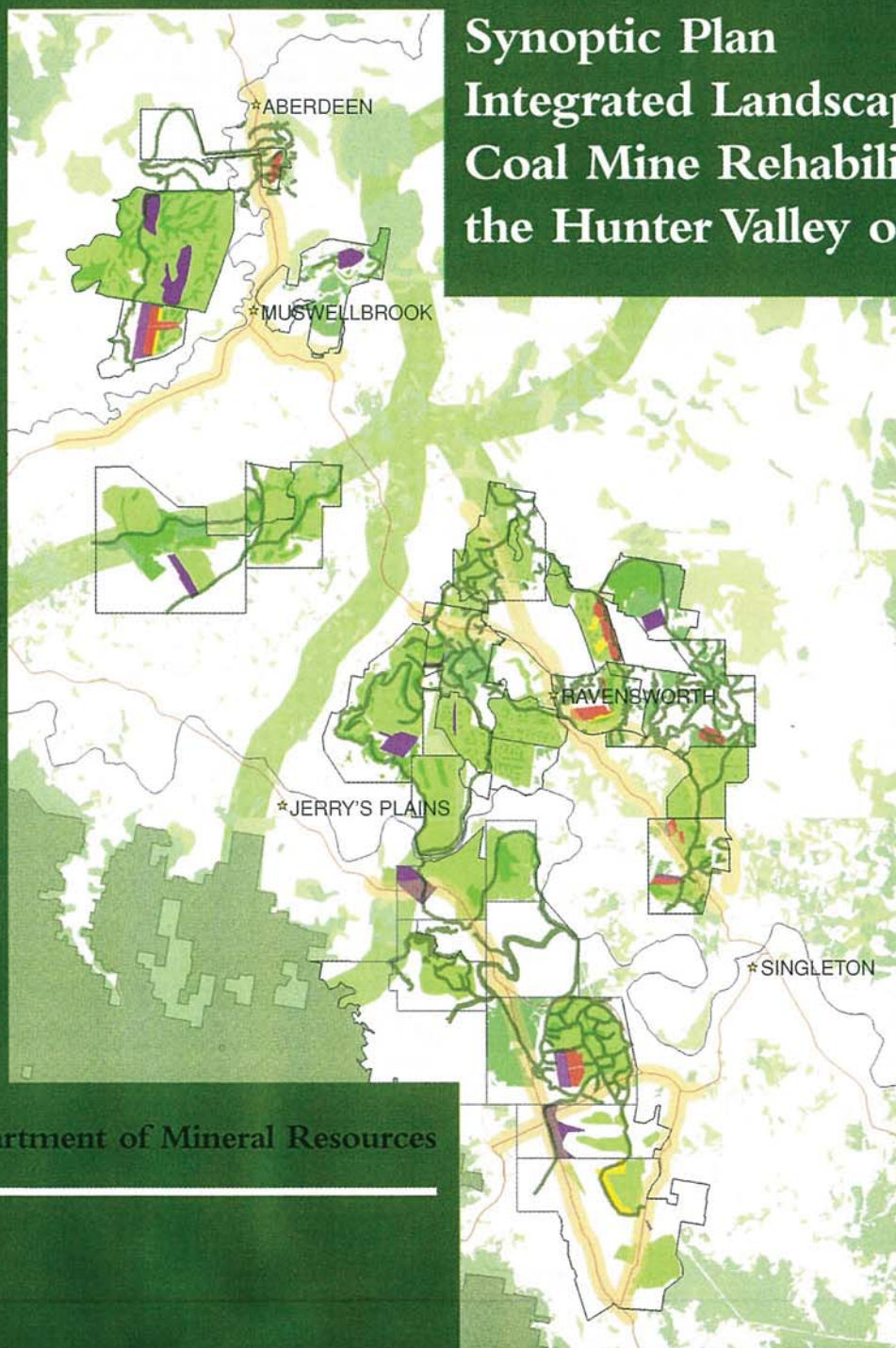
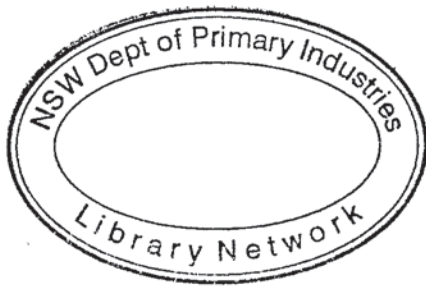




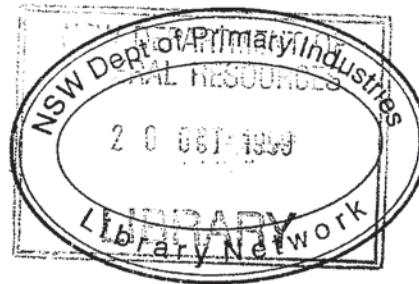
Synoptic Plan Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of NSW



NSW Department of Mineral Resources



Department of Mineral Resources



**SYNOPTIC PLAN
INTEGRATED LANDSCAPES
FOR COAL MINE
REHABILITATION IN THE
HUNTER VALLEY OF NSW**

Prepared by
ANDREWS.NEIL
Architects Planners Landscape Consultants

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Executive Summary

Progressive integrated landscape management of the Hunter Valley has recently focused on policy formation to assess and control cumulative environmental impacts of current land uses. To this end, policy agreements between governments, industry and the community have been developing although an appropriate focus on design and technology has been lacking. This document attempts to redress this inadequacy by combining the expertise and knowledge of recent advances in the management of the Hunter Valley mines in addition to the objectives of broader federal, state and regional environmental and economic objectives. In doing so, policy formation outlined in previous documents, including the Upper Hunter Cumulative Impact Study (UHCIS), is advanced to the imperative stage of implementation, monitoring and evaluation.

Restoration of mined areas to achieve visual amenity, biodiversity conservation and land management practices for ecologically sustainable development emerge as important completion criteria. Determining and quantifying the final land use during the progression of mining is a requisite for meeting such criteria. The need to undertake reassessment of rehabilitation outcomes in the coalfield has stemmed from the perception identified in the UHCIS, of a subtle paradigm shift. This is a shift in focus from agricultural land use to habitat/biodiversity restoration, and from traditional land uses to more innovative integrated land uses. These innovative land uses include the development of timber plantations with potential financial returns from both timber and carbon sequestration.

The Action Strategy nominated the Department of Mineral Resources (DMR) as the lead agency to establish a demonstration program for mine site rehabilitation and prepare an integrated landscape master plan for the Upper Hunter Coalfield. Such a brief extends beyond the traditional paradigm of environmental assessment associated with single developments as required under the Mining Act 1992.

The DMR undertook this work by the facilitation of a steering committee comprising representatives of:

- NSW Minerals Council.
- Singleton and Muswellbrook Shire Councils.
- Department of Land and Water Conservation (DLWC).
- NSW State Forests.

The collation and drafting of mining data, based on current approved mine sequencing and planned rehabilitation was fundamental to this work.

The study provides an overview of:

- Current practices and trends in mine rehabilitation.
- Regional initiatives in vegetation management.
- Emerging environmental issues and their implications on mine rehabilitation.
- A comparative analysis of mine rehabilitation plans at 1998 and 2020.
- Principles for an integrated approach towards landscape management for the coalfield.

Coal mining in the Hunter Valley has matured, over more than two decades, as a land use fundamental to socioeconomic development and as an industry capable of meeting the environmental expectations of the community. Coal mining has a dynamic but relatively short tenure of land occupancy. At this juncture, there is need for a strategic direction to lead into the next century. The broad application of integrated landscape principles, as addressed by the Synoptic Plan, can significantly enhance the outcomes of mine site rehabilitation for the lasting benefit of all stakeholders.

The mining industry is well positioned to achieve this progression through the regulatory procedures adopted in the Department of Mineral Resources' Mining, Rehabilitation and Environmental Management Process (MREMP).

The purpose of this study is to provide a basis for development of a long term integrated strategy for the rehabilitation of mines. This initiative will hopefully encourage adjacent landowners, government and the broader community to contribute in planning and land management terms to a region-wide landscape strategy.

The study is confined to an area of 260,900 hectares comprising 14.5% of the study area of the Upper Hunter Cumulative Impact Study. The study area comprises the coalfield of the Upper Hunter Valley extending from south west of Singleton to north of Muswellbrook. It is defined by the extent of the eight 1:25,000 topographic maps, Aberdeen, Muswellbrook, Dawson's Hill, Jerrys Plains, Camberwell, Doyles Creek, Singleton and Bulga. Mine holdings cover approximately 61,045 hectares or 23.4% of the study area.

The initial stage in the preparation of the Synoptic Plan was the collation of mining and rehabilitation data and drafting of two plans of the coalfield onto a Geographic Information System. The first plan shows the status of current mine development and rehabilitation at 1998. Whereas the second plan shows mine development at 2020 based on current approved mine sequencing and planned rehabilitation. The fundamental benefit to the community and other stakeholders is in the presentation of snapshot plans of the coalfield at the two points in time. The 2020 Synoptic Plan is conceptual and proposes opportunities for revegetation across the coalfield in an integrated approach that considers biodiversity,

agroforestry for amenity and commercial return, catchment protection, and bioengineering of mined landforms.

The papers in Part 2 of the Synoptic Plan have been compiled by academics, consultants and government agencies with expertise in the fields mentioned above. The Strategy Matrix of the Synoptic Plan presents key issues of contemporary mine site rehabilitation, the status of policy/procedure/practice and strategic actions to achieve the desired outcomes. These strategic actions will involve policy change, continued best practice, quality improvement, focused research and, perhaps most significantly, consensus on renewed activity in order that

environmental and socioeconomic outcomes are realised. There is still much to learn about ecological processes in the Hunter Valley and specifically the interaction of soils, vegetation and fauna with natural and constructed landforms. The experience from nearly 20 years of tree establishment on mine spoil in the Hunter Valley indicates that while natural processes may be complicated, the physical solutions can often be simple and parallel the natural processes.

This sets the opportunity for achieving the goals integral to success of the Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Upper Hunter Coalfield of NSW.

Strategy Matrix

The principles and concepts embodied in this Strategy recognise the need for flexibility to meet inevitable changes in mine planning and development. In addition, as improved base data becomes available from the Hunter Remnant Vegetation Survey, and a Vegetation Management Plan is developed for the Hunter Region, there will be a need for review and refinement. Continued research, ongoing development of mine rehabilitation techniques, incorporation of emerging technologies and opportunities created by waste water reuse, bio solids, tradable carbon credits and the potential for commercial forestry will all influence implementation of the Strategy. The treatment of final voids as utility assets within rehabilitated mine landscapes will become progressively apparent as currently active mines are decommissioned and value adding after mining uses are developed.

The strategy is ambitious and will require a long-term commitment from the industry, regulators and the broader community. The matrix highlights key actions that need to be progressed to implement the Synoptic Plan.

This Synoptic Plan has identified a number of peripheral issues which can energise and provide initiative to fundamental landscape planning for mine site rehabilitation. These issues; biodiversity, remnant vegetation enhancement, commercial forestry, greenhouse challenge and carbon credits therefore appear in the Strategy Matrix and Vision Statements for the coalfield.

Much of the success of the Strategy will be contingent upon the cooperation of private landholders outside the mine holdings. The continuity of vegetated corridors along and across waterways, agricultural lands and transport corridors is a catchment wide challenge. The mining industry's contribution to this challenge can be significant, but limited in extent.

STRATEGY MATRIX

Vision Statement No 1

By application of the *Synoptic Plan Integrated Landscapes for Coal Mine Rehabilitation for the Hunter Valley of NSW*, the mining industry, together with local and state government, will demonstrate an integrated approach to natural resource management of lasting benefit to the region.

Issues	Status	Strategy
There is no comprehensive vegetation management plan for the Upper Hunter.	- DLWC has initiated stakeholder forums for the development of a Hunter Vegetation Management Plan. - The Upper Hunter Catchment Management Trust is compiling a database of remnant vegetation for the Upper Hunter Region.	A regional approach for areas outside mine holdings is required to enable integration of mine rehabilitation plans with a strategic approach to landscape management for the Upper Hunter.
- Rehabilitation within existing mine holdings has been dealt with on an individual basis without due regard to regional opportunities. - The Upper Hunter Cumulative Impact Study identified a need for a regional (synoptic) plan for mine site rehabilitation. - Numerous stakeholders are involved in the management of vegetation throughout the region.	- A compilation of mine rehabilitation plans for 1998 and 2020 has been completed. - Recent EISs have begun to address issues of cumulative change. However, landscape and vegetation management are still largely dealt with on an individual mine basis. - DUAP is implementing various actions including further work on indicators and future development scenarios as part of a Sub-regional Plan for the Upper Hunter. - Consultation has begun with NSW State Forests, local councils and other community and industry groups.	- The Mining Operations Plans for individual mines can be enhanced in light of this Synoptic Plan. - This Synoptic Plan should be used as a guide for landscape outcomes for environmental impact assessment of new mining proposals. The Synoptic Plan should not be used as a prescriptive planning instrument. - The viability of corridors proposed in the Synoptic Plan needs to be confirmed at the completion of the Hunter Vegetation Management Plan. - DMR will facilitate ongoing coordination between mine holdings, local government and other agencies. Consensus of stakeholders is necessary to realise a paradigm shift in revegetation objectives on mines.

Vision Statement No 2 Rehabilitation and land management practices in relation to coal mining can provide significant regional contributions to the Government biodiversity initiatives and Greenhouse emission reduction targets.		
Issues	Status	Strategy Actions
- Clearing of remnant vegetation through past land uses has led to a reduction in biodiversity. - Current emphasis on mine site rehabilitation to exotic pasture grass, while sustainable, has limited benefits for biodiversity.	- Various initiatives have been undertaken including: - Bushcare: the National Vegetation Initiative. - The Farm Forestry Program. - Plantations for Australia: the 2020 Vision. - Bush for Greenhouse, and Greenhouse Challenge for the mining industry. - Mount Owen Mine is undertaking rehabilitation to create natural ecosystems and wildlife corridors - Research into the use of native understorey plants in mine rehabilitation is proceeding	- Results of field trials and research on native forest systems on mines can be applied as best practice rehabilitation and land management procedures. - Rehabilitation practices should consider the potential for creating diverse habitats in appropriate areas on mine sites. - Native vegetation corridors between mine holdings and adjoining remnant vegetation areas should be incorporated into rehabilitation planning so far as practical with adjoining landholders' cooperation.
Rehabilitation and land management practices relating to coal mining have the potential to improve performance in relation to Greenhouse gas emission targets	- Current mine practices have generally been aimed at restoring grazing land with 14% of rehabilitated land planted to native trees - Potential for tradable carbon credits is being investigated as a factor in determining rehabilitation programs for mined areas and for land management by power utilities.	- Accelerated tree planting, in anticipation of tradable carbon credits, should be realised as a <i>no regrets</i> strategy by the mining industry. - The feasibility of commercial forestry as a basis for carbon sequestration needs to be examined in broadacre demonstration programs.
Vision Statement No 3 By integrated planning, mine site rehabilitation can realise a diversity of post mining landscapes based on sustainable land use including commercial timber plantations and management of biodiversity and visual amenity.		
Mine rehabilitation policy has focused on returning mine land back to its pre-mining land use. This has delivered landscapes lacking variety, with limited potential for biodiversity	- There is now an increasing emphasis on achieving a higher proportion of native forest vegetation cover as opposed to grazing pasture. - Opportunities for other forms of post mining use, e.g. waste management facilities, ash disposal, commercial forestry and wildlife habitat have been undertaken or are under consideration on specific mine holdings.	- An integrated approach can determine optimum end land use strategies for mine holdings with regard to the location and characteristics of the particular mine site. - The potential for Farm Forest Agreements over mine holdings should be investigated as a means of achieving improved economic, environmental and landscape outcomes.

Vision Statement No 4

Given fundamental criteria of stability, safety and sustainability, rehabilitated mine sites and their surrounding mine holdings can provide alternative land uses integrating with and contributing to regional economies.

Issues	Status	Strategy Actions
- Mine holdings represent a considerable land resource. There is need to optimise feasible beneficial uses of this resource. This relates to interim land uses on mine holdings as well as after mining uses. - Stable, vegetated landforms engineered for safe, sustainable land use capability is a prime objective of mine site rehabilitation. - Final voids impose many constraints on after mining land use options. However, they also provide potential resources for certain land uses such as mine and power generation residues, waste management, industrial use, forestry, water storages, recreation and wildlife conservation.	- Integrated uses on mine holdings include traditional agriculture (dairying, beef grazing, horse husbandry) and industrial uses/infrastructure. In a number of cases, the potential uses of final voids as a positive resource has been achieved, e.g. backfilling from adjoining mining operations, disposal sites for ash generated by power stations, local and regional waste management facilities and water storages. - The potential for alternative treatments of final voids has not been given due consideration because of the long term nature of mining operations and potential for changes in the location and shape of the final void as mining proceeds.	- Rehabilitation and adaptive re-use of final voids for appropriate land uses needs to be given increasing priority by mine planning engineers with sufficient lead times in mine operating plans as mine closure is approached. - The application of contemporary legislation (Mining Act and EP&A Act) can provide for stakeholder input to active and passive land uses after mining. This is to be facilitated through the DMR's Mining Operations Plans and Annual Environmental Management Reports. - Further evaluation of implementation and maintenance costs in terms of decommissioning completion criteria should be progressed by the DMR.

Vision Statement No 5

A coordinated approach amongst stakeholders to the monitoring of vegetation management will provide the necessary evaluation of vegetation reforms generally in the Hunter region, and particularly in the coalfield.

- Methods of describing and mapping vegetation types are inconsistent between individual mine holdings. Consequently the ability for analysis and planning in Mining Operations Plans has been limited. - At present, the objectives and outcomes of rehabilitation to native tree systems (e.g. Habitat, forestry, landscape amenity, catchment protection) are unspecified. - Lack of appropriate performance targets and indicators limit the ability to monitor progress.	- Overall notional targets have been established to increase the percentage of tree cover on mine holdings as part of rehabilitation programs. - The 1998 and 2020 composite mine plans provide a valuable tool for monitoring reforestation progress. - Mount Owen Mine has established a management plan for native flora and fauna providing a useful model for other mines.	- Quality improvement in best practice for mine rehabilitation can be achieved having regard to broader regional objectives identified in this Synoptic Plan. Particular procedures are needed for monitoring rehabilitation progress on mined areas in relation to these regional objectives. - Methods of classifying vegetation type need to be refined to ensure consistency between mine rehabilitation and broader Hunter vegetation reforms - The industry in conjunction with the community needs to establish targets and indicators in relation to the use of native plants in rehabilitation and in catchment management generally.
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Steering Committee and Study Team

Contributions of time, expertise and enthusiasm are gratefully acknowledged from:

The Steering Committee Members

Greg Summerhayes (Coordinator)
Peter Smith
Allan Wells & Keith Davies
Rosemary Rohr
Tony Voller
Mick Cooper

Department of Mineral Resources
NSW Minerals Council
Singleton Shire Council
Muswellbrook Shire Council
Department of Land and Water Conservation
State Forests of NSW

The Study Team

Greg Summerhayes & Tim Martin
Geoff Baxter & Simon McKee

Department of Mineral Resources
Department of Land and Water Conservation

Consultants

Peter Andrews, Peter Cowper & Jason Hildridge

Andrews.Neil: Architects, Planners, Landscape Consultants
Environmental & Landscape issues
Report preparation

Authors of Invited Papers

Mark Burns
David Mulligan & Melina Gillespie

Travis Peake
David Bonjer & John Palmer
Mick Cooper
Peter Smith
Greg Summerhayes

Global Soil Systems
Centre for Mined Land Rehabilitation,
University of Queensland
Hunter Catchment Management Committee
Department of Land and Water Conservation
State Forests of NSW
NSW Minerals Council
Department of Mineral Resources

Credits

Unless otherwise noted, all photographs in Part 1 of the Synoptic Plan provided by Andrews.Neil and the Department of Mineral Resources. Illustrations, maps and digital terrain renderings provided by Andrews.Neil.

PART 1: REVIEW

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1.0 Introduction

The Upper Hunter significantly contributes to state and national economies through activities including mining, agriculture, energy production, service industries and urban and rural developments. The Hunter Coalfield is the largest coal producing area in New South Wales.

In rural areas such as the Upper Hunter, the main drivers of regional economies are mining, agriculture and tourism. Some key indicators for the Upper Hunter region are shown in Table 1.

