five years</td>
<td>2,500</td>
</tr>
<tr>
<td><strong>Conventional strip-coalmining</strong></td>
<td></td>
</tr>
<tr>
<td>Average recontouring and drainage cost</td>
<td>19,000</td>
</tr>
<tr>
<td>Average other cost</td>
<td>7,000</td>
</tr>
<tr>
<td>Average total cost</td>
<td>26,000</td>
</tr>
<tr>
<td><strong>Strip-coalmining with prestripping</strong></td>
<td></td>
</tr>
<tr>
<td>Average recontouring and drainage cost</td>
<td>9,000</td>
</tr>
<tr>
<td>Average other cost</td>
<td>7,000</td>
</tr>
<tr>
<td>Average total cost</td>
<td>16,000</td>
</tr>
</tbody>
</table>
The majority of the Bowen Basin strip-coalmines have been operating for over 10 years and most have changed ownership; Moura and Burton Downs, South Blackwater, German Creek and Curragh coalmines only recently. The first large strip-coalmine was the Moura mine, which commenced exporting in 1965. There have been to date three major expansions in mine development, the first expansion commencing with the CQCA mines in 1968, the second expansion commencing in 1979 and the last expansion commencing in 1990. For the earlier developed mines, which have the same ownership, the original capital cost may be disregarded as the construction costs would have been fully depreciated and only capital for replacing equipment is relevant. Nevertheless, since many mines have changed ownership recently, it is logical to include the purchase price in the model.

The generic mine is assumed to be a recently purchased operating mine. The new owner paid $400 million in 2000 plus an agreed inventory price estimated to be five million dollars. In the period 1998-2000 several mines changed hands at prices between $50 million and $100 million per one million saleable tonnes. It is assumed that all equipment has recently had major rebuilds and is in good working order. These rebuilds were classed as capital expenditure and consequently the capital cost amount of $50 million will be depreciated over 10 years. An amount of $200 million is borrowed from a foreign bank and the remaining purchase price will come from the buyer's own funds. These assumptions enable the cost-benefit analysis to focus on the last ten years of the mine's life whilst ignoring the mine's past history.

The geographic features of the generic mine are also simplified by assuming that all spoil piles except the last spoil pile built and the box-cut spoil have been rehabilitated. The new owners have liability for rehabilitating this spoil pile and any more they create as well as the haul roads and the box-cut spoil. The analysis considers only the spoil pile and haul road rehabilitation and excludes any other rehabilitation costs which might result from rehabilitating tailings dams and dumps or the demolition or removal of mine infrastructure.
The generic Bowen Basin strip-coalmine (GB’s mine) will have the following characteristics:

**Geography**
- Annual rainfall: 600 mm
- Annual evaporation: 1200 mm
- Location: 250 km by rail to port

**Geology**
- Single coal seam: 3m thick
- First strip at: 15m depth
- Dip of coal: 2.5°

**Mine design**
- Strip length: 3,600 m
- Number of pits: 6
- Current depth to coal: 35 m
- Number of draglines: 3

Coal production from strip-coalmines is limited by the capacity of the draglines to remove overburden. Current best practice for overburden productivity is about 20 million cubic metres moved per annum. The mine has three draglines with each dragline working two pits. Each year therefore 10 million cubic metres of overburden will be removed to spoil in each pit. For simplicity it is assumed that all pits are currently mined to 35 metres depth. The maximum digging depth for the dragline is assumed to be 45 metres and the overburden in excess of 45 metres depth is removed by prestripping equipment. Details of the design of one of these pits and the relevant parameters are shown in Figure 4.2
Using the parameters set out in Figure 4.2 the volume of overburden, which must be removed by the dragline in order to expose the coal in the first strip, can be calculated. These calculations are shown in Table 4.3.
Table 4.3: Overburden and coal in a single mining strip

<table>
<thead>
<tr>
<th>First strip mined in economic model</th>
<th>Overburden</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incremental wedge area W*d/2</td>
<td>= 77 m²</td>
<td></td>
</tr>
<tr>
<td>Remaining cross section area W*D1</td>
<td>= 2,100 m²</td>
<td></td>
</tr>
<tr>
<td>Total cross section area A1</td>
<td>= 2,177 m²</td>
<td></td>
</tr>
<tr>
<td>First strip volume V1</td>
<td>= 7,835,966 m³</td>
<td></td>
</tr>
<tr>
<td>Incremental volume W<em>d/2</em>S</td>
<td>= 275,966 m³</td>
<td></td>
</tr>
<tr>
<td>True thickness Tc = t*Cosφ</td>
<td>= 2.997 m</td>
<td></td>
</tr>
<tr>
<td>Area of coal Ac = 180 m²</td>
<td>= 647,383 m³</td>
<td></td>
</tr>
<tr>
<td>Coal volume Vc =</td>
<td>= 0.88 t x 10^6</td>
<td></td>
</tr>
<tr>
<td>Coal mass Mc =</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Assuming a constant dip of the coal seam, the volume of overburden in each subsequent strip will increase by an amount equal to the area, represented by the incremental wedge in Figure 4.2, multiplied by the length of the strip. The amount of coal exposed remains constant in each strip. The amount of overburden removed annually also remains constant because it is restricted to the capacity of the draglines. Therefore, the amount of coal mined each year reduces. However, once the pit depth reaches 45 metres the top layer of overburden will be removed by prestripping equipment so that the maximum dragline digging depth does not exceed 45 metres. From this time on the volume of coal mined annually is constant. The coal is extracted by front-end-loaders or shovels that load the coal trucks.

Most of the mining costs relate to the total material removed rather than the coal mined; consequently, the cost to produce a tonne of coal increases each year. This is the nature of mining; each year less product is produced for the same effort until the mine is no longer profitable.

The generic model has assumed three draglines will operate in six pits. The total overburden removed each year is 60 million cubic metres as shown in Table 4.4; however, the tonnes of run of mine (ROM) coal decreases from 5.2 million tonnes in the first year to four million tonnes in the tenth year.

The following productivity and production costs and coal prices have been taken from various sources including (Coxhead and Smith 2000), (ABS 2000) and personal communications during the numerous mine visits.
Table 4.4: Annual coal production

<table>
<thead>
<tr>
<th>Generic Bowen Basin strip-coalmine (GB's mine) - Production</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Pits</td>
</tr>
<tr>
<td>Rail distance from port</td>
</tr>
<tr>
<td>Rail rate - cents/t kilometer</td>
</tr>
<tr>
<td>Rail rate - $/t</td>
</tr>
<tr>
<td>Employee productivity</td>
</tr>
<tr>
<td>Average wage</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal mined (ROM)</td>
<td>tonnes x 10$^6$</td>
<td>5.2</td>
<td>5.0</td>
<td>4.9</td>
<td>4.7</td>
<td>4.6</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.5</td>
<td>4.7</td>
<td>47</td>
</tr>
<tr>
<td>Coal mined volume</td>
<td>m$^3$ x 10$^6$</td>
<td>3.8</td>
<td>3.7</td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>3.3</td>
<td>35</td>
</tr>
<tr>
<td>Area mined per pit</td>
<td>Ha</td>
<td>21.2</td>
<td>21.2</td>
<td>20.5</td>
<td>19.9</td>
<td>19.3</td>
<td>18.8</td>
<td>18.6</td>
<td>18.6</td>
<td>18.6</td>
<td>18.6</td>
<td>193</td>
</tr>
<tr>
<td>Total area mined</td>
<td>Ha</td>
<td>127</td>
<td>127</td>
<td>123</td>
<td>119</td>
<td>116</td>
<td>113</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>112</td>
<td>1,155</td>
</tr>
<tr>
<td>Topsoil depth/volume</td>
<td>m$^3$ x 10$^6$</td>
<td>0.2</td>
<td>0.3</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
<td>2</td>
</tr>
<tr>
<td>Prime overburden</td>
<td>m$^3$ x 10$^6$</td>
<td>7.7</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>46.2</td>
<td>462</td>
</tr>
<tr>
<td>Total dragline overburden</td>
<td>m$^3$ x 10$^6$</td>
<td>10.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>60.0</td>
<td>600</td>
</tr>
<tr>
<td>Total prestrip</td>
<td>m$^3$ x 10$^6$</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.3</td>
<td>0.5</td>
<td>0.7</td>
<td>0.9</td>
<td>3</td>
</tr>
<tr>
<td>Total coal &amp; overburden</td>
<td>m$^3$ x 10$^6$</td>
<td>63.8</td>
<td>63.7</td>
<td>63.6</td>
<td>63.5</td>
<td>63.4</td>
<td>63.3</td>
<td>63.3</td>
<td>63.3</td>
<td>63.3</td>
<td>63.3</td>
<td>635</td>
</tr>
<tr>
<td>Washery Yield</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Coking Coal Proportion</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
<td>75%</td>
</tr>
<tr>
<td>Steam Coal Proportion</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
<td>25%</td>
</tr>
<tr>
<td>Coking Coal Production</td>
<td>tonnes x 10$^6$</td>
<td>2.92</td>
<td>2.82</td>
<td>2.73</td>
<td>2.65</td>
<td>2.58</td>
<td>2.56</td>
<td>2.56</td>
<td>2.56</td>
<td>2.56</td>
<td>2.56</td>
<td>26.5</td>
</tr>
<tr>
<td>Steam Coal Production</td>
<td>tonnes x 10$^6$</td>
<td>0.97</td>
<td>0.94</td>
<td>0.91</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>0.86</td>
<td>8.8</td>
</tr>
<tr>
<td>Total Production</td>
<td>tonnes x 10$^6$</td>
<td>3.89</td>
<td>3.76</td>
<td>3.64</td>
<td>3.54</td>
<td>3.44</td>
<td>3.41</td>
<td>3.41</td>
<td>3.41</td>
<td>3.41</td>
<td>3.41</td>
<td>35.3</td>
</tr>
</tbody>
</table>

As is generally the case in the Bowen Basin mines two products are sold, a coking coal for use in steel making and a thermal coal for heating, typically for power stations. During washing waste material is rejected, reducing the volume of coal for sale. The model assumes 25% of the ROM coal is rejected.

4.2.2.1 Production costs and revenue of the generic mine

For simplicity most costs are captured in three categories, overburden removal, coal extraction and coal washing. All other mining and processing costs have been shown under the single category of mine services.

Rehabilitation has been shown under a separate category. This is appropriate as many mines carry out rehabilitation under a separate contract and do not employ mining company labour or equipment other than in a supervisory role. Marketing is usually carried out remote from the mine site and is not volume dependent. In fact the marketing effort may increase as tonnes decrease. Buyers may be reluctant to commit to buying from
a mine nearing the end of its economic life because there is a risk that coal supply commitments may not be honoured.

Table 4.5: Production costs

<table>
<thead>
<tr>
<th>Mining costs</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clear &amp; Topsoil</td>
<td>$2.30</td>
<td>0.6</td>
<td>0.6</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>0.5</td>
<td>$2.30</td>
</tr>
<tr>
<td>Overburden</td>
<td>$0.35</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>21.0</td>
<td>$0.35</td>
</tr>
<tr>
<td>Prestrip</td>
<td>$1.70</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.2</td>
<td>0.6</td>
<td>0.6</td>
<td>1.2</td>
<td>1.6</td>
<td>3.0</td>
<td>$1.70</td>
</tr>
<tr>
<td>Coal removal variable</td>
<td>$0.75</td>
<td>3.9</td>
<td>3.8</td>
<td>3.6</td>
<td>3.5</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>3.4</td>
<td>$0.75</td>
</tr>
<tr>
<td>Coal removal fixed</td>
<td></td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>$4.0</td>
</tr>
<tr>
<td>Sub total - mining</td>
<td></td>
<td>38.7</td>
<td>38.6</td>
<td>38.4</td>
<td>38.3</td>
<td>38.2</td>
<td>38.1</td>
<td>38.1</td>
<td>38.1</td>
<td>38.1</td>
<td>38.1</td>
<td>$38.7</td>
</tr>
<tr>
<td>Coal Processing costs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>$0.0</td>
</tr>
<tr>
<td>Crushing Cost</td>
<td>$0.60</td>
<td>3.1</td>
<td>3.0</td>
<td>2.9</td>
<td>2.8</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>2.7</td>
<td>$0.60</td>
</tr>
<tr>
<td>Processing variable Cost</td>
<td>$2.00</td>
<td>10.4</td>
<td>10.0</td>
<td>9.7</td>
<td>9.4</td>
<td>9.2</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>9.1</td>
<td>$2.00</td>
</tr>
<tr>
<td>Processing fixed Cost</td>
<td></td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>5.0</td>
<td>$5.0</td>
</tr>
<tr>
<td>Sub total - Coal Processing</td>
<td></td>
<td>18.5</td>
<td>18.0</td>
<td>17.6</td>
<td>17.3</td>
<td>16.9</td>
<td>16.8</td>
<td>16.8</td>
<td>16.8</td>
<td>16.8</td>
<td>16.8</td>
<td>$18.5</td>
</tr>
<tr>
<td>Mine services</td>
<td>$0.35</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>22.3</td>
<td>$2.233</td>
</tr>
<tr>
<td>Total mining &amp; processing</td>
<td>79.5</td>
<td>78.9</td>
<td>78.3</td>
<td>77.7</td>
<td>77.1</td>
<td>76.5</td>
<td>75.9</td>
<td>75.4</td>
<td>75.0</td>
<td>74.6</td>
<td>72.2</td>
<td>$79.5</td>
</tr>
<tr>
<td>Number employees</td>
<td></td>
<td>425.4</td>
<td>424.6</td>
<td>423.8</td>
<td>423.1</td>
<td>422.5</td>
<td>422.3</td>
<td>422.3</td>
<td>422.3</td>
<td>422.3</td>
<td>422.3</td>
<td>$425.4</td>
</tr>
<tr>
<td>Operations labour component</td>
<td>38.3</td>
<td>38.2</td>
<td>38.1</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>38.0</td>
<td>$38.3</td>
</tr>
<tr>
<td>Operations excluding labour</td>
<td>41.2</td>
<td>40.7</td>
<td>40.3</td>
<td>39.7</td>
<td>39.3</td>
<td>38.9</td>
<td>38.5</td>
<td>38.1</td>
<td>37.7</td>
<td>37.2</td>
<td>36.8</td>
<td>$41.2</td>
</tr>
<tr>
<td>Rehabilitation</td>
<td>$26.00</td>
<td>3.3</td>
<td>3.3</td>
<td>3.2</td>
<td>3.1</td>
<td>3.0</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>2.9</td>
<td>$26.00</td>
</tr>
<tr>
<td>Rail</td>
<td>$7.50/t Prod</td>
<td>29.2</td>
<td>28.7</td>
<td>28.3</td>
<td>27.9</td>
<td>27.6</td>
<td>27.3</td>
<td>27.0</td>
<td>26.7</td>
<td>26.4</td>
<td>26.1</td>
<td>$29.2</td>
</tr>
<tr>
<td>Port Charges</td>
<td>$2.46/t Prod</td>
<td>9.6</td>
<td>9.5</td>
<td>9.4</td>
<td>9.3</td>
<td>9.2</td>
<td>9.1</td>
<td>9.0</td>
<td>8.9</td>
<td>8.8</td>
<td>8.7</td>
<td>$9.6</td>
</tr>
<tr>
<td>Royalty</td>
<td>7% FOR</td>
<td>17.8</td>
<td>17.3</td>
<td>16.7</td>
<td>16.1</td>
<td>15.5</td>
<td>15.0</td>
<td>14.5</td>
<td>14.0</td>
<td>13.5</td>
<td>13.0</td>
<td>$17.8</td>
</tr>
<tr>
<td>Total Costs</td>
<td></td>
<td>139</td>
<td>137</td>
<td>134</td>
<td>132</td>
<td>130</td>
<td>128</td>
<td>128</td>
<td>128</td>
<td>128</td>
<td>128</td>
<td>$139</td>
</tr>
<tr>
<td>Cash Operating Surplus</td>
<td>151</td>
<td>144</td>
<td>138</td>
<td>132</td>
<td>126</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>120</td>
<td>$151</td>
</tr>
</tbody>
</table>

The company tax rate was reduced from 36 per cent to 34 per cent for the 2000/01 income tax year and is to be reduced to 30 per cent thereafter. As is revealed, the use of 36% in both mine and farm models does not impact the conclusions drawn from the models.

4.2.3 The generic farm model

Historically, one strategy, which was expected to achieve lease surrender, has been to rehabilitate land so that it is suitable for grazing. Grazing properties surround most Bowen Basin strip-coalmines. In a few exceptional circumstances the surrounding land is suitable for more intensive agriculture; however, such agriculture is generally restricted to alluvial river flats. Grazing is therefore the most likely possible and profitable post mining land use and was therefore chosen for the cost-benefit analysis. The generic farm model has
been developed from information published by the Australian Bureau of Agricultural and Resource Economics (ABARE) in *Australian Beef Industry 2000*.

Although the combined area of the spoil piles and the haul roads to be rehabilitated is approximately 1000 hectares, the generic farm will cover an area of 10,000 hectares. This size property is considered appropriate for two reasons; firstly, a smaller property would not be viable in the Bowen Basin and, secondly, since the six pits may extend for up to 22 kilometres parallel to the strike of the coal seam an area of 10,000 hectares will allow an adequate width for the property of approximately four kilometres. The costs were derived from the selected financial performance estimates for specialist beef properties for herd sizes from 550 to 1000 cattle. This category had an average property size of 11,698 hectares. GB's Pastoral Company represents an average Bowen Basin cattle property carrying between 550 and 1000 beef cattle. The financial data summarised in Table 4.6 was derived from the five-year average results for the period 1993-94 to 1997-8 (Australia Bureau of Agricultural and Resource Economics 2000)

A very moderate allowance for labour results in a cash loss even before any allowance for capital costs. For the purpose of the farm model it can be assumed that no tax is paid and the only payment toward the State is in rent and rates, which is offset by Government assistance. Consequently there is no net State benefit flowing from GB's Pastoral Company.
Table 4.6: Operating income for Bowen Basin cattle property - 550 to 1000 cattle

Generic Bowen Basin Pastoral Company
(GB’s Pastoral Co.)

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Rate</th>
<th>Annual $</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COSTS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef cattle purchases</td>
<td>$11,914</td>
<td></td>
</tr>
<tr>
<td>Fodder purchases</td>
<td>$8,440</td>
<td></td>
</tr>
<tr>
<td>Fuel, oil and grease</td>
<td>$9,971</td>
<td></td>
</tr>
<tr>
<td>Repairs and maintenance</td>
<td>$13,519</td>
<td></td>
</tr>
<tr>
<td>Rental</td>
<td>$5,099</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>$55,682</td>
<td></td>
</tr>
<tr>
<td><strong>Total cash costs</strong></td>
<td></td>
<td>$104,625</td>
</tr>
<tr>
<td>Imputed labour costs</td>
<td></td>
<td>$40,185</td>
</tr>
<tr>
<td><strong>BENEFITS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beef cattle sales</td>
<td>$102,263</td>
<td></td>
</tr>
<tr>
<td>Government assistance</td>
<td>$5,853</td>
<td></td>
</tr>
<tr>
<td>Other cash receipts</td>
<td>$32,392</td>
<td></td>
</tr>
<tr>
<td><strong>Total cash receipts</strong></td>
<td></td>
<td>$140,508</td>
</tr>
<tr>
<td><strong>Net cash flow before labour</strong></td>
<td>$35,883</td>
<td></td>
</tr>
<tr>
<td><strong>Net cash flow after labour</strong></td>
<td>($4,302)</td>
<td></td>
</tr>
<tr>
<td><strong>NET CASH FLOW before tax</strong></td>
<td>($4,302)</td>
<td></td>
</tr>
<tr>
<td>Tax</td>
<td>36%</td>
<td></td>
</tr>
<tr>
<td><strong>NET CASH FLOW after tax</strong></td>
<td>($4,302)</td>
<td></td>
</tr>
</tbody>
</table>

4.2.4 Cost-benefit analysis

The cost-benefit analysis considered the cash flows in relation to the mining company the State and Federal Governments and from a world view. A ten year period was selected to coincide with the remaining mine life. The original intention was to continue the analysis for another ten years of the pastoral company's life. This was unwarranted given the negative return from the pastoral company. Discount rates from zero to twenty percent were used. A summary of the cost-benefit analysis results is presented in Table 4.7.
Table 4.7: Summary of results from the Cost-Benefit Analysis

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>IRR</th>
<th>0</th>
<th>5%</th>
<th>10%</th>
<th>15%</th>
<th>20%</th>
</tr>
</thead>
<tbody>
<tr>
<td>GB’s(after tax)</td>
<td>18.8%</td>
<td>484</td>
<td>276</td>
<td>140</td>
<td>49</td>
<td>-13</td>
</tr>
<tr>
<td>GB’s(own funds)</td>
<td>27.9%</td>
<td>396</td>
<td>249</td>
<td>154</td>
<td>90</td>
<td>45</td>
</tr>
<tr>
<td>World view</td>
<td>36.9%</td>
<td>1,068</td>
<td>707</td>
<td>470</td>
<td>308</td>
<td>196</td>
</tr>
<tr>
<td>Referent Group</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland Government</td>
<td></td>
<td>162</td>
<td>120</td>
<td>92</td>
<td>72</td>
<td>58</td>
</tr>
<tr>
<td>Federal Government</td>
<td></td>
<td>422</td>
<td>312</td>
<td>238</td>
<td>187</td>
<td>151</td>
</tr>
</tbody>
</table>

As is to be expected the Net Present Value (NPV) for GB’s Mining Co is positive for discount rates up to the Internal Rate of Return (IRR) of 18.8%. This is considerably higher than the 4.5% return on equity reported by Queensland's only publicly listed coal company, Queensland Coal Trust (QCT) for the 1998/99 financial year. QCT was the taken over by BHP in 2000 and consequently did not report for the year 1999/00. The higher return from the model may be explained by the combined impact of increased coal prices and a simultaneous reduction in the value of the Australian dollar.

