Hunter Valley Operations
River Red Gum
Rehabilitation and Restoration Strategy

March 2010
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Prepared by
Umwelt (Australia) Pty Limited
on behalf of
EMGA Mitchell McLennan

Project Director: Travis Peake
Project Manager: Liza Hill
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Executive Summary

Hunter Valley Operations (HVO) is an open cut coal mine located 20 kilometres north-west of Singleton in the Hunter Valley region of New South Wales. HVO is owned and operated by Coal & Allied Operations Pty Limited (Coal & Allied) and consists of Hunter Valley Operations South (HVO South) and Hunter Valley Operations North (HVO North).

River red gums (Eucalyptus camaldulensis) are a widespread riparian and floodplain tree that have become increasingly rare in the Hunter Valley, to the extent that the entire population of the trees occurring within the Hunter Valley is now listed as an Endangered Population under the NSW Threatened Species Conservation Act 1995 (TSC Act). Naturally-occurring river red gums are thought to be largely dependent on groundwater for the majority of their water requirements, and occur mostly in shallow alluvial groundwater systems in the Hunter Valley. The vast majority of river red gums present in the Hunter Valley have been cleared, with estimates suggesting that as little as 1 per cent of their natural habitat is now occupied by the trees.

As part of an approval to extend open-cut mining in the Carrington Pit, located in HVO North, Coal & Allied was required by the Department of Planning (DoP) to prepare a comprehensive Rehabilitation and Restoration Strategy for the nearby Carrington Billabong and its river red gum population. A draft Strategy was submitted to DoP and the then Department of Environment and Climate Change (DECC; now the Department of Environment, Climate Change and Water, DECCW) on 30 June 2007. DoP subsequently approved the Strategy on 19 May 2008, without change. A request was made by DECC for a number of minor alterations to the Strategy, which are reflected in this Strategy. The HVO South project approval requires that the Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy be reviewed and revised to include the Hunter River and Wollombi Brook stands of river red gum occurring within the HVO South project approval boundary.

Coal & Allied has commissioned extensive surveys and monitoring of river red gum stands at HVO. The surveys also incorporated the establishment of ex situ monitoring sites to gather baseline data against which to compare, in future, the progress of recovery of the river red gums in Carrington Billabong and along the Hunter River and Wollombi Brook. Coal & Allied has also assisted DECCW with studies on river red gums that it has commissioned in the Hunter Valley in recent years. The results of these studies and others have been referenced in the development of this Strategy.

During the development of the Strategy Coal & Allied has consulted widely with the relevant Community Consultative Committee, DECCW, DoP, the former Department of Water and Energy and with other relevant experts.

The Strategy set out in this document applies to the Carrington Billabong, which is situated in HVO North, as well as the Hunter River and Wollombi Brook stands of river red gum occurring within HVO South. Although not formally part of the Strategy under the conditions in the HVO North development consent and HVO South project approval, the scope of this document also includes the management of some known nearby stands at HVO North.

The results of studies at Carrington Billabong show that it has been impacted over time, most likely through a number of events including:

- alteration of the water regime through irrigation;
- alteration of the water regime after the commissioning of Glenbawn Dam in 1958 and recently modified surface runoff;
- unrestricted grazing across most of the billabong;
pest plants and animals; and
previous vegetation clearance.

These factors have contributed to the decline of the billabong as a whole, as well as the river red gums more specifically.

The key results obtained from surveys of the Carrington Billabong and other river red gums along the Hunter River and Wollombi Brook are:

- there is generally relatively low recruitment of river red gums;
- many old trees are dying or have already died;
- a high proportion of adult trees are suffering dieback;
- in most places there are few native groundcover species;
- there is an abundance of herbaceous weed species; and
- notwithstanding that shrubs are not always naturally abundant in river red gum woodland, there is nonetheless very low diversity and abundance in shrub or low tree species.

Taking into consideration the key results, as well as information gained from consultation with other experts and from an assessment of relevant literature, the key causal factors that are likely to be contributing to the decline of river red gums at Carrington Billabong and HVO South are:

- relatively unrestricted access to remnants, particularly by stock;
- historical vegetation clearance throughout the catchment;
- periodic drought conditions, most recently pre June 2007;
- at Carrington Billabong local mining activities may have interfered with the water usage regime of the river red gums; and
- the surface water catchment around Carrington Billabong has been temporarily modified due to local mining activities such that surface water runoff to the billabong is currently reduced.