Expanding development of coal resources in the region has generated environmental concerns that have been the subject of various studies over the past two decades. The Upper Hunter Cumulative Impact Study and Action Strategy (UHCIS) released by the Department of Urban Affairs and Planning (DUAP) in 1997 is a pioneering document assessing cumulative impacts of developments in the Upper Hunter. Amongst other things, the study identified three objectives, which were to:

- Establish cumulative impacts of various land uses and developments.
- Establish a regional framework of assessment of environmental impacts of development proposals.
- Assist future strategic land use planning.

The Action Strategy nominated the Department of Mineral Resources (DMR) as the lead agency to establish a demonstration program for mine site rehabilitation and prepare an integrated landscape master plan for the Upper Hunter Coalfield. Such a brief extends beyond the traditional paradigm of environmental assessment associated with single developments as required under the Mining Act 1992.

The DMR undertook this work by the facilitation of a steering committee comprising representatives of:

- NSW Minerals Council.
- Singleton and Muswellbrook Shire Councils.

- Department of Land and Water Conservation (DLWC).
- NSW State Forests.

The collation and drafting of mining data, based on current approved mine sequencing and planned rehabilitation was fundamental to this work. Mining Operations Plans for all coal mines and their coal handling facilities were collated by the DMR as hard copy and digital plans. These were then formatted by DLWC onto a central Geographic Information System (GIS) database to provide synoptic maps of the coalfield as two snapshots being year 1998 and year 2020.

Stakeholder feedback during the preparation of the Synoptic Plan was facilitated through:

- Progress reports to the Upper Hunter Cumulative Impact Study Consultative Committee.
- Progress reports to the Hunter Coal Environment Group, a representation of environmental, mining practitioners and consultants.
- A review forum at draft stages with all stakeholders.

The Department of Urban Affairs and Planning has recently commenced preparation of a Sub-regional Plan for the Upper Hunter which is also a follow on from the Action Strategy in the Upper Hunter Cumulative Impact Study. This work will involve extensive community consultation to address social, economic and environmental indicators. As such, it will provide valuable feedback to the implementation of the Synoptic Plan: Integrated Landscapes for Coal Mine Rehabilitation in the Hunter Valley of New South Wales.

1.1 AIMS

The purpose of the study is to provide a basis for the development of a long term integrated strategy for rehabilitation of mines. Whilst the focus of the study is on land within mine holdings, from a regional perspective, there is a need to address land outside mine holdings and involve a variety of stakeholders, including government agencies and the broader community.

TABLE 1: UPPER HUNTER MINING AND RURAL ECONOMIES

Indicator	Mining	Agriculture	Tourism
Value of production	\$ 2695.7 M	\$ 160.8 M	\$ 56.0 M
Land area	61 045 Ha	1 039 000 Ha	1 830 950 Ha
% of region	3.3%	56.7%	100%
Income generated per Hectare	\$ 44 160.00	\$ 154.76	\$ 30.58

Sources: Upper Hunter Cumulative Impact Study. 1997 DUAP
NSW Coal Industry Profile. 1997 DMR

1.2 OUTCOMES

The "Synoptic Plan: Integrated Landscapes for Mine Site Rehabilitation in the Upper Hunter Coalfield" comprises two parts:

- Part 1 Review and Strategy Matrix.
- Part 2 Invited Papers.

The Synoptic Plan is also supported by Mining Operations Plans for 1998 and 2020 which cover the eight 1:25000 maps sheets defined in the study area.

The Synoptic Plan provides the frame work for identifying means to develop links between researchers, managers, local and state government and the general public to facilitate integrated, strategic rehabilitation of mining affected land in the Hunter Valley of NSW. Perhaps the greatest challenge which emerges is to develop dynamic methods to utilise the resources of the Hunter Valley in a sustainable manner. Such a challenge requires ongoing research and development as existing mines near the end of their economic life and new mines emerge. In particular, the study provides an overview of:

- Current practices and trends in mine rehabilitation.
- Regional initiatives in vegetation management.
- Emerging environmental issues and their implications on mine rehabilitation.
- A comparative analysis of mine rehabilitation plans at 1998 and 2020.
- Principles for an integrated approach towards landscape management for the coalfield.

1.3 THE STUDY AREA

The study area comprises the coalfield of the Upper Hunter Valley extending from south west of Singleton to north of Muswellbrook (Figure 1). Some sixty coal seams are developed in three measures, the Greta Coal Measures, the Wittingham Coal Measures and the Wollombi Coal Measures. Most of the coal is at comparatively shallow depths making it accessible to large-scale, multi-seam open-cut operations. A

congregation of voids (active, interim and final) occurs in the Hunter Coalfield, within the Singleton and Muswellbrook Shire areas.

The study is confined to an area of 260,900 hectares comprising 14.5% of the study area of the Upper Hunter Cumulative Impact Study. It is defined by the extent of the eight 1:25,000 topographic maps, Aberdeen, Muswellbrook, Dawson's Hill, Jerrys Plains, Camberwell, Doyles Creek, Singleton and Bulga. Mine holdings cover approximately 61,045 hectares or 23.4% of the study area. Wollemi and Yengo National Parks cover a combined area of 19,558 hectares or 7.5 percent of the study area whereas Ravensworth State Forest, the only state forest located in the study area, comprises approximately 538 hectares. Beyond the study area, numerous state forests and national parks form large expanses of continuous vegetation on the Barrington Plateau and along the Great Dividing Range.

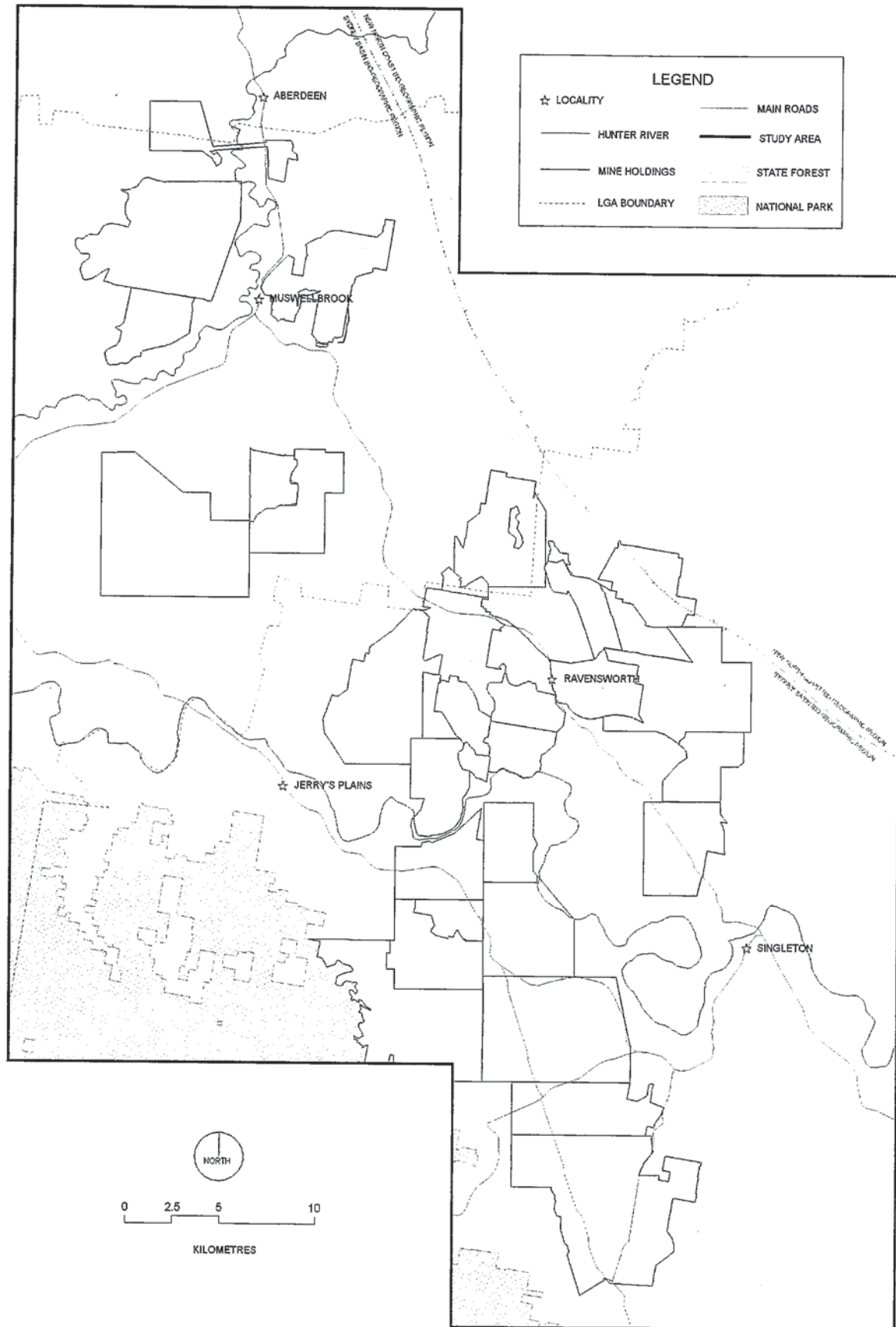
Mine (or colliery) holdings are defined for the purposes of this report as the area of mining leases identified on the Synoptic Plan map sheets. Note that in some instances areas within mine holdings are not held as freehold ownership.

The geology of the area is diverse and generally defined by a variety of landforms. For example, five main geological groups are encountered throughout the study area:

- Triassic Narrabeen Sandstone to the west and south.
- Late Permian River Sediments and Quaternary Alluvium along the valley floor with outcrops of Early Permian Marine Sediments.
- Carboniferous/Devonian Sediments to the north and east.

Regional climate is restrictive for certain types of revegetation, as evaporation is approximately double precipitation, causing moisture deficits in most months. Average annual rainfall varies from 706 mm to 619 mm from Singleton to Muswellbrook respectively.

FIGURE 1: STUDY AREA



1.4 BIODIVERSITY AND ECOLOGICAL SUSTAINABILITY

The north-eastern side of the Hunter Valley, within the study area represents the interface of the Sydney Basin and NSW North Coast Bio-geographic Regions. A distinct change in bio-geographical character occurs between the Triassic Sandstone formations on the south-western side of the valley and the Carboniferous - Devonian formations on the north - eastern side. Extensive clearing for agriculture and resource development has removed most of the native vegetation from the valley floor and caused a discontinuity between the two Regions and a subsequent loss of biodiversity.

Ecosystems that once may have occurred across the catchment have been modified, with natural habitat now mostly confined to the slopes and rugged areas where clearing has been limited. Many fauna are particularly sensitive to the size and shape of remnant vegetation patches, as well as the distance between remnants. As a result, the decreasing size and increasing distance between remnants in the valley has reduced the viability of natural ecosystems.

Global concerns in relation to greenhouse emissions and biodiversity, place a new focus on rehabilitation and vegetation management.

1.5 REGULATORY ENVIRONMENT

Numerous environmental regulations imposed on coal mines have a bearing on rehabilitation requirements and land management. Such legislation includes development consent conditions, mining lease conditions and conditional licenses or approvals from authorities such as the DMR, Environment Protection Authority (EPA), DLWC, National Parks and Wildlife Service (NPWS) and others.

The Synoptic Plan addresses environmental legislation as it affects present and future strategies for integrated rehabilitation of the Hunter Valley coal mines.

1.6 COMMUNITY EXPECTATIONS

The extent and proximity of coal mines within a discrete, socio-geographic area inevitably pose regional planning questions and responses. The community's first preference may be that mine areas show no evidence of excavation after rehabilitation.

Such preference may be moderated if:

- The community recognises that the "opportunity cost" of the mine is offset by the benefits to the community derived during the operating life of the mine.
- There is some alternate after-use identifiable for the mining area.
- The mine site does not represent a future public liability.

Increased public awareness of the planning for after mining use may be beneficial. Public consultation is part of the approval process where an after mining land use is designated and requires development consent through the environmental impact assessment procedures.

The range of potential after-mining uses offer challenges and opportunities to the mining industry and government regulatory agencies alike. Rehabilitation with native vegetation for commercial forestry and agroforestry can contribute to the local economy and provide a valuable resource. Such opportunities can diversify the rural economy and should be considered especially in areas where the long term viability and economic returns of traditional agricultural after-use is marginal. Furthermore, an integrated approach to mine rehabilitation can provide social and environmental benefits by opening up new land for active and passive recreation as well as nature and geological conservation in addition to increasing the opportunities for public access.

This report does not prescribe specific restoration practices for achieving completion criteria, nor does it prescribe land use outcomes or define preferred landscapes. Rather, it identifies constraints and opportunities between contiguous mine areas, and highlights past and proven rehabilitation techniques used within the Hunter Valley. It also provides a database from which strategic quantitative rehabilitation decisions, on a regional level, can be based. Given that the prime objective of rehabilitation is a stable final landform, the aspects in determining a rehabilitation method for each unit of the final landform begin to emerge. These are the visual landscape, biodiversity and land management for sustainable after-uses.

In this respect, the Synoptic Plan provides a basis for community and industry debate on opportunities for enhancement of the regional landscape.

2.0 Background to Rehabilitation of Coal Mines

2.1 LEGISLATIVE ASPECTS AND MINE CLOSURE

The aim of the DMR's rehabilitation and environment process is to ensure that adverse effects of mining and processing are minimised and that a consistently high standard of environmental protection and rehabilitation is practised throughout the State. All mining proponents are expected to give adequate consideration to the environment from the design stage, through the operational phases to mine closure. Figure 2 illustrates the overall conceptual process for the environmental management of operating mines.

The DMR Mining Rehabilitation and Environmental Management Process is the legal mechanism to implement any shift in the focus of rehabilitation objectives. This will be achieved through the identification of the most appropriate rehabilitation technique for disturbed land in Mining Operations Plan documents and monitoring of rehabilitation activities in Annual Environment Management Report documents.

2.1.1 The Mining Operations Plan

Prior to commencement of mining operations, mine leaseholders must lodge a Mining Operations Plan with the DMR. The Mining Operations Plan sets out the proposed development and scheduling of the mine for a nominated period which may be a two, five or seven year

sequence depending on mine life and mine size. The Mining Operations Plan addresses the mining and rehabilitation operations necessary for compliance with the collective conditions imposed upon the mining development. Consequently, the Mining Operations Plan documents the design, engineering and methods necessary to achieve the outcomes of resource recovery, progressive rehabilitation and protection of the environment as generally prescribed under the Mining Act.

Annual Environmental Management Reporting (AEMR) by the mines, allows the DMR to determine compliance of the mining operations with the Mining Operations Plan from which change and quality improvement can be facilitated. Where change to mining operations is necessary, the leaseholder may make application for amendment of the Mining Operations Plan. Changes in operation which are not consistent with the original development consents to the mine development, requires an Environmental Impact Assessment to be prepared as a prerequisite to a new Mining Operations Plan.

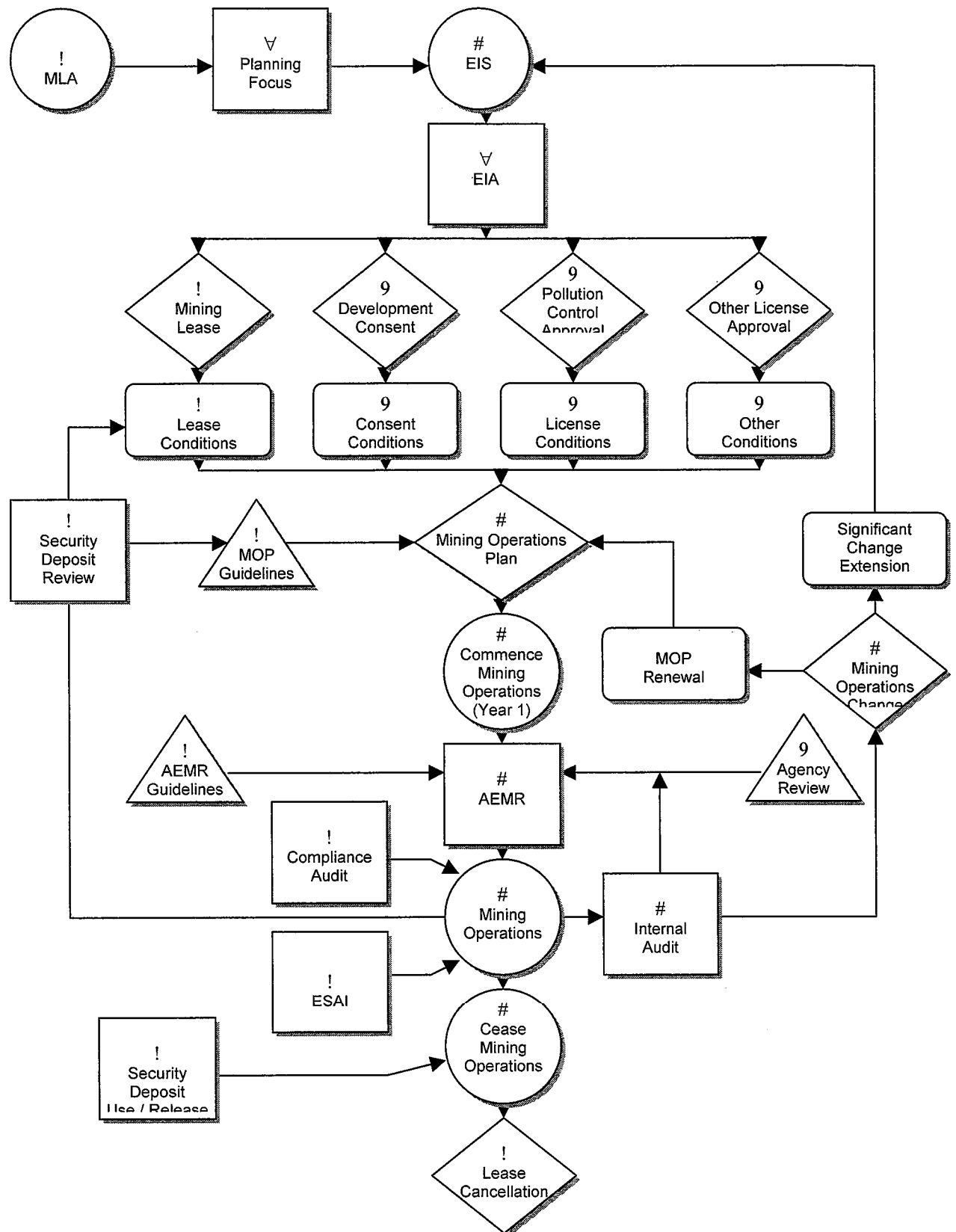
2.1.2 Annual Environmental Management Reporting

The AEMR consolidates government requirements for reporting of environmental management and rehabilitation. It measures progress towards the environmental performance and rehabilitation objectives. Environmental and rehabilitation targets to be achieved in the following 12 month period are specified in the context of the overall objectives. Mine leaseholders must lodge an AEMR that sets out the environmental and rehabilitation performance of the mine.

FLOWSHEET LEGEND

	Operation Activity		Connect	#	Mine Management Activity
	Decision Approval		Inspection Investigation	!	DMR Activity
	Information in Guidelines			∇	DMR & Other Agency Activity
				9	Other Agency Activity
				MLA	Mining Lease Application
				EIS	Environmental Impact Statement
				EIA	Environmental Impact Assessment
				AEMR	Annual Environmental Management Report
				ESAI	Environmental System Accident Investigation

FIGURE 2: ENVIRONMENTAL MANAGEMENT OF OPERATING MINES; CONCEPTUAL PROCESS FLOWSHEET



2.1.3 Mine Closure and Final Voids

Closure of mines is an inevitable consequence as resources become depleted and the cost of extraction becomes uneconomical. Timely planning for final rehabilitation, site restoration to an appropriate end use and the assessment of rehabilitation completion criteria are consequential to orderly lease administration.

The status of an open-cut coal mine void may be arbitrarily described according to the mine activity:

- Active void (mining advancing).
- Interim void (non active mining, awaiting further potential activity).
- Final void (non active, mining ceased, mine closed or abandoned, coal-depleted).

Generally, the decisions leading to the final configuration of the void, in the past have been made by the mining leaseholder in consensus with the landowner in consideration of the relative usefulness of the hole and its encompassing geological material.

Detailed configurations for final voids are addressed in the Mining Operations Plan for each mine holding. With a few exceptions the current plans for mines in the Upper Hunter Coalfield do not contain a final void as at 1998. Rather these mines are advancing beyond a 7-year mine sequence within the lease and so identify with active and interim voids. These are identified on the 2020 Synoptic Plan.