Typically Bowen Basin strip-coalmines purchased the pastoral properties on which they mine prior to mining commencing. The NPV analysis assumes the mine sells the property to GB’s Pastoral company when rehabilitation is complete in 2010. GB’s Pastoral Company commences in 2011 and continues for 10 years. GB’s Pastoral Company makes a small annual loss and its impact on the NPV of the combined project which includes both the mine and the pastoral company over a period of twenty years is minute.

Since the net present value of Pastoral Co is negative there is no economic justification for the rehabilitation expense unless there are other unaccounted for benefits or if the option of doing no rehabilitation results in additional costs. The impact of eliminating the rehabilitation costs is shown in Table 4.8.
Table 4.8: Summary of CBA results with and without rehabilitation cost

**IRR % and Net Present Value ($'000,000) without rehabilitation**

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>IRR</th>
<th>NPV at discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>0</td>
</tr>
<tr>
<td>GB's(after tax)</td>
<td>19.4%</td>
<td>503</td>
</tr>
<tr>
<td>GB's(Own funds)</td>
<td>29.1%</td>
<td>415</td>
</tr>
<tr>
<td>World View</td>
<td>37.8%</td>
<td>1,098</td>
</tr>
<tr>
<td>Referent Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland Government</td>
<td>162</td>
<td>120</td>
</tr>
<tr>
<td>Federal Government</td>
<td>433</td>
<td>320</td>
</tr>
</tbody>
</table>

**IRR % and Net Present Value ($'000,000) with current rehabilitation practice**

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>IRR</th>
<th>NPV at discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>0</td>
</tr>
<tr>
<td>GB's(after tax &amp; financing)</td>
<td>18.8%</td>
<td>484</td>
</tr>
<tr>
<td>GB's(Own funds)</td>
<td>27.9%</td>
<td>396</td>
</tr>
<tr>
<td>World View</td>
<td>36.9%</td>
<td>1,068</td>
</tr>
<tr>
<td>Referent Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland Government</td>
<td>162</td>
<td>120</td>
</tr>
<tr>
<td>Federal Government</td>
<td>422</td>
<td>312</td>
</tr>
</tbody>
</table>

**Percentage improvement in IRR and NPV without rehabilitation**

<table>
<thead>
<tr>
<th>FUNCTION</th>
<th>IRR</th>
<th>Discount rate</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>%</td>
<td>0</td>
</tr>
<tr>
<td>GB's(after tax &amp; financing)</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>GB's(Own funds)</td>
<td>4%</td>
<td>5%</td>
</tr>
<tr>
<td>World View</td>
<td>2%</td>
<td>3%</td>
</tr>
<tr>
<td>Referent Group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Queensland Government</td>
<td>0%</td>
<td>0%</td>
</tr>
<tr>
<td>Federal Government</td>
<td>3%</td>
<td>3%</td>
</tr>
</tbody>
</table>

The impact of totally removing the cost of rehabilitation from the GB's Mining's costs reveals an interesting phenomenon. At the 10% discount rate the company's return on its own funds increases from 154 to 165 million dollars, an increase of $11 million and the Federal Governments return increases by six million dollars as a result of increased company taxes.
Whilst the net present value improves for both the mining company and the Federal Government, there is no change in the net present value for the Queensland Government. This unexpected difference between the impact on the Federal and State government occurs because the Queensland Government royalty is *Ad Valorem*, that is it is calculated on the sale price of coal which is unaffected by environmental costs. Thus the Queensland Government, which is responsible for imposing the rehabilitation requirements, is indifferent to the financial impact of the cost of the rehabilitation. Nevertheless, if the mine's life was extended as a consequence of reducing the cost of rehabilitation, the Queensland Government would benefit by the amount of royalty paid on the additional coal produced. If coal companies were permitted to deduct the cost of rehabilitation from the sale price of the coal when calculating royalty payments, then the Queensland Government would be impacted by rehabilitation cost and perhaps be more concerned to ensure that rehabilitation expenditure was cost-effective.

Recontouring the saw tooth spoil piles, shown diagrammatically in Figure 4.3, by dozing from high points to low points is a major component of the cost of rehabilitation. Rehabilitation costs decrease once prestripping commences, as shown in year 7 of Table 4.5, because filling in the hollows is part of mining process and more than half the cost of prestripping is offset by the reduced cost of recontouring.

**Figure 4.3: Transition from recontouring by dozing to infill by prestrip overburden**

Based on the calculations previously presented it is economically inefficient to rehabilitate mined land for grazing use unless there is a cost associated with not rehabilitating the mined land. Since there is a significant improvement in NPV for both the mining company and the Federal Government and possibly for the Queensland Government and its citizens, if there is no rehabilitation of spoil piles, why has there been so much criticism regarding the extent of the coal mining companies rehabilitation liabilities? One explanation is that
the preceding cost-benefit analysis has failed to taken account of other future benefits of rehabilitation.

4.2.5 Other future benefits of rehabilitating spoil piles

The cost-benefit analysis clearly shows that, if the objective of rehabilitation is the return of the spoil piles to productive grazing land, then the expenditure on rehabilitation is unjustifiable. Can the expenditure of $26,000 per hectare to turn unproductive spoil piles into equally unproductive grazing land be justified for other benefits that might ensue?

Since there is no economic benefit from the most obvious land use of grazing, the possible benefits from rehabilitation would most likely come from a reduction in either off-site impacts or some non-use improvement such as the improved aesthetic value. Evaluating the cost of spoil pile rehabilitation required the construction of a mine model and a grazing property model. Having constructed the models the cost-benefit analysis and interpretation is relatively uncomplicated and the results are supported by existing data. The exercise of calculating the other possible benefits of rehabilitation is more difficult. Others have observed this problem as explained by Myrick Freeman III. "The problem faced by EPA (the US Environmental Protection Agency) benefit-cost analysts is not so much one of refining the existing tools of benefit estimation or developing new methods. Their problem is more immediate and serious. It is that they have neither the time nor the staff resources, nor research funds that would be required to execute the conceptually correct research plan". (Smith 1984, p. 168). These research plans are necessary because firstly there are conceptional problems evaluating the reduced risk from, say, rehabilitating mined land and, secondly, because of a lack of scientific data and scientific consensus.

The benefits which may flow from mined land rehabilitation include: improved downstream water quality; improved aesthetic value; a reduction in unwanted flora and fauna; and an improved image for the mining industry which may be reflected in the share price of the mining companies. There is limited available research on any of these topics, and this thesis has commenced the process by having experts rank the environmental attributes impacted by mining in order of importance. Fortunately, two excellent studies *Downstream effects of land use in the Fitzroy catchment* and *Testing the waters* have recently been completed. The reports acknowledge that the data available are limited and
that collecting data is expensive. The information presented, however, establishes a baseline for evaluating future trends as well as indicating the need for and direction and scope of future data gathering (Department of Environment and Heritage and Department of Natural Resources 1999), (Noble et al. 1996).

The reports comment on acid mine drainage from the 100 year old gold and copper mining operations of Mount Morgan. The drainage has a serious impact on the Dee River, which is a tributary of the Dawson River as shown on Figure 4.4. The data presented covered four measures of water quality: conductivity and pH; suspended solids; nitrogen and phosphorous; and insecticides. The data indicated values in each category which exceed that which would be desired for drinkable or fishable waters, but acknowledges that the catchment is generally in better health than the Murray-Darling, hardly a favourable comparison. The pesticide, Atrazine, a pesticide used in dry land sorghum farming, was detected in the Dawson, Mackenzie, Comet, Nogoa and Fitzroy sub-basins, at levels which exceeded Australian drinking water guidelines. The dominant land use in the Fitzroy catchment is however, cattle grazing which covers 80 to 90 percent of the area of the catchment. Low concentrations of the grazing herbicide tebuthiuron (GRASLAN) have been found in the waters of the Comet, Mackenzie, Dawson and Fitzroy sub-basins (Noble et al. 1996). The highest percentage of coalmines are located in the Isaac River sub-basin (Figure 4.4). When all the measures of water quality are considered, the Isaac River sub-basin would appear to have the best water quality in the Fitzroy catchment. One conclusion that can be draw is that currently the impact from coal mining on water quality is low and that if GB’s coalmine were to be returned to grazing this may have a negative impact on water quality because of the possible increased risk from grazing herbicides.

Although available data indicate no link between mining activity and current water quality will there be an increased impact when mines close? To date no major strip-coalmine has closed in Queensland so there are no available data on possible impacts; however, one possible impact based on overseas experience would be acid mine drainage. Evidence already presented indicates the "blood stains of acid mine drainage only appear when mines are killed." Will this be the case in the Bowen Basin Strip-coalmines? This project has not attempted to address the likelihood or impact of acid mine drainage, nor the likelihood of the other possible as yet unidentified off-site impacts.
Figure 4.4: Mine location with respect to river catchments

Source: BHP Coal
Disappointingly, neither of the reports on the health of the rivers attempts to set a vision for the catchment or any goals that might indicate we are heading toward that vision. Noble et al. (1996), however, suggested the need for any future development to be assessed on a cost-benefit basis taking into account the real cost of rehabilitating water quality as evidenced in the Murray-Darling Basin. Two possible goals, swimmable and fishable water, are however mentioned in the reports. Although the goals were not defined and although many would consider them to be minimal, they are perhaps the only statements of possible goals in the existing literature on the Fitzroy catchment. The international trend is toward taking a more holistic approach to catchment quality and this concept is explored later in this chapter.

Even though there is a lack of defined objectives in relation to the environmental attribute of water, scientific evaluation has commenced and is ongoing. In contrast no research has been carried out to evaluate how people value the aesthetics of mined and rehabilitated land. The next phase of the project was to identify and rank the environmental attributes not accounted for in the preceding CBA.
4.3 RANKING ENVIRONMENTAL VALUES

4.3.1 Establishing the environmental values

The object of the EP Act is Ecologically Sustainable Development (ESD) (Queensland Government 2001, p. 32). A fortiori the current environmental vision of the Queensland Government is also ESD. The Government environmental regulator, the EPA, has established an environmental objective underpinning the ESD vision. This objective is to protect and enhance certain environmental values. An environmental value is defined as a characteristic of the environment that is conducive to ecological health or public amenity.

Under the EP Act strip-coalmines in Queensland are issued with an Environmental Authority (EA). The conditions of the EA flow from a coalmine's Environmental Management Overview Strategy or EMOS. An EMOS is intended to be an environmental overview strategy for the life of the mine, and is a vehicle to ensure that the EA conditions are consistent with this strategy and provide for appropriate levels of environmental protection. The EMOS should include, amongst other information, environmental protection commitments proposed to protect and enhance the identified environmental values or attributes.

Environmental values may include, but are not limited to, air quality, water quality and land management issues. Although the EPA has chosen to use the term environmental values as explained in Chapter 2 the more precise term environmental attributes will be used synonymously with environmental values. The challenge for the mine owners and the regulators is to establish the strategies that will cost effectively achieve the objective of protecting and enhancing the identified and ranked environmental attributes.

Ideally the financial benefits and costs of various options to protect or enhance the environmental attributes could be compared and the alternative delivering the highest net benefit recommended. Unfortunately, the task of valuing environmental benefits is in its infancy in Queensland. In the absence of measurable economic benefits for protecting or enhancing environmental attributes the next best alternative may be to maximise the utility achieved by protecting or enhancing these environmental attributes subject to a cost restraint. Providing the various environmental attributes can be ranked utility is maximised within this cost restraint when the more highly ranked attributes are protected or enhanced the most. Assuming the current expenditure on rehabilitation per hectare
remains unchanged, options for protecting the environmental attributes may be compared and the option which best protects the highest ranked environmental attributes may be chosen. The challenge is to rank the environmental values which stakeholders wish to protect. The design and implementation of a survey to elicit such a ranking is considered a core contribution of this thesis to the advancement of the use of economic methods in environmental management.

The first task of identifying the environmental issues associated with strip-coalmining was undertaken during visits to the mines. The Bowen Basin strip-coalmines visited (Table 4.9) account for over 90% of the coal produced from strip-coalmines in Queensland.

Table 4.9: Mines visited

<table>
<thead>
<tr>
<th>Mine</th>
<th>Production Million tonnes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Bowen Basin strip-coalmines visited</strong></td>
<td>1999/00</td>
</tr>
<tr>
<td>Blackwater</td>
<td>6.5</td>
</tr>
<tr>
<td>Collinsville</td>
<td>2.3</td>
</tr>
<tr>
<td>Curragh</td>
<td>5.0</td>
</tr>
<tr>
<td>Ensham</td>
<td>3.5</td>
</tr>
<tr>
<td>German Creek</td>
<td>4.9</td>
</tr>
<tr>
<td>Goonyella-Riverside</td>
<td>9.9</td>
</tr>
<tr>
<td>Gregory</td>
<td>4.6</td>
</tr>
<tr>
<td>Jellinbah</td>
<td>2.5</td>
</tr>
<tr>
<td>Moura</td>
<td>4.4</td>
</tr>
<tr>
<td>Norwich Park</td>
<td>3.9</td>
</tr>
<tr>
<td>Oaky Creek</td>
<td>7.4</td>
</tr>
<tr>
<td>Peak Downs</td>
<td>6.9</td>
</tr>
<tr>
<td>Saraji</td>
<td>4.7</td>
</tr>
<tr>
<td>South Blackwater</td>
<td>4.4</td>
</tr>
<tr>
<td>South Walker Creek</td>
<td>2.6</td>
</tr>
<tr>
<td>Yarrabee</td>
<td>0.8</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td><strong>74.5</strong></td>
</tr>
<tr>
<td><strong>Bowen Basin strip-coalmines not visited</strong></td>
<td></td>
</tr>
<tr>
<td>Newlands</td>
<td>7.2</td>
</tr>
<tr>
<td><strong>Other coalmines visited</strong></td>
<td></td>
</tr>
<tr>
<td>Callide</td>
<td>6.0</td>
</tr>
<tr>
<td>Boundary Hill</td>
<td>1.2</td>
</tr>
<tr>
<td>Blair Athol</td>
<td>10.8</td>
</tr>
<tr>
<td>Tarong</td>
<td>4.8</td>
</tr>
<tr>
<td><strong>Sub total</strong></td>
<td><strong>22.9</strong></td>
</tr>
<tr>
<td><strong>Production from mines visited</strong></td>
<td><strong>104.5</strong></td>
</tr>
<tr>
<td><strong>Total saleable production</strong></td>
<td><strong>124.4</strong></td>
</tr>
</tbody>
</table>
A detailed questionnaire was developed with the intention of having the relevant personnel at the mine site complete the questionnaire. The target personnel were the Mine Manager, the Technical Services Manager and the Environmental Officer. However, given the concern to use the time spent with the mine site personnel most effectively and having a desire to inspect as many rehabilitated sites as possible in the limited time available, it proved more effective to ask the relevant questions verbally. The strategy was to firstly identify the relevant environment issues associated with strip-coalmining and then to rank these issues in order of importance. Each issue would then be categorised with its associated environmental attribute thus making it possible to rank the associated environmental attribute.

The issues considered important to achieve the expected environmental outcomes from rehabilitating mined land were identified during the mine visits. Furthermore a list of the actions required to address these issues was compiled. During the mine sites visits it became apparent that there was a possible divergence between the environmental issues and actions considered important to the individuals interviewed and the view which these individuals perceived the Government held. By Government view is meant that view which the participant perceives the political party in power to hold and which is manifested in the relevant legislation and mining lease conditions. Any survey to rank the issues would have additional benefit if it was designed so as to also capture any significant difference between the issues each reference group considered to be important and the issues each group thought the Government and legislators considered important.

Having identified the issues during the site visits, it was possible to design an issues and actions questionnaire (Table 4.10) to rank the issues in order of importance. Additionally, the questionnaire was designed to establish if there was a significant difference between the issues and actions each participant considered important and the issues and actions each participant perceived were important to the Government and legislators.
Table 4.10: Rehabilitation issues and actions questionnaire.

Please indicate the importance of the following issues at the time of mine closure, firstly from your perspective and secondly from the Government's perspective. Indicate the importance with a number from 1 to 5, 1 being of most importance and 5 of least importance, or 1 if you strongly agree and 5 if you strongly disagree.

<table>
<thead>
<tr>
<th>No</th>
<th>From the perspective of</th>
<th>ISSUE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Personal</td>
<td>All spoil visible from public roads to have grass cover</td>
</tr>
<tr>
<td>2</td>
<td>Government</td>
<td>All spoil visible from public roads to have tree cover</td>
</tr>
<tr>
<td>3</td>
<td>Personal</td>
<td>Topography of spoil visible from public roads blended with surrounding undisturbed land</td>
</tr>
<tr>
<td>4</td>
<td>Government</td>
<td>Angle of repose slopes acceptable if internally draining and not visible from public roads</td>
</tr>
<tr>
<td>5</td>
<td>Personal</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
</tr>
<tr>
<td>6</td>
<td>Government</td>
<td>Contour and downslope waterways designed for a 1 in 1000 event</td>
</tr>
<tr>
<td>7</td>
<td>Personal</td>
<td>Creek diversions designed for a 1 in 100 event</td>
</tr>
<tr>
<td>8</td>
<td>Government</td>
<td>Creek diversions designed for a 1 in 1000 event</td>
</tr>
<tr>
<td>9</td>
<td>Personal</td>
<td>Eradication of exotic fauna</td>
</tr>
<tr>
<td>10</td>
<td>Government</td>
<td>Eradication of exotic flora</td>
</tr>
<tr>
<td>11</td>
<td>Personal</td>
<td>Grass cover of all spoil</td>
</tr>
<tr>
<td>12</td>
<td>Government</td>
<td>Tree cover of all spoil</td>
</tr>
<tr>
<td>13</td>
<td>Personal</td>
<td>Vegetative cover of all spoil</td>
</tr>
<tr>
<td>14</td>
<td>Government</td>
<td>Grazing after surrender</td>
</tr>
<tr>
<td>15</td>
<td>Personal</td>
<td>No grazing after surrender</td>
</tr>
<tr>
<td>16</td>
<td>Government</td>
<td>Maximum external spoil slope of 10%</td>
</tr>
<tr>
<td>17</td>
<td>Personal</td>
<td>Maximum spoil slope of 15%</td>
</tr>
<tr>
<td>18</td>
<td>Government</td>
<td>Topsoil all Tertiary spoil</td>
</tr>
<tr>
<td>19</td>
<td>Personal</td>
<td>Topsoil all Permian spoil</td>
</tr>
<tr>
<td>20</td>
<td>Government</td>
<td>Ramps must be filled</td>
</tr>
<tr>
<td>21</td>
<td>Personal</td>
<td>Sediment dams designed for a 1 in 100 event</td>
</tr>
<tr>
<td>22</td>
<td>Government</td>
<td>Sediment dams designed for a 1 in 1000 event</td>
</tr>
<tr>
<td>23</td>
<td>Personal</td>
<td>Voids must be filled</td>
</tr>
<tr>
<td>24</td>
<td>Government</td>
<td>Void spoil must be stable</td>
</tr>
<tr>
<td>25</td>
<td>Personal</td>
<td>No impact in downstream water salinity above natural after lease surrender</td>
</tr>
<tr>
<td>26</td>
<td>Government</td>
<td>No impact in downstream water pH from natural after lease surrender</td>
</tr>
<tr>
<td>27</td>
<td>Personal</td>
<td>No impact in downstream water sediment above natural after lease surrender</td>
</tr>
<tr>
<td>28</td>
<td>Government</td>
<td>No increase in offsite financial impacts</td>
</tr>
<tr>
<td>29</td>
<td>Personal</td>
<td>No offsite health risk impacts</td>
</tr>
<tr>
<td>30</td>
<td>Government</td>
<td>No visual offsite impacts</td>
</tr>
<tr>
<td>31</td>
<td>Personal</td>
<td>Other - Please specify</td>
</tr>
<tr>
<td>32</td>
<td>Government</td>
<td>Other - Please specify</td>
</tr>
<tr>
<td>33</td>
<td>Personal</td>
<td>Other - Please specify</td>
</tr>
<tr>
<td>34</td>
<td>Government</td>
<td>Other - Please specify</td>
</tr>
</tbody>
</table>

List the priorities to fulfil the objectives of spoil rehabilitation, from 1 to 12, 1 being of most importance.

<table>
<thead>
<tr>
<th>No</th>
<th>From the perspective of</th>
<th>ACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Personal</td>
<td>Creek diversion stability studies</td>
</tr>
<tr>
<td>2</td>
<td>Government</td>
<td>Downstream water quality studies</td>
</tr>
<tr>
<td>3</td>
<td>Personal</td>
<td>EPA setting prescriptive standards, eg. no grades &gt; 15%</td>
</tr>
<tr>
<td>4</td>
<td>Government</td>
<td>EPA setting the vision &amp; allowing mines to establish standards</td>
</tr>
<tr>
<td>5</td>
<td>Personal</td>
<td>Final void water quality studies</td>
</tr>
<tr>
<td>6</td>
<td>Government</td>
<td>Grass species growing trials</td>
</tr>
<tr>
<td>7</td>
<td>Personal</td>
<td>Mine closure final land form plans</td>
</tr>
<tr>
<td>8</td>
<td>Government</td>
<td>Permian material chemical/physical properties</td>
</tr>
<tr>
<td>9</td>
<td>Personal</td>
<td>Erosion studies on steep spoil slopes</td>
</tr>
<tr>
<td>10</td>
<td>Government</td>
<td>Tertiary material chemical/physical parameters</td>
</tr>
<tr>
<td>11</td>
<td>Personal</td>
<td>Tree species growing trials</td>
</tr>
<tr>
<td>12</td>
<td>Government</td>
<td>Water hydrology studies</td>
</tr>
<tr>
<td>13</td>
<td>Personal</td>
<td>Other - Please specify</td>
</tr>
<tr>
<td>14</td>
<td>Government</td>
<td>Other - Please specify</td>
</tr>
<tr>
<td>15</td>
<td>Personal</td>
<td>Other - Please specify</td>
</tr>
</tbody>
</table>
Having developed the questionnaire to rank the issues and possible actions to address these issues, the next task was to seek stakeholder opinion as to the importance of the issues. A certain level of knowledge would be necessary to complete the questionnaire. Respondents would need to have or be presented with information on the possible environmental impacts of strip-coalmining, past and current rehabilitation practices and Government legislation. A minimum of two hours would be required to present the background information that was deemed necessary for a respondent to sensibly complete the questionnaire. A workshop was designed of four hours duration in which time the information was presented, the questionnaire completed after which the group had an opportunity to ask questions and comment.

Selecting informed focus groups was considered the best way of maximising the value of information with the minimum number of responses. Individuals with previous knowledge or interest in the subject were invited to a workshop to be presented with the information and to provide their opinion.

Respondents would be asked to indicate the importance, at the time of mine closure, of the thirty one issues identified during mine visits; firstly from their own perspective and secondly from what they believed to be the Government's perspective. The respondents were asked to indicate the importance of each issue with a number from one to five, the number one indicating the issue was of most importance and five indicating least importance. The respondent were then be required to apply similar reasoning to the action items; however, since there were only twelve action items identified respondents were asked to rank them from one to twelve, with one being of most importance.

The targeted expert groups were, mine employees and environmental consultants and Government regulators. A group of people living in close proximity to the mines and groups from the University of Queensland were also selected in order to see if there was a difference between the expert groups and groups which would be more reliant on the information presented in the workshop. Pairs of similar focus groups from Central Queensland and Brisbane (Table 4.11) were identified so that responses from the two regions could be compared. This approach of using selected knowledgable focus groups is gaining acceptance as the initial phase of broader contingent valuation and conjoint analyses (Morrison et al. 1997, p. 1), (Brouwer et al. 1999, p. 327), (Ladson 2000, p. 290),
Focus groups may provide dependable data quickly at a fraction of the cost of broader population sampling. Facilitating focus groups of approximately ten people to discuss the environmental issues and complete a questionnaire in a non-threatening and participatory environment can identify questionnaire design faults and missing attributes. Focus groups may; however, the small sample size would generally preclude extrapolating the results to predict the population's response. In this instance the focus groups' membership were chosen for their expertise and knowledge of the subject and so extended the concept of focus groups to groups which have typically been referred to as a council of elders, a committee of experts or a specialist reference group. By this extension it is argued that the results may be considered to represent the views which would be forthcoming from an equally informed community or citizens jury.

4.3.2 Issues and actions surveys

Eight workshops were conducted, three in central Queensland and five in Brisbane. A group size of between ten and twenty was chosen. The lower limit of ten was considered necessary to achieve a good degree of informal discussion. If the group exceeded twenty then discussion may have been curtailed in order to complete the workshop on time. Some similar groups were combined and the six composite groups are listed in Table 4.11

Table 4.11: Focus groups

<table>
<thead>
<tr>
<th>Focus Group</th>
<th>Group title</th>
<th>Location</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mining and environmental professionals</td>
<td>Mining - Central Qld</td>
<td>Central Queensland</td>
<td>19</td>
</tr>
<tr>
<td>Government agency professionals</td>
<td>Government agents - Central Qld</td>
<td>Central Queensland</td>
<td>12</td>
</tr>
<tr>
<td>Mining and environmental professionals</td>
<td>Mining - Brisbane</td>
<td>Brisbane</td>
<td>19</td>
</tr>
<tr>
<td>Government agency professionals</td>
<td>Government agents - Brisbane</td>
<td>Brisbane</td>
<td>13</td>
</tr>
<tr>
<td>University of Queensland</td>
<td>University of Qld</td>
<td>Brisbane</td>
<td>24</td>
</tr>
<tr>
<td>Local residents, Emerald and surrounds</td>
<td>Residents - Central Qld</td>
<td>Central Queensland</td>
<td>17</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>87</td>
</tr>
</tbody>
</table>

The workshop commenced with a brief outline of the project followed by an explanation of the current rehabilitation practices. There followed an in-depth exploration of the environmental hazards of strip-coal mining and their possible consequences. Next the possible range of costs and benefits of rehabilitation were presented. The participants then
completed the issues and actions questionnaire prior to a refreshment break. A group discussion followed and participants were encouraged to discuss the issues and actions listed and any unlisted issues or actions. During the refreshment break and the group discussion the completed questionnaires were correlated on a spreadsheet program and the results of the survey were presented to the group prior to the close of the workshop.

This process was not followed for the University of Queensland staff and postgraduate group. In this case the participants were asked to return the completed forms within a week. The smaller number of responses from this group, only eight of the twenty responded, shows the importance of having participants complete the survey during the workshop. The University of Queensland staff and postgraduate group's results were combined with the first year mining engineering students' results and reported as the University of Queensland group. Responses from two Brisbane mining groups were also combined.

The issues and actions questionnaire was generally completed without any obvious signs of confusion. Apart from the University of Queensland students very few participants failed to complete the questionnaire. Those participants who deliberately did not complete the questionnaire appeared quite capable of completing the questionnaire; however, they possibly took the ideological position that one cannot place a monetary value on the environment. Such individuals may have held a deontological ethic that would require certain actions even when such actions produce a lower welfare. Such bounded constraints are sometimes expressed as rights that cannot be over-ridden by general welfare. A participant who has this belief may be able to express a lexicographic preference and rank issues in order of choice nevertheless, rejecting the premise of substitution between issues, will choose not to complete the questionnaire. This behaviour is manifest in environmental valuation by those who refuse to bid in contingent valuation method studies. Monetary value estimates would not then truly reflect the environmental value of the attribute under study (O'Neill and Spash 2000, p. 523). Discussion during the workshop suggested that a few participants felt that the land should be returned to its original form no matter what the cost and that a monetary value should not be placed on the environment.

Initially some participants had difficulty in ranking the twelve action items. In the following workshops participants were advised to first fill in the three most important
actions then the three least important actions and to carry out the same procedure for the remaining six action items. This technique proved successful; nevertheless, in hindsight respondents may have found it easier to rank the actions with a rating of one to five, similar to that used for the issues. It is interesting to note however that, at the Federal Government election in 2001, the general public were expected to rank the 32 Senate candidates from 1 to 32, so perhaps ranking from 1 to 12 was not to much to expect.

4.3.3 Additional issues identified

As previously stated, focus groups are commonly used to test questionnaire design and to ensure all environmental attributes are identified prior to a broader stated preference or conjoint surveys. If significant attributes have been overlooked then they may be added prior to a broader survey. Participants identified additional issues and actions; however, as will be explained, it appears unlikely that failure to include these issues and actions in the questionnaire impacted the broad findings.

The additional issues listed by some respondents were:

(i) identifying an attractive post closure land use;
(ii) on mine site as opposed to off mine site salinity and water quality;
(iii) ensuring the surrendered mine site did not represent a danger to domestic animals;
(iv) stable landform; and
(v) no non-native flora or fauna to remain at closure.

Each of the additional issues is addressed in the order listed above.

Identifying an attractive post closure land use relates to aesthetics. Aesthetics appears to be of greater importance than anticipated by the researcher. There were, however, five questions relating to aesthetics and this should have been sufficient to rank the amenity of aesthetics.

Water quality and salinity impacts contained within the mine site as opposed to water quality and salinity impacts from the mine extending outside the mine site were not considered to be significant by the majority of participants.
Ensuring the surrendered mine site does not represent a danger to domestic animals is a concern especially if the land is to be used for grazing. Nevertheless there was no question relating to health risks either to humans or animals on the surrendered mine sites because this is a fundamental requirement for surrendered land, whether mined or unmined.

The issue of a stable landform was deliberately excluded from the questionnaire because of the many possible interpretations and possible misinterpretations of the words "stable landform". For a geotechnical engineer, well-drained slopes of less than the angle of repose, typically 37º for spoil piles, are stable. To a grazier the slope has to be stable under grazing and cattle must find the slope acceptable. Typically the slope would be less than half the angle of repose. To an agriculturist it may be a slope of less than five degrees. The Department of Mines and Energy's policy guideline *Environmental Management for Mining in Queensland* in 1992, stated that a *stable post-disturbance landform* was achieved when mine wastes and disturbed land was rehabilitated to a condition which was self sustaining, or to a condition where the maintenance requirements were consistent with an agreed post mining land use. The Departments was concerned to ensure no ongoing maintenance cost and consequently chose the measure of stability as maintenance cost rather than any physical parameter.

The Macquarie dictionary has several definitions of stable including *permanent and enduring*. This definition highlights the dilemma of using the term stable landform. Stable landform is an oxymoron when considered in a geological time frame as all landforms are evolving and no landform is stable. If, however, the objective is to have no ongoing maintenance costs after mine closure then this should be the paramount requirement. The final landform may or may not be an important factor in achieving zero maintenance. If a fundamental requirement is that at surrender there be no ongoing maintenance costs or that the company pay for ongoing maintenance then the company's least cost option may be to pay for that ongoing maintenance cost. Such a decision would need to be taken early in the mine's life, however, to enable the mining company to make the most cost-effective choices. It would not be cost effective to leave this decision to be negotiated at the time of surrender.

The issues questionnaire did ask the importance of eradicating exotic flora and fauna. This question could have referred to eradicating non-native species or eradicating pests either
native or non-native. In hindsight the word "pest" or "undesirable" may have been more appropriate than the word "exotic"\textsuperscript{1}.

4.3.4 Additional actions identified

The additional actions were:

(i) grazing trials and grazing management studies;
(ii) fire management studies;
(iii) identifying land capability criteria for acceptance of the surrendered mine lease;
(iv) establishing a legal framework to enable surrender of rehabilitated areas of land;
(v) communicating with and gaining acceptance from other stakeholders;
(vi) on mine site water quality studies;
(vii) ecosystem health and services studies;
(viii) identifying methods of achieving sustainable ecosystems;
(ix) identify strategies which are compatible with local regional strategy guidelines such as the Central Queensland Strategy for Sustainability (CQSS); and
(x) legislation to allow mining companies to protect or enhance the environmental values of adjacent unmined lands that will offset the reduced environmental values of the mined land.

Grazing trials and grazing management studies, fire management studies, and identifying land capability criteria for acceptance of the surrendered mine lease all relate to the issue of post mine closure land management. There would appear to be no reasons why cattle would not be able to graze the grassed rehabilitated areas. The challenge, however is to determine if grazing delivers the best long-term environmental outcome. The question is rather one of which land management policy will best protect the fragile layer of relatively thin topsoil on the mined land. Choices of land use range from grazing to native habitat. The risk of damaging fires increases with fuel load and there is an argument that grazing is an effective way of keeping the fuel load low. On the other hand native vegetation that has evolved to accommodate fire will recover following fire. Choosing the land uses and vegetation strategies to best protect the fragile soil is not restricted to mined land. It may be more productive to draw on the current knowledge on protecting fragile soils from

\textsuperscript{1} Mark Twain said one should "write not just to be understood but so that you can never be misunderstood." His advice is doubly applicable to questionnaire design
The participant who suggested the fourth action item saw a need for the mining companies to be able to surrender discrete portions of the mine lease where rehabilitation was complete. There appear to be legal issues associated with surrender of mining leases because the underlying land title boundaries differ from the mining lease boundaries. This is a land title issue that could be resolved providing the Government was willing to establish the legal framework to enable the surrender of parcels of mined land but the mining companies would have to establish the need for such a process.

Achieving the fifth listed additional action item may not be so easily accomplished however. Identifying, communicating with and gaining acceptance from other stakeholders is a difficult and undefined process. Establishing contact with and arranging the meeting with the local resident focus group for this project took almost twelve months and there were two failed attempts when the targeted participants had concurrent commitments to attend meetings of other regional committees on the days selected. There are at least three impediments to the process: firstly there is a small pool of community minded people to draw on, secondly they may have large distances to travel, and thirdly they are being asked to give up their valuable time without recompense. There appears to be an increasing desire of both governments and companies to ask uninformed volunteers to assist them to solve matters that previously would have been resolved by local Government. If stakeholder or focus groups are to work they will need to be established and funded at a local Government or regional level. The three adjacent local Governments were invited to send representatives to the Emerald workshop. Only one responded saying that although they would have liked to send a representative there was a council meeting on the same day. This indicates that either mine rehabilitation is not high on the agenda of local councils or that they cannot afford to allow people to attend meetings unless they are absolutely necessary. Even if there are stakeholders willing to participate there is no legal mechanism for deciding the extent to which any one stakeholder's desires should be valued over another's, or if in fact the stakeholder opinion is of any value at all. The pragmatic
approach is for the experts, primarily the mining companies environmental officers and the Government regulators, to propose alternative possible rehabilitation approaches and involve the stakeholders in risk and cost-effectiveness analyses to determine an agreed approach. Expecting stakeholders to present solutions, which are the legal responsibility of the mining company and the Government, may at best waste time and money and at the worst delay making decisions regarding rehabilitation, which may result in a poorer final environmental outcome.

On mine site water quality studies are important; however, it may be argued that this was covered under the broader action item, "Water hydrology studies". Ecosystem health and services studies, and identifying methods of achieving a sustainable ecosystems are of fundamental importance if the surrendered mind land impacts areas external to the mine lease. It was unclear if the respondent was referring to ecosystems within the mine site or ecosystems outside the mine site. Ecosystem health of mined land is of much less importance if there is no impact on ecosystems external to the mined land. Reaching agreement on what represents a sustainable ecosystem on mined land is unlikely to be achieved within the remaining working life of any of the mines studied. On the other hand it is essential that the risk to ecosystems outside the mining lease are minimised; however this issues was in part covered by the action item "Down stream water quality studies".

Developing rehabilitation strategies compatible with the CQSS is a sensible suggestion. The CQSS could fulfil the important and currently missing role as the coordinating regional stakeholder group to work with the mines and the government to set environmental value protection priorities for mine rehabilitation. This regional group might also consider the last and most difficult additional action, environmental offsets.

Apart from the need for grazing and fire trials each additional issue or action was mentioned only once and the majority of respondents did not suggest any additional issues or actions. Unfortunately it was not possible to add these suggested items to the questionnaire part way through the survey without reducing the statistical integrity of the survey. Indeed one of the purposes of focus group surveys is to ensure that all the important issues are captured prior to embarking on expensive contingent valuation or choice modelling surveys which require many person hours of input from the surveyors and the surveyed.
4.4 SURVEY RESULTS AND ANALYSIS

4.4.1 Ranking the Issues and Actions

A Microsoft Excel spreadsheet program was used to analyse the responses. First the total vote for each issue was calculated and the average score obtained. The issues and action items were then ranked. The top ten of the thirty one issues chosen by each group and the top five of the twelve action items were examined both for commonality and difference. The top ten issues and top five actions are presented in Tables 4.14-4.18.