Four mines have reached interim or final void status according to the definitions described above. Eighteen mines are expected to proceed with open cut activity into the twenty first century up until about 2045. During the decade 2005 to 2015, eleven of these open cut mines are anticipated to deplete their known resources and reach final void status. Final voids are identified on the 2020 Synoptic Plan.

Guidelines for final void treatment are typically applicable to multi-benched hard rock metalliferous mines and quarries. Configurations require treatment of the crest and top benches by blasting and battering. Selective blasting of the crest-face followed by top-dressing and revegetation of the crest is sometimes referred to as "restoration blasting" which has a key objective to create a landform of natural appearance. Guidelines may also involve a bund-wall and safety trench around the high-wall located outside the unstable edge zone.

2.1.4 Expectations for Final Voids

After mining use opportunities for final voids are presented only after the safety, environment, and financial expectations are met in an integrated way to the satisfaction of community, government and industry. Management and minimisation of any substance or event

hazardous to the public is a priority concern in mining activity. The long term risk of a final void to the public varies on a case by case basis depending on proximity to urban development and accessibility to public roads. The level of risk may be engineered down, to a level of public acceptance, by rehabilitation of the void according to safety criteria and by restricting access to the site. The potential safety and health hazards of final voids may include contaminated water, rock fall and fumes, and fire from combustion of coal. Hard, engineered barriers must be used to reduce the risk of such hazards.

The variety of potential environmental impacts indicate that a complementary combination of hard barriers (engineering, design and construction) and soft barriers (bioengineering and monitoring) be utilised to achieve community expectations for satisfactory rehabilitation treatment. Appropriate documentation procedures and public review (or targeted review involvement with community consultative committees) will be required for final void planning, treatment and monitoring.

Determination of a void being final and confirmation that potentially recoverable resources are not sterilised are important in the first expectations of management of the voids. Mines regularly operate in several different voids at once, mining intermittently the most economically attractive ore at any particular time. Voids may be left inactive for many years while mining continues elsewhere, only to be mined again at a later time. A void may become final if ore is exhausted or a lease boundary is encountered. It may also become final for economic reasons such as change in overburden/ore ratio and price fluctuations, or for technical reasons such as slope instability. If the mine still contains ore but the void is deemed final for economic reasons, then there is always a possibility that, due to the changeable nature of economic circumstances, the resumption of mining in the pit may once again become viable in the future. This remaining resource provides a difficult challenge for final void rehabilitation.

The expectation of void treatment must be economically achievable with state of the art mining techniques available at the time of mine closure. This requires pre-planning and optimal use of the mining equipment fleet (draglines, shovels, dozers) from up to five years prior to the anticipated final strip, and the application of innovative restoration blasting techniques.

Security deposits/bonds are held by the DMR against the liability for rehabilitation. The component of security held against treatment of the final void is a financial consideration for the mine operator. This is usually by way of a banker's guarantee for which the mine operator pays an annual interest. It is a reasonable expectation that this security is determined in an equitable and open manner, and that closure of the financial liability is determined at some reasonable time by the government and Mining Company.

Finally, there is the expectation of financial sustainability of the after use of the final void. This is particularly relevant where regulatory authorities require an aftercare period involving maintenance and environmental monitoring. This period may be up to five years after mine closure and before completion criteria are satisfied. For an agricultural after-use of the overall mine site, where the quality of water impounded in a final void is suitable, the financial sustainability of access and pumping cost is straightforward. For an industrial after-use, where initial cost advantages (cheap land purchase and rates, and established buffer zone) would apply, long term income is realised and financial sustainability is secure.

2.1.5 Strategic Issues

In January 1992, ANZECC and the National Health and Medical Research Council of Australia published its Guidelines on the Assessment and Management of Contaminated Sites. Although coal mining sites are essentially benign and would not be considered a contaminated site, there are useful strategic parallels to be recognised. The guidelines state that the fundamental goals of site remediation should be to select a socially acceptable and cost effective management strategy which provides a net benefit to society. The choice of whether remediation will be achieved by means of site clean-up, installation of engineered barriers or implementing controls and restrictions on use of the site, will depend upon a variety of factors including engineering feasibility and cost.

The industry requires guiding principles to facilitate lease/site relinquishment at the end of mine life. The government and individual mining companies do not want the responsibility for management of a final void unresolved for an indefinite undetermined time. For this reason, after use at specific mining operations must be addressed progressively throughout the mine life - with escalating responsibility and urgency to establish the final configuration and the after-use.

2.2 ESTABLISHMENT OF NATIVE TREE SYSTEMS ON COAL MINES

2.2.1 The Development of Tree Establishment Procedures

General strategies for rehabilitation of open cut coalmines in the Upper Hunter Valley had developed by 1982. Much of the early research was in response to the general shortage of information on coal mine rehabilitation within Australia at that time and the unique nature of spoil materials from coal measures.

Erosion control and surface stability are generally the initial objectives of rehabilitation. Owing to the earlier importance of restoration of agricultural land, past research concentrated on the development of grass and

pasture species for cattle grazing. Drought and chemically hostile spoil materials, resulted in the rapid selection of a limited range of drought and salt resistant pasture species which still largely dominate most sowing specifications. Prevailing drought and competition from pasture species and weeds limited tree revegetation trials.

Trees can positively interact with spoil physio-chemical conditions, hydrology and geotechnical aspects of slopes. The maintenance requirements of woodland/forest are less than pasture which requires more fertiliser input and longer term management. Treed systems are more resilient to drought and provide more diverse habitat for insects, birds and other fauna. Many other benefits accrue including the ability of trees to shade and significantly reduce ground temperatures, which in turn impact on other cycles.

Investigation into the potential for tree establishment on coal mine spoil commenced in 1983. Much of the developmental work at this time was focused on establishment of the upper tree canopy of a forest system. Burns in Part 2 provides a more detailed account of this development. Tree planting trials by the Forestry Commission on six (6) coal mines were undertaken in 1984 on both top dressed and overburden sites and were particularly successful on weed free overburden. Decompaction, using deep ripping, and avoidance of grass or weed areas were two important site preparation factors.

A similar study by the former New South Wales Forestry Commission in 1985 examined the effectiveness of tree seeding onto mine spoil. The study clearly demonstrated the suitability of a range of overburden for native tree establishment using direct seeding techniques. No obvious advantage to germination, survival and growth of native tree species was established by using top dressing material. Subsequent broadacre seeding programs showed superior development of seeded trees on raw overburden compared to top dressed sites due to reduced weed competition.

Some overburden can be saline and/or sodic, which is often unsuitable to many native shrub species, which tend to prefer slightly to moderate acid soils with low salinity levels. The practical outcome, therefore, is to source species, which can tolerate such conditions. Despite the limitations of unfavourable chemical conditions, a high rock content of most materials appears to favour tree establishment as roots follow preferred water pathways deep into spoils. Five year old trees at Drayton Mine exhibited root development in excess of three to four metres. The health of trees can be dependent on the extent of their root systems and the opportunity for mine spoil to provide for deep unhindered root development in comparison to locally occurring duplex soils.

A follow-up Forestry Commission study examined factors affecting management of tree stands. The growth of an indicative species, Spotted Gum *Corymbia maculata* on reshaped mine overburden was found to be commensurate with growth in naturally regenerating stands, and better than that observed on areas of non mined pasture. Soil moisture availability was more limiting to growth than nutrient availability and plants on chitter had least moisture stress compared to those on overburden.

2.2.2 Important Physical and Chemical Parameters

Soil water availability is the dominant factor affecting successful tree establishment. A range of direct and indirect factors can affect the amount of water available to tree roots.

Infiltration is greatly improved by deep ripping as smooth surfaces shed water and do not hold seed and fertiliser. Infiltration can be further affected by parameters such as slope gradient, rockiness, soil texture, compaction and surface crusting. In general (and particularly for tree establishment) "the rougher the better" is a good maxim for successful ecosystem reconstruction.

Chemical characteristics, which may restrict plant growth, include salinity, sodicity and pH extremes. The physical and chemical nature of surface overburden has been observed to ameliorate over time due to the processes of weathering, leaching and biological activity.

Applying gypsum to artificially vary the ratio of Sodium ions to Calcium or Magnesium ions may also alleviate Sodicity. Nutrient deficiencies are not considered a major problem in rehabilitation as fertiliser can be readily (and relatively cheaply) applied at planting or sowing time. Some mines apply maintenance fertiliser annually until soil nutrient levels reach a predetermined level.

More research is needed to further understand long term spoil development trends and their effects on vegetation in the Upper Hunter Valley.

2.2.3 The Emerging Role of Trees

The emerging use of trees in rehabilitation has continued with several large companies now (1998) choosing to establish trees on 30% or more of their rehabilitated areas. Most of these areas are being direct seeded, although tree planting is still undertaken for visual screening on surrounding buffer areas or where grass competition restricts the use of direct seeding.

The DMR indicate that 4,100 hectares have been rehabilitated, which is 28% of total disturbed areas up to 1997. Of the rehabilitated areas, 522 hectares (or 13%) consists of native tree seeding and tubestock planting.

2.2.4 Successful Species

There has been variability in the success of trials of species for both tree seeding and tree planting in different spoil types. Most planting programs more commonly use dominant forest species indigenous to the Upper Hunter since a more diverse range of species can usually be established through tree planting than through seeding. Despite this, a generally accepted core group of species are in common use for both tree planting and seeding.

2.2.5 Tree Planting

Trees are often planted at 4m x 4m spacing (625 per hectare), however, the optimal spacing will vary depending on the purpose of planting (e.g. visual screening, habitat establishment, commercial forestry, etc.). An important factor that can affect spacing is the proportion of shrubs versus taller trees. The range of species can be considerably expanded on natural soils or unmined sites. Individual species sowing rates vary depending on spoil conditions. Initial tree/shrub densities are often high but decline quickly with age as many of the shorter lived *Acacia* species reach senescence and as tree and shrub mortality increases with competition for soil moisture. This process can be very beneficial to soil organic and nutrient processes.

Indicative changes in stem densities on a direct seeded site over time, which highlights the dynamic nature of directly sown tree stands, are as shown in Table 2. Interactions between vegetation, substrates, the landform, weather and time of sowing will affect revegetation success.

TABLE 2: STEM DENSITIES

Time	Stems / Hectare
Immediately after germination	10,000
After 12 months	5,000 – 10,000
After 5 years	3,000 – 5,000
After 8 years	2,000 – 3,000

2.2.6 Indicators of Successful Tree Establishment

Success in planted tree establishment has largely been based on tree survival and growth. Most monitoring of tree seeded stands focuses on the changing nature of tree density, growth, survival and species composition. Since many situations use *Acacia* species as a nurse crop to provide erosion control and protection during the early years, the long term success of the seeded areas may be difficult to assess. There are no consistently reliable indicators currently in use for tree establishment.

2.2.7 Recent Research: Establishment of Native Understorey Species

The greatest diversity of native ecosystems is beneath the tree canopy, included among which are the low trees and

shrubs that constitute the understorey. The plants that make up this strata have received considerably less attention than the major tree genera in revegetation programs, both within and beyond the mining industry. These plants are critical to the sustainability of native ecosystems as they support soil fauna communities, assist in erosion control, and provide food, shelter and habitat for fauna.

The successful establishment of sufficient numbers of understorey species on rehabilitated mine sites requires consideration of many factors. These include, availability of sufficient viable seed, the suitability of species to the particular replaced soils and spoils, the germination of seeds, the survival and growth of seedlings, the development of seedlings into fertile mature plants and survival of self-sown progeny. Against this background, the goal of the recent research program by the Centre for Mined Land Rehabilitation was to investigate the seed germination of a wide range of understorey species native to areas that are affected by coal mining activities in New South Wales.

The research was intended to understand the germination characteristics of the species. In addition, it was intended to determine the rate of emergence in ideal conditions, and assess the ability of species to cope with the chemical and physical properties of the various mine media likely to be encountered. The study included monitoring actual performance in the field.

Four (4) Hunter Valley mines; Hunter Valley No. 1, Mount Owen, Ravensworth and Warkworth, and nine (9) mine media (two or three from each site) were involved with the project. These media ranged in pH, electrical conductivity, water content and exchangeable sodium percentages. The majority of media were nutrient deficient, with all of the non-soil media having available phosphorus levels less than 5 mg/kg.

The project has identified a diverse range of understorey (and middle storey) species, indigenous to the region, that have the potential to re-establish on those areas of the post-mined landscape that are targeted for return to native vegetation communities. Most of the species have been shown to be tolerant of the substrate conditions that will dominate the landscape at each of the sites, the greatest threat to success being a lack of available moisture. Trials were undertaken of the species likely to have higher germination rates than recorded currently, and further investigation into the breaking of dormancy mechanisms will be continued in the extension project.

Higher initial rates of seedling establishment in the field for many species would be likely if seed pretreatment were imposed to overcome dormancy mechanisms.

This is the subject of future studies, recognising however, that improving germination from the outset can in some circumstances (e.g. variable climate and hence water

deficits) have negative impacts on post-emergence survival. Water availability, or lack thereof, is a major limiting factor in the field, in not only decreasing germination/ emergence, but also increasing seedling mortality. Given their potential shown in the glasshouse experiments, several of the other species may also have some success in the field under improved moisture conditions.

2.2.8 Recent Research: Commercial Forestry and Waste Utilisation

A joint project between Muswellbrook Shire Council, Bayswater Colliery Co., The University of New England and CSIRO Forestry and Forestry Products has been established on a reformed overburden slope at Bayswater Colliery. The project attempts to integrate mine site rehabilitation, beneficial utilisation of community wastes and the production of a commercial forest.

The overall objectives of the trial are to:

- Determine a rate of irrigation that maximises tree growth and minimises environmental impact;
- Determine the effect on tree growth of adding compost to the overburden;
- Test silvicultural systems that maximise productivity by varying tree spacing.

The 10,156 trees to be used in the trial include; *Corymbia maculata*, *Eucalyptus grandis*, *E. nitens*, *E. botyroides*, *E. punctata*, *E. dunnii* and *E. saligna*.

A monitoring program is presently being conducted of effluent quality and various overburden and vegetation parameters. Climatic conditions are also being monitored to determine effluent loading rates for the plantation. If successful, the results of the trial will have positive implications for the long term land use of rehabilitated coal mines and sewage effluent reuse.

2.2.9 Tree Growing Potential and Yields for Commercial Native Plantations

State Forests of NSW investigated several areas important to tree growing on rehabilitated mine sites and cleared grazing lands in the Upper Hunter between 1984 and 1995. The Hunter Valley Research Program investigated the influence of:

- Site conditions on early age survival and subsequent growth.
- Site preparation and establishment techniques on survival and growth.
- Interactions between site and tree physiology, including nutrition and water availability.
- Silviculture to maximise stand productivity on mine sites.
- Total biomass productivity for a range of different species.

Trials were undertaken on the survival and growth of a range of species across 14 sites between Newcastle and Muswellbrook, and compared with productivity on regional native forests and North Coast plantations. The trial sites varied in management history, rainfall and soil types. A sub-set of the site-species trials were subject to ongoing monitoring as part of the State Forests Permanent Growth Plot Program, and were most recently re-measured in late 1998.

The growth and performance of the *Eucalyptus* and *Corymbia* species are comparable with low to medium commercial productivity in hardwood plantations on the North Coast of NSW. A comparison of establishment techniques showed similar productivity could be achieved for *Corymbia maculata* across a range of sites and establishment techniques. The research showed the importance of ripping and confirmed the importance of available moisture as the single most important attribute for achieving high growth in the Hunter. The influence of stocking on stand productivity was also investigated, resulting in the establishment of optimal stocking rates for maximising commercial wood production under direct seeding techniques.

Research into the above ground biomass for 13 species provided the basis for investigating carbon sequestration options in the Hunter Valley. Growth rates under current practices are slow and not commercial, with a mean annual increment well below eucalypts of the same age in North Coast plantations. Site conditions are not conducive for fast growth. The climate of the Upper Hunter can be described as sub-humid with hot summers and cool to cold winters. The average rainfall for most mines can be

assumed at 650 – 700mm. This is well below the commonly accepted rainfall for commercial plantations of 900mm. Wind exposure and frost is also important considerations for tree establishment on mine holdings.

However, there is a great opportunity to improve the productivity of overburden for commercial tree production and sustained site rehabilitation. It is suggested that growth could be increased at least 5-fold with the addition of both nutrients and water. Commercial plantations could be realised with improved site quality.

Recycling of wastes by applying them to land is becoming an available option for wastes with some nutritional or soil improving value. Wastes with potential for forest land application include:

- Sewage products, such as effluent or biosolids.
- Biomass residues, such as municipal green waste, composts or sawmill residues.
- Industrial wastes, such as cannery wastes.
- Agricultural wastes, such as manure.

State Forests of NSW preliminary research has indicated that there is potential to boost yields on rehabilitated sites using organic wastes. However, transport costs and environmental issues are constraints. State Forests of NSW will be conducting research trials proposing that readily available, nutrient supplying wastes (biosolids, flyash and composted green waste) could amend these marginal areas for plantation establishment purposes and boost the growth rates of selected species to commercially viable levels.

FIGURE 3: MONITORING FOREST TRIAL ESTABLISHED ON MINE SPOIL



3.0 Challenges and Opportunities for Mine Rehabilitation

3.1 NSW VEGETATION PLANNING REFORMS

3.1.1 Background

In 1995, the NSW government embarked on vegetation reforms with the aim of achieving sustainable management of the State's native vegetation. The objectives of the reforms have been stated in the Native Vegetation Conservation Act 1997 (NVC Act) and include provision for the conservation and management of native vegetation on a regional basis.

Introduction of the NVC Act followed consultation and review of State Environmental Planning Policy No 46. The government is currently in the implementation and monitoring phase that involves implementing the NVC Act and supporting activities to achieve the objectives of the legislation.

3.1.2 Approvals for Clearing of Native Vegetation

To prevent indiscriminate or inappropriate clearing the NVC Act requires landowners to obtain consent from the DLWC for clearing native vegetation. Clearing activities and land tenure defined as designated development under the Environmental Planning and Assessment Act 1979 and/or authorised under the Mining Act 1992 are exempt from obtaining consent. As a consequence, most clearing activities for mining are exempt from the need to obtain consent.

3.1.3 Regional Vegetation Management Plans

Regional Vegetation Management Plans (RVMP) allow for strategic planning and management of native vegetation to suit environmental, social and economic needs of a region. While plans have not yet been approved by the Minister, it is anticipated that they will nominate areas of conservation value, archaeological and geological significance and recommend where revegetation and other active management is appropriate.

The NVC Act establishes a Native Vegetation Advisory Council to, among other things, report to the Minister on the status of native vegetation throughout the state and develop a conservation strategy to help achieve the goals of the Act. The NVC Act also establishes a Native Vegetation Fund to support activities that are consistent with the objectives of the Act. The funds are to be allocated by the Minister of Land and Water Conservation who must seek advice from the Native Vegetation Advisory Council on priorities for spending.

It is anticipated that funds would not be available for works that are required as a condition of consent for development, such as rehabilitation of mined areas. However, where landholders of mining land would like to carry out vegetation protection or rehabilitation "over and above" that required by their Consent, funds may be available depending on the priorities set by the Native Vegetation Advisory Council.

3.1.4 Regional Vegetation Planning in the Hunter

In September 1998 the Hunter Catchment Management Trust facilitated a community forum on vegetation programs in the Hunter Valley. Over 100 people attended representing community organisations, government departments, researchers, landholders and individuals. Consensus in most participants was reached for the initiation of a Hunter RVMP. If a Regional Vegetation Committee is established, the following stages are likely for the preparation of the RVMP plan:

- Data compilation.
- Identification of issues.
- Community involvement.
- Developing solutions to issues.
- Preparing a draft plan.
- Community consultation.
- Presentation to the Minister.

The Synoptic Plan and ensuing strategic activity by the mining industry would be applicable in each of these stages. There is significant opportunity for integration of the RVMP to provide a regional context for mine rehabilitation. Corridors or remnants identified in this Synoptic Plan can be linked to corridors and remnants identified in the RVMP.