The data from the Central Queensland mining group was analysed in more detail for the standard descriptive statistics and the results shown in Tables 4.12 and 4.13. The first observation of the data in Table 4.12 reveals that there is a good spread of the ratings ranging from 1.11 to 4.79. This indicates that the respondents could and did distinguish between the most important and least important issues. A rating of 1.11 on the highest ranked issue means that most respondents gave that issue a rating of one. Likewise a rating of 4.79 for the lowest ranked issue indicates that most respondents gave that issue a rating of five. The Standard Deviation was calculated for all 31 issues and ranged from 0.315 for the highest ranked issue and went up to 1.4 for issue two at the middle of the ranking and then fell to 0.419 for the lowest ranked issue.
Table 4.12: Rating and standard deviation for the Central Queensland mining group

<table>
<thead>
<tr>
<th>No</th>
<th>ISSUE-PERSONAL VIEW</th>
<th>Rating</th>
<th>Ranking</th>
<th>Standard Dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.11</td>
<td>1</td>
<td>0.315</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health impacts</td>
<td>1.11</td>
<td>2</td>
<td>0.459</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.21</td>
<td>3</td>
<td>0.419</td>
</tr>
<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.42</td>
<td>4</td>
<td>0.769</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.53</td>
<td>5</td>
<td>0.905</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>1.58</td>
<td>6</td>
<td>1.170</td>
</tr>
<tr>
<td>3</td>
<td>All spoil visible from public roads to be vegetated</td>
<td>1.89</td>
<td>7</td>
<td>1.197</td>
</tr>
<tr>
<td>16</td>
<td>No grazing after surrender</td>
<td>1.89</td>
<td>8</td>
<td>1.150</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>1.89</td>
<td>9</td>
<td>1.100</td>
</tr>
<tr>
<td>5</td>
<td>Angle of repose slopes acceptable if internally draining and not visible from public roads</td>
<td>2.21</td>
<td>10</td>
<td>1.316</td>
</tr>
<tr>
<td>19</td>
<td>Topsoil all Tertiary spoil</td>
<td>2.21</td>
<td>11</td>
<td>1.084</td>
</tr>
<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>2.26</td>
<td>12</td>
<td>1.368</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>2.26</td>
<td>13</td>
<td>1.147</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>2.53</td>
<td>14</td>
<td>1.429</td>
</tr>
<tr>
<td>20</td>
<td>Topsoil all Permian spoil</td>
<td>2.68</td>
<td>15</td>
<td>1.293</td>
</tr>
<tr>
<td>2</td>
<td>All spoil visible from public roads to have tree cover</td>
<td>2.74</td>
<td>16</td>
<td>1.408</td>
</tr>
<tr>
<td>31</td>
<td>No visual offsite impacts</td>
<td>2.74</td>
<td>17</td>
<td>1.284</td>
</tr>
<tr>
<td>1</td>
<td>All spoil visible from public roads to have grass cover</td>
<td>3.11</td>
<td>18</td>
<td>1.286</td>
</tr>
<tr>
<td>13</td>
<td>Tree cover of all spoil</td>
<td>3.11</td>
<td>19</td>
<td>1.448</td>
</tr>
<tr>
<td>4</td>
<td>Topography of spoil visible from public roads blended with surrounding undisturbed land</td>
<td>3.16</td>
<td>20</td>
<td>1.385</td>
</tr>
<tr>
<td>9</td>
<td>Creek diversions designed for a 1 in 1000 event</td>
<td>3.16</td>
<td>21</td>
<td>1.642</td>
</tr>
<tr>
<td>11</td>
<td>Eradication of exotic flora</td>
<td>3.16</td>
<td>22</td>
<td>1.344</td>
</tr>
<tr>
<td>18</td>
<td>Maximum spoil slope of 15%</td>
<td>3.16</td>
<td>23</td>
<td>1.344</td>
</tr>
<tr>
<td>17</td>
<td>Maximum external spoil slope of 10%</td>
<td>3.32</td>
<td>24</td>
<td>1.293</td>
</tr>
<tr>
<td>12</td>
<td>Grass cover of all spoil</td>
<td>3.68</td>
<td>25</td>
<td>1.204</td>
</tr>
<tr>
<td>7</td>
<td>Contour and downslope waterways designed for a 1 in 1000 event</td>
<td>3.74</td>
<td>26</td>
<td>1.368</td>
</tr>
<tr>
<td>10</td>
<td>Eradication of exotic fauna</td>
<td>3.74</td>
<td>27</td>
<td>1.098</td>
</tr>
<tr>
<td>21</td>
<td>Ramps must be filled</td>
<td>4.00</td>
<td>28</td>
<td>1.247</td>
</tr>
<tr>
<td>23</td>
<td>Sediment dams designed for a 1 in 1000 event</td>
<td>4.05</td>
<td>29</td>
<td>0.705</td>
</tr>
<tr>
<td>15</td>
<td>Grazing after surrender</td>
<td>4.47</td>
<td>30</td>
<td>0.841</td>
</tr>
<tr>
<td>24</td>
<td>Voids must be filled</td>
<td>4.79</td>
<td>31</td>
<td>0.419</td>
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</tbody>
</table>

A statistical examination of the individual scores given to issue number 27, the highest ranked issue "No increase in downstream water salinity from surrendered lease" and issue 1 "All spoil visible from public Roads to have grass cover" is presented in Table 4.13. The Kurtosis and Skewness is high for issue 27 as would be expected because the minimum score which may be given is one and the majority of respondents would have needed to give the issue a score of one to achieve the rating of 1.1.

The values shown in the rating column in table 4.12 provides an indication of the expected descriptive statistics. If the rating values at the extremities are close to one, as is the case for issue 27, or five then most respondents have given a score of one or five to those issues respectively. Rating values ranging from close to one up to close to five indicates comprehension of the questionnaire and differentiation between important and least important environmental parameters.
All groups produced a similar spread of scores on the issues, which is evidence of universal comprehension of the questionnaire and a willingness and ability to place both low and high scores. The action items forced participants to rank the items of the full range from one to twelve. This method of forcing a distinction has an advantage providing the number of items is small. The group rating scores from the action items shows a minimum score for the most favoured action of around 3.6. This indicates that the individual choices were not as unanimous as was the case for the issues. A unanimous choice would have produced scores close to one and twelve at the extremities. If individual opinions varied randomly then all scores would be close to 6.5. Group ratings ranged from below four to above nine or greater than half the choice range. More importantly, as the subsequent tables and graphs will show the action choices were consistent across all groups.
Table 4.14: Top ten issues - Central Queensland Govt. agents and mining groups

### Government agents - Central Queensland

<table>
<thead>
<tr>
<th>No</th>
<th>ISSUE-PERSONAL VIEW</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.42</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.50</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.58</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.58</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.67</td>
</tr>
<tr>
<td>8</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>1.83</td>
</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.83</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.83</td>
</tr>
<tr>
<td>11</td>
<td>Eradication of exotic flora</td>
<td>2.00</td>
</tr>
<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>2.00</td>
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### Mining group - Central Queensland

<table>
<thead>
<tr>
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<th>ISSUE-PERSONAL VIEW</th>
<th>RATING</th>
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</thead>
<tbody>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.11</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.11</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.21</td>
</tr>
<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.42</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.53</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>1.58</td>
</tr>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.89</td>
</tr>
<tr>
<td>16</td>
<td>No grazing after surrender</td>
<td>1.89</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>1.89</td>
</tr>
<tr>
<td>5</td>
<td>Angle of repose slopes acceptable if internally draining and not visible from public roads</td>
<td>2.21</td>
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### ISSUE-GOVERNMENT VIEW

<table>
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<th>RATING</th>
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<tr>
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<td>All spoil visible from public Roads to be vegetated</td>
<td>1.58</td>
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<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>1.58</td>
</tr>
<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>1.67</td>
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<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.67</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.67</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>1.75</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.75</td>
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<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.83</td>
</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.92</td>
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<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
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### ISSUE-ADMINISTRATION VIEW

<table>
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<tbody>
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<td>All spoil visible from public Roads to be vegetated</td>
<td>1.67</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.67</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.67</td>
</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.67</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.67</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.67</td>
</tr>
<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
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### ISSUE-PERSONAL VIEW

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<td>All spoil visible from public Roads to be vegetated</td>
<td>1.42</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.50</td>
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<tr>
<td>25</td>
<td>Void spoil must be stable</td>
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<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.58</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
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</tr>
<tr>
<td>8</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
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<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.83</td>
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<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.83</td>
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<tr>
<td>11</td>
<td>Eradication of exotic flora</td>
<td>2.00</td>
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<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>2.00</td>
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### ISSUE-GOVERNMENT VIEW

<table>
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<tbody>
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<td>All spoil visible from public Roads to be vegetated</td>
<td>1.58</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>1.58</td>
</tr>
<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>1.67</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.67</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.67</td>
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<tr>
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<td>25</td>
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<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.83</td>
</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.92</td>
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<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
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### ISSUE-ADMINISTRATION VIEW

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<td>1.67</td>
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<td>No increase in downstream water sediment from surrendered lease</td>
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<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.67</td>
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<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.67</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.67</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>1.74</td>
</tr>
<tr>
<td>31</td>
<td>No visual offsite impacts</td>
<td>1.74</td>
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### ISSUE-PERSONAL VIEW

<table>
<thead>
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</tr>
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<tbody>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.42</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.50</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.58</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.58</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.67</td>
</tr>
<tr>
<td>8</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
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<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.83</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.83</td>
</tr>
<tr>
<td>11</td>
<td>Eradication of exotic flora</td>
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<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>2.00</td>
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</table>
Table 4.15: Top ten issues - Brisbane Government agents and mining groups

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<th>RATING</th>
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<td>26</td>
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<td>1.31</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.38</td>
</tr>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.46</td>
</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.46</td>
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<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.54</td>
</tr>
<tr>
<td>4</td>
<td>Topography of spoil visible from public Roads blended with surrounding undisturbed land</td>
<td>1.69</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.69</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.69</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.77</td>
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<tr>
<td>19</td>
<td>Topsoil all Tertiary spoil</td>
<td>1.85</td>
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<table>
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<tbody>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.23</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.38</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
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<td>25</td>
<td>Void spoil must be stable</td>
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<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.77</td>
</tr>
<tr>
<td>19</td>
<td>Topsoil all Tertiary spoil</td>
<td>2.00</td>
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<tr>
<td>1</td>
<td>All spoil visible from public Roads to have grass cover</td>
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<table>
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<tr>
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<td>No offsite health risk impacts</td>
<td>1.53</td>
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<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.58</td>
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<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.58</td>
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<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
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<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>2.21</td>
</tr>
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<td>Vegetative cover of all spoil</td>
<td>2.26</td>
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<table>
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<th>ISSUE-GOVERNMENT VIEW</th>
<th>RATING</th>
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<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.26</td>
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<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.26</td>
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<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.26</td>
</tr>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.37</td>
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<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.53</td>
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<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.58</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>1.58</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.74</td>
</tr>
<tr>
<td>31</td>
<td>No visual offsite impacts</td>
<td>2.00</td>
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<td>4</td>
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Table 4.16: Top ten issues - Residents and University of Queensland groups

**Residents Central Queensland**

<table>
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<td>No increase in downstream water salinity from surrendered lease</td>
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<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>1.53</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.71</td>
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<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.82</td>
</tr>
<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>2.00</td>
</tr>
<tr>
<td>13</td>
<td>Tree cover of all spoil</td>
<td>2.06</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>2.12</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>2.12</td>
</tr>
</tbody>
</table>

**Residents Central Queensland**

<table>
<thead>
<tr>
<th>No</th>
<th>ISSUE-GOVERNMENT VIEW</th>
<th>RATING</th>
</tr>
</thead>
<tbody>
<tr>
<td>26</td>
<td>No increase in downstream water sediment from surrendered lease</td>
<td>1.76</td>
</tr>
<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
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</tr>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.82</td>
</tr>
<tr>
<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.94</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>2.06</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>2.06</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>2.06</td>
</tr>
<tr>
<td>30</td>
<td>No offsite health risk impacts</td>
<td>2.06</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>2.12</td>
</tr>
<tr>
<td>29</td>
<td>No offsite financial impacts</td>
<td>2.12</td>
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**University of Queensland**

<table>
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</tr>
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<tbody>
<tr>
<td>27</td>
<td>No increase in downstream water salinity from surrendered lease</td>
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<td>No increase in downstream water sediment from surrendered lease</td>
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<td>30</td>
<td>No offsite health risk impacts</td>
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<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
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<td>2.13</td>
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<tr>
<td>6</td>
<td>Contour and downslope waterways designed for a 1 in 100 event</td>
<td>2.17</td>
</tr>
<tr>
<td>19</td>
<td>Topsoil all Tertiary spoil</td>
<td>2.17</td>
</tr>
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</table>

**University of Queensland**

<table>
<thead>
<tr>
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<th>RATING</th>
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</thead>
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<tr>
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<td>No increase in downstream water salinity from surrendered lease</td>
<td>1.42</td>
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<td>30</td>
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<td>28</td>
<td>No increase in downstream water acidity from surrendered lease</td>
<td>1.54</td>
</tr>
<tr>
<td>14</td>
<td>Vegetative cover of all spoil</td>
<td>1.63</td>
</tr>
<tr>
<td>3</td>
<td>All spoil visible from public Roads to be vegetated</td>
<td>1.83</td>
</tr>
<tr>
<td>19</td>
<td>Topsoil all Tertiary spoil</td>
<td>1.83</td>
</tr>
<tr>
<td>22</td>
<td>Sediment dams designed for a 1 in 100 event</td>
<td>1.83</td>
</tr>
<tr>
<td>25</td>
<td>Void spoil must be stable</td>
<td>1.83</td>
</tr>
<tr>
<td>8</td>
<td>Creek diversions designed for a 1 in 100 event</td>
<td>2.00</td>
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### Table 4.17: Top five action items - Central Queensland groups

<table>
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<th>(a) Government agents - Central Queensland</th>
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<tr>
<td>No</td>
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</tr>
<tr>
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</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

| (b) No | ACTION-GOVERNMENT VIEW | RATING |
| --- |
| 3 | EPA setting prescriptive standards, eg. no grades > 15% | 3.83 |
| 1 | Creek diversion stability studies | 4.92 |
| 2 | Downstream water quality studies | 5.00 |
| 7 | Mine closure topographic plans | 5.17 |
| 11 | Tree species/growing trials | 5.75 |

<table>
<thead>
<tr>
<th>(c) Mining group - Central Queensland</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>7</td>
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<td>1</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>4</td>
</tr>
</tbody>
</table>

| (d) No | ACTION-GOVERNMENT VIEW | RATING |
| --- |
| 2 | Downstream water quality studies | 3.37 |
| 3 | EPA setting prescriptive standards, eg. no grades > 15% | 4.63 |
| 5 | Final void water quality studies | 5.16 |
| 7 | Mine closure topographic plans | 5.21 |
| 12 | Water hydrology studies | 5.74 |

<table>
<thead>
<tr>
<th>(e) Residents - Central Queensland</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
</tr>
<tr>
<td>2</td>
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<tr>
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<tr>
<td>1</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>9</td>
</tr>
</tbody>
</table>

| (f) No | ACTION-GOVERNMENT VIEW | RATING |
| --- |
| 2 | Downstream water quality studies | 4.71 |
| 7 | Mine closure topographic plans | 4.94 |
| 9 | Erosion studies on steep spoil slopes | 5.76 |
| 11 | Tree species/growing trials | 5.82 |
| 12 | Water hydrology studies | 5.82 |
Table 4.18: Top five action items - Brisbane groups

<table>
<thead>
<tr>
<th></th>
<th>Government agents - Brisbane</th>
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<tr>
<td>(a)</td>
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<tr>
<td>4</td>
<td>EPA setting the Vision &amp; allowing mines to establish standards 3.54</td>
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<tr>
<td>7</td>
<td>Mine closure topographic plans 3.85</td>
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<tr>
<td>2</td>
<td>Downstream water quality studies 4.38</td>
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<tr>
<td>5</td>
<td>Final void water quality studies 5.85</td>
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<tr>
<td>11</td>
<td>Tree species/growing trials 6.46</td>
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<tr>
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<td>No ACTION-GOVERNMENT VIEW RATING</td>
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<tr>
<td>4</td>
<td>EPA setting the Vision &amp; allowing mines to establish standards 2.77</td>
</tr>
<tr>
<td>7</td>
<td>Mine closure topographic plans 4.62</td>
</tr>
<tr>
<td>2</td>
<td>Downstream water quality studies 5.54</td>
</tr>
<tr>
<td>6</td>
<td>Grass species/growing trials 5.85</td>
</tr>
<tr>
<td>11</td>
<td>Tree species/growing trials 6.31</td>
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<table>
<thead>
<tr>
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<tr>
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<td>Downstream water quality studies 3.79</td>
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<td>Creek diversion stability studies 5.58</td>
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<td>Final void water quality studies 5.84</td>
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<tr>
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<td>2</td>
<td>Downstream water quality studies 3.63</td>
</tr>
<tr>
<td>3</td>
<td>EPA setting prescriptive standards, eg. no grades &gt; 15% 4.74</td>
</tr>
<tr>
<td>7</td>
<td>Mine closure topographic plans 4.95</td>
</tr>
<tr>
<td>1</td>
<td>Creek diversion stability studies 5.32</td>
</tr>
<tr>
<td>5</td>
<td>Final void water quality studies 5.74</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>University of Queensland</th>
</tr>
</thead>
<tbody>
<tr>
<td>(e)</td>
<td>No ACTION-PERSONAL VIEW RATING</td>
</tr>
<tr>
<td>2</td>
<td>Downstream water quality studies 3.94</td>
</tr>
<tr>
<td>9</td>
<td>Erosion studies on steep spoil slopes 5.19</td>
</tr>
<tr>
<td>7</td>
<td>Mine closure topographic plans 5.73</td>
</tr>
<tr>
<td>6</td>
<td>Grass species/growing trials 6.06</td>
</tr>
<tr>
<td>12</td>
<td>Water hydrology studies 6.23</td>
</tr>
<tr>
<td>(f)</td>
<td>No ACTION-GOVERNMENT VIEW RATING</td>
</tr>
<tr>
<td>7</td>
<td>Mine closure topographic plans 4.31</td>
</tr>
<tr>
<td>2</td>
<td>Downstream water quality studies 4.77</td>
</tr>
<tr>
<td>4</td>
<td>EPA setting the Vision &amp; allowing mines to establish standards 5.23</td>
</tr>
<tr>
<td>3</td>
<td>EPA setting prescriptive standards, eg. no grades &gt; 15% 5.90</td>
</tr>
<tr>
<td>12</td>
<td>Water hydrology studies 5.90</td>
</tr>
</tbody>
</table>
4.4.2 Analysis and comparison of the ranking for each group

The Environmental Protection Agency's Guideline for Preparing an Environmental Management Overview Strategy (EMOS) recommends that the EMOS should include a description of the environmental values or attributes likely to be affected by the mining activities and an assessment of the beneficial and adverse impacts on these attributes (EPA 2001, p. 5). Environmental attributes may include but are not limited to:

(i) air quality which may be reduced by airborne particles from the mine area;
(ii) water quality values including surface and groundwaters, aquatic ecosystems (both local and regional) and downstream users;
(iii) noise and blasting impacts on the community, including natural communities;
(iv) cultural heritage, historical or socio-economic values;
(v) ecological process values, such as local or regional impacts on rare or threatened organisms and their supporting ecosystems; and
(vi) land management issues especially in relation to post mining land capability and land use and surrounding land uses.

Environmental attributes are those qualities or physical characteristics of the environment that are conducive to ecological health, public amenity or safety. The potential impact on environmental attributes may extend beyond the mining lease to surrounding off lease areas and include potential impacts of regional extent, for example, the catchment area or airshed. The EPA Guideline further recommends that the EMOS commitments should describe the environmental protection objectives for enhancing or protecting each relevant environmental attribute (EPA 2001).

For mined land rehabilitation the relevant environmental values to be enhanced or protected are air quality, downstream water quality and land quality. Since there is a desire to protect these environmental attributes it follows that each has a certain value or amenity. The importance of visual appearance was raised in several of the focus groups workshops and therefore the attribute or amenity of aesthetics may be added to the amenities of air, land and water. Table 4.19 shows the issues and actions sorted according to these four amenities. Air quality after mining had ceased was not considered relevant for the Bowen Basin coalmines. Nevertheless airborne particles may be of great concern in other situations such as the abandoned tailings dams in suburban Johannesburg.
Table 4.19: Issues and actions sorted by amenity

### ISSUES SORTED BY ATTRIBUTE OR AMENITY

<table>
<thead>
<tr>
<th>AMENITY</th>
<th>ISSUE</th>
</tr>
</thead>
</table>
| **Aesthetic** | All spoil visible from public roads to have grass cover  
| | All spoil visible from public roads to have tree cover  
| | All spoil visible from public roads to be vegetated  
| | Topography of spoil visible from public roads blended with surrounding undisturbed land  
| | No visual offsite impacts |
| **Land** | Angle of repose slopes acceptable if internally draining and not visible from public roads  
| | Contour and downslope waterways designed for a 1 in 100 event  
| | Contour and downslope waterways designed for a 1 in 1000 event  
| | Eradication of exotic fauna  
| | Eradication of exotic flora  
| | Grass cover of all spoil  
| | Tree cover of all spoil  
| | Vegetative cover of all spoil  
| | Grazing after surrender  
| | No grazing after surrender  
| | Maximum external spoil slope of 10%  
| | Maximum spoil slope of 15%  
| | Topsoil all Tertiary spoil  
| | Topsoil all Permian spoil  
| | Ramps must be filled  
| | Voids must be filled  
| | Void spoil must be stable |
| **Water** | Creek diversions designed for a 1 in 100 event  
| | Creek diversions designed for a 1 in 1000 event  
| | Sediment dams designed for a 1 in 100 event  
| | Sediment dams designed for a 1 in 1000 event  
| | No impact in downstream water salinity above natural after lease surrender  
| | No impact in downstream water pH from natural after lease surrender  
| | No impact in downstream water sediment above natural after lease surrender |
| **Other** | No increase in offsite financial impacts  
| | No offsite health risk impacts |

### ACTIONS SORTED BY ATTRIBUTE OR AMENITY

<table>
<thead>
<tr>
<th>AMENITY</th>
<th>ACTION</th>
</tr>
</thead>
</table>
| **Land** | Grass species/growing trials  
| | Permian material chemical/physical properties  
| | Erosion studies on steep spoil slopes  
| | Tertiary material chemical/physical parameters  
| | Tree species/growing trials |
| **Water** | Creek diversion stability studies  
| | Downstream water quality studies  
| | Final void water quality studies  
| | Water hydrology studies |
| **Other** | EPA setting prescriptive standards, eg. no grades > 15%  
| | EPA setting the vision & allowing mines to establish standards  
| | Mine closure final land form plans |
The primary task of the survey was to rank the issues and hence rank the attributes considered important to each of the focus groups. Of the thirty-one issues listed, five relate to aesthetics, seventeen relate to land and seven to down-stream water quality. The top ten issues were ranked for each of the groups and are shown in Tables 4.14 - 4.16.

Items categorised under the attribute of water quality ranked as number one in five of the six personal views and in all cases water quality ranked above land value. In the exceptional case (Table 4.14(a)) the highest ranked item was from the aesthetics category. Similarly four of the six Government views rated water most highly and once again in the two exceptional cases (Table 4.14(b) and Table 4.15(b)) water was only surpassed by aesthetics. The emphasis on water is also evident from the over-representation of water related issues among the top ten issues. Table 4.19 shows that of the thirty-one issues only seven issues or twenty three percent are in the water category yet water related issues represent approximately forty percent of the top ten issues. This emphasis on water quality ahead of land quality was even more pronounced in the case of the action items. There were five action items relating to land and four relating to water. Nevertheless the top five recommended actions (Table 4.17(a), 4.17(c), 4.17(e) and Table 4.18(a), 4.18(c), 4.18(e)) from the personal viewpoint, apart from the EPA setting an environmental vision and mine topographic plans, relate predominantly to down stream water quality, whereas land related activities are poorly represented.

The secondary tasks of the survey were to:

(i) show if there was any significant divergence between each group's view and what they perceived to be the Government view, or to show the degree of correlation between the views; and

(ii) establish the degree of correlation between the various personal views.

4.4.3 Analysis of the correlation between views

The data available for examination are sets of the average score each group assigned to the individual issues and actions. All scores are positive and for the issues must range between zero and five and for the actions between zero and twelve. For each group there is a personal view data set and a Government view data set that may be compared for correlation. In a perfectly informed democracy where the Government knows and acts in
accordance with the majority view of its citizens both views should be identical. The personal view from each group may also be compared and if the environmental objectives were clearly understood then these should be similar. As well the perceived Government views may be compared. The latter comparison was not carried out, however, as this would involve comparing views twice removed from respondents and therefore not necessarily meaningful. The objective was to firstly determine if the perceived Government view was concordant with the personal view and secondly if there was agreement between the personal views of the groups.

There are three common statistical coefficients used to assess the degree of correlation between data sets; the coefficient of determination, the coefficient of correlation and Spearman's rank-correlation coefficient. The coefficient of determination is the most universally accepted; however, this technique is more commonly used to specify a linear function or regression describing the relationship between an independent variable and a dependent variable. Nevertheless, reversing the independent variable and the dependent variable will not change the value of the coefficient of determination. Other statistics such as the intercept will vary and the order of the variables is important if the results were to be used to predict values of the dependent variable from the independent variable. This is not the situation with the data sets from the issues and actions questionnaire and there is no statistical relevance as to which data set is chosen as the independent variable. In this instance there are two independent data sets and the objective is to evaluate the extent to which the variables covary in a linear fashion. For this situation the coefficient of correlation may be more appropriate. The coefficient of correlation is, however, simply the square root of the coefficient of determination. Alternatively, when the value of the variable has been obtained by a subjective decision of the respondent, as is the case in the issues and actions survey, it is the rank of the item and not the absolute value that is important and Spearman's rank-correlation coefficient may be more appropriate. The Spearman rank-correlation coefficient has the advantage of being easier to calculate by hand; however, this advantage is negligible when a computer is available.

The mathematical basis of each method is discussed and the three methods are compared for the first sets of data to ascertain their relevance. The calculation of the coefficient of determination and the coefficient of correlation are shown in Table 4.20 for the first
questionnaire conducted for the Central Queensland mining group. For ease of display, only the first and last two of the thirty-one issues are shown.

Table 4.20: Coefficient of determination and coefficient of correlation calculations

<table>
<thead>
<tr>
<th>Issue No</th>
<th>Government view</th>
<th>Personal view</th>
<th>$y_i=(Y-Y)$</th>
<th>$x_i=(X-X)$</th>
<th>$y_i^2$</th>
<th>$y_i^2$</th>
<th>$x_i^2$</th>
<th>$x_i^2$</th>
<th>$\bar{y}_i$</th>
<th>$\bar{y}_i^2$</th>
<th>$\bar{y}_i$</th>
<th>$\bar{y}_i^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.94</td>
<td>2.11</td>
<td>6.05</td>
<td>5.64</td>
<td>-0.16</td>
<td>0.026</td>
<td>0.40</td>
<td>-0.06</td>
<td>0.16</td>
<td>0.20</td>
<td>-0.36</td>
<td>0.12</td>
</tr>
<tr>
<td>2</td>
<td>2.16</td>
<td>2.74</td>
<td>5.91</td>
<td>7.49</td>
<td>0.05</td>
<td>0.002</td>
<td>0.03</td>
<td>0.00</td>
<td>0.00</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
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<tr>
<td>30</td>
<td>1.16</td>
<td>1.11</td>
<td>1.28</td>
<td>1.22</td>
<td>-0.95</td>
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<td>-1.60</td>
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<td>-0.81</td>
<td>-0.14</td>
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<tr>
<td>31</td>
<td>1.74</td>
<td>2.74</td>
<td>4.76</td>
<td>7.49</td>
<td>-0.37</td>
<td>0.138</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>-0.39</td>
<td>0.15</td>
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<tr>
<td>Total</td>
<td>65.4</td>
<td>83.9</td>
<td>192.1</td>
<td>257.2</td>
<td>0.0</td>
<td>13.9</td>
<td>0.0</td>
<td>15.2</td>
<td>30.1</td>
<td>0.0</td>
<td>0.0</td>
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<td>Mean</td>
<td>2.11</td>
<td>2.71</td>
<td>6.20</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
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</tr>
</tbody>
</table>

It may be shown that:

Total sum of squares = Sum of squares due to regression + Sum of squares due to residual

TSS = RSS + ESS

$\sum y_i^2 = \beta x_i y_i + \gamma_i^2$

$1 = RSS/TSS + ESS/TSS$

Coefficient of determination $R^2 = RSS/TSS$

$1 - \frac{\sum y_i^2}{TSS} = 0.54873$

Coefficient of correlation $r = \frac{cov(X,Y)}{S_X S_Y}$

$r = \sqrt{R^2} = 0.74976$

Calculation of the coefficient of correlation and the coefficient of determination place significance on the magnitude of the averaged response. The tests are therefore parametric in nature requiring an inference with regards to the value of the population parameters. Parametric tests are built on a set of assumptions about the underlying nature of the population, assumptions such as the normality of the population. Nonparametric procedures have been developed to surmount these difficulties. These methods are not influenced by the value of the parameters nor the population distribution (Parsons 1978, p. 692).

The calculation of the coefficient of correlation and coefficient of determination is predicated upon the assumption of an underlying population that is bivariate normal. If that assumption is violated the two series may be expressed in ranked data and a distribution free or nonparametric technique called the Spearman's rank-correlation employed. This technique requires the issue items to be ranked based on the average scores. The calculation of the Spearman's rank-correlation coefficient for the Central
Queensland mining group is shown in Table 4.21. Once again only the first and last two issues are shown.

Table 4.21: Spearman's rank correlation coefficient.

<table>
<thead>
<tr>
<th>Issues personal versus Government view</th>
<th>n</th>
<th>Own</th>
<th>Govt.</th>
<th>d</th>
<th>d²</th>
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<tbody>
<tr>
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<td>1</td>
<td>18</td>
<td>15</td>
<td>3</td>
<td>9.0</td>
</tr>
<tr>
<td>All spoil visible from public roads to have tree cover</td>
<td>2</td>
<td>16</td>
<td>17</td>
<td>-1</td>
<td>1.0</td>
</tr>
<tr>
<td>No offsite health risk impacts</td>
<td>30</td>
<td>2</td>
<td>4</td>
<td>-2</td>
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</tr>
<tr>
<td>No visual offsite impacts</td>
<td>31</td>
<td>17</td>
<td>10</td>
<td>7</td>
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<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1200</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
\text{n}^2 &= 961 \\
\text{Spearman rank-correlation coefficient} &= 1-6(\sum d^2)/n(n^2-1) \\
r' &= 0.758
\end{align*}
\]

The difference between the Spearman rank-correlation coefficient and the coefficient of correlation is small in the case of the questionnaires completed by the Central Queensland mining group. The coefficient of correlation was chosen for reporting correlation because it is more widely used and accepted and in this situation almost identical to the perhaps more statistically appropriate Spearman rank-correlation coefficient. The F test for statistical significance was carried out on the first set of data and the results shown in Table 4.22. This test was not carried out on the remaining group's results because of the high degree of correlation evidenced by the coefficient of correlation values.
Table 4.22: Testing the significance of the correlation (Parsons 1978, p. 621)

ANOVA table for two variables

<table>
<thead>
<tr>
<th>Source</th>
<th>Degrees of Freedom</th>
<th>Sum of Squares</th>
<th>Mean Squares</th>
<th>F ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>df</td>
<td>df</td>
<td>SS</td>
<td>SS</td>
</tr>
<tr>
<td>Due to reg</td>
<td>RSS</td>
<td>k-1</td>
<td>1</td>
<td>7.6</td>
</tr>
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<td>Due to res</td>
<td>ESS</td>
<td>n-k</td>
<td>29</td>
<td>6.3</td>
</tr>
<tr>
<td>Total</td>
<td>TSS</td>
<td>n-1</td>
<td>30</td>
<td>13.9</td>
</tr>
</tbody>
</table>

\[ n = \text{number of observations} \]
\[ k = \text{number of parameters estimated. Two in a two variable model. ie } \alpha \text{ & } \beta \]

This hypothesis states that the independent variable (X) has no influence on Y

\[ H_0: \beta = 0 \]
\[ F_{\text{tab}} = 4.17 \text{ or } 7.56 \text{ Area to the right of } .01 \]
\[ F = \frac{RSS/df}{ESS/df} = \frac{MSS \text{ due to regression}}{MSS \text{ due to error}} \]
\[ F_{\text{calc}} = 35.26 \]
\[ F_{\text{calc}} > F_{\text{tab}} \]
Reject the Null hypothesis

The relevance of the F test in this situation is not to show that there is interdependence but that the two variable are correlated and the F statistic is identical no matter which variable is chosen as the independent variable.

Freund (Freund 1973, p. 425) cautions against two possible misinterpretations of the coefficient of correlation by firstly pointing out that it is \( R^2 \) that gives the proportion of total variation in the dependent variable attributed to the relationship with the independent variable. Thus an \( r = 0.8 \) is not twice as strong as an \( r = 0.4 \) because the \( R^2 \) values are 0.64 and 0.16 respectively and therefore an \( r = 0.8 \) is four times as strong a correlation as \( r = 0.4 \). Secondly that \( r \) measures only the strength of a linear relationship and does not necessarily imply cause and effect. The issues and actions survey was not designed to establish cause and effect but only the degree of correlation and therefore the latter possible misinterpretation is of no concern in this analysis.

A regression analysis was carried out on the personal pairs of data obtained by averaging the score for each issue for each group. Firstly the personal and government view pairs of data are compared and then various pairs of data from the personal views are compared.
As well as showing visually the degree of correlation, the regression analysis diagrams reveal the extent to which there is any significant divergence of opinion on any particular issue. As already discussed the variables are not being analysed for dependence on one another but rather their correlation. There is no particular reason why one variable should be chosen as the x axis or independent variable; however, for consistency of presentation the respondent's own view is generally shown on the x axis. Nevertheless, there is no assumption of cause and effect. The correlation coefficient has been calculated and shown on each graph. The results of the regression analysis are shown graphically in figures 4.5-4.8.
Figure 4.5: Rehabilitation issues regression - Govt. view versus personal view

(a) Govt agents  Central Qld

Grazing after surrender

Coefficient of correlation = 0.77

(b) Govt agents  Brisbane

Grazing after surrender

Coefficient of correlation = 0.75

(c) Mining group  Central Qld

No grazing after surrender

Angle of repose slopes

Coefficient of correlation = 0.74

(d) Mining group  Brisbane

Coefficient of correlation = 0.85

(e) Residents  Central Qld

Coefficient of correlation = 0.81

(f) University of Queensland

Coefficient of correlation = 0.85
Figure 4.6: Rehabilitation actions regression - Govt. view versus personal view

(a) Govt agents  Central Qld  

(b) Govt agents  Brisbane

(c) Mining group  Central Qld  

(d) Mining group  Brisbane

(e) Residents  Central Qld  

(f) University of Queensland

Coefficient of correlation = 0.53

Coefficient of correlation = 0.85

Coefficient of correlation = 0.38

Coefficient of correlation = 0.35

Coefficient of correlation = 0.80

Coefficient of correlation = 0.59
Figure 4.7: Rehabilitation issues regression - personal views

(a) Mining Vs Govt agents
Central Qld

(b) Residents Vs Govt agents
Central Qld

(c) Mining Vs Govt agents
Brisbane

(d) Residents Vs Govt agents
Brisbane

(e) Residents Vs UQ

(f) Residents Vs Central Qld
Minning group

Voids must be filled

Grazing after surrender

No grazing after surrender

Coefficient of correlation = 0.77

Coefficient of correlation = 0.67

Coefficient of correlation = 0.77

Coefficient of correlation = 0.65

Coefficient of correlation = 0.91

Coefficient of correlation = 0.49

Figure 4.8: Rehabilitation actions regression - personal views

(a) Mining Vs Govt agents
   Central Qld
   EPA setting standards
   Coefficient of correlation = 0.81

(b) Residents Vs Govt agents
   Central Qld
   Coefficient of correlation = 0.75

(c) Mining Vs Govt agents
   Brisbane
   Coefficient of correlation = 0.82

(d) Residents Vs Govt agents
   Brisbane
   Coefficient of correlation = 0.51

(e) Residents Vs UQ
   University of Qld
   Coefficient of correlation = 0.81

(f) Residents Vs Central Qld
   Mining group
   Coefficient of correlation = 0.50
4.4.4 Interpreting focus groups versus Government view regression analysis

Perfectly correlated views would be shown on the graphs by all points being on the forty five degree line and the trend line would coincide with the forty five degree line. If the trend line is at an angle to the forty five degree line and yet all points lie on the trend line then there is still perfect correlation; however, the scoring on one view is universally higher than for the other view. Such a divergence may have little significance. The coefficient of correlation has been shown on the graphs as an indication of the degree of correlation between the views.

The Government versus personal views (Figures 4.5 and 4.6) are compared first. The coefficient of correlation between the two views in the case of the rehabilitation issues (Figure 4.5) is around 0.8. If the pairs of data were being examined for cause and effect then a coefficient of correlation of 0.8 would indicate that over sixty percent of changes in the dependent variable is explained by the regression. In this comparison, however the coefficient simply indicates a high degree of correlation. Nevertheless there are some differences notably:

(i) grazing after surrender is less favourable than the perceived Government view (Figure 4.5 (a), and (b));
(ii) angle of repose slopes are favoured by the mining professions in Central Queensland (Figure 4.5 (c)); and
(iii) the mining group in Central Queensland were more opposed to grazing after surrender (Figure 4.5 (c).

The correlation was much weaker for the action items (Figure 4.6). The rehabilitation actions regression graphs reveal the reason for the weaker correlation. The low correlation coefficients occurs when actions items are further removed from the trend line (Figure 4.6 (c) and (d)) indicating a larger than average divergence between the personal and the perceived Government view. The significant divergences were:

(i) the perception that the government was more concerned with setting standards rather than the vision for rehabilitation (Figure 4.6 (a), (c) and (d)); and
(ii) the central Queensland mining group considered the Tertiary and Permian materials chemical and physical properties (Figure 4.6 (c)) to be of more importance than was the perceived Government view.

4.4.5 Interpreting personal views regression analysis

Finally the personal views of each group were compared. As there were six groups the number of combinations possible is \(^{6}\text{C}_2\) or fifteen. Six of the possible combinations were analysed such that each group was included at least once. Figure 4.7 reveals that the degree of correlation for the rehabilitation issues was as high as the personal versus Government views. There were, however, some obvious differences. Although the University of Queensland group and the residents group received the same amount of information during the workshop prior to completing the questionnaire, they did not have the advantage of having the detailed background knowledge of the other groups. The residents group and the University of Queensland group (Figure 4.7 (e)) had the highest correlation of any group compared; however, the smallest correlation was between the residents group and the mining group (Figure 4.7 (f)). The most significant differences were that:

(i) the mining groups and the Government agents in Central Queensland placed less importance on filling the final voids (Figure 4.7 (b), (c) and (f)); and

(ii) the mining group in Central Queensland were more opposed to grazing after surrender (Figure 4.7 (f)).

The graphs of rehabilitation actions (Figure 4.8) may be contrasted with the personal versus Government views. In the latter (Figure 4.6 (a), (c), (d) and (f)), correlation was below 0.6 for all bar the Government agents in Brisbane and the residents. In the former (Figure 4.8 (a), (c) and (e)), the correlation was above 0.8 in the case of the central Queensland mining and Government groups, the Brisbane mining and Government groups and the residents and University of Queensland group.
The significant outliers were:

(i) in Central Queensland the mining group was less concerned to have the EPA set standards than was the Government group (Figure 4.8 (a)); and
(ii) the residents had less desire to have the EPA set the vision than were the Government agents in Brisbane (Figure 4.8 (d)).

4.5 CONCLUSIONS FROM ISSUES AND ACTIONS SURVEY

The primary objective was to rank the environmental values or attributes in order of their importance. In an ideal world the economic value of protecting these environmental attributes would also be known and an appropriate cost-benefit analysis conducted to find the best economic solution. In the absence of any estimates of monetary values for protecting these environmental attributes, ranking of the environmental attributes to be protected enables rehabilitation strategies to be developed which give preference to protecting the most highly rated attributes. Agreement on the importance of these values enables all parties to agree on the most cost-effective rehabilitation strategies\(^2\). Based on views from the knowledgable focus groups the most important environmental value was downstream water quality. Several landowners commented that they considered the amount per hectare being spent on rehabilitation to be a waste of money, nevertheless they were very concerned about downstream water quality.

The survey results presented in Tables 4.14 - 4.16 show that downstream water quality was by far the most highly rated attribute followed by aesthetics. Land quality was considered to be much less important and the issue of air quality was not raised except in relation to dust from tailings dams which was outside the scope of this study. This same emphasis on water quality can be seen in the action items (Tables 4.17 and 4.18) with downstream water quality studies at or near the top for all groups. The other highly rated action was for the EPA to set the vision and allow the mines to set the standards to achieve this vision. There was a view, however, that the Government had a desire for the EPA to set standards (Table 4.17 (b), (d) and Table 4.18 (d) ).

\(^2\) “If one does not know to which port one is sailing no wind is favourable.” (Seneca 4BC-AD65)
The correlation graphs Figures (4.5 - 4.8) show that the views of the technical expert
groups differ from the perceived Government view with the correlation decreasing as the
distance from Brisbane increases. Nevertheless the views of the various technical groups
are fairly closely aligned.

In summary the issues and action survey indicates that the views of the focus groups are
not aligned with current rehabilitation practices for the following reasons:

(i) personal views show downstream water quality and aesthetics are of more
importance than the issues of land quality within the mine, whereas most
environmental expenditure is focused on land related activities;
(ii) there is an over emphasis on land management whereas the focus should be on
containing the impacts of mining to the mine site;
(iii) aesthetics is an important attribute which to date has been largely overlooked;
(iv) there is a need for the EPA to clearly enunciate its environmental vision and how
that relates to mine rehabilitation;
(v) the mines wish to set the standards once they understand the vision and
environmental objectives flowing from that vision;
(vi) grazing is not the preferred final land use;
(vii) the mining groups do not consider it necessary to fill final voids; and
(viii) studies of the chemical and physical characteristics of the Tertiary and Permian
material are necessary.