3.2 REMNANT VEGETATION IN THE COALFIELDS

The term "Remnant Vegetation" refers to native vegetation that has not been cleared and still retains the basic characteristics of the original vegetation communities of the area within which it occurs. Native vegetation is defined by the NVC Act as any indigenous trees, understorey plants, groundcover and plants occurring in a wetland. The diversity of landforms and systems in the study area means that remnant native vegetation may include swamps and riverine forests as well as a range of woodland and dry forest types. In some locations there may even be remnants of gully rainforest systems.

3.2.1 Background to Vegetation Issues in the Hunter Valley

Vegetation in the Hunter Valley has been in a constant state of decline since the arrival of Europeans in the early 1800s. Decline in the native vegetation communities has been the result of clearing for agriculture, mining, forestry

and settlement. Vegetation that has not been removed is generally in poor condition with the overall diversity of flora and fauna species occurring within the remnants reduced. Resulting soil erosion, dryland salinity, declining water quality, streambank degradation, stream channel widening, have facilitated declines in biological diversity and increasing numbers of threatened flora and fauna. General decline in the health of remnant vegetation is at least in part, the legacy of poor vegetation management in the past.

The effect of vegetation removal on the fauna communities has resulted in the loss of species which once would have commonly occurred across the study area in addition to others now occurring rarely or uncommonly. Some fauna species are particularly dependent on large tracts of undisturbed forest. These include large forest owls, large gliders, macropods and migratory or transient species such as honeyeaters which follow the flowering of canopy species, and are now either never seen or restricted to the slopes and rugged areas where clearing has been limited.

The isolation of many of the remnant patches of vegetation in the study area also adversely affects the potential for many of the fauna species from occurring as usually the size of individual remnants is insufficient to support discrete populations. Further fragmentation and dissection of the landscape through the various human activities place an increasing strain on the viability of natural systems in the study area.

3.2.2 Outline of the Hunter Remnant Vegetation Project

The Hunter Remnant Vegetation Project was established in mid 1996 in the Upper Hunter Valley because of its increasing pressure from agriculture, infrastructure and mining and the limited amount of useful available information regarding the conservation status of its vegetation communities. The project is primarily funded and managed by the Hunter Catchment Management Trust, with the other major financial support being provided by the Natural Heritage Trust. The project is also supported by the NPWS and the DLWC. The study area of the project covers approximately 3,200 km² of parts of Scone, Muswellbrook and Singleton Local Government Areas.

The goal of the Hunter Remnant Vegetation Project is to collate scientifically sound information on the state of vegetation management and conservation in the Upper Hunter catchment and use this information to encourage and support appropriate land management practices in the future.

The objectives of the project are to determine the distribution and ecological significance of remnant native vegetation in the Hunter Valley floor and identify potential corridors that may link them. This is hoped to

enable appropriate management of remnants by government agencies, local government, community groups and individual landholders. Development of a database and implementation of a public awareness and consultation program are further objectives. The Upper Hunter is expected to be completely mapped and surveyed by the end of 1999, with a detailed technical report documenting the condition, cover and conservation status of vegetation in the study area.

3.2.3 Characteristics of the Remnant Vegetation

The most widespread vegetation communities in the mapped areas are Narrow-leaved Ironbark *E. crebra* - Forest Red Gum *E. tereticornis*, White/Grey Box intergrade *E. albens* / *moluccana* - Narrow-leaved Ironbark, Spotted Gum *Corymbia maculata*, Narrow-leaved Ironbark and Slaty Box *E. dawsonii* - Grey Box *E. moluccana*. Narrow-leaved Ironbark is the most common dominant canopy species in the study area. Some vegetation communities are uncommon in the study area, and most are very poorly reserved in conservation areas. Many are suffering from the effects of dieback and tree decline.

Valley floor remnants are generally more degraded than those occurring on the slopes and escarpment foothills. These remnants are highly fragmented and have been grazed by cattle and sheep in addition to other feral animals such as rabbits for upwards of 150 years.

The rate of vegetation removal in the Upper Hunter Valley has slowed in recent decades. Despite this, the continuing removal of vegetation is in the form of controlling the development of regrowth. Additionally, woodland and forest have been removed in the process of open cut mining.

A large proportion of remnant vegetation has either a very limited degree of regeneration of canopy species and understorey or shrub species. In some locations there has been observed to be no regeneration at all. This is of particular concern, especially since tree decline and dieback affect large areas of the Upper Hunter. The limited regeneration can be attributed to the grazing of domestic stock which preferentially graze on new growth.

3.2.4 Enhancement of Remnant Vegetation

Mine site rehabilitation can make a significant contribution to the establishment of new areas of forest in the valley through the linking of remnant native vegetation on mine holdings.

Increased connectivity through linking remnants is anticipated to result in increases in richness and diversity of both flora and fauna. The planting of locally occurring native flora species will enhance the viability of existing isolated patches of vegetation. Movement of wildlife increases gene flow between fragmented populations,

increasing the likelihood that populations will be viable. Corridors also provide native animals with shelter and protection from feral predators as they move between habitat remnants.

Changes in land use philosophies regarding grazing will assist in the management of remnants. Even without the planting of additional vegetation, remnant patches can be enhanced by the exclusion of domestic stock and other introduced fauna including rabbits, foxes and cloven-hoofed animals. Such change is yet to be accepted and adopted by land holders.

3.2.5 Rehabilitation and Catchment Management

Rehabilitation has the potential to restore the land to a state that may exceed its previous background level in terms of biomass, species diversity and species richness. From a regional perspective, catchment management is the primary responsibility of the Hunter River Catchment Management Trust. Mine rehabilitation and management practices are important components because of the extent and nature of land disturbance involved. Coordination of the protection of remnant native vegetation, site drainage design, erosion and sediment control and water quality management offers the potential of enhancing the sustainability of remnant vegetation.

There are additional opportunities to maximise the benefits of tree planting on mine holdings to manage land degradation issues such as dryland salinity, streambank erosion, mass movement and soil erosion which are legacies of past land use practices. Integration of the mining operations database with the DLWC's GIS database can highlight priority areas for tree planting to arrest land degradation.

The management of native vegetation remnants requires an holistic approach whereby the integrity of the natural system being managed is not compromised by ad hoc decision making on piece-meal, localised solutions. Enhancement of the natural systems of the study area can be realised by consideration of the principles of Ecologically Sustainable Development and Total Catchment Management and incorporated into policy tools such as the proposed RVMP.

3.3 SUSTAINABLE DEVELOPMENT AND THE GREENHOUSE CHALLENGE

International and national policy, and current programs in relation to greenhouse emissions have implications for the coal mining industry's role in rehabilitation, land management and vegetation management. These policies in turn also have direct relevance to the issue of sustainable development.

Under Australia's commitment to the National Strategy for Ecologically Sustainable Development (1992), the precautionary principle and six other principles are

always to be considered together as a "package" so that "no principle should predominate over the others". The National Strategy for Ecologically Sustainable Development (1992) states the following;

"The Guiding Principles are:

- Decision making processes should effectively integrate both long and short term economic, environmental, social and equity considerations;
- Where there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- The global dimension of environmental impacts of actions and policies should be recognised and considered;
- The need to develop a strong, growing and diversified economy which can enhance the capacity for environmental protection should be recognised;
- Cost effective and flexible policy instruments should be adopted, such as improved valuation, pricing and incentive mechanisms;
- Decisions and actions should provide for broad community involvement on issues which affect them.

These guiding principles and core objectives need to be considered as a package. No objective or principle should predominate over the others. A balanced approach is required that takes into account all these objectives and principles to pursue the goal of ESD."

3.3.1 National and International Greenhouse Policy

The United Nations Framework Convention on Climate Change (FCCC) has progressed through considerable policy development since its introduction at Rio de Janeiro in 1992.

In keeping with the objectives of the FCCC, the Commonwealth Government's Greenhouse Challenge program was developed as a part of the Government's "No Regrets" approach to greenhouse emissions.

Subsequent commitments made by Australia were a result of the 1997 Kyoto Protocol under which Australia has committed to limit its greenhouse emissions growth between 1990 and 2012 to 8%. This represents a reduction of approximately 33% below the "business-as-usual" level. The fourth Conference of the Parties in Buenos Aires in November 1998 commenced the detailed consideration of the international carbon trading and emissions offset rules. Australia's position is that the mechanisms must include carbon sink activity to ensure that countries can take full advantage of low cost and environmentally effective options to reduce greenhouse emissions.

The Commonwealth Government released its National Greenhouse Strategy (NGS) in late November 1998. This strategy sets out national measures by which Australia aims to meet its emission control obligations by limiting growth of emissions as at 2012 to only 8% beyond 1990 levels.

3.3.2 Review of Land Clearing, Forestry and Carbon Accounting

The Australian Greenhouse Office (AGO) is the lead Commonwealth agency on greenhouse matters. The role of AGO is to establish:

- Accurate emissions baseline.
- A framework for greenhouse gas emissions accounting.
- Scientific services for sink enhancement programs.
- An inventory of land clearing and afforestation.

Australia differs from other developed countries in that its land use patterns are still undergoing considerable change. Land clearing for agriculture in Australia in 1990 was the main contributor to the net greenhouse emissions. Since 1990, carbon sinks for land clearing emissions were agreed under the Kyoto Protocol to contribute towards the Kyoto target period of 2008-2012. Following which, forestry plantations associated with mine site rehabilitation or buffer zone plantings, could be incorporated into an emissions trading system by allocating permits, similar to emission permits, for the amount of carbon sequestered. Despite this, the AGO cautions that there are carbon measurement and other issues to be worked through before options on carbon sinks can be fully developed.

New South Wales has seen the initial "carbon trading action" in a deal between Pacific Power and State Forests in 1998. This early speculation in carbon credits signaled not only these organisations' interest in the issue, but also that of the NSW Government. A discussion paper has been produced by an emissions trading working group convened by the NSW Department of Energy in October 1998. Such actions, even though they may be positive in the emissions management sense, are expected to be driven initially by other justifications as well as other environmental planning objectives consistent with a "no regrets" approach.

3.3.3 Greenhouse Challenge

A major thrust of the NGS is the partnerships for GHG (Greenhouse Gas) emission reductions. Of these, the most significant to date is the Greenhouse Challenge which is a joint initiative of the Commonwealth Government and Australian industry, working in partnership to reduce Australia's GHG emissions.

The program encourages companies to take a voluntary approach to reducing their emissions through innovation,

greater efficiency and a commitment to continually improving the environmental performance of their businesses. The aim is to achieve maximum net reductions in greenhouse gas emissions, while at the same time enhancing the competitiveness of Australian industry. The AGO outlines that companies involved in the Greenhouse Challenge commit themselves to the following actions:

- Developing an inventory of emissions and sequestration.
- Developing an action plan to minimise net emissions.
- Forecasting expected reductions in emissions.
- Signing of a Greenhouse Challenge agreement with the Commonwealth.
- Monitoring progress and providing reports to the Commonwealth and the broader Australian community.
- Agreeing to random independent verification.

3.3.4 Specific Initiatives for Land Clearing, Forestry and Vegetation Management

The Prime Minister's 1997 statement, Safeguarding the Future: Australia's Response to Climate Change, highlighted Australia's comprehensive range of programs in place to address natural resource management and sustainable agriculture issues, including support for revegetation, plantation establishment and protection of native vegetation.

AGO describes the following programs, and it is noted that they comprise elements that are potentially relevant to mining lands in the Hunter Valley, and particularly those companies involved in the Greenhouse Challenge:

- Bushcare: the National Vegetation Initiative.
- The Farm Forestry Program.
- Plantations for Australia: the 2020 Vision.
- Bush for Greenhouse.

In New South Wales, legislation has been enacted to facilitate greenhouse initiatives related to forestry and vegetation management. Some of the relevant legislation includes the following:

- Timber Plantation Harvest Guarantee Act.
- Native Vegetation Conservation Act.
- Conveyancing Act.
- Carbon Rights Legislation Amendment Act.

3.3.5 Commercial Native Forest Plantations

The use of trees as a component of rehabilitation programs has the potential to provide benefits to the leaseholder, local industry and form a component of a carbon sequestration strategy. The establishment of trees for the purpose of plantation timber can be implemented through an integrated landscape approach to also include

opportunities for public recreation and enhanced aesthetic landscape values, in addition to complimenting wildlife corridors, habitat and biodiversity values. Additionally, plantation establishment on mines could potentially reduce the cost of mine rehabilitation.

State Forests of NSW is embarking on a hardwood plantation establishment program focused on the establishment of plantations on land purchased by State Forests or in small joint venture arrangements with landholders.

There has been recent focus also on external investment, with increasing areas of plantation funded through third party investment. This includes an active facilitation role in potential plantation establishments in the Upper Hunter by:

- Optimising yields.

Despite the inherent poor nutrient status of the soils and low rainfall, there is an opportunity through site preparation techniques to optimise use of rainwater, the use of irrigated water and the use of biosolids/green waste/flyash to substantially boost site potential. Pulpwood production is feasible on low productivity areas close to the Port of Newcastle managed on a coppice rotation.

- Fire, pest and insect protection.

Planted forest grow over a 30 year rotation period therefore successful management must include protection against fire, insects and disease. State Forests maintains a central and regional fire fighting capability which includes fire preparedness planning, modern fire-fighting equipment, aerial and tower surveillance in high fire danger periods, and rapid response systems to fires. Additionally, investors can arrange fire insurance for plantation areas. State Forests, through its Research and Development Division, maintains an ongoing forest health survey that identifies any pest or disease outbreaks and prescribe treatments to address those problems.

- Wood and carbon security.

The system of land titles recognises the creation of Forestry rights separating the ownership of the land from rights to the timber. State Forests of NSW developed a survey system with the Land Titles Office that allows the efficient identification of forestry land. The green economy based on consumers desire to pursue their lifestyle with limited impact on the environment will see carbon credits for vehicles, travel, consumption and energy use as growing areas of product differentiation.

The Timber Plantations (Harvest Guarantee) Act 1995 provides a voluntary scheme for the accreditation of timber plantations. Accredited plantations are exempt from certain provisions in the Environmental Planning and Assessment Act 1979, the National Parks and Wildlife Act 1974, Heritage Act 1977 and the Local Government Act 1993.

This Act also provides for the protection of the environment. Compensation is provided in circumstances where harvesting may be modified or suspended in order to protect unique or special wildlife values. This is supported by the Timber Plantations Harvesting Code based upon sound forestry practices and aims to protect the environment by minimising the impact of harvesting operations on accredited plantations.

3.3.6 Market Opportunities

One of the non-physical values of plantations is the ability of trees to capture Greenhouse gases such as carbon dioxide from the atmosphere. This carbon capture is developing a tradeable monetary value, currently about \$15 per tonne of carbon stored. A carbon accounting methodology has been developed based on the State Forests of NSW Forest Planning System incorporating best available data and carbon sequestration models. State Forests of NSW is investigating a variety of offsetting measures with coal fired power stations in the Hunter Valley. These include:

- Offsetting emissions with carbon captured by plantings on mine and buffer areas.
- Using biomass grown on mine and buffer areas to supplement coal as a renewable energy source.

World market trends in demand for timber are expected to continue due to:

- Projected low agricultural returns from grazing land and investors turning to other forms of land use such as forestry.
- The reduced amount of wood available from state forests, as they are reserved for national park.
- The potential replacement of South East Asian rainforest species in high value end uses such as furniture and veneer.
- The tradeable market in carbon sequestration by the plantations that investors may be willing to pay for.
- The increased use of timber in buildings due to the environmental benefits such as the low release of atmospheric carbon from timber construction compared with other materials.

As major world economies shift to favour lower-emission business strategies, there is likely to be a growing demand for wood products. The market for green or renewable energy sources is rapidly growing. In NSW, for example, the growth in market demand for renewable energy has been 25% per quarter, albeit off a low starting base.

Biomass energy, with wind and solar power, is one of the three main possibilities for meeting rapid growth in green energy demand. State Forests is currently working on feasibility studies with generators and industry for significant bioenergy developments based on thinnings from planted forests and sawmill waste. Charcoal, for smelting silicon for use in computer chips and solar power cells, and in steel making, will also be a growing 'green market' for forest products in the next few years.

Apart from potential economic values associated with green technology, other traditional markets for wood products contribute to the sustainability of commercial forest. Recent projections of world supply and demand for wood products show significant supply gaps. At the same time, wood products market predictions show significant demand growth for both pulp and paper and solid wood products. It is likely that this strong demand will lead to solid, long-term price maintenance and growth for forest products.

Consumer demand for specialty timbers in furniture, panelling, weather-exposed timbers and joinery will ensure a continued demand for hardwood. Eucalypt pulpwood is already well known in world markets. With continuing technical research and market development, Australian hardwoods can win further markets for specialty and structural products. Eucalypt pulpwood, from logs too small to saw and also from sawmill waste, is highly sought after because it produces high quality printing and writing paper. Australian demand for paper products is projected to increase at 3% per annum. Eucalypt pulpwood is also used for other reconstituted products such as hardboard and medium density fibreboard.

Non wood products such as foliage, leaf oils, and honey are other potential markets associated with commercial plantations.

3.3.7 Implications for Upper Hunter Valley Coal Mines

Any program to increase plantation areas in the Upper Hunter will need active consultation with key stakeholders and the wider community. Issues that may require special attention include:

- The loss of grazing land to eucalypt plantation establishments. Opportunities for agroforestry involving wider tree spacing and increased grazing potential could be considered.
- The application of biosolids and other wastes to boost plantation growth rates.
- Initial community support for the plantation establishment but not for the subsequent harvesting involving clearing of native trees.

Many Upper Hunter coal mining companies and operations are party to Greenhouse Challenge agreements. Other companies have submitted letters of intent to establish an agreement in the near future while others are signatories that only operate in the Lower Hunter region or elsewhere. The agreements established by the mining operations are dominated by undertakings for operational and maintenance improvements related to energy conservation and efficiency. Vegetation carbon sinks have been a secondary priority in the greenhouse agreements to date.

However, all mines in the Upper Hunter, whether a Greenhouse Challenge signatory or not, follow general best practice trends towards land and vegetation management programs. The local coal industry has demonstrated its interest in considering "greenhouse-friendly" initiatives in land use management with investigations into alternative management techniques and post-mining land uses.

5.0 The Landscape of the Coalfield

Apart from ecological considerations, coal mining, together with agriculture and power generation, has transformed the landscape of the Upper Hunter Valley. In considering the visual implication of mining, which has taken place and is planned to continue to the year 2020 and beyond, it is necessary to establish the regional landscape context.

Prior to the 1970's, the Upper Hunter was largely characterised by extensive agriculture on the valley floor contrasting with remnant native vegetation and the rugged, forested terrain of the (now) Barrington and Wollemi National Parks bounding the valley.

Extensive clearing for agriculture has radically changed the visual quality of the valley since European settlement, and contributed to the landscape character by creating a rich contrast between the forested slopes and farmland on the valley floor (Figure 11).

The impact of power and coal development over the past thirty years has significantly impacted the visual character in a relatively short time. The dominance of the mountainous terrain which defines the valley, coupled with the lower ridge system running north south through the centre of the valley from Muswellbrook to Singleton has assisted in reducing visual impact of mining.

Development planned over the next twenty years and beyond will increase the extent and rate of change to the regional landscape. The approximate extent of current mining activities can be best appreciated from an aerial photomontage prepared from 1996 photography (Figure 12). The extent of change over the period to 2020 can be determined by comparing the 1998 and 2020 synoptic mine plans.

5.1 VISUAL CONSIDERATIONS

Mining activities on individual mine holdings and in a cumulative sense across the valley, has changed and will continue to change the landscape character of the region. The cumulative effect on the regional landscape is compounded by the presence of Bayswater and Liddell power stations. Change to the landscape character can also be considered in terms of temporal effects, that is, intermittent and temporary, and, in terms of spatial distribution.

Visual impacts arising from coal mining are:

- Land clearing.
- Extensive modification of landforms.
- Infrastructure associated with mine operations.
- Night lighting and localised air borne particulate.

These impacts occur at varying scales depending on the location of the mine in relation to surrounding land uses and terrain. In some cases, they are temporary but can occur for many years, often for the duration of the mine. The very nature of open cut coal mining leads to permanent change in the landscape by reshaping the terrain and vegetation patterns. There is scope for this change to enhance visual amenity.

5.1.1 Temporal Visual Impacts

Impacts caused by dust on the visual environment are intermittent and temporary and depend on weather conditions. Dust from mining operations can also act in a cumulative way with airborne particulate from other land uses such as power generation and agriculture. Dust and other airborne particulate produce haze that changes the landscape character by reducing visibility, particularly long distance vistas, and affecting the quality of light. Night lighting can also be considered as intermittent but also can act in a cumulative way where night lighting from several mines and uses such as power stations combine to increase night time lighting levels across the region.

Progressive rehabilitation can partly mitigate the visual impacts of dust by vegetating exposed surfaces and to a lesser extent by planting trees and shrubs as visual screens. Landscape treatment can also assist in reducing some of the direct impacts of night lighting by screening with vegetation and reshaped landforms.

Although some impacts are described as temporary, they can often occur for periods of five to ten years or more depending on the rate of coal extraction. As the active mine moves and is followed by rehabilitation in one location, another location is exposed to land disturbance by the moving active area. There are numerous examples throughout the valley, but the Warkworth, Mt Thorley and Bulga mines provide one example where large scale visual disturbance along Broke Road and Jerrys Plains Road has gradually reduced as the active mine areas proceed westward and created vegetated landforms have obscured the active mine area. As the mines progress westward, the impacts on Putty Road progressively increase. The change to the landscape character is intensified as the active areas of the mines converge.

FIGURE 11: CONTRASTING VALLEY LANDSCAPES



FIGURE 12: 1996 PHOTO-MONTAGE OF THE COALFIELD



Source: AAM Surveys Pty Ltd, "Hunter Valley Coalfields" 3/8/96

5.1.2 Spatial Distribution of Visual Impacts

The concept of sequential views is important in considering the implications of mining on the landscape character of the Upper Hunter. For example, viewing the landscape from a car travelling at 100 km/h provides a different impression than viewing the landscape from a stationary position. One allows a very brief glimpse of sequential views, focused on the centre of the field of vision, the other provides a more detailed comprehension of one location by scanning the entire field of vision. Residents in urban areas and rural properties, and visitors to scenic lookouts and picnic areas are more likely to focus on the panorama available from those areas.

The degree of impact is dependent on the locations from which the active mine areas, mine infrastructure and rehabilitated landforms will be visible in relation to sensitive viewing locations. Sensitive viewing locations might include:

- Roads.
- Passenger rail networks.
- Townships and urban areas.
- Historic buildings.
- Rural homes.
- Tourist facilities.
- Vantage points and viewing areas such as lookouts and public reserves.

5.1.3 Mitigating Measures

Mitigating factors may include:

- Intervening landforms which obscure the active mine area and infrastructure.
- Distance between the viewing position and the mine. As a general rule the impact is less from greater distances.
- Frequency of use of the viewing location and its social and cultural significance.
- The character of the terrain including the texture and contrast of the mine in relation to the background terrain, and the prospect of the mine and infrastructure being silhouetted against the sky, and hence be more prominent. This is sometimes referred to as visual absorption capacity.

These factors determine the extent and nature of engineered solutions which may be required to reduce visual impacts and are generally identified in the initial Environmental Impact Statement (EIS). Typically they include:

- Screen planting.
- Creation of visual bunds.
- Locating infrastructure in a less prominent position.
- Painting of plant and equipment to reduce contrast against the surrounding landscape.
- Revegetation of overburden as mining proceeds.

Notwithstanding, there have been significant improvements in landscape design since the early days of open cut coal mining in the Upper Hunter. In the context of the Synoptic Plan, some of the deficiencies in current assessment practices in relation to visual considerations are:

- Limited capability to deal with cumulative visual impacts, and an overall context for the development of landscape strategies for individual mines.
- A lack of a clear link between the EIS and Mining Operations Plans.
- Limited attempts at integrating visual considerations and landscape objectives with other objectives relating to mine planning, water quality, rehabilitation and environmental management.

Development of a long term strategy will provide consistency between mine rehabilitation and broader Hunter vegetation reforms. The Synoptic Plan provides a useful tool for considering the implications of other existing and planned mining activities on new proposals at the Environmental Impact Assessment stage. It also enables individual Mining Operations Plans to be developed within a regional context.

5.2 REGIONAL LANDSCAPE FACTORS

Within the scope of available base data, preparation of a comprehensive view-shed and visual analyses was not possible. However, based on the extent and distribution of existing and future mining between 1998 and 2020, it is possible to draw broad conclusions on where individual mining operations or multiple operations exist or are planned in locations of regional visual importance. By analysis of the existing configuration of mine activities and planned activities to the year 2020, the areas considered most important in a regional sense have been identified (Figure 17). They include the visual impacts on urban communities and significant transport corridors, including the New England Highway and secondary roads used by local traffic, through traffic and as scenic routes.

These visually sensitive locations include:

- Muswellbrook township and its surrounds, in the northern part of the coalfield.
- The New England Highway Corridor, between Liddell and Camberwell.
- Putty Road, Broke Road and Warkworth in the south east of the coalfield.
- Jerrys Plains Road, south of the village of Jerrys Plains.

• Muswellbrook township and its surrounds

Muswellbrook and Aberdeen are urban communities where mining activities have a significant and direct visual impact on the townships. Singleton, Denman and Jerrys Plain are largely obscured from mining activities. Although impacts arise indirectly through the approaches on surrounding roads which influence the landscape settings of these communities.

The Bengalla, Mt Pleasant and Dartbrook Mines will dramatically transform the landscape character surrounding Muswellbrook and will occur over an extended time frame. The western area of Muswellbrook township is characterised by the riparian agricultural areas of the Hunter River (Figure 13). Most of these areas have little tree cover and the existing terrain is flat to gently undulating.

To the northeast and south of Muswellbrook, existing mines are partly obscured by steeper terrain, although Muswellbrook Mine to the northeast is visible from some residential areas and the New England Highway. The terrain shields Drayton and Bayswater mines. Although it has not reached the assessment stage, and is therefore not included in the 2020 Synoptic Plans, if the Mt Arthur North Mine proceeds it will have a further impact on the visual and landscape values south of Muswellbrook.

The synoptic plans highlight the extent of change between 1998 and 2020. At 1998, there is minimal mining to the west of Muswellbrook. By 2020, areas to the west of the township will be extensively mined. Rehabilitation of Dartbrook to Mt Pleasant will be complete. Bengalla will continue to operate beyond 2020. Bengalla is progressing west, away from Muswellbrook. The 2020 plan shows isolated clumps of trees on top of the easterly overburden dump. Mt Pleasant adopts a similar revegetation approach, but with an emphasis on continuous planting along ridgelines. In addition, in the Bengalla EIS, street planting in Muswellbrook is proposed to obscure views of the mine.

• The New England Highway Corridor

The Upper Hunter is a gateway to the Sydney Metropolitan Region and a significant visitor destination in its own right. The New England Highway is a major link in the State and National Highway system and maintenance of natural scenic values through the region should be an objective for long term strategies in mine rehabilitation.

The Great Northern Railway also runs through the coalfield.

Due to the nature of the terrain, existing mines are visible from the Highway from an area extending south from Liddell to south of Rixs Creek. The impact varies in nature. Lack of screen planting and shaping of visual bunds in the foreground immediately adjacent the southwestern side of the Highway, and distant views of various mine operations on the northeastern side emerge as concerns (Figures 14 & 15). The 2020 Mining Operations Plans show mines in the Rixs Creek area progressing towards the New England Highway, potentially becoming more visible.

• Putty Road, Broke Road and Warkworth

Putty Road, Broke Road, Denman Road and Jerrys Plains Road carry moderate volumes of local traffic, through traffic and tourists. The convergence of Warkworth and Mt Thorley Mines towards Putty Road and views of Mt Thorley and Mt Bulga from Broke Road, and Warkworth from Jerrys Plains Road have a significant impact on the region's secondary road network. Mine operations along Putty Road south of the Mt Thorley industrial area have a significant visual impact, despite screen planting and visual bunds (Figure 16).

Visual bunds and screen planting along Broke Road and Jerrys Plains Road have assisted in reducing impact as mining moves away from these roads in a westerly direction. However, although landforms have obscured the active mining areas, the shaping and landscape treatment of the bunds has in some cases been only moderately successful. This is emphasised by the fact that the bunds are immediately adjacent the road, and as with treatment along parts of the New England Highway the immediacy of the rehabilitation to the observer, requires more detailed thought in the design.

Advanced screen planting has commenced along Charlton Road, which forms the southern extent of the Warkworth, Mt Thorley and Mt Bulga operations.

• Jerrys Plains Road

Landscape quality southeast of Jerrys Plains village is affected by a number of mines. The road is part of the scenic tourist route from Cessnock and Singleton to Denman, Muswellbrook and beyond.

At present the impact of these mines is partly mitigated by a combination of distance, terrain, and intervening planting, and the diversion of Jerrys Plains Road south of its original alignment.

FIGURE 13: BENGALLA MINE LOOKING SOUTH FROM MUSWELLBROOK



FIGURE 14: VISUAL BUNDS WEST OF THE NEW ENGLAND HIGHWAY



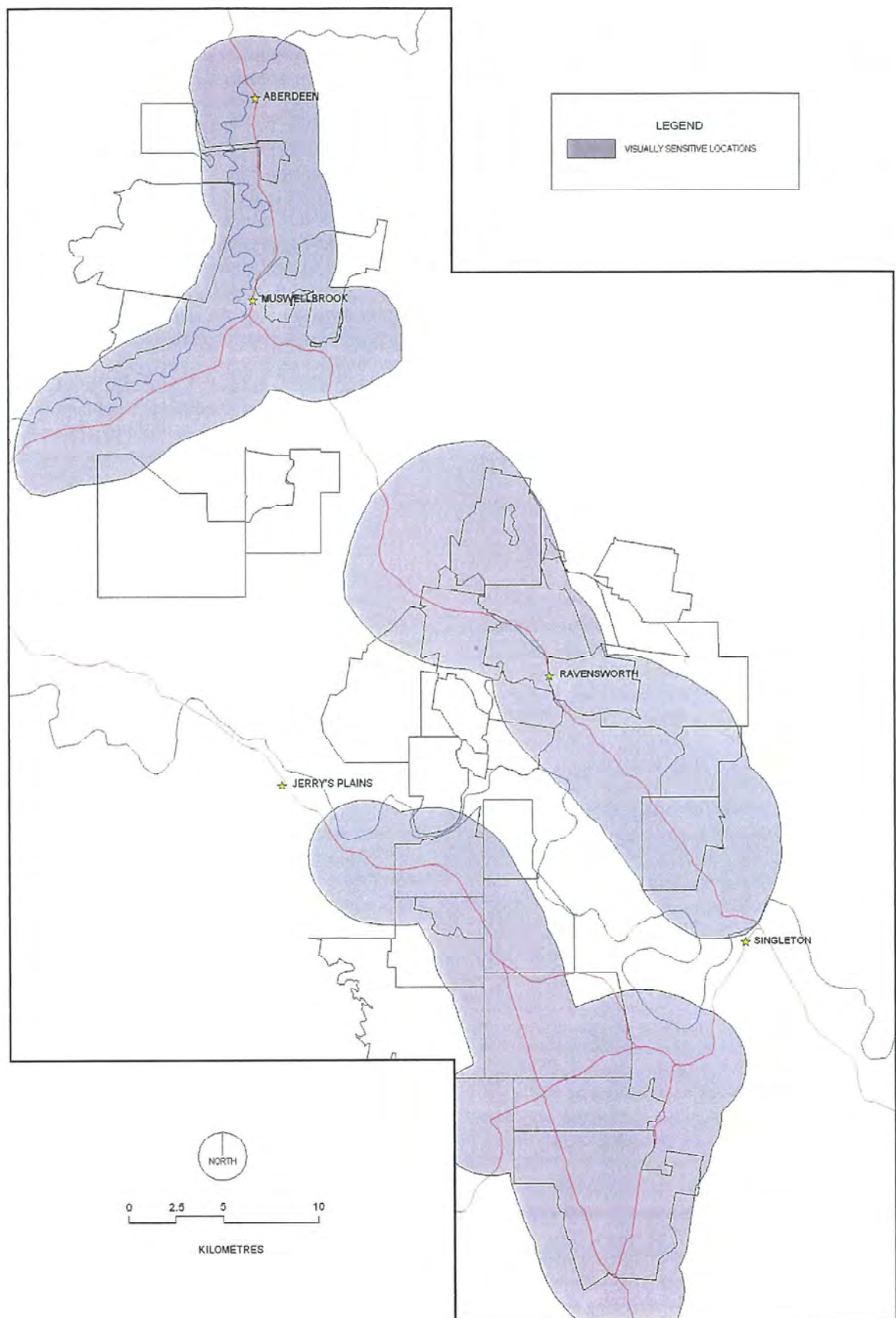
FIGURE 15: MINING EAST OF THE NEW ENGLAND HIGHWAY



FIGURE 16: PUTTY ROAD



FIGURE 17: MINING AREAS OF REGIONAL VISUAL SENSITIVITY



6.0 Integrating Rehabilitation Design

A successful rehabilitation program relies on addressing multiple objectives in an integrated manner. In a regional sense and for individual mines these objectives should include:

- Creation of stable landforms.
- Facilitating productive and sustainable land use prior to mining.
- Designing for sustainable after-mining use, including establishment and initial maintenance cost.
- Meeting environmental criteria in relation to catchment management and biodiversity.
- Mitigating visual impacts and enhancing landscape amenity.
- Preservation of downstream water quality.

Considerable documentation is available on environmental best practice and mine rehabilitation. The rehabilitation of coal mining areas in the Upper Hunter coalfield is recognised and benchmarked amongst the best in the world. While the mines are creating maintained productive pastures, procedures have not been applied on a regional basis for creation of sustainable native forest ecosystems, and landscape amenity. Determining opportunities for interim and after-mining use in relation to the mining program and existing site conditions is a logical basis for determining the rehabilitation design. This should be done having regard to economic, ecological and landscape considerations.

6.1 INTERIM AND AFTER-MINING LAND USE

From both a mine planning perspective and in terms of delivering a regional strategy for landscape rehabilitation it is essential that after-mining use and interim uses be considered as priority components of mine planning. The major landscape elements of landform, drainage, plant selection and design must be considered in relation to other environmental objectives and intended after-mining use.

To date, grazing has been the predominant interim and after-mining land use. The 2020 Mining Operations Plans maintain this emphasis. Given the historical importance of grazing to the regional economy, it likely that this will continue to be the predominant use of land in mine holding.

Meeting the emerging challenges of enhancing biodiversity and landscape values requires an evolutionary shift in focus. Diversification of land uses before and after mining has the potential to value add in economic and environmental terms. Designing for after use of final voids represent a particular challenge to the industry.

6.1.1 Revegetation and Intended Land Use

Important factors for mining operations when considering tree or plantation forest establishment and land uses before and after mining are:

- Purpose of revegetation.
- Dislocation of existing land uses.
- Environmental benefits such as screening, riverbank protection and shelter belts.
- Mitigation of mining dust.
- Potential for permanent forested buffers around final voids.
- Requirements, such as earthworks, drainage or soil amelioration.
- Maintenance requirements, including fire hazard controls.
- Potential benefits and risks to habitat and wildlife.
- Potential to convert buffer land to forest and acquire land water entitlements for mining purposes.
- Uncertainties regarding carbon accounting and trading.
- Use of mine waters or waste waters for forest irrigation.
- Cost (capital and operating).
- Cost of alternative uses including licensing fees and monitoring.
- Implications for land resale values at the post-mining stage.
- DMR and other regulatory authorities' requirements.
- Management responsibilities and obligations (especially in relation to mining leases).
- Commitments made in company Greenhouse Challenge agreements or other policies.
- Strategies for soil erosion control.

There must remain in any prescription for the treatment of mining landscapes, some provision for flexibility. Such flexibility is necessary in order to realise alternate after-use potential. Guidelines must be used for the treatment of final voids to address the priority issue of risk/safety for the public and for after-use operators. For amenity and agroforestry after-use, up to 5 years may be appropriate before compliance certification and lease cancellation is achieved. For active recreational and industrial after-uses an environmental impact assessment and development approval would trigger the transition. Aftercare conditions should be anticipated in such development approvals.

6.1.2 Commercial Plantations

Interest in farm forestry is on the rise in the Upper and Lower Hunter. Already, State Forests of NSW has a number of joint venture landholders in the area. The acceptance of trees as a legitimate form of rehabilitation of land is apparent. Plantations can provide financial benefits to investors, with markets in the following areas:

Potential market for wood to supplement coal in power stations.

- The general acceptance of pulpwood exports from eucalypt plantations.
- Emerging markets for carbon credits.
- The increasing potential for value-added timber products from plantations.

The Port of Newcastle is well serviced by transport infrastructure from the Hunter Valley. The Port is currently a major outlet for pulpwood export, with the Hunter also home to domestic pulpwood processing. The potential also exists for a pulp mill or other processing site to be developed in the region.

Agroforestry also has environmental benefits:

- Reduced erosion risk.
- Enhanced catchment protection.
- Shelter for crops and livestock.
- Greenhouse gas absorption.
- Weed suppression.

Establishing forests as carbon sinks, particularly by coal burning industries is a potential new area for interim and after-mining use. Setting of renewable energy targets by regulators has increased interest in the use of forest residues (biomass) in energy generation, with the possible ready inclusion of biomass into coal fired power stations.

Plantation development on mine land holdings has potential future employment benefits as a flow on from land that has been mined and which is currently returned to (low value) grazing land. State Forests of NSW has identified areas in the Upper Hunter as potentially available for hardwood plantations by:

- Buffer zones around coal mines.
- Mined land under progressive rehabilitation.
- Planned mining areas.

Rehabilitation has traditionally been an expensive process (up to \$25,000 per hectare) and has typically been to establish pasture for cattle grazing. A significant portion of this cost is concerned with topsoil re-spreading and other activities that may not be required in reestablishing the site for trees. Approximately 500 hectares of mine land has been sown or planted with trees to date, but this is increasing with some mines now wishing to put trees on 30 – 40 % of their mined land.

Prior to expansion in tree planting for commercial plantation purposes there will need to be extensive consultation with other agencies (DMR, DLWC) and the wider community.

6.1.3 Final voids

Final voids are a unique aspect of the landform that must be considered in rehabilitating open cut coal mines. The end use of voids in mining areas is important for setting completion criteria. Figures 17 and 18 show the typical configurations of final voids. The main elements comprise:

- The low wall.
- End walls.
- High wall and crest.
- Ramp.

The configuration of the final void is due primarily to geologic characteristics including rock homogeneity, ore grade and seam thickness, moderated by economics and engineering constraints. Additionally, the position and orientation of the void may be determined by other constraints such as the location of highways, urban areas, railways, local and state government boundaries as well as geographic barriers including rivers and terrain. Due to their nature they present a significant challenge for the development and prescription of rehabilitation practices to meet completion criteria. Factors influencing the treatment of final voids include:

- Safety and stability.
- Method of mining.
- Physical shape in relation to surrounding terrain.
- Control of spontaneous combustion.
- Ground and surface water hydrology.
- Potential end use.
- Proximity to other active mines.

Projected positions of most of the final voids shown on the 2020 Mining Operations Plans are conceptual due to variations in progression of mining and economic factors. At year 2020, with the exception of Mt Owen, all final voids are conceptually proposed to be rehabilitated to pasture. Clearly, this is not an accurate reflection of likely treatment since many of the final voids will be captured water catchments and a number mines are considering the potential for using high walls as entries for underground mining.

6.1.4 Opportunities for After Use of Final Voids

The varied attributes of a rehabilitated open cut mine lend themselves to multiple use of the site after mining. Multiple use includes segregated use (where industrial, agricultural and amenity uses may occur on the one site) and integrated use (where selected amenity activities on the one site complement each other).

Mine sites contain many of the attributes potentially suitable to industrial after-use. These include infrastructure provision (road/rail access, water, power, buildings, workshops), buffer zones to residential development, land forms to mitigate against noise and visual impact, and inexpensive, low ratable land. These attributes lend themselves to otherwise offensive, hazardous or noisy industry.

The void configuration and availability of capping fill have been opportunistic to long term waste disposal. The Ravensworth No 2 mine void has been approved for long term (25 years) power station ash disposal under the management of the power authority. A number of coal mine voids have been approved and are in use as solid waste disposal landfills including:

- Muswellbrook Colliery 'common open cut' void with a capacity for 25 years of domestic waste disposal by the local council.
- Newcastle City Council's Summerhill waste management facility at the former Wallsend Borehole Colliery which has 13.2Mm³ of land fill space representing 50 years of capacity.

The waste facility option for voids has limited scope for all but a few sites sufficiently close to infrastructure centres of road/rail facilities. These proposals would expect to come under tight scrutiny in environmental impact assessment and specifically investigation of the groundwater regime for possible leachate contamination.