Unfortunately presenting only the top ten issues and top five actions does not reveal the
issues and actions considered least important. Knowledge of the items considered least
important may reveal information regarding the ranking of the various environmental
parameters. It also reveals a possible weakness in questionnaire design. For example one
issues question was "how important is grazing after surrender?" Those that thought the
mined land should not be grazed after surrender would place a low ranking on grazing after
surrender. All of the expert groups placed grazing either last or second last on the list of
thirty one issues. Thus although grazing after surrender was not ranked in the top ten its
ranking at the bottom indicates all groups felt strongly that grazing should not occur after
surrender. The appearance of an item at the bottom of the list may also be meaningful and
may indicate that a group felt strongly that something for example grazing after surrender
should not happen. In the groups surveyed the expert groups felt strongly that grazing of rehabilitated land should not occur after surrender. To counter this possible loss of information the inverse question "no grazing occur after surrender" was asked and as expected this question received a relatively high rank.

Other issues that appeared in the lower third of the ranking in all of the expert groups were:
(i) Maximum spoil slope of $15^0$;
(ii) Maximum spoil slope of $10^0$; and
(iii) Grass cover over all spoil.

The appearance of these three issues in the lower third of ranking indicates that the expert groups were ambivalent to the notion of specifying standards for slope angles and grass cover. This also supports the previous evidence that land quality falls well below water quality and aesthetics in ranking. Similarly grass species growing trials and erosion studies were ranked lowly in the actions questionnaire. As mentioned earlier the expert groups ranked land quality below water and aesthetics and many would have been aware of the historical emphasis and considerable expenditure on erosion studies in the past.

The data so far presented would indicate that mined land rehabilitation should firstly protect down stream water quality and secondly protect the mined land topsoil in areas that drain away from the mine and report to the river catchment.

The survey results show that for those without a detailed knowledge of the mining rehabilitation process, namely the resident group and the University of Queensland group, their views were closely correlated (Figure 4.7(e)) and they thought the Government view was similar (Figure 4.6 (e) and (f)). Those with a detailed knowledge had a much lower correlation with the perceived Government view but, nevertheless, were in close agreement with each other (Figures 4.7 (a) and (c)). However, the residents group, which did not have a detailed knowledge of mining or its impact, was far less correlated with the more informed groups (Fig 4.7 (b), (d) and (f)). This finding has important implications for the conduct of and results flowing from any contingent valuation or conjoint study on complex environmental issues. The inference which may be drawn is that the views of those who have greater knowledge and, hopefully, are more aware of the best action to achieve the desired environmental outcome, may differ from the views of less informed citizens even
following a three or more hour information session. The outcome resulting from a focus group of technical experts may be very different from that arrived by democratically canvassing a cross section of the population. No matter how good the questionnaire design, the proposition that a group of citizens with less than full knowledge of the subject may deliver the environmental solution which is in the best long term interest of society may be fundamentally flawed. The corollary of this proposition would be that if a sample of Queenslanders did not return a result that conformed to that of the experts then the most likely reason for the difference would be that they had been insufficiently informed. An alternative view would be that the Government agents have been captured by the mining industry and they are simply conforming to the mining industry position. The latter view is unlikely to be correct, however, given the lack of opportunity for the industry to influence the experts surveyed and the lack of any agreed mining industry position.

The following findings of the survey are considered relevant to finding a more cost-effective allocation of rehabilitation expenditure:

(i) down-stream water quality and aesthetics are of more importance than land quality within the mine, whereas most environmental expenditure is focused on land related activities;
(ii) aesthetics is an important attribute which to date has been largely overlooked and is rated above general land quality;
(iii) there is an over emphasis on land management whereas the focus should be on containing the impacts of mining to the mine site;
(iv) grazing is not the preferred final land use; and
(v) the EPA needs to clearly enunciate its environmental vision and objective in relation to mine rehabilitation.

These findings suggest that the rehabilitation expenditure would be more cost-effective if redirected toward downstream water quality and aesthetics. These findings have an interesting historical precedence. When concern for the environment was growing in Queensland in the 1960’s the first legislation was the Clean Air Act 1963, followed by the Clean Waters Act. The first environmental conditions applied to mining were in legislation applying to the Moura Mine which required only limited regrading of spoil peaks adjacent to public roads, assumingly for aesthetic reasons. The next relevant legislation in the
CQCA Act required protection of downstream water quality. Unfortunately, the early emphasis on water quality was subsumed by policy requiring the land to be returned to its previous land use capability, usually grazing. The ranking study indicates that protecting water quality is the paramount objective. One rehabilitation objective flowing from this would be to ensure that water falling on the rehabilitated mined land is contained within the mine. Any water reporting to the catchment should be as free from contaminants as possible. If land quality is important then it is doubly important in areas that drain into the catchment. In such areas the emphasis should be on the most cost-effective way of protecting the fragile and relatively thin layer of topsoil that has been placed at great expense on mined land. Such areas need to be self-sustaining. It may be many years after mine closure before rehabilitated land can be judged with certainty to be self-sustaining. Nevertheless, the probability and consequences of loss of the topsoil growing medium should be known and contingency planning carried out in case of such an event. Grazing may not be the best strategy to achieve the aforementioned self-sustaining objective.

Other observations from the study were:

(i) Although all groups considered water quality to be the paramount attribute to be protected there was a significant difference between the four expert groups and the two non-expert groups as shown when Figure 4.7 (e) is compared with Figure 4.7 (f). This difference may be amplified if the non-expert group was drawn from a random sample of Queenslanders. A questionnaire used to elicit opinion from the general population would need to be designed so that questions could not be misunderstood and the participants given sufficient information such that their answers would not be expected to differ from that of an expert in the field due to a lack of information. To achieve this state of knowledge participants would need to attend an information session considerably longer than the three hours provided in this study.

(ii) In an age where free time is considered by many a scarce luxury, it is becoming increasingly difficult to find people willing to freely give of their time. There is a continuous litany of complaint from volunteer organisations such as the Scouts and school parent groups that people are no longer volunteering for leadership roles in these volunteer organisations. Even the compulsory jury system is under threat
because many prospective jurors are granted exemption due to other commitments. Any survey requiring participants to give freely of the significant amount of time necessary to fully inform them would most probably be biased because such a group of people would not be representative of the population. The bias would be toward people with abundant free time and within that group only those with a particular interest may wish to participate.

The Waverley Council recently conducted what was reported to be Australia's' first Citizens Jury in relation to the environment. The jury focused on a single topic, "reducing stormwater pollution" and a group of sixteen residents of the Bronte catchment were required to attend three full days of information sessions before presenting a series of recommendations to local decision makers. Funding of $285,000 was provided through a NSW Government Stormwater Trust Grant for the Citizens Jury along with a televoting survey (De Blas 2001). The survey was for a very small highly populated catchment and focussed on a single issue of water quality. One would expect if the same technique were to be applied to Australia's' largest easterly flowing catchment, and encompassed not only all aspects of water quality but all other environmental attributes, the cost of such a survey may be ten times the cost of the Bronte Catchment Project. Nevertheless, given the amount being spent annually on strip-coalmine rehabilitation, such an approach would be justified providing it resulted in clear environmental objectives and these objectives were understood and accepted by Queenslanders. Paid expert focus groups may, however, be the most cost-effective method of setting objectives, which are in the best long term interest of society, when making environmental decisions which impact the economic well being of that society. Once these objectives are established and the likely benefits and cost known then the population are in a position to assess their willingness to pay for the various options presented.

(iii) Coordinating the meeting of residents in this survey was made difficult by the lack of a single body to represent the geographic area of interest, which in this instance coincided with the Fitzroy River catchment. There is an obvious need for bodies that represent the interests of catchments or sub-catchments. The established local government boundaries are a reflection of the progress of European settlement rather than any attempt to create boundaries based on geography. In time local
government boundaries could be changed to align with river catchments; however, there is an obvious immediate need for river catchment bodies which have the authority to manage the water resources of the catchment. Members of such a group who were paid to manage the interests of the catchment along with other experts from the EPA and mining industry could be expected to come up with rehabilitation policies which are in the best long term interest of the catchment.

4.6 THE CHOICE OF COST-EFFECTIVENESS ANALYSIS OVER COST-BENEFIT ANALYSIS

Cost-benefit analysis (CBA) requires all costs and benefits to be expressed in money units. This is not yet possible when assessing the economic effectiveness of rehabilitating strip-coalmines in the Bowen Basin because the environmental benefits have not been costed. Cost-effectiveness analysis (CEA) differs from CBA in that the benefits are expressed in units of effectiveness (Potterton 1991, p. 94). CEA offers a relaxation from CBA in that only costs need be specified in money terms. Nevertheless, CEA is as stringent as CBA in another sense because it requires a single measure of effectiveness. For example, if alternative road safety improvements are to be ranked then the single measure of effectiveness may be the number of fatalities forestalled. It is important to understand the limitations of using a single measure such as fatalities forestalled. In this instance, the effectiveness measure may lead to the conclusion that seat belts be ranked ahead of, say, installing lights on a dangerous intersection or widening a narrow bridge. However, whilst seat belts reduce the severity of accidents, the latter two actions will reduce the number of accidents and hence reduce injuries and property damage as well as loss of life. The single measure of benefit, fatalities forestalled, does not take account of the reduction in injuries and property damage (Potterton 1991, p. 95).

CEA is most useful when a fixed amount of expenditure has to be allocated among a set of measures, each of which contributes to a common and readily measurable goal. Each of the alternatives being compared must have a common predominant effect enabling a common measure of effectiveness to be used. Because CEA focuses on a single measure of effectiveness it is important that the measure adequately captures the predominant output or objective of the alternatives being considered. The closer the measure is to the ultimate objective of the activity the less need for concern there is about other unaccounted for or overlooked benefits. (Potterton 1991, p. 99).
4.7 COST-EFFECTIVENESS ANALYSIS

The aesthetics of a strip-coalmine spoil pile is a diseconomy for some individuals because it diminishes their utility. Abatement of this external diseconomy is both a non-marketable good, since it is non-exclusive and a public good since it is non-rival (Randal 1974, p. 440).

An individual cannot choose the amount of public good provided, except possibly as a member of a collective that makes a collective choice. In the case of aesthetics and water, the amount of the good supplied is a function of both quantity and quality. Since the good is non-rival, the aggregate demand may be calculated by vertically summing the marginal amount of benefit each individual derives from a particular amount of the public good as shown in Figure 4.9.

Figure 4.9: Demand for the environmental attribute of aesthetics

The total benefit, which at any particular quantity of aesthetics is the area under the demand curve to the left of that particular quantity, and the total cost may represented by the curves shown in Figure 4.10 (Randal 1974, p. 441), (Hartwick and Olewiler 1998, p. 226). The efficient level of the public good is provided when the difference between total benefit and total cost is maximised. Choosing the option which delivers the maximum
present value of net benefits in CBA is equivalent to being at the point where marginal cost equals marginal benefit (Hartwick and Olewiler 1998, p. 226). This occurs when the first derivative of the total benefit curve, which yields the marginal benefit, is equal to the first derivative of the total cost curve, which yields the marginal cost.

**Figure 4.10: The efficient level of aesthetic quality**

In Figure 4.10, $E_B$ represent the total benefit from the efficient provision of the attribute of aesthetics and $E_C$ the cost to provide that amount of the attribute aesthetics. $(E_B - E_C)$ is the maximum difference between benefit and cost. Observing the graph, this is intuitively so since, if the first derivatives were not equal, a change in the amount of aesthetics supplied would increase or decrease the difference between total benefit and total cost. This theoretical framework could be extended to include all the environmental attributes that are considered important. The efficient level of expenditure on each of these environmental attributes would occur when the marginal benefit equals marginal cost for each attribute and the efficient level of total expenditure would equal the sum of the individual efficient levels of expenditure on water, aesthetics and land.
As explained in Chapter 3, the primal approach of maximising utility subject to a budget constraint has been selected. This approach is shown diagrammatically in Figure 4.11 which illustrates possible behaviour when choosing between water or catchment protection a strategy to improve water quality, and vegetation cover as a possible strategy to improve land quality.

**Figure 4.11: Primal approach to CBA and CEA**

\[
\text{Primal}\hspace{2cm}
\text{Maximise } U(V,C) \text{ s.t. } E = P_vV + P_cC
\]

The prime objective of this thesis has been to ascertain the nature of the preferences summarized by the utility curve. The three environmental attributes, which have been ranked, are water, aesthetics and land quality. Assuming the expenditure on environmental rehabilitation is fixed then the problem is to divide the total budget between the three identified attributes of water, aesthetics and land quality such that the difference between total benefit and cost is maximised. Assuming the equations representing each of the total cost and total benefit curves are known then the mathematical solution can be found.

The results from the focus group surveys show that water quality ranked substantially higher than aesthetics and land. If it were possible to place a monetary value on benefits by methods such as contingent or conjoint valuation then theoretically it would be possible to calculate the demand curves for each attribute. Assuming a fixed amount of expenditure
on rehabilitation the efficient level of expenditure on each of these environmental attributes would occur when the marginal benefits from a dollar spent on each attribute are equal. The question is, can reallocating the environmental budget increase total utility?

Utility is maximised when:

\[ \frac{\text{MU}_W}{P_W} = \frac{\text{MU}_A}{P_A} = \frac{\text{MU}_L}{P_L} \]

Where:

\( \text{MU} \) = the marginal utility of quality improvement;
\( P \) = the price of the unit of quality improvement; and
Subscripts \( W, A, L \) = water, aesthetic and land quality.

The theoretical solution to this problem may be demonstrated by assuming that the utility gained by an improvement in each of the attributes of water, aesthetic and land quality can be measured by a single cardinal measure and that the consumption of these three goods is not impacted by the consumption of other goods. The law of diminishing utility states that there is a diminishing marginal utility gain from the consumption of each successive equal unit of any good (Byrns and Stone 1981, p. 427). Assuming the law holds true for the attributes of water, aesthetics and land then the marginal utility gain for water, aesthetic and land quality would have the characteristics shown in Table 4.23.

**Table 4.23: Marginal utility gain for the attributes of water aesthetics and land.**

<table>
<thead>
<tr>
<th>Units of attribute</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
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<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Aesthetics</td>
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<td>0</td>
</tr>
<tr>
<td>Land</td>
<td>40</td>
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<td>20</td>
<td>10</td>
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<td>0</td>
<td>0</td>
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<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Providing the cost of providing each unit of the attribute is known then the marginal utility per unit of cost may be calculated as shown in table 4.24
Table 4.24: Marginal utility per million dollars spent

<table>
<thead>
<tr>
<th>Cost per additional unit of the attribute</th>
<th>Water $P_W = $2 M</th>
<th>Aesthetics $P_A = $1 M</th>
<th>Land $P_L = $4 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>Units of attribute</td>
<td>0</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Marginal utility per $M spent</td>
<td>Water</td>
<td>50</td>
<td>45</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>60</td>
<td>50</td>
<td>40</td>
</tr>
<tr>
<td>Land</td>
<td>10</td>
<td>7.5</td>
<td>5</td>
</tr>
</tbody>
</table>

As previously stated utility is maximised, subject to the expenditure constraint, when the marginal utility per unit of cost is equal for each of the attributes. This relationship is shown graphically in Figure 4.12, where the total expenditure is assumed to be $28 million.

Figure 4.12: Expenditure on the attributes of land, aesthetics and water

<table>
<thead>
<tr>
<th>Units of attribute</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cost</td>
<td>Water</td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>8</td>
<td>10</td>
<td>12</td>
<td>14</td>
<td>16</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Aesthetics</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land</td>
<td>4</td>
<td>8</td>
<td>12</td>
<td>16</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cost when each attribute delivers 10 units of marginal utility per marginal $1 M spent

The vertical axis represents the marginal utility divided by the unit cost and the horizontal axis the quantity of the good chosen. For simplicity the curves are shown as straight lines and each variable is assumed to move independently of the other. In practice there may be interactions between variables and the curves may be non-linear.
Along the line $\alpha - \Omega$ the marginal benefit per million dollars spent equals 10. The total expenditure however must equal the fixed amount of expenditure on rehabilitation.

$$E_T = E_W + E_A + E_L$$

Where:

$E_T$ = Total environmental rehabilitation expenditure

$E_W$ = Catchment or water expenditure

$E_A$ = Aesthetics expenditure

$E_L$ = Vegetation or land expenditure

And,

$$E_T = P_W * Q_W + P_A * Q_A + P_L * Q_L$$

In this instance the total expenditure is $28 million made up of $18 million on water, $6 million on aesthetics and $4 million on land.

This principle can be stated generally as follows:

If by choosing appropriate units $P_W = P_A = P_L$ and $MU_W > MU_A > MU_L$ and the law of diminishing utility holds, then the expenditure should be greatest on water and least on land, or $E_W > E_A > E_L$

The preceding example demonstrates that with perfect knowledge it would be possible to allocate expenditure among the three attributes such that utility is maximised. If the utility curves were known and the cost per unit established, a solution could theoretically be found using constrained maxima and LaGrange multipliers or by linear programming. However, the solution to the optimum division of expenditure between the attributes of water, aesthetics and land requires a common measure of utility for water, aesthetics and land. The difficulty of accomplishing this task may be best illustrated by focusing on just one of the attributes. Consider the attribute water. What is the most appropriate measure of water utility? Should it be based on chemical analysis or should it be measured by the diversity of life that the water supports? If aquatic fauna is to be measured should it be fauna at the top of the food chain such as platypus or should the focus be on the invertebrates at the base of the food chain or even lower the aquatic flora? Should water quality be the sole measure or should the state of the riparian zone be included? If a common measure of utility could be agreed upon then we would next have to establish a common measure of improvement in utility and then the cost per unit of improvement in this measure of utility. That is the task faced for water alone. Aesthetics will bring in a
whole new field of subjective judgment. A uniformly sloped field of grass may look like a visually pleasing meadow reminiscent of a manicured golf course to one person or a barren monoculture to another. Finally there is the task of linking the utility of the attributes of water, aesthetics and land by a common measure of benefit.

In the absence of data, sufficient to establish the marginal utility curves, one pragmatic solution, until sufficient economic research is carried out, would be to make the following assumptions. All groups surveyed in the issues and actions survey put the highest priority on the attribute water and the lowest on the attribute land. Assume, by way of example, that the first dollar spent on water generates twice the utility of the first dollar spent on aesthetics and the first dollar spent on aesthetics will yield twice the utility of the first dollar spent on land. Assume also the marginal utility curves for the three attributes are straight and parallel lines. Then the previous example can be further simplified by choosing units of utility for water aesthetics and land such that:

\[ P_W = P_A = P_L \]

This simplification produces a graph as shown in Figure 4.13.

Figure 4.13: Equally priced units of utility

Therefore to maximise utility:

\[ Q_W = 2 \cdot Q_A; \quad \text{and} \]
\[ Q_A = 2 \cdot Q_L \]
Therefore:

\[ E_T = P^* (2^*2^*Q_L) + (2^*Q_L) + (Q_L) \]

\[ E_T = P^* (7^*Q_L) \]

If $28,000 were currently being spent per hectare on rehabilitation then the following expenditure per hectare on each of the environmental attributes would be most efficient:

- Water quality expenditure = $16,000
- Aesthetics expenditure = $8,000
- Land quality expenditure = $4,000

Based on these assumptions and in the absence of data sufficient to establish the marginal utility curves we would conclude that a higher amount of environmental expenditure should be directed to the highest ranked attribute and the least environmental expenditure on the lowest ranked attribute. Unfortunately, without further economic research, no conclusion can be drawn as to the division of expenditure between the environmental attributes. Conversely there is no economic justification for directing the bulk of the expenditure toward any one environmental attribute. For legislative and historical reasons the bulk of expenditure is currently directed toward growing vegetation or land quality. Given the lack of economic justification for this position and in the absence of more detailed research to value water and aesthetic quality, the precautionary principle would dictate the redistribution of some of the current expenditure on vegetation toward reducing the potential risk of long term off mine site environmental impacts, the most obvious impact being on water quality.

An alternative and more theoretically correct approach for CEA is to rank the alternative environmental options according to a single effectiveness measure. Based on the focus group surveys this single measure would have to be water quality. The combinations of alternatives which deliver the least decrease or largest increase in water quality down stream of the mine lease, following mine closure, would be the highest ranked alternative. Choosing this single criterion would not necessary preclude rehabilitation to improve land and aesthetics attributes; however, it would mean that any expenditure in these areas would have to be justified on the basis of the contribution to improving the environmental attribute of water.
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Chapter 5

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Farewell, farewell! but this I tell
To thee, thou Wedding-Guest!
He prayeth well, who loveth well
Both man and bird and beast.
He prayeth best, who loveth best
All things both great and small;
For the dear God who loveth us,
He made and loveth all.