Many voids will fill with water since they are not self draining. Depending on the catchment characteristics or the availability of a suitable water supply nearby, voids have the potential to form water storages for flood

mitigation and other purposes such as agricultural irrigation or recreation.

The proximity of the final void at Mount Thorley mine to Wollombi Brook provides an opportunity to create such a storage. The void can be designed to capture overland surface flows from the adjacent creek flood plain. The water quality from flood events will dilute saline water draining from the mine, and create a supply of useable water. Figures 20 to 23 conceptually show a possible rehabilitation sequence for the Mount Thorley void, using rehabilitation blasting and revegetation coupled with progressive filling from surface flows. The illustrations provide one example of the possibilities of combining a sustainable end use with enhanced visual and environmental values.

Reclamation to amenity is an exciting area requiring a responsiveness to site conditions, flexibility in design and implementation and a clear understanding of the natural processes which would influence the development of these sites if left undisturbed following extraction. Amenity after-uses may require specialist long term management of the landscape. Table 3 identifies a wide range of amenity and resource uses for rehabilitated mining areas and their final voids

For amenity after-uses to be successful beyond the five year aftercare period, it is essential that they are financially sustainable, either producing revenue to balance running costs or supported by funding from other sources. Amenity after-uses may be considered under the categories, sport and active recreation, passive recreation, water conservation and water sports, habitat restoration for biodiversity and aesthetic amenity.

TABLE 3: AMENITY AND RESOURCE USES OF FINAL VOIDS AND ASSOCIATED REHABILITATED MINING AREAS

Sport and Active Recreation	Resource Management	Resource Conservation
Land Based Sports Playing Fields, Golf Archery Parks/Public Open Space Grass Ski Slopes Small-bore Rifle and Pistol Shooting Clay Pigeon Shooting Climbing, Orienteering Horse Riding Camping, Caravanning Motor Sports: Trials/rallies, Formal Circuits, Cycle-cross & BMX Water Sports Model Boating, Sailing and Windsurfing, Rowing, Canoeing, Sub Aqua, Water Skiing, Jet Skiing, Power Boating, Recreational Fishing	Water Storage, Flood Mitigation Aqua Culture Industrial Sites Waste Management Facility, Fill Site for Adjoining Mine Coal Reject Disposal Power Station Ash Disposal Portal for Underground Mining Commercial forestry Agroforestry Biomass energy forest Carbon sequestration Grazing Viticulture Orchards	Wetlands Standing Open Water Bodies Flora and fauna habitat Wildlife corridors Native Bushland Geological Heritage Mining Heritage

FIGURE 18: ACTIVE VOID

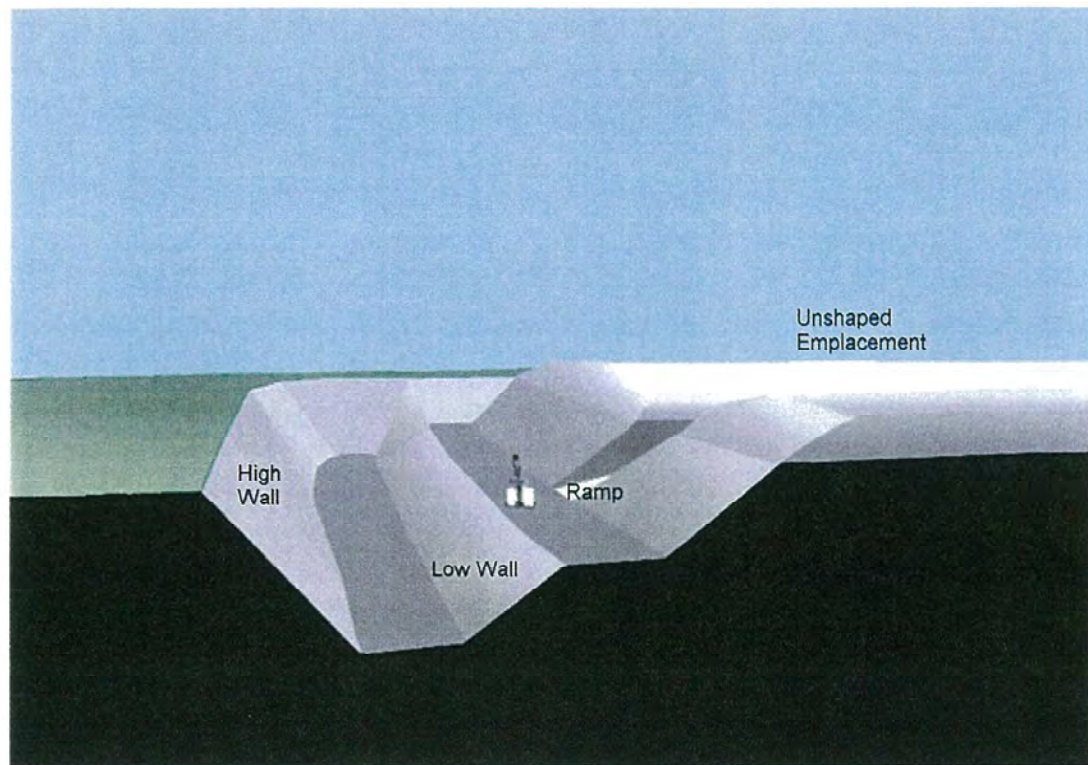


FIGURE 19: FINAL VOID PRIOR TO RESTORATION

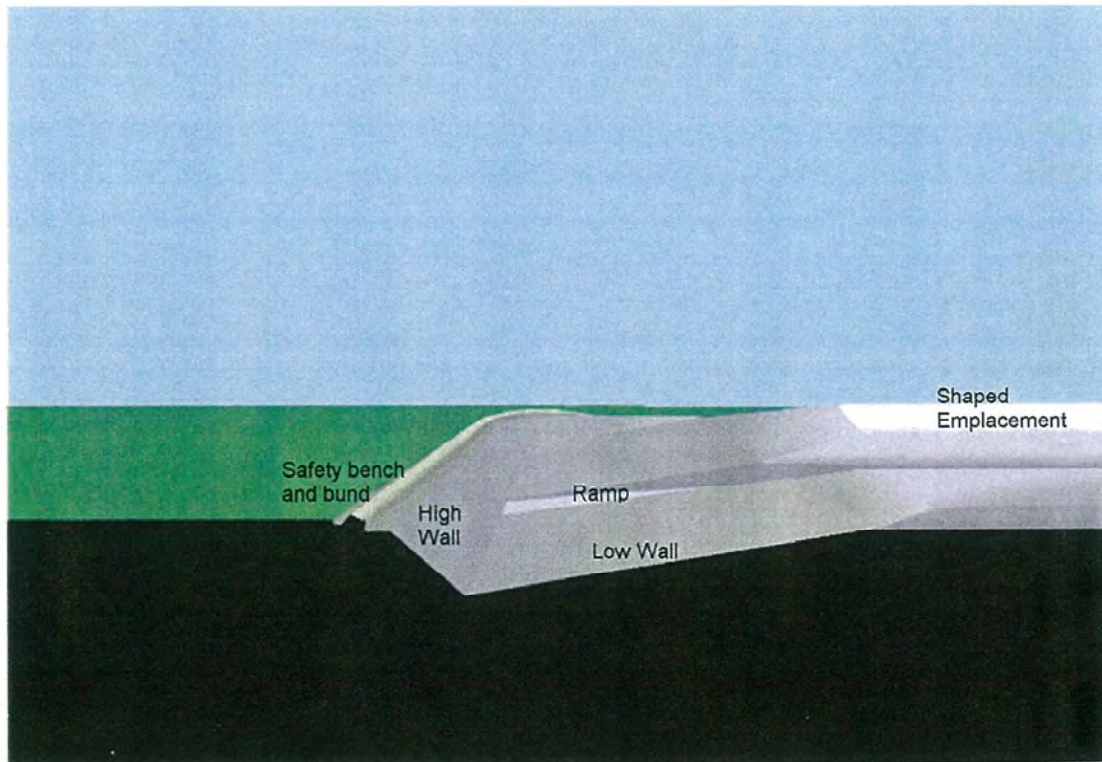


FIGURE 20: HIGH WALL AND SAFETY BENCH PRIOR TO REHABILITATION

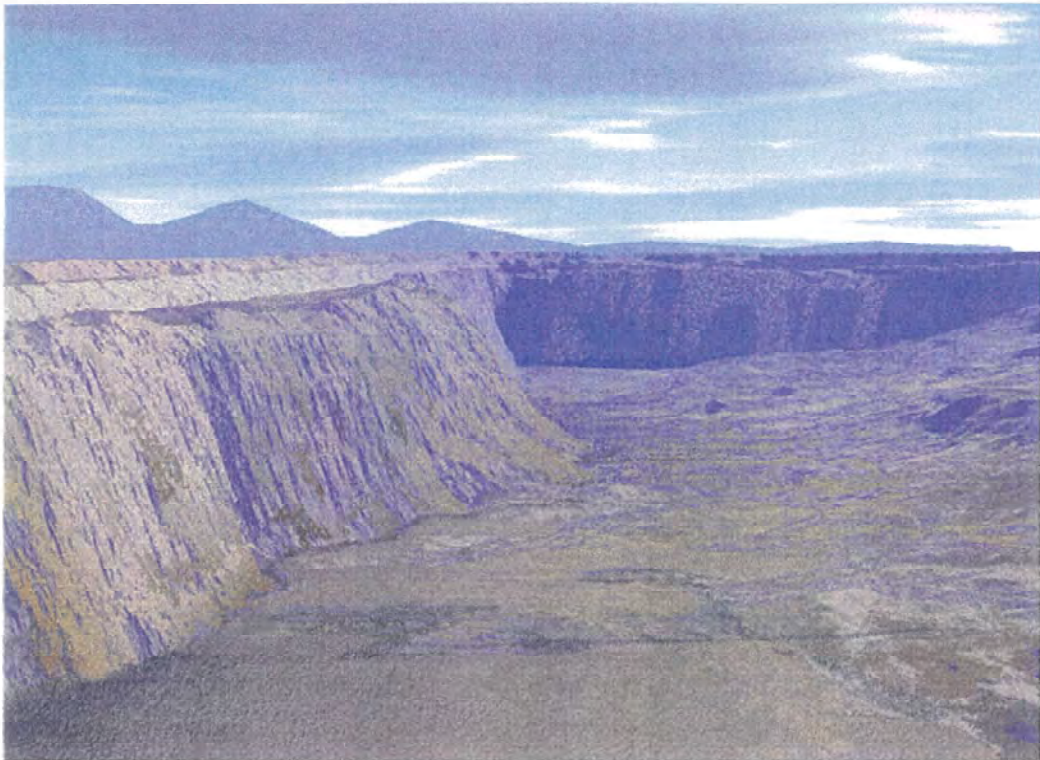


FIGURE 21: BLASTING OF THE HIGH WALL CREST

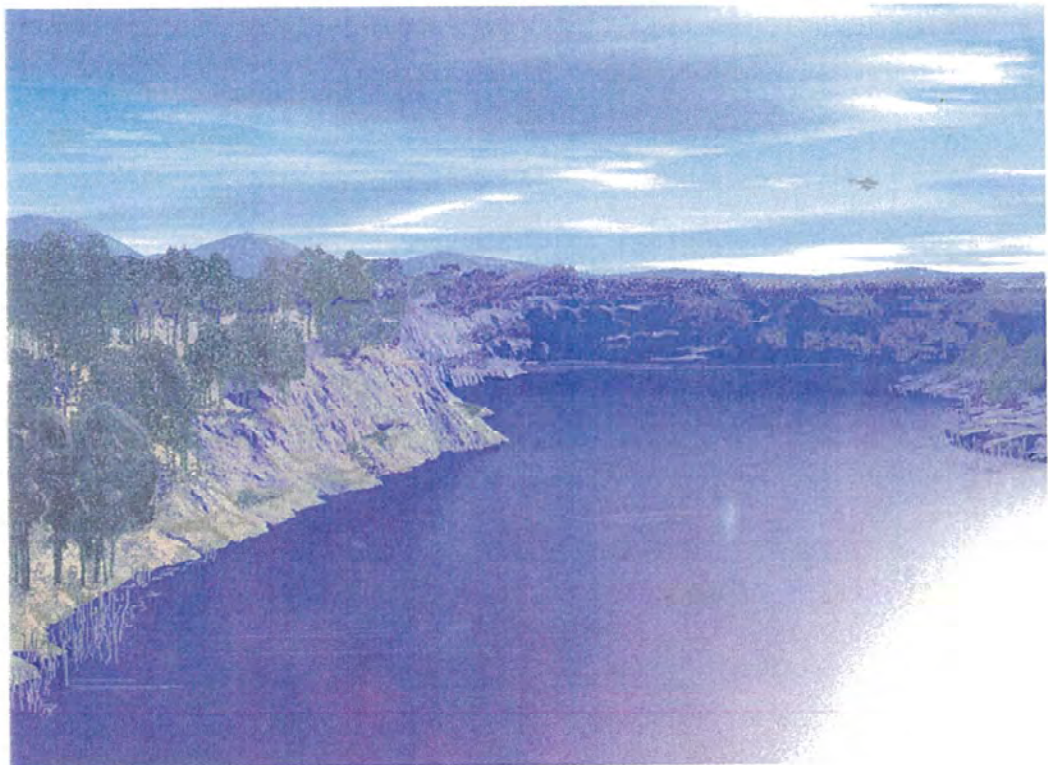


All illustrations digital terrain renderings prepared by Andrews.Neil

FIGURE 22: PARTIALLY FILLED VOID FROM ONSITE DRAINAGE



FIGURE 23: REHABILITATED VOID WITH BIOENGINEERING AND WATER STORAGE FROM ADJACENT FLOOD PLAIN



6.2 LANDSCAPE DESIGN

In terms of landscape and visual amenity, the key considerations are the degree to which mining activities contrast with the existing landscape character. In many cases, it is not possible to mitigate these visual impacts, due to the nature of the materials being handled and the limitations of the mining process. This is particularly so with temporary disturbance during the mining process. However, an understanding of the factors influencing landscape values provides a basis for dealing with landscape issues in rehabilitation design.

The landscape can be described in basic elements of form, colour, and texture. The extent to which these visual properties vary from those of the surrounding landscape determine the degree of contrast and hence the manner in which mining activities integrate with the surrounding environment. The existing landforms, particularly along the sides of the valley comprise weathered sandstone or basalt caps, resulting in a rugged terrain of pronounced peaks, escarpment and foot slopes.

The escarpment faces are often devoid of vegetation providing contrast in texture and colour, which defines changes in the form of the natural landscape. The background of surrounding hills is usually seen as a dark green or blue grey, with a rough surface texture of trees. This tends to reflect less light. In the valley floor, the landforms are flat to gently undulating with incised slopes. The vegetation cover is more variable due to agriculture, hence there is a contrast in surface texture between trees generally along the ridge tops and incised side slopes, and pasture grass or crops.

In considering landscape character as part of rehabilitation design, it is necessary to address form, colour and texture in relation to the surrounding environment. For example, the stockpiled overburden material is usually a light grey or brown colour depending on the parent material. In addition, the stockpile has minimal surface texture when seen from even a distance. The combination of these two features leads to a high reflectance of light (Figure 24). Lastly, the stockpiles of overburden are placed by equipment to their natural angle of repose, which leaves uniform side slopes, either in a peaked formation or a large flat crest.

Coal stockpiles and coal reject are darker in colour and contrast against the lighter background of cleared agricultural land. Contrast is also emphasised by the shape of the stockpiles viewed against gently undulating to flat terrain, whereas they may be less prominent when viewed against the darker vegetated rugged terrain of the side of the valley (Figure 25).

6.2.1 Landform Creation and Drainage

Landforms created during the mining process typically follow the sequence of initial stripping, removal and

stockpiling of the overburden, which is often used to create a visual bund around the early stages of the active mine area.

Clearing, stripping of topsoil and removal of overburden and creation of unshaped emplacements continues as mining proceeds, followed by shaping of the emplacements and rehabilitation. The emplacements are significant features in the landscape sometimes up to sixty metres above the surrounding natural terrain.

Early mining paid little regard to the appearance of the shaped overburden, with stability and economy of effort the overriding concerns. In general, a requirement for maximum slopes of 10 degrees became the dominant factor in determining the final profile. As a consequence the resulting post mining landscape is sometimes unnatural and monotonous although difficult to distinguish from cleared grazing lands adjoining the mine. Often, this is also the case with visual bunds where little attempt is made to vary the shape of the constructed landform to create visual interest and reduce contrast with the surrounding landscape.

Creating variable slopes and emphasising features such as drainage paths and catch dams provides a basis for creating variation and interest in constructed landforms. It also provides opportunities for variation in the plant

selection and design, and creating interest and potential for more diverse ecosystems. The interface between adjacent mine operations creates particular needs in terms of a strategic approach to rehabilitation. A cooperative approach to created landforms across common boundaries has potential benefits in resource management and visual amenity. The interface between Bayswater No 2 Mine and Drayton Mine is such an example. Overburden from the active Bayswater Mine has been used to fill and reshape the void on the completed Drayton Mine. This is illustrated in figures 26 and 27, which are computer-generated images developed from the 1998 and 2020 Mining Operations Plans.

The shape of final voids is dictated by many factors including, the geological formation, presence of barriers such as major roads, watercourses and railway lines, and the mining techniques used for example truck and shovel, dragline or a combination of these techniques.

The high wall of the void can be a near vertical face up to 70 metres high. The final shape must be engineered to ensure stability and safety requirements are met. Application of a combination of hard engineering and bio-engineering techniques has the potential to further modify the shape to improve visual amenity and enhance opportunities for after-mining use. In some instances restorative blasting can reduce the height of the high wall and end wall and reduce the slope of the face. In combination with planting, this technique can soften the profile of the high wall and end walls (Figures 28 and 29).