The Mariner, whose eye is bright,
Whose beard with age is hoar,
Is gone: and now the Wedding-Guest
Turned from the bridegroom's door.

He went like one that hath been stunned,
And is of sense forlorn:
A sadder and a wiser man,
He rose the morrow morn.

-Samuel Taylor Coleridge
The Rime of the Ancient Mariner

The core tenet of ecologically sustainable development or ESD is protecting our ecosystems, on which all life depends, for the benefit of future generations. The term sustainable development is axiomatic without the qualification that it is the ecology which must be sustained since most development is economically sustainable or else funding would not be forthcoming. The statement; 'development should not result in an ecology which is less sustainable' is more perspicuous. More practically 'we should not leave a polluted environment that our children will have to clean up'. ESD requires the protection of all things both great and small, and like the wedding guest, for me, this insight only came after a long travail.
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Spoil piles rehabilitated with intermittent grass and trees

Unrehabilitated spoil piles
5 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 SUMMARY

The *Central Queensland Coal Associates Agreement Act 1968* required payment of a bond prior to mining, refundable if the surface was restored to not less than its former value for purposes connected with grazing. The bond, calculated at fifty dollars per acre, was an indication of the value that the Government of the day placed on grazing land in the Bowen Basin. Choosing grazing capacity as a measure of successful rehabilitation was a rational choice at that time. There was also an implicit link between the cost of rehabilitation and the economic value of the land.

In the following years and in the absence of an overarching environmental vision, legislators and regulators focused on land rehabilitation and the link to actual land value was discarded. Succeeding environmental guidelines appear to accept restoration to the former productive value as a cardinal tenet. Rather than questioning or rejecting this tenet, the regulator attempted to develop standards, which focused on returning mined land to a productive use. Whilst succeeding regulation became less prescriptive as to the future use of rehabilitated mined land, it became more focused on the land as the primary environmental attribute to be protected. The regulator produced very prescriptive guidelines relating to landform and slope angles which mining companies accepted as the prerequisite to gaining surrender of their lease. The environmental risks are site specific, varying greatly between coalmines and with even greater variation between coalmines and metalliferous mines. For example the environmental risks presented by a small gold mine, using cyanide to extract the gold, are vastly different from those of a strip-coalmine. Attempting to apply prescriptive universal legislation or guidelines in the absence of an overarching environmental vision was courageously idealistic at best and a desperate action in the face of criticism at worst.

Most first world governments and the global mining industry have embraced the vision of ESD. The Queensland Government and the Queensland mining industry have also embraced the vision of ESD. Environmental regulation of Queensland mines has been transferred from the DME to the EPA. With an agreed vision of ESD, the EPA has been able to state that the environmental objective for mines is to protect or enhance environmental attributes. Providing the EPA ranks the environmental attributes in order of
importance, there is now an opportunity for the regulator and the mining industry to work cooperatively to develop rehabilitation strategies that will cost-effectively achieve the objective.

5.2 CONCLUSION

5.2.1 Environmental rehabilitation hierarchy

The rehabilitation tactics mines employ depend on agreed environmental strategies developed in cooperation with the Government regulator. These agreed strategies should be designed to achieve the goals or objectives, which flow from the Government's environmental vision.

5.2.1.1 Vision and objective

The Australian Government recognised and accepted ESD in its 1992 publication, *National Strategy for Ecologically Sustainable Development*. The Queensland Government incorporated the ESD vision in the *Environmental Protection Act 1994*. Under the ESD vision, the EMOS guidelines established the goal of protecting and enhancing certain environmental values or more precisely environmental attributes. Those attributes associated with the natural environment include; ecology, water, air and land.

5.2.1.2 A new strategy - self sustaining rehabilitation designed for failure

Currently almost all Queensland strip-coalmines are located in the Fitzroy catchment. Applying the ESD vision and EPA objectives at the regional level will dictate the strategies necessary to achieve these objectives. There is now an opportunity to look afresh at the strategies rather than automatically accepting the previously developed strategies of:

(i) achievement of acceptable post-disturbance land use capability;
(ii) stable post-disturbance landform; and
(iii) preservation of downstream water quality.

The mines in cooperation with the EPA can design strategies to achieve the stated EPA objectives. The mine owners should have the freedom to develop tactics to achieve these strategies in the most efficient and cost-effective manner possible. Unfortunately, in the
past, the lack of a stated vision and objectives has been paralleled by a lack of risk taking by mine owners. Some more courageous owners have looked at alternative strategies; however, these have not strayed far from the straight jacket of land management for grazing or other land use. Some initiatives have been taken to reintroduce endangered species, and to investigate alternative land use. Removing the shackles which currently bind the environmental officers on the mine sites will enable them to use their creative energy to develop tactics which will deliver agreed goals rather than blindly following prescriptive guidelines.

To be self-sustaining, any made structures or landform must be designed so as not to fail catastrophically. The statement that a structure has been designed to withstand a 1:1,000 year event is sometimes misinterpreted to mean that the structure will last 1,000 years. The fact is it could fail tomorrow as the 1 in 1,000 year event can occur at any time within a 1,000-year period. The correct interpretation is that there is a 1 in 1000th chance that the event, which may cause failure, will occur in any year. The landforms and structures created after mining will fail eventually and therefore they should be designed with failure in mind. Mining companies have provided considerable funding for research into soil erosion from mined land in Australia. Research indicates that Bowen Basin Permian strip-coalmine spoil piles have the erosion characteristics shown in Figure 5.1.
Figure 5.1: Erosion characteristics of spoil piles in the Bowen Basin

This graph indicates that for slopes up to 30% the erosion follows along the transport limited curve and above 30% erosion follows the detachment limited curve. Given that mine spoil piles are built to a certain predetermined height the slope length increases as the slope angle decreases (Williams 2001, p. 54). The table at the end of Figure 5.1 shows the erosion rate in tonnes per metre width of the spoil pile for a spoil dump height of 40 metres. The unexpected result is that erosion is least for the steeper slope of 70%. Flattening the slope of a spoil pile, not only results in higher erosion, but also results in more unmined land at the toe of the spoil pile being covered by spoil.

Erosion rates are even higher for the more dispersable Tertiary material and topsoil. Topsoil loss for a 15% slope which is 50% vegetated may be as high as 10mm per annum (Williams 2001, p. 58). Soil creation is estimated to be only 0.01mm per annum. Based on these estimates, the 100mm depth of topsoil typically placed on spoil piles in the Bowen Basin will be eroded in just over ten years. Even if the erosion rates were reduced by a factor of ten the topsoil would still be gone in 100 years. For rehabilitation to be sustainable it must be designed to take account of failure including the total loss of topsoil.
5.2.2 Cost-benefit analysis

Based on the generic mine and farm models previously presented, it is economically inefficient to rehabilitate mined land for grazing use unless there is an unidentified cost associated with not rehabilitating the mined land or an as yet unidentified benefit of rehabilitation. There is a significant improvement in NPV for both the mining company and the Federal Government and possibly for the Queensland Government and its citizens, if spoil piles were left unrehabilitated. The possible explanation for the perceived community demand for rehabilitation is that the preceding cost-benefit analysis failed to take account of the unidentified future benefits of rehabilitation such as downstream water quality and aesthetics.

5.2.2.1 Environmental values or attributes

An important contribution of this thesis was the design and testing of a survey technique on groups of environmental experts. The primary objective was to rank the environmental values or attributes in order of their importance. In an ideal world, the economic value of protecting these environmental attributes would be known and a cost-benefit analysis could be carried out and the strategy with the highest NPV recommended. Unfortunately the economic value of improving or enhancing these environmental attributes is as yet unknown. Nevertheless, the survey results presented in Tables 4.14 - 4.16 show that downstream water quality was the most highly rated attribute followed by aesthetics. Land quality was considered to be much less important and the issue of air quality was not raised except in relation to dust from tailings dams which were outside the scope of this study.

CEA offers a relaxation from CBA in that only costs need be specified in money terms. Nevertheless, CEA is as stringent as CBA in another sense because it requires a single measure of effectiveness.

5.2.3 Cost-effectiveness analysis

The theoretical solution to the problem of determining the most cost-effective expenditure on rehabilitation has been demonstrated by assuming that the utility gained by an improvement in each of the attributes of water, aesthetic and land quality can be measured by a single cardinal measure. The law of diminishing utility states that there is a
diminishing marginal utility gain from the consumption of each successive equal unit of any good. Assuming the law holds true for the attributes of water, aesthetics and land then environmental expenditure is most cost effective when there is an equal marginal utility gain for each additional dollar spent on water, aesthetic and land. The research indicates that it is far more effective to direct environmental rehabilitation expenditure toward minimising stream pollution rather than growing vegetation on spoil piles. Nevertheless, in the absence of more precise economic data application of the precautionary principle would dictate that environmental expenditure be directed toward eliminating the risk of any long term regional environmental damage ahead of reducing environmental damage which can be contained within the mine site.

5.2.4 The role for economics

The tools and techniques of economics provide unbiased methods to analyse and compare alternative rehabilitation strategies. The greatest potential for benefit arises when such economic analysis is applied at the beginning of a mine's life. Landform creation is the greatest rehabilitation cost. Early application of CBA and CEA techniques would ensure a greater net benefit to all parties because it is most efficient and cheaper to construct the requisite landform as mining is proceeding when overburden is being placed initially rather than shifting material a second time. Given the nature of mining the best time to create the landform is when the mine is prosperous and that is generally during the early to middle years of an operation. Toward the end of a mine's life and after closure there may be only limited funds available for rehabilitation.

There is a need for currently unavailable data, which are vital, if decision-making is to be assisted by CBA or CEA. At present the economic value of the environmental benefit to be gained from rehabilitation is unknown. These benefits appear to flow mostly from reducing the off-site impacts. A list of the possible causes of environmental harm have been stated previously; however, the most likely villains are stream pollution, unacceptable aesthetics of spoil piles and unwanted flora and fauna both exotic and native. The data necessary to place a value on the environmental attributes are expensive to gather; however, since an estimated $90 million is spent annually on coalmine rehabilitation the cost of gathering the data appears warranted. If the value of the environmental attributes
were established, then rehabilitation expenditure could be distributed more cost-effectively and research could be directed to the most needed areas.

On the mine sites, it is important to understand the mine water balance and hydrology at the time of mine closure. Data on the quality of water downstream of mines are necessary and, although limited data are available, this activity needs expanding and coordination. One unacknowledged possible reason for carrying out rehabilitation is to improve the aesthetics of mined land. It appears that research into the value the community places on the aesthetics of rehabilitated mined land in the Bowen Basin is required. Since the human eye judges aesthetics, this research should be directed at mined land that is visible to the public gaze. Mined land, which is out of public view after mine closure, may have no aesthetic value. Coincidently this appears to be the position taken in the first environmental legislation that was applied to the Moura mine in 1962.

The role of the economist is as part of a team taking a holistic approach to developing strategies that will deliver the desired goals. Although strip-coal mining is similar on most mines in the Bowen Basin, each mine has a unique set of environmental conditions. Rehabilitation solutions will differ for each mine. Nevertheless, for each mine, a holistic approach incorporating the disciplines of engineering, hydrology, environmental science, and economics, along with thorough environmental risk assessment is essential to delivering the best economic and environmental outcome for Queenslanders. The economic analysis techniques of CBA and CEA in combination with risk analysis provide an unbiased method of examining rehabilitation alternatives. However, before either can be effectively used it is necessary to put a value on each environmental attribute and a probability of the likely impact on each attribute both during and perhaps more importantly after mining ceases.

This thesis has identified and ranked the environmental attributes using expert groups and compared the outcome against groups drawn from the local community and the University of Queensland community. The most pertinent findings were that:

(i) down-stream water quality and aesthetics are of more importance than land quality within the mine, whereas most environmental expenditure is focused on land related activities;
(ii) aesthetics is an important attribute which to date has been overlooked and is rated above general land quality;

(iii) there is an over emphasis on land management whereas the focus should be on containing the impacts of mining to the mine site;

(iv) grazing is not the preferred final land use; and

(v) the EPA needs to clearly enunciate its environmental vision and objective in relation to mine rehabilitation.

Although it has been possible to place the attributes in ordinal rank, it is not yet possible to place a cardinal value on the attributes. Nor is there an accepted common measure of effectiveness, a prerequisite of cost-effectiveness analysis. If, however, downstream water quality was to be accepted as the single measure of effectiveness then expenditure on mined land rehabilitation could be directed so as to most cost-effectively maximise downstream water quality. A subjective judgement would have to be made as to the amount of expenditure directed toward improving aesthetics and reducing unwanted flora and fauna. The data economists need most are the values of improving water quality in the Fitzroy catchment and values of improving aesthetics and reducing unwanted flora and fauna. If this data were available then a cost-benefit analysis would identify not only where expenditure should be directed, but also the amount of expenditure to yield the greatest net benefit. Nevertheless, given the information presented herein, it is possible to make certain recommendations that may lead to more cost-effective rehabilitation of mined land.
5.3 RECOMMENDATIONS

5.3.1 Alternative strategies

Mined land rehabilitation has followed a philosophy similar to our forebears’ approach to the land. For them, nature much more than technology, was seen as the opponent and in our forbears’ era, wild nature was an opponent to be tamed (Blainey 2001). Rehabilitation has focussed on reshaping the land to some perceived ideal landform and establishing grass that may be productively used for grazing. Slope angles would be decreased so as to facilitate grass cover and reduce erosion even though it meant increasing the area of unmined land covered by the spoil piles. History has taught us that treating the land as an opponent to be tamed can be very costly to future generations especially when salt contained in ancient soils is released. The younger generation of environmental scientists will take a more holistic approach to rehabilitation, examining the long-term benefit to be gained by various rehabilitation strategies. These alternative strategies will hopefully take account of landforms, which when they erode over time, will not result in a deterioration of downstream water quality. They will also examine the environmental risks and apply the Pareto principle of addressing first the risks with the greatest potential for long term regional damage. It is hoped that the new generation will also have concern for the cost-effectiveness of their rehabilitation practices.

5.3.1.1 Reallocating of expenditure

The surveys conducted indicate that the greatest environmental concern is to protect downstream water quality, followed by recognition of the need for the mined land, which is visible to the public, to be rehabilitated so as to be aesthetically appealing. The current emphasis and expenditure on land management may be more cost effective if directed to reducing the risk of stream pollution in the years after mining ceases. Many mines are already moving in this direction designing internally drained landforms so that contaminated water does not report off the lease. Nevertheless, ensuring that water, which flows over the external areas of the mined land and reports to the streams is not contaminated is more important. On those slopes from which water drains into the catchment, protecting the relatively thin layer of topsoil against erosion is critical. If this topsoil cannot be guaranteed to be sustainable then leaving the slopes at the angle of repose and rock armouring them may be more sustainable in the long term. Whichever strategies are chosen, there is a need to move away from the emphasis on a productive use for the
small amount of land effected by mining toward ensuring that there is no long term off site impact emanating from the mined land.

5.3.1.2 Design for failure

Just as nature is destroying the pyramids, so in time nature will destroy all made structures. The naive belief that structures can be designed to last indefinitely is evident in attempts to build engineering structures to protect the environment. For rehabilitation to be sustainable it must be designed to take account of failure, whether that failure be loss of topsoil, or failures caused by droughts, fires, streams changing course, 1 in 1,000 year events, or graziers, who on finding land unsuitable for grazing, simply leave it unattended or worse over-graze and then abandon it.

5.3.2 Public policy

Lyons (Lyons 1999, p. 274) lists three categories of public environmental management policy:

Type I - tangible and specific, examples being fish stocking and preservation of natural wonders;

Type II - tangible yet diffuse, examples being protection of significant endangered species such as the Bald Eagle; and

Type III - intangible and diffuse, such as the protection of insignificant endangered species.

Lyons contends that political self-interest forces politicians to focus on Type I and to a lesser extent Type II categories with little political incentive to focus on category III. Vig and Kraft concluded that "Perhaps the greatest obstacle to more rational and effective environmental policy making at present is absence of any mechanism for integrating and coordinating policy actions on the basis of an overall strategy of priorities." Cited in Lyons 1999, p. 282.

A nation is more likely to embrace nature when most of its people have reached a comfortable standard of living. Until the latter half of the twentieth century in Australia a sound clean environment had been seen as an expensive luxury (Blainey 2001). In the 21st Century the citizens of Queensland might reasonably expect that they could swim in and

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catch and eat the fish from the Fitzroy River catchment. They may also have a vision of continually improving water quality that would allow their grandchildren to safely drink the river water.

5.3.2.1 Valuing the environmental attributes

Placing a value on the environmental attributes will be a herculean task. Even after using economic techniques such as stated or revealed preference to place a value on say water quality there remains the question of the value future generations place on water quality. The current generation places a high value on coal mining because it supplies considerable wealth to Queenslanders. Once mined and sold coal has no value to future generations. On the other hand, if streams are polluted as a consequence of flowing through mined land, there will be a disbenefit to future generations. Current economic analysis takes no account of this possible disbenefit.

The fieldwork for this thesis used expert focus groups to rank the environmental attributes. This process produced a logical conclusion; however, it may not have arrived at a finding that represents the democratic will of the population of Queensland. The Mining Minerals and Sustainable Development project previously mentioned has taken a novel commercial approach to soliciting stakeholder input. The MMSD project conducted stakeholder forums in some Australian state capital cities and charged people $450 to participate. At the other end of the spectrum is the Delphi method listed by the US Office of Management and Budget (OMB 1996, p. 13). As its name suggests the original intent of this method, created by the Rand cooperation in 1962, was to survey respondents in an attempt to predict the future. The intention of this method is that all respondents to the questionnaire are anonymous; however, each respondent is able to see the groups' responses and given the opportunity to change their answers to the questionnaire (Dewar 2000, p. 43).

The Waverley Council recently conducted what was reported to be Australia's first Citizens Jury in relation to the environment as part of its Bronte Catchment Project. The jury focused on a single topic, "reducing stormwater pollution." The survey was conducted in a very small, highly populated catchment and focussed on the single issue of water quality. One would expect if the same technique were to be applied to Australia's largest easterly flowing catchment, and encompassed not only all aspects of water quality but all other...
environmental attributes, the cost of such a survey would be at least ten times the $285,000 spent on the Bronte Catchment Project. Nevertheless, given the amount being spent annually on strip-coalmine rehabilitation, such an approach could easily be justified. Another less democratic, but perhaps more effective method would be to employ paid expert focus groups to set environmental objectives, which are in the best long-term interest of society. Once these objectives are established and the likely benefits and costs known, then the population will be in a position to assess their willingness to pay for the various options presented.

There is a need for a single body that has control of the water resources of the catchment and represents the interests of catchments or sub-catchments. Currently there are catchment groups, landcare groups and local interest groups funded by Commonwealth, State and local Government. As a consequence their efforts are uncoordinated and their effectiveness is limited. They often draw on the same groups of community volunteers. The established local government boundaries are a reflection of the progress of European settlement rather than any attempt to create boundaries based on natural geographic features. In time local government boundaries could be changed to align with river catchments; however, there is an immediate need for river catchment bodies which have the authority to manage the water resources of the catchment. Such a body may initially be set up as Government Owned Enterprise as was the case for regional electricity boards. Such a Fitzroy Catchment Board located in Emerald or Rockhampton would have responsibility for, and reap the benefit of, managing the water resources of the catchment. Resources of the many other groups could be pooled and managed by this organisation much more effectively. Members of such a group who were paid to manage the interests of the catchment could be expected to come up with rehabilitation policies which are in the best long term interest of the catchment. Perhaps a Coasian property rights approach combined with cooperative ownership could provide the most cost-effective solution and deliver the best possible environmental outcome for the catchment.

5.3.2.2 Property rights

After mining ceases there is potential for water emanating from the mined land to affect downstream water quality. This may have serious regional impacts. In order to assess the significance of such impacts, there has to be a vision for the catchment, which if not agreed
to by the people of Queensland is at least broadly known and accepted. This is a difficult task for it involves educating all Queenslanders about the current state of the Fitzroy basin and then seeking their opinion on the appropriate vision for the catchment. In 1992, Rowland proposed an Integrated Catchment Plan be developed and suggested the following goals:

(i) community understanding, coordination and cooperation;
(ii) common goals and priority action; and
(iii) economic and ecological sustainability (Rowland 1992, p. 171).