FIGURE 24: CONTRASTING FORM AND COLOUR



FIGURE 25: COAL STOCKPILES AGAINST LIGHT BACKGROUND

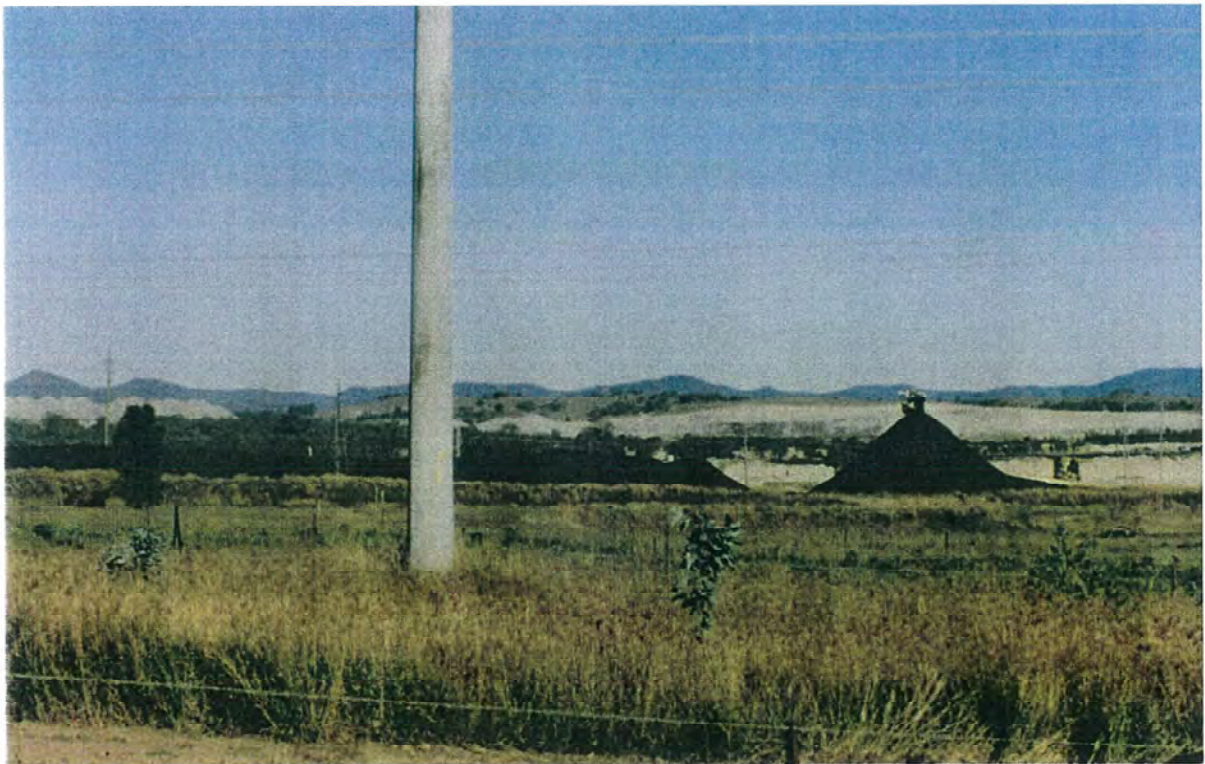
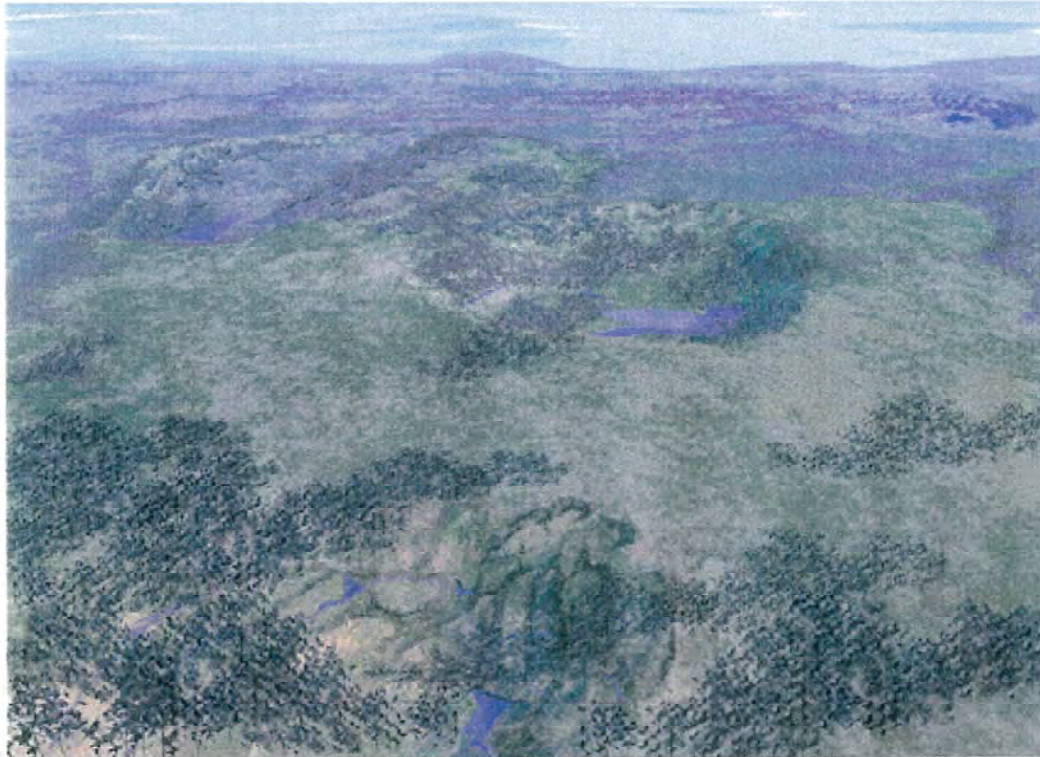


FIGURE 26: BAYSWATER – DRAYTON MINE INTERFACE 1998



FIGURE 27: BAYSWATER – DRAYTON MINE INTERFACE 2020



Above illustrations digital terrain renderings prepared by Andrews.Neil

FIGURE 28: SAFETY BENCH AND BUND AT CREST OF HIGH WALL PRIOR TO REHABILITATION

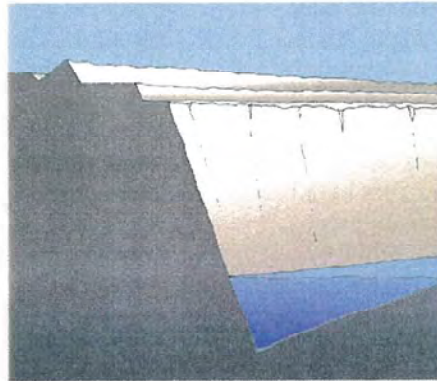
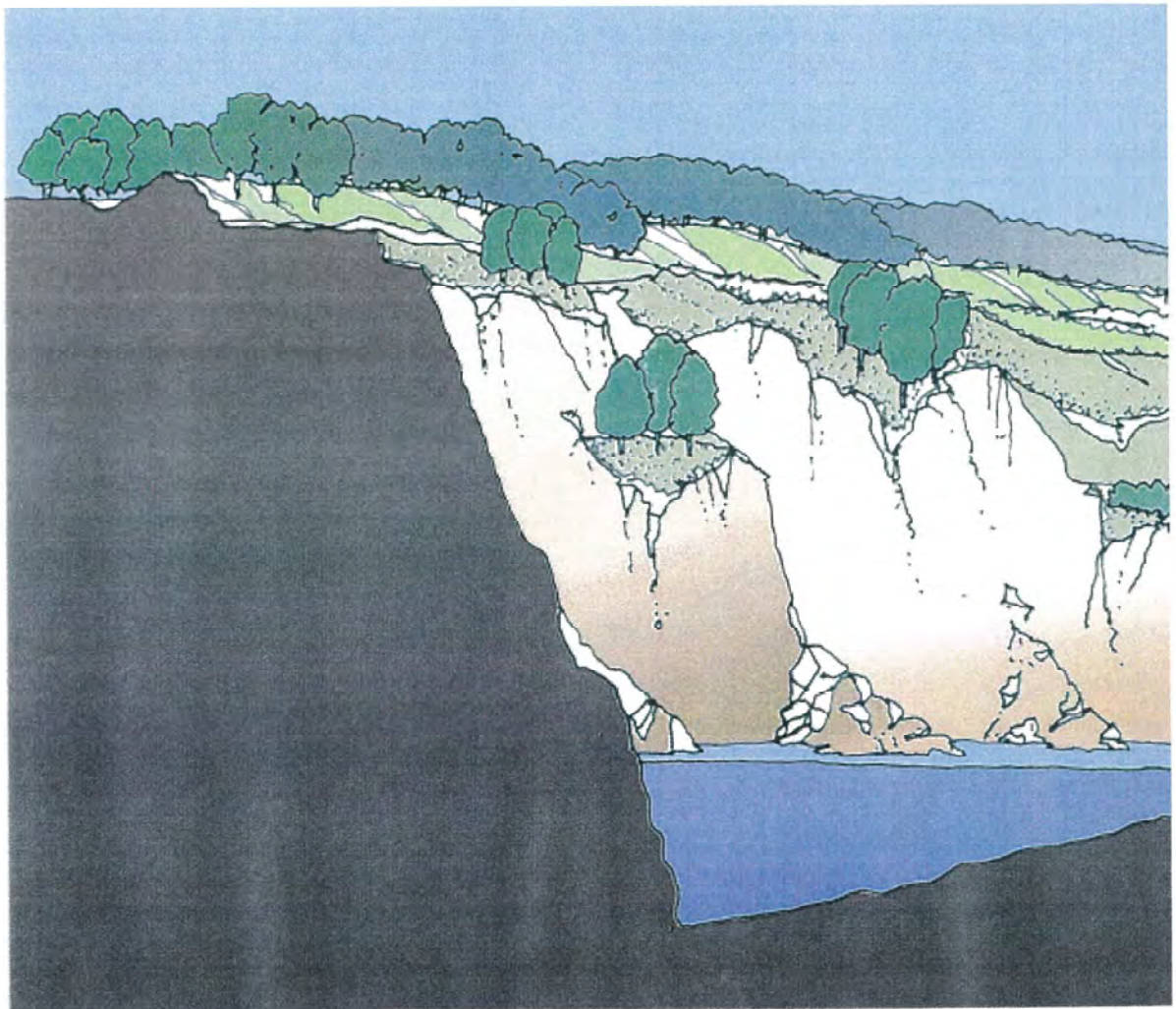


FIGURE 29: CREST OF HIGH WALL AFTER REHABILITATION BLASTING



6.2.2 Planting Design and Species Selection

A primary requirement of mine rehabilitation has been restoration of agricultural land capability to pre mining conditions. With increased environmental awareness by the broader community, there have been progressive changes in rehabilitation on mined land. Early examples reflect an almost universal return to grazing land post mining, with little or no tree cover. Where trees have been introduced they are typically a monoculture of fast growing *Acacia*, *Eucalyptus* or *Casuarina*, with little regard to the resulting landscape. Often it has been a case of providing a visual screen to obscure the mine, without concern for the appearance of the visual screen itself. Where trees have been introduced for other than screening purposes the plant material and design has again had little regard for the resulting landscape form. Additionally, trees on a number of mines have been planted in isolated regularly spaced and shaped clump, amongst grass rehabilitation. This is a pronounced contrast to the typical character of the valley floor and lower slopes.

Consideration of form, colour and texture also applies to the selection of plant material and its placement. The surrounding landscape, particularly the background against which the rehabilitated area will be seen, provides the most obvious cue to developing a planting strategy.

Advanced screen planting has been used with varying degrees of success as means of mitigating visual impacts of future mining. Direct seeding of a random mix of a variety of local native species as opposed to a limited range of species planted at regular spacing has generally resulted in a more natural appearance. This is particular so when remnant native vegetation occurs nearby. Effective screen planting must be established well in advance of mining. Again, the performance of the industry in this regard has been variable. It may take up to ten years or more to establish a functional visual screen. Mining Operations Plans need to consider the timing of screen planting well in advance (Figure 30), and to design the screen planting having regard to other functional values such as habitat corridors and commercial plantations.

Whilst mitigating visual impact of voids, present challenges in rehabilitation design can also create interesting features in the landscape. The presence of water bodies, common in many voids, adds visual interest, even if the water quality is unsuitable for other purposes. This coupled with other water bodies such as water storage for mine purposes, natural features such as existing watercourses, and irregularities in the shape of the void can create a more natural appearance (Figure 31).

Planting design to enhance the amenity of final voids is dependent on the void configuration, soil composition, availability, and particularly in the case of captured voids, quality of water. In many cases these factors are likely to

present a hostile environment to plant growth. It is therefore, more likely that planting will be concentrated around the crest of the void and on the low wall. Typically the slope of the low wall is shaped to approximately 18°, making it unsuitable for sustainable grazing. Planting of the low wall for either commercial forestry or habitat, or a combination of both will assist in improving visual amenity. Treatment of the high wall will largely rely on rehabilitative blasting to create variety and interest. This may also provide opportunities for creating benches as part of the blasting which in turn creates an area where planting can occur. Depending on the difficulty of access to plant such pockets it may be a case of plant generation by seeding from birds or wind blown seed. This is likely to increase the risk of unwanted exotic plants establishing on the blasted face. The crest of the high wall is likely to be engineered for safety reasons to include a bench and berm. This provides opportunities for planting which should follow the principles for screen planting of visual bunds by establishing an informal landscape theme rather than regular spacing of a single species.

Where amenity reclamation is considered as an end use the planting design will need to consider functional objectives in relation to the proposed use. For example, the need to provide shade and shelter, grassed seating areas and viewing areas where recreational activities are planned. Rehabilitation of the void to create habitat will be determined by the functional attributes of the habitat proposed and the limitations of the void. For example, the potential to create wetland habitat with a variety of flora and fauna is dependent amongst other things on the quality of the water. Moderate salinity levels will restrict the range of aquatic plants and may be constraint for diverse wetland systems in voids.

6.3 BIODIVERSITY AND ECOLOGICAL CONSIDERATIONS

6.3.1 Biodiversity

The preliminary findings of the Hunter Remnant Vegetation Study show the lack of remnant vegetation in the valley is a concern. Between 1998 and 2020 approximately 19% of the existing native vegetation on mine holdings will be cleared. Biodiversity in a regional sense is an issue that needs to be addressed in a coordinated way in mine rehabilitation and other initiatives relating vegetation management beyond mine holdings.

Biodiversity can be defined as the variety of life forms, different plants, animals and micro-organisms, the genes they contain, and ecosystems they form. It is usually considered at three levels, genetic diversity, species diversity and ecosystem diversity.

FIGURE 30: VISUAL SCREEN



FIGURE 31: ANTIENE MINE: CONCEPTUAL EXAMPLE OF INTEGRATED LANDSCAPE REHABILITATION

BEFORE



AFTER



Above image digital enhancement prepared by Andrews.Neil

FIGURE 32: MOUNT OWEN MINE



Greater community awareness of the threats to biodiversity has led to the formulation of a number of government strategies such as the National Strategy for the Conservation of Australia's Biological Diversity, the National Strategy for Ecologically Sustainable Development and the Draft NSW Biodiversity Strategy. As a general principle, the greater the range of indigenous species planted, the greater the contribution to biodiversity. Spatial and temporal variation are important contributors to biodiversity. Temporal variation can be incorporated by planting species which flower or set fruit at different times of the year. This can, for example, provide arboreal mammals with a year long supply of food.

Biodiversity can be promoted by protecting sensitive ecosystems from damage during mining and by establishing more diverse ecosystems in rehabilitation. As a general principle the greater the number of indigenous species planted in rehabilitation, the greater the resulting biodiversity. In addition, by increasing the variety of niches created, more species of flora and fauna are supported. This can be achieved through:

- Planting understorey species, as well as trees.
- Planting a variety of species as opposed to a monoculture.
- Creating a diversity of landforms.
- Creating a number of different types of habitat, such as riparian habitat as well as ridge-top habitat.
- Placing logs and rocks in rehabilitated areas to provide shelter for fauna.
- Planting species that flower at different times of the year and which support different insects and animals.
- Linking rehabilitation areas planted to trees with remnant native vegetation.

The placement of logs and other habitat features has been found to hasten the return of wildlife into revegetated areas. Past practice involved stockpiling and burning logs following initial clearing and top soil stripping. Reuse of logs and other woody debris from these areas in rehabilitation programs will increase habitat diversity by providing a range of niches for fauna and flora. Topsoil

containing native seed bank and micro flora is also a valuable resource for cost effective rehabilitation of natural forest.

The Plan of Management, Revegetation and Wildlife Management in Relation to the Mount Owen Mine (1995) provides a useful basis for development of practices for native vegetation rehabilitation on other mines (Figure 32).

Some of the factors that influence the plant species to be used in rehabilitation include:

- The end use of the land.
- The altitude, aspect and micro-climate.
- The topography.
- Soil type and nutrient status.
- Drainage.

Vegetation succession is influenced by temporal and topographic factors and is important in enhancing biodiversity, since different species occupy different vegetation successions. For example, pioneer species are often found in recently disturbed vegetation, but are less common in late successional vegetation. Hence to maximise diversity it is important to manage vegetation to ensure that a range of vegetation successions are present. Existing and reconstructed watercourses provide a major opportunity to develop diversity in mine rehabilitation. Appropriate planting of drainage swales and catch dams is beneficial to water quality and catchment management by increasing bank stability.

Spatial variation must also be considered when rehabilitating an area to promote diversity. Different species have different requirements, such as the position in the landscape (gullies versus ridge tops), aspect, moisture levels and soil type. As different species require different niches, a more heterogeneous environment will support a greater range of species. Much of the groundwater in the Upper Hunter Valley is saline, salt-tolerant species such as *Casuarina* would be suited to riparian areas.

FIGURE 33: CONCEPTUAL CROSS SECTION

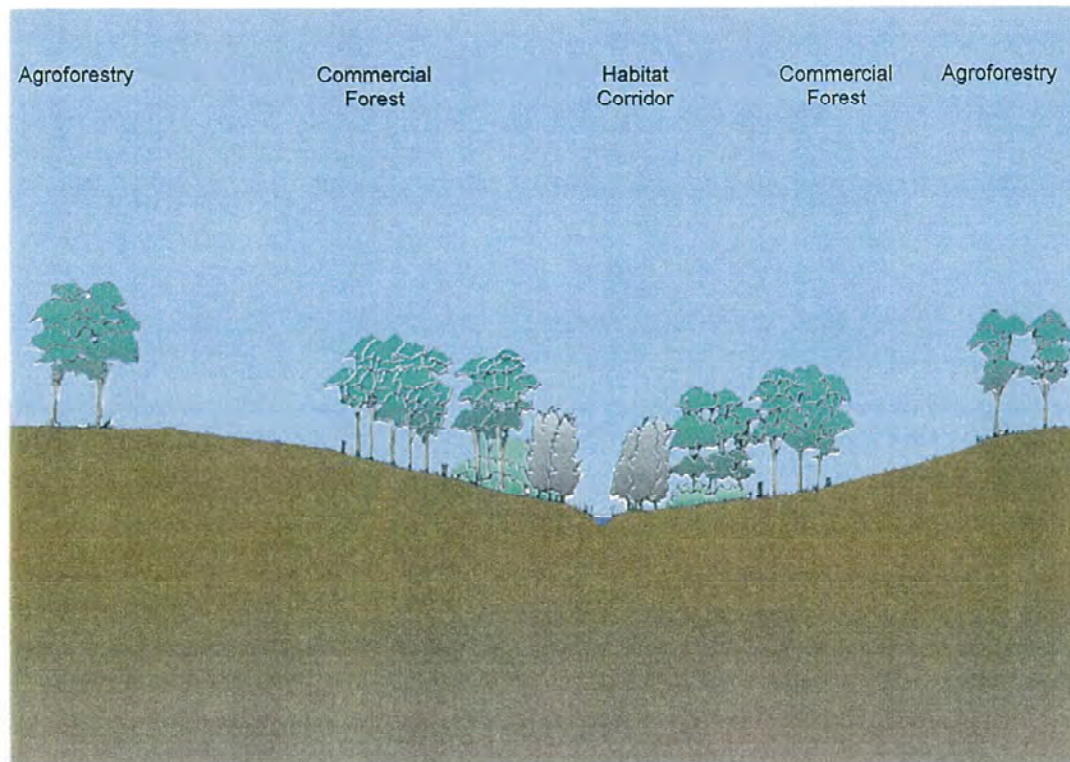


Figure 33 illustrates a cross-section of an area to be rehabilitated with different species suggested at different points.

Establishing diverse ecosystems requires the management of threatening processes. Besides clearing there are other processes that threaten biodiversity, such as weed and feral animal invasion, changes to hydrology, fire, landform stability and erosion. Rehabilitation design can assist in reducing some of these threatening processes by:

- Minimising edge effects through the design and shape of rehabilitated areas.
- Incorporating buffer zones of commercial plantations and agroforestry around areas intended as habitat.
- Providing fencing to restrict grazing on areas intended as habitat.
- Planting of riparian areas to improve bank stability and lower the water table.