Unfortunately, there is currently an asymmetry of information with a few scientists and Government employees having a knowledge of the health of the catchment, whilst the remainder of the population are blissfully ignorant. Such a "tyranny of the uninformed." (Tisdell 1991, p. 219) may result in less than ideal outcomes. The first priority of those with the scientific knowledge should be to share that knowledge with all those involved in the decision-making process. The public policy maker's job is to ensure that their constituency is informed and that decisions are in the public's best interest.

If the environmental objective is to protect or enhance downstream water quality, there are many possible strategies to achieve that objective. Since it is possible to define a geographic area (the Fitzroy catchment) property rights to the catchment could be established. Tradeable rights to emit pollution could be created and a steady improvement in the environment achieved by reducing the volume of tradeable rights. Alternatively, a Pigouvian pollution tax could be considered. Unfortunately, when the pollution occurs after mining ceases and the mined land is surrendered, then there is little or no opportunity to seek payment from the mining company. It would be prudent to reduce the risk of such an occurrence and options such as concentrating the rehabilitation effort on specific areas, which have the potential to increase downstream pollution, could be explored. There are many possibilities that may yield a Pareto improvement once environmental goals are set in preference to prescriptive rehabilitation requirements.

Legislation generally follows rather than precedes society's expectations. In the case of ESD, however, it has preceded the general knowledge and understanding of many Queenslanders. Before proceeding to more prescriptive legislation, the legislators may first have to make explicit the concept of ESD by practical example. A current example is
the ambivalence of many Queenslanders as to the need to reduce or maintain the current level of land clearing. However, an obvious example of ESD in practice would be to legislate against land clearing in and adjacent to the riparian zones of streams as a strategy for achieving the water quality objectives. Acceptance of this legislation by the community would be more likely if our politicians and regulators could explain the purpose of the legislation and the link to ESD so that the concept is understood and accepted by the electorate. Assuming the goals of say potable or fishable or swimmable water, what additional legislation is required to achieve these goals?

5.3.2.3 Legislation

As a consequence of the 1994 CJC inquiry into the improper disposal of liquid waste in south-east Queensland, R.S. O'Regan produced a report regarding evidence received on mining issues. He found it strange that the regulation of the multi-million dollar mining industry could be reworked over many years without a clear legislative basis for the policy initiatives being taken by the DME and that the officers of the DME relied on departmental policy rather than legislation (O'Regan 1994, p. 25). He pressed strongly for a further investigation which he hoped would result in the establishment of appropriate legislation to produce a clear basis for the policies now applied to the mining industry (O'Regan 1994, p. 26).

The Environmental Protection and Other Legislation Amendment Act 2000, or EPOLA Act, of October 2000 transferred environmental legislation of mining from the Mineral Resources Act to the Environmental Protection Act. The EPOLA Act was incorporated into the Environmental Protection Act 1994, or EP Act, in January 2001. The overriding legislation governing the environmental issues related to mining is therefore the EP Act. The goal or objective of the EP Act "is to protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends (ecologically sustainable development)." (Queensland Government 1994, p. 14). The EP Act has partially addressed the concerns raised by O'Regan; however, there is as yet no clear legislative basis for the policy initiatives being taken by the EPA and the officers of the EPA still rely on departmental policy rather than legislation. This is not an argument for more prescriptive legislation but rather an argument for legislation making explicit the
need to protect or enhance environmental values or attributes and to clearly define these attributes in legislation. Legislation should also distinguish between protecting attributes within the mine site and the more important protection of attributes outside the mine site and thereby introduce the concept of ranking the attributes in accordance to their importance in achieving the ESD vision.

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* prepared by the Australian and New Zealand Environment and Conservation Council (ANZECC) struggled with a definition of environmental attributes or values. They noted that environmental values are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health. They have possibly unintentionally combined the protection of the environmental attributes necessary for a healthy ecosystem with value in use. The confusion created by such an approach is evident in the conflict between using water for agriculture and protecting the environmental attributes. The guideline does not attempt to place a value on aquatic ecosystems or suggest how a conflict between the commercial use of water and the ecology might be resolved. The EP Act defines 'environmental value' as a characteristic of the environment conducive to ecological health or public amenity. Unfortunately this definition could also be interpreted to mean that if, for example, water used to grow cotton produces a greater public benefit than using that water to protect an ecosystem then the water should go to cotton growing. If public amenity were defined in such a way as to link amenity to the environmental characteristics of the environmental value then the definition would be clearer.

The ANZECC guideline prescribes levels of many elements such as copper and arsenic, which should not be exceeded. The Coasian approach of commencing with the current situation and examining how that situation may be improved is a more practical approach. Having recommended water quality standards, it would have been beneficial if the water quality of the major Australian and New Zealand rivers were compared against these standards. Progress at enhancing or protecting ecosystems could be measured against this base line data. If this data were unavailable then the committee could have recommended collection of the data and how and where data collecting stations should be established.
Miners and the public need easily understood and realistic guidelines. For example, if river water is currently potable, then the objective is to maintain that quality. It should be up to the regulator and the mining company to establish the pre-mining water quality. Although mining companies and government agencies have attempted to establish water monitoring stations it would be more efficient if these initiatives were coordinated by one body. The establishment of water quality stations, which can operate automatically in all conditions, should be considered. Perhaps the Queensland Government would be more committed to ensuring cost-effective expenditure on rehabilitation if the rehabilitation costs were an allowable deduction for the company when calculating the amount of royalty to be paid to the Government.

5.3.2.4 The regulator's role

The DME submitted evidence to the CJC inquiry in 1994, that the security liability for rehabilitation of coal mining operations was $480 million and for metalliferous operations $220 million compared to the total security held by the DME of $62 million. Subsequently the DME took steps to increase the security held. There are several reasons why holding security is a second best alternative to the sound planning for and execution of rehabilitation during mining. Firstly, if the necessary precautionary design and landform creating earthworks are not carried out during mining then it is unlikely the amount of the bond will be sufficient to carry out the rehabilitation necessary to eliminate the risk of long term environmental damage. It is much more efficient to place the overburden material once only. The mining of 108 million tonnes of coal in 2000/2001 required the removal of approximately 800,000 cubic metres of overburden. A security of $480 million would allow for the reshaping of less than one half of the annual overburden removed. Secondly, the mining companies least likely to carry out rehabilitation are those at risk of financial failure. Should a mining company incur financial problems then the company may fail to make the payments necessary to maintain the Bank Guarantee required as security and if the company fails there will be no funds for rehabilitation. Thirdly, if the calculation of the security is based on hectares mined then security may bear little relationship to either the environmental risk of the mining operation or the rehabilitation costs.
security. The CJC report author would no doubt be disappointed that this is still a guideline requiring the subjective judgement of officers within the EPA to assess the financial assurance. Nevertheless, it would be more disappointing if legislation followed the same course of considering hectares mined to be the measure of environmental risk rather than the potential for long term environmental damage to the ecological processes on which life depends. Neither the legislators nor the EPA have yet addressed the risk associated with the potential for pollutants to emanate from mines long after mining ceases. This is possibly because there is no international precedence of legislation based on the potential risk to the environment. Guideline 17 does give incentive for companies to carry out progressive rehabilitation by discounting the assurance by up to 75% and this should encourage companies to rehabilitate in accordance with their EMOS commitments. Whether these EMOS commitments deliver the best outcome for the environment under the vision of ESD is difficult to judge in the absence of any environmental risk analysis. In adhering to EMOS commitments the mining companies may not be encouraged to develop cost effective methods of achieving the ESD vision. The public would have more confidence in the process if EMOS and EA documents and environmental audits against the EA commitments were made more readily available to the public by placing the documents on the EPA web site. This would also give credibility to companies who espouse a triple bottom line philosophy.

5.3.3 Mining company environmental philosophy

5.3.3.1 Response to the ESD vision

Ten of the world's largest mining, minerals and metals companies initiated the Global Mining Initiative (GMI) in 1999 to provide global leadership for the mining and minerals industry by developing a sustainable development model. A central activity within the GMI is the Mining Minerals and Sustainable Development (MMSD) project which seeks to identify how mining and minerals can best contribute to the global transition to sustainable development. Why ESD has been shortened to sustainable development is unclear given that the latter is axiomatic as previously explained. Since the global mining industry has already committed to ESD, we may assume that by sustainable development is meant ESD.
This is not a difficult task providing the mining industry understands, accepts and inculcates into its employees the central tenet of ESD. As stated in Chapter 2, ESD is defined as using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be maintained. The central tenet of ESD, captured in the second part of the definition of ESD, i.e. the ecological processes, on which life depends, are maintained, so that the total quality of life, now and in the future, can be maintained. Comments from mining executives indicate a degree of confusion with ESD in relation to mining possibly because they have focused on the first part of the definition of ESD. Individual mines extract exhaustible resources. Mining a resource or conserving and enhancing that resource are mutually exclusive options. Nevertheless, ceasing mining would put the environment at greater risk, as the current world human population could not be sustained without the products of mining. The majority of the world's population will benefit if mining companies continue to mine and explore for new resources and keep the world informed as to the availability of new mineral and energy resources on which their children's future depend. However, future generations will be disadvantaged if the mining industry fails to meet the central tenet of ESD. Mines should not leave the ecological processes, on which life depends, impoverished nor should they abandon mines in such a state that future generations have to bear the cost of clean up after mining ceases.

Mining occupies relatively small areas of land and the land is often barren and remote from human inhabitation. The greatest environmental risk mining presents to the ecological processes, on which life depends, is to areas outside of the mining area. The most common transmitting vector causing environmental damage is water. Adopting the Pareto principle approach, the companies which initiated the GMI could commit to protecting or enhancing the water quality downstream of their existing mines both during and more especially after mining. This would be an important first step in gaining the confidence and support of the communities living in areas where they currently mine. Companies with a reputation for adhering to such a commitment would no doubt have a better chance of gaining approval for, and community acceptance of new mines.

The mining companies who adopt the ESD vision would be able to take a leadership role in establishing their environmental objectives in conjunction with the environmental regulatory authority. Providing a thorough environmental risk analysis is conducted the
mining company would be able to develop strategies to cost effectively meet the environmental objectives with greater assurance of gaining lease surrender at the completion of mining and with the reassuring knowledge that they had met the community's expectations. In order to achieve this, however, there needs to be a clear matrix of responsibility that commits both miner and regulator to progressive signoff of the objectives.

In Queensland, given the Government's ESD vision and the EPA's objectives of protecting or enhancing certain environmental attributes, the mines need to develop strategies to ensure that, following mine closure, the environment surrounding the mine will at least be no worse than prior to mining. If expenditure on rehabilitation is to be cost-effective, the attributes to be protected must be ranked so that the most important attributes can be given the greatest priority and so that equal marginal benefit is gained from an additional dollar spent on protecting each of the various attributes. There is an increasing emphasis on environmental quality perhaps evidenced by the doubling of votes for Greens in the Federal Election of 10th November 2001. Following a twenty-year trend, environmental legislation will most likely continue to increase. The mining industry needs to take an active role if it hopes to influence and gain better environmental legislation. The mining industry cannot rely on glossy pamphlets or unctuous statements but must set and achieve measurable targets and make public these target and progress toward these targets. There are actions that the mining companies could take to show their concern for the long-term environment. One such action would be to establish nature refuges for threatened native species adjacent to mined land and then fence both the refuge and the mined land to protect the threatened native species. At least one mining company is progressing down this path. More important would be industry support for permanent water quality testing stations throughout the Fitzroy catchment and support for research into more holistic methods of measuring the quality of riverine ecosystems.

5.3.3.2 Mine closure planning

The need for measurable targets is most obvious in mine closure planning. The Queensland Mining Council (QMC) represents the interests of companies that explore, produce and process minerals in Queensland and is the industry's policy making body. The QMC issued Guidelines for Mine Closure Planning in Queensland in May 2001. This
document describes a practical mine closure planning framework that can be used on the broad range of mine sites throughout Queensland. The guidelines provide guidance to QMC members on the development and implementation of mine closure plans that are appropriate to the nature and scale of individual operations. The QMC hopes that achievement of the key elements of the framework including consultation, program development and implementation will aid successful progression to mine closure and prompt relinquishment of tenure. This document is available on the QMC web site. Section 3.4 (QMC 2001, p. 3.4) on Developing environmental management strategies and mine closure plan is an excellent example of the industry defining and making public, measurable targets.

Australian and New Zealand Minerals and Energy Council and the Minerals Council of Australia also published a Strategic Framework for Mine Closure in 2001 and amongst other activities the document recommends both risk assessment and cost-benefit analysis for part of the mine closure plan (ANZMEC 2001, p. 7). The document notes that a risk-based approach to environmental planning will reduce both cost and uncertainty. The document goes on to suggest the need for a set of indicators which will demonstrate the successful completion of rehabilitation. Such indicators are necessary; however, they cannot be established unless the rehabilitation objective is first agreed between the mine and the regulator. The need to plan for closure is also recognised in the Code for Environmental Management 2000 published by the Minerals Council of Australia (Minerals Council of Australia 2000, p. 8). All three of the aforementioned documents note the need to carry out environmental risk assessment.

5.3.3.3 Environmental risk analysis -

In 1997 the Queensland Department of Environment attempted to refocus the debate on licensing by adopting a risk management approach. Unfortunately, the risk categories were very broad and the Chief Executive Officer of the Queensland Mining Council was concerned that mining received a rating higher than more environmentally hazardous industries (Sanderson 1997). Disappointingly, the full report was never made available to the public and no further attempt has been made to pursue risk-based evaluation. The concept of risk rating industries was an example of attempting to apply prescriptive universal rules to industry as a whole rather than accepting the principle of risk
management and applying these principles to each individual mine or industrial site. The purpose of risk-based assessment is to assess individual projects for risk rather than categorise industries.

Risk has two dimensions: consequence and likelihood (Dryden 1999, p. 10). Loss of topsoil, droughts, fires, floods, and land mismanagement are identifiable environmental hazard events. There is a real probability of such events occurring and the environmental consequences may be serious. If the probability and consequence of these events are known it is possible to rehabilitate mined land to best accommodate these events. Lester Thurow explains that people and institutions accept and design for risk. However, the world is marked by uncertainty as well as risk. Uncertainty occurs when it is impossible to assign probabilities to different possible outcomes where all the different possible outcomes are unknown (Thurow 1983, p. 236). Human beings are unpredictable, one only has to study the stock market to see how unpredictable we are. John Meynard Keynes was also at pains to distinguish the concept of uncertainty from the simpler concept of risk. Risk can be assigned a probability because there exists a history of previous similar events. The outcome of a toss of a coin or the roll of a die are events to which a probability can be applied. Uncertainty is fundamentally different in that an event is unpredictable, where the past provides no reliable guide to future events (Keen 2001, p. 151). Just such an event occurred on the 11th September when two passenger jets were flown into the twin towers in New York. We cannot yet predict if the world is entering a phase of global warming or about to enter a glacial period. Such events relate to the unpredictable behaviour of the natural environment including human behaviour. Nevertheless, in the past three hundred years, considerable progress has been made in converting events, which were previously considered uncertain, into a definable risk by mathematical endeavour and the collection of data. In fact there is gradation from events which are predictable with known probability, through events which may be predictable in the future when more information as to their probability is made available, to events which may never be predicted and are truly uncertain.

In the case of mine site rehabilitation we may attempt to predict the extent of environmental regulations which may exist in twenty years time based on previous trends. Nevertheless, human nature is unpredictable and there remains uncertainty as to the specific environmental regulation people and governments will demand in the future.
Companies faced with uncertainty will be conservative in their approach to rehabilitation. It is the role of government to reduce the uncertainty, which is created by constantly changing environmental legislation and regulation, to quantifiable risk. One way to reduce uncertainty is for the regulator to sign off on actions as soon as it is practically possible and not rescind these decisions. The best insurance for companies, if they desire a more predictable outcome, is to become involved in the development of regulation and this means first reaching agreement with the regulator on the vision and objectives of rehabilitation. Without known and community accepted environmental objectives no amount of standards will guarantee a company will be able to surrender its mining lessee.

Having identified water quality as the issue of most concern, the next task is to identify the hazards. Strip-coalmining produces strips of mined land many kilometers in length but comparatively narrow in width. Because mining occurs at the edge of the Bowen Basin these strips are generally orientated north - south. Since streams flow east to reach the coast most strip mines are likely to be intersected by streams. The streams are typically non-perennial. Where mining occurs close to streams there is a probability that the residual voids, which may exceed one hundred metres in depth, may capture an adjacent stream. This may have serious environmental consequences. Firstly erosion will occur up stream as nature tries to eliminate the one hundred meter high waterfall created as the stream flows into the void. In the case of streams with small catchments and low flows the water captured is lost to downstream users and the stream may cease to flow immediately downstream of the mine. If the stream flow is greater and the void water polluted then this will pollute waters downstream in flood times if the void overflows. Of course if the water flowing into the void remains unpolluted then this could be a valuable source of water. Possibly the greatest hazard to the Fitzroy would be the introduction of exotic fish such as carp (Cyprinus carpio) which suck up silt from the bottom and expel it into the water increasing turbidity in enclosed waters. Introduction of such a fish would most likely be more devastating on the environment than all the coal mines combined. These fish thrive in streams made turbid by erosion, which may give the carp an advantage over native species. Reducing water turbidity may be the best protection for native fish.
5.3.4 Research required

Many millions of dollars have been spent on research into how the environmental attribute of land might be protected or enhanced; however, relatively little has been spent on how the environmental attribute of water can be protected or enhanced. There is a need for research into water quality, hydrology and ecology both on and off the mine site. Within the mine, research is needed into how streams migrate and the risk of stream capture by voids left after mining. Research into predicting the likely quality of the water, which accumulates in voids after mining ceases, has commenced but needs greater priority. The relationship between the water quality and the various materials mined such as Permian and Tertiary strata is important in identifying possible pollution materials. Materials with a potential to generate acid mine water should be identified as a priority. The data gained from research is of little value if it cannot be easily used in mine planning. Research into computer programs which generated landforms whilst taking into account such things as depth of burial of pollution generating materials, water tables and drainage would be of great assistance to mine environmental scientists. Such programs should also record the location of materials in the as-built landform.

Importantly data on the current state of the waters downstream of each mine is needed. This would enable the base line to be set on current water quality and it would establish the standards against which future improvement could be measured. Only then is it possible to look at the tactics for improving on the current ambient quality. These tactics would include developing mine closure plans which address all the issues of mine water hydrology, including final stream locations, reducing polluted water runoff, containing all water sourced within the mined area to the mined area and as a last resort having this water report to the final void left by the last strip mined.

The draft Australian and New Zealand Guidelines for Fresh and Marine Water Quality prepared by ANZECC present standards for water quality in terms of the maximum amount of a particular element such as copper or arsenic. Perhaps research into a more holistic and less expensive measure where animal life or other life is used as an indicator of steam health is needed. Research is certainly required to define when water is potable, swimmable, fishable, fit for stock or agriculture or not fit for any life form.
The groups surveyed raised the risk of fire along with feral fauna and flora emanating from rehabilitated mined land as additional issues of concern. The likely culprits were ferrel pigs and Parthenium hysterophorus. Research into the risk and possible impact of fire and undesirable fauna and flora would assist decision makers. This research could be conducted in conjunction with research into the benefit of the mining companies providing offsets of native fauna and flora refuges. The latter proposal put forward at the workshops was for mining companies to purchase land adjacent to the mining lease for nature reserves as a way of offsetting the impact of mining on the environment. A similar suggestion was for adjoining mining leases to be amalgamated on surrender to provide extended horse riding trails or four-wheel drive tracks.

Although considerable research has been carried out into land management, research has tended to focus on growing vegetation on mined land. The major question of how to best protect the 100 mm of topsoil, which has been placed on mined land at great expense, has yet to be answered. It appears from observation that loss of topsoil may not be a great concern if the underlying material is of Permian origin. On the other hand loss of topsoil from Tertiary material may preclude future vegetation growth and erosion may increase downstream pollution.

Lastly economics research is required to place value on the various environmental attributes including aesthetics, but most importantly water.
5.4 References