FIGURE 34: CURRENT MINE REHABILITATION PRACTICE

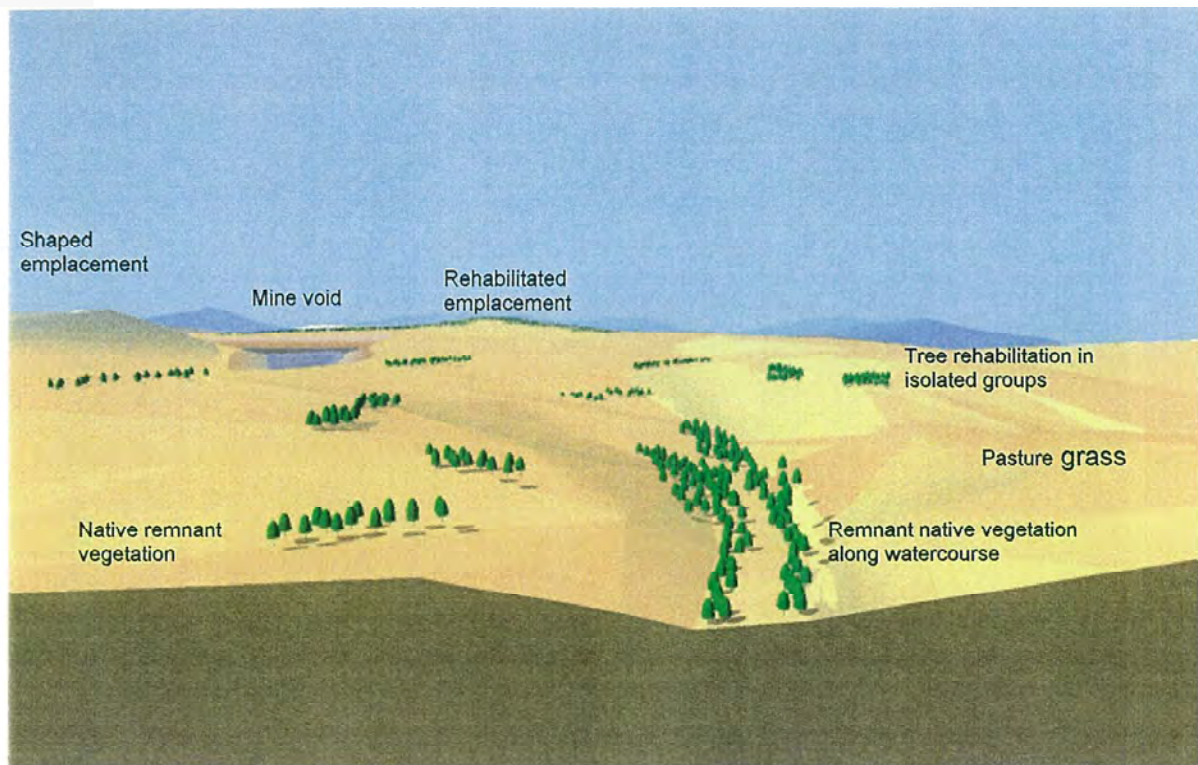
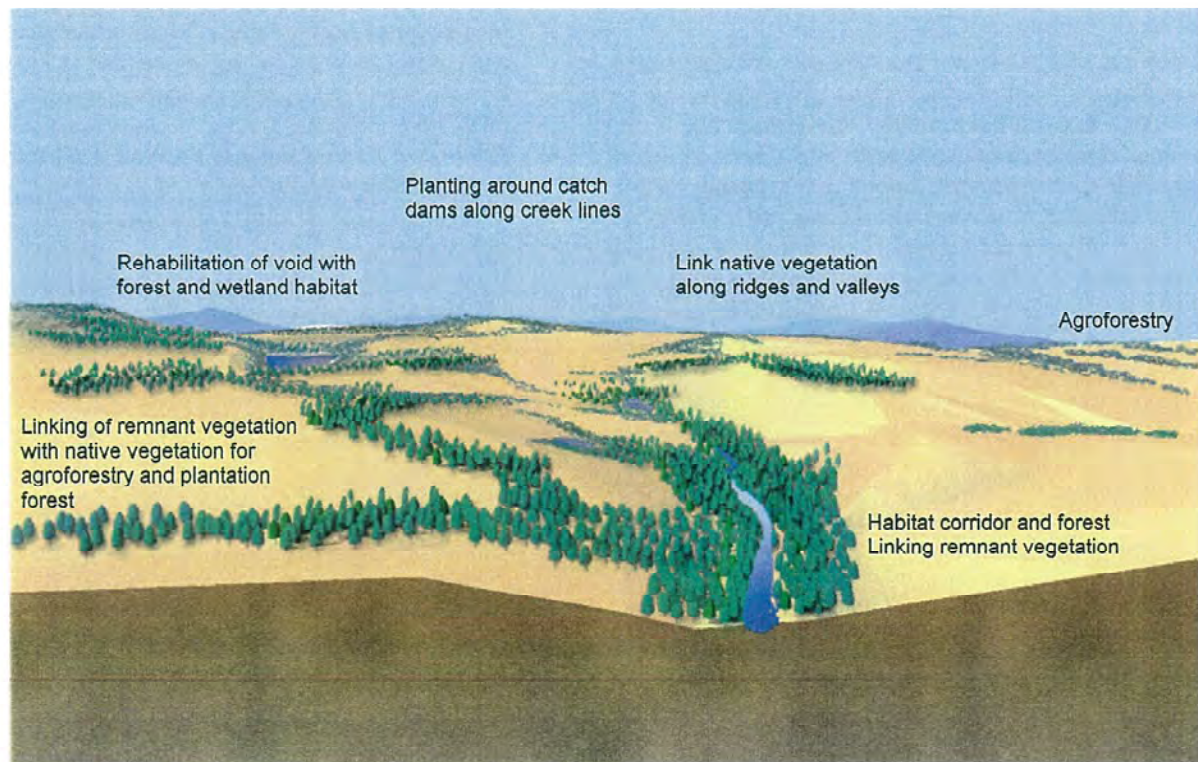


FIGURE 35: INTEGRATED LANDSCAPE REHABILITATION



6.3.2 Regional Environmental Corridors

Achieving objectives in relation to biodiversity requires a coordinated mine by mine approach to rehabilitation set within a regional framework. Should a RVMP be developed in the Hunter, it has the potential to provide a more precise database for formulating such a regional strategy. Notwithstanding this, addressing the present discontinuity in native vegetation across the valley floor is considered to be a primary objective. This would re-establish a link between the Sydney Basin and NSW North Coast Bio-geographic Regions. Achievement of this objective will rely on integration of individual mine rehabilitation programs in collaboration with initiatives on lands adjoining mine holdings. In particular, the power stations and private land holdings between the power stations and foothills are strategically important.

Potential locations for regional corridors include:

- A broad scale vegetation corridor across the valley floor connecting Wollemi National Park and the Barrington Tops National Park. This would involve a link from the Hunter Valley South Mine through the central coalfield including Liddell and Bayswater Power Stations. It can be achieved with minimal impact on prime agricultural alluvial flats while still providing opportunities for the movement of fauna across the valley.
- A corridor linking areas of remnant vegetation extending south east of Muswellbrook across the Bayswater and Drayton Mines to Ogilvie's Hill. Rehabilitation shown on the 2020 Mining Operations Plans goes part way to achieving this corridor. Linking the proposed tree planting and providing additional planting through mine buffers would create a continuous link across the mine holdings. Cooperation from land owners adjoining the mines would enable the corridor to extend along the ridge across the valley.

Planting selection and design of the corridor would need to be developed in consultation with the mine owners and adjoining land owners.

Establishing corridors of native plants serves a number of purposes, including facilitating the movement of fauna between habitat remnants. Movement of wildlife allows gene flow between fragmented populations, increasing the likelihood that populations will be viable. Corridors also provide native animals with shelter and protection from feral predators as they move between habitat remnants.

The width of a corridor may vary from rows of trees to several kilometres depending on a number of factors including the cost of establishment and maintenance in addition to its intended function. Generally, the wider a corridor, the better it is able to provide habitat opportunities through minimising edge effects and external disturbances like weed infestation and feral predation. While the purpose of the corridor may be initially to link remnant vegetation it must also be sufficiently wide to ensure ecological processes can persist within it. Consequently, a corridor must serve not only to allow fauna movement but also as habitat in its own right. Figure 34 shows the current practice adopted for the rehabilitation of mining landscapes. Whereas Figure 35 is an example of integrated landscape design which aims to achieve the objectives for environmental planning of vegetation corridors.

In order to create corridors which are able to fulfil these expectations, the issues of vegetation species selection, location and route, length and intended purpose all need to be considered together. In the context of the study area, other considerations such as geology, soil origin and soil type in addition to regional biodiversity, should also be a component of the design of local and regional habitat corridors. Constraints to the continuity of habitat corridors include highways, main roads, railways and prime agricultural land. These discontinuities must be recognised and planned for in a regional context.

7.0 The Synoptic Plan - Integrated Landscape Principles

Although many of the mines have developed effective rehabilitation programs to date, there has been no comprehensive strategy to coordinate rehabilitation across the mines to achieve multiple regional objectives of:

- Visual amenity.
- Biodiversity.
- Sustainable after-use.

Whilst the focus is on land within mine holdings, some of the principles rely on integrating mine planning and rehabilitation with other programs outside the mine holdings. This will require future stakeholder consensus and facilitation.

The Strategy can be broadly defined into the interrelated concepts of:

- Environmental corridors.
- Creation of natural ecosystems in rehabilitated Areas.
- Sustainable interim and after mine land use.

7.1 ENVIRONMENTAL CORRIDORS

7.1.1 Regional Corridors

Land clearing in the Upper Hunter Valley has created a major discontinuity in natural vegetation along the Great Dividing Range. In a strategic sense, establishing vegetated corridors across the valley is a high priority. The corridors are conceptually illustrated on the Strategic Landscape Master Plan.

These corridors have the potential to provide multiple benefits of increased ecological sustainability, selective commercial opportunities and enhanced visual amenity. A conceptual design for these corridors was shown previously in Figure 33. The actual width for each of the strips would vary depending on a variety of factors including:

- Topography, soils and water availability.
- Mine Operations Planning.
- Intended post-mining use.

Conceptually, the central strip of the corridor would be designed to create flora and fauna habitat. A range of indigenous species would be planted along this strip with leaf litter and logs being allowed to accumulate to maximise biodiversity potential. This would be assisted by fencing the area to keep out stock. The outer strips could serve as buffers to the area of habitat and be used for commercial forestry, biomass energy fuel, and agroforestry.

7.1.2 Vegetated Corridors along Transport Routes

The main transport route in the Upper Hunter Valley is the New England Highway and The Great Northern Railway. Other transport routes include the Putty Road, Wollombi Road, Jerrys Plains Road, Charlton Road, Denman Road and roads leading southwest from Muswellbrook.

Many of the mines have already planted trees along roadside boundaries. These routes provide opportunities to create wildlife corridors and enhance visual amenity (Figures 36 to 39).

Figures 36 and 37 show possible concepts for developing corridors within contiguous mine holdings, as a means to achieving an integrated approach towards creating regional corridors. The examples shown are purely indicative but illustrate the concepts of:

- Establishing vegetation along drainage paths.
- Linking existing remnant vegetation.
- Establishing commercial forestry and using this as a buffer to environmental corridors.
- Enabling agroforestry and grazing land to be maintained in an integrated rehabilitation plan.

Figures 38 and 39 show the progression from rehabilitation by individual mine holdings, towards a concept for integrated landscape rehabilitation across the study area.

7.2 PLANTING DESIGN AND SPECIES SELECTION

From a strategic perspective, individual Mining Operations Plans should address the following principles:

- Include riparian vegetation that extends in corridors to the ridges and upper slopes.
- Plant trees to link with vegetation remnants and other areas of planting.
- Extend corridors beyond mine boundaries so that they are contiguous across mines and link with remnant vegetation on mine boundaries.

Linking vegetation in this way will enhance both biodiversity and visual amenity. Species used in rehabilitation should be representative of the local flora. Where possible, seed should be collected from native vegetation remnants in the area or from remnants, which will be cleared. A range of species should be used in rehabilitation to increase the diversity of flora and fauna that can be supported.

Where possible, screen planting should be established well in advance of mining to ensure plant growth is sufficient to provide a functional visual barrier. A variety of native canopy and understorey species will increase ecological values.

The selection and design of rehabilitation using native canopy and understorey plants should be made having regard to multiple land use objectives including:

- Habitat creation.
- Commercial forestry.
- Agroforestry.
- Biomass energy.
- Carbon sequestration.

7.3 DESIGN OF CREATED LANDFORMS

Modification of landforms is important from three main perspectives:

- Visual impact.
- Biodiversity and environmental values.
- Interim and after mining use of the land.

Elements such as drainage paths, contour drains, ridgelines, emplacements and visual bunds should be shaped in undulating informal profiles in keeping with natural landforms of the surrounding environment. A more diverse topography provides opportunities for a greater diversity of plant species. Where possible the design of created landforms should be integrated across adjoining mines.

7.4 INTERIM AND AFTER MINING USE AND TREATMENT OF FINAL VOIDS

The rehabilitation program needs to be based on clear objectives in relation to interim and after mining use. It should also address these uses in relation to use of buffer

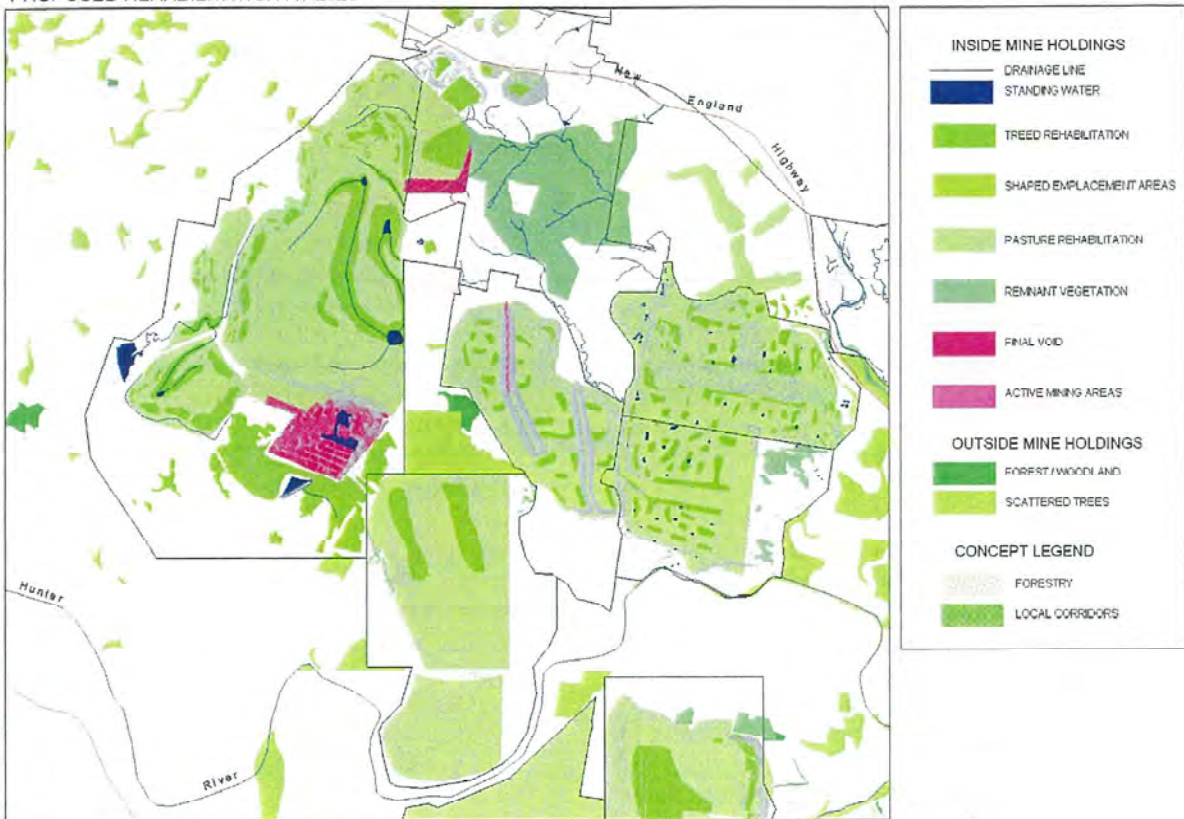
areas that will not be mined. A concerted approach is required by mine planning engineers to ensure final voids are developed as assets to the regional economy, and to achieve beneficial environmental outcomes.

The following principles should be addressed in the preparation of Mining Operations Plans well in advance of developing designs for the final void and its rehabilitation:

- Overall depth of the void and the feasibility of reducing the slope of the high wall to overcome safety considerations, reduce visual impact and increase opportunities for alternate end use.
- Whether the void will drain or create a captured drainage basin which will eventually fill with water, and the likely water quality.
- Control of spontaneous combustion.
- The potential for restoration blasting to reduce the height of the high wall to improve safety and visual amenity.
- Varying the design of the safety berm and bench on the crest of the high wall to create a more natural profile without compromising public safety.
- The after-use potential of the void including (See Table 3):
 - Industrial use.
 - Resource management such as waste product.
 - Commercial forestry.
 - Habitat creation.
 - Recreation.

FIGURE 36: EXAMPLE OF INTEGRATED LANDSCAPE REHABILITATION FOR CENTRAL AREA OF COALFIELD

PROPOSED REHABILITATION AT 2020



CONCEPT FOR INTEGRATED REHABILITATION AT 2020



FIGURE 37: EXAMPLE OF INTEGRATED LANDSCAPE REHABILITATION FOR NORTHERN AREA OF COALFIELD

PROPOSED REHABILITATION AT 2020



CONCEPT FOR INTEGRATED REHABILITATION AT 2020

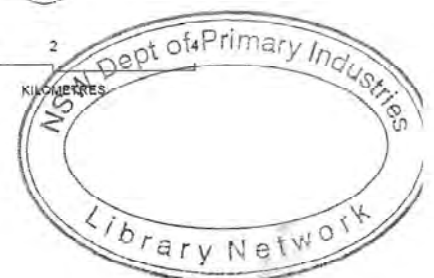
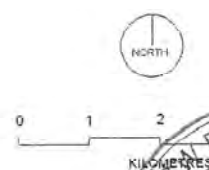


FIGURE 38: LINKING OF PROPOSED REHABILITATION AT 2020 WITH LOCAL CORRIDORS

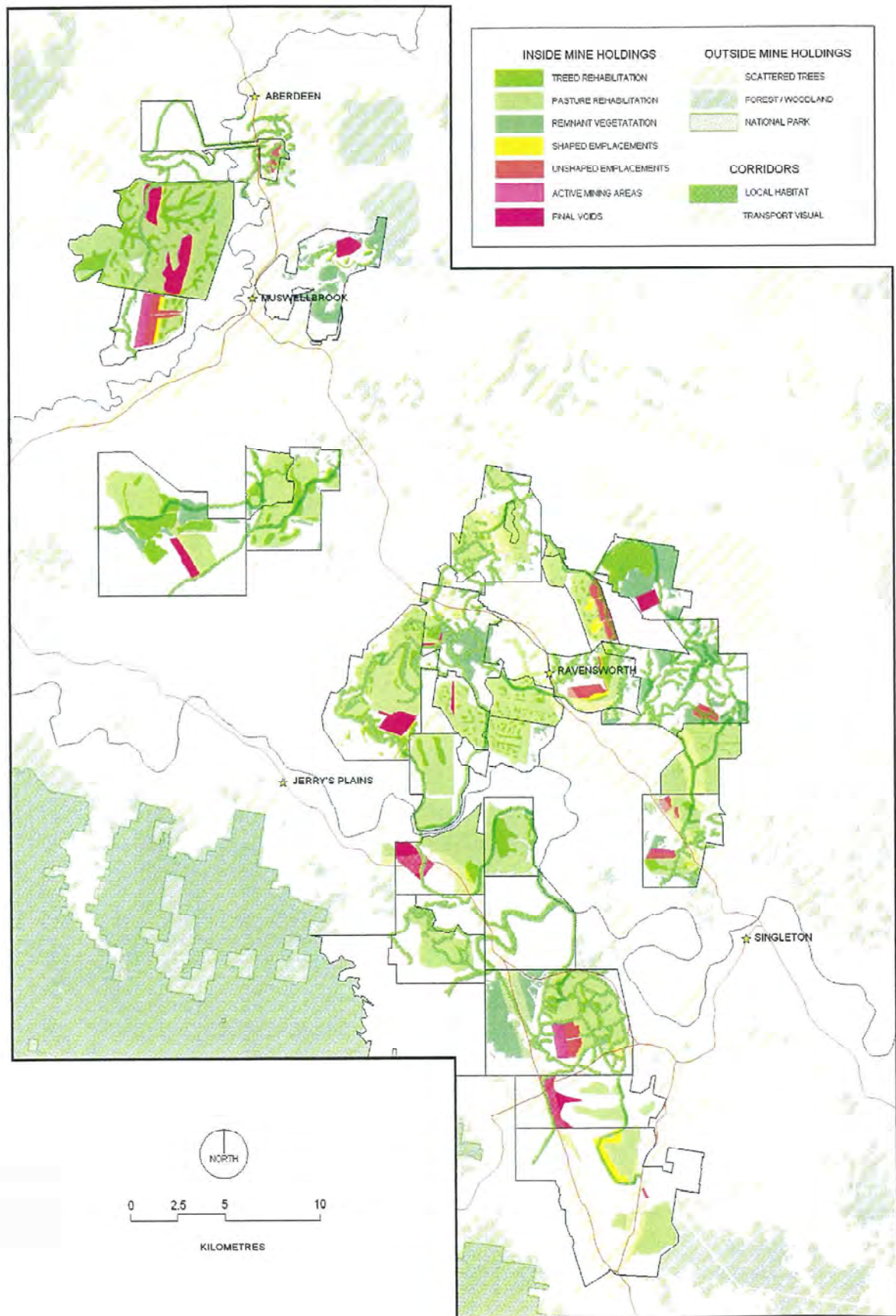


FIGURE 39: REGIONAL LANDSCAPE INTRGRATION AT 2020