Importantly no sites within HVO South will be impacted by mining; however these factors are most likely to have significantly contributed to the decline of the remnant populations at Carrington Billabong and HVO South. Symptoms of the remnants’ ecological decline are exhibited as poor health, poor recruitment, tree death, high weed incidence and low diversity.

Of the above causal factors, the latter four are considered the most important and are similarly the most difficult to address. The first three causal factors are processes that occur across the catchment, including at Carrington Billabong and HVO South.

This strategy proposes to dedicate resources for restoration and management of river red gum remnants to target sites through a three tier management approach based on the level of impact and probability of success. The three tiered management approach involves the management of land under the categories of high, intermediate or low level management. As a guide, stands of river red gums have been classified according to the following:
• **High level intervention.** The Carrington Billabong has been identified as a high level site and management of this site is treated in detail in the Strategy.

• **Intermediate level intervention.** These comprise 11 other remnants where vegetation is in relatively better condition, such as those with more native recruitment, connectivity and floristic and structural diversity. Moderate level management of these sites is proposed.

• **Low level intervention.** These comprise the remaining river red gum remnants at HVO South, where vegetation is in relatively poorer condition and restoration would require significant application of time and resources.

Importantly, no intermediate and low level sites will be impacted by mining activities associated with HVO South. Carrington Billabong will be marginally impacted by mining activities. The lack of impacts on priority sites and low priority sites is a key factor in determining the level of management intervention and in the development of completion and performance criteria for intermediate and low level sites.

The Strategy documents goals and objectives for the restoration and rehabilitation of Carrington Billabong, priority sites and low priority sites, together with preliminary completion criteria and performance measures for Carrington Billabong. A series of performance criteria and performance measures are documented for the priority sites. Management commitments are established for the low priority sites to ensure that these sites are adequately captured by Coal & Allied’s comprehensive land management and maintenance activities. A comprehensive implementation plan is established to guide the means through which restoration and rehabilitation is to be achieved, such as through fencing, access control, weed management, planting and natural regeneration.

Overall, all sites require some or all of the following:

• fencing and stock access control;

• weed management: particularly targeted control of serious weeds;

• support of naturally recruited natives, through weed control around the seedlings until they have become established;

• supplementary planting of natives to boost natural regeneration; and

• erosion control/bank stabilisation on streambanks.

Carrington Billabong will require a more substantial resource commitment, although reasonable intervention will be required at priority sites as well.

The Strategy provides nominal timing for its implementation. It includes a monitoring program to assess the changes in environmental conditions over time with a feedback loop to be used between monitoring outcomes and the tailoring of management actions. Baseline and follow-up monitoring has already been undertaken at Carrington Billabong and a number of priority sites.

This Strategy will be managed and reviewed in accordance with the document management requirements. Future revisions will be provided to relevant government agencies if any comprehensive changes are required. A review of the effectiveness of the Strategy, together with monitoring outcomes, will be reported annually in the AEMR.
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2  Hunter Valley Operations South River Red Gum Rehabilitation and Restoration Implementation Plan

3  Preliminary Completion Criteria and Performance Measures for Carrington Billabong and HVO South Priority Sites
1.0 Introduction

Hunter Valley Operations (HVO) is an open cut coal mine located 20 kilometres north-west of Singleton in the Hunter Valley region of New South Wales (Figure 1.1). HVO is owned and operated by Coal & Allied Operations Pty Limited (Coal & Allied) and consists of Hunter Valley Operations South (HVO South) and Hunter Valley Operations North (HVO North).

As part of an approval to extend open-cut mining in the Carrington Pit, located in HVO North, Coal & Allied was required by the Department of Planning (DoP) to prepare a comprehensive Rehabilitation and Restoration Strategy for the nearby Carrington Billabong and its river red gum population. In March 2007 Umwelt (Australia) Pty Limited (Umwelt) was engaged to prepare the Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy so that Coal & Allied, the operators of HVO, could undertake appropriate actions to ensure the long-term viability of the stand of river red gums and the Carrington Billabong.

A draft Strategy was submitted to DoP and the then Department of Environment and Climate Change (DECC; now the Department of Environment, Climate Change and Water, DECCW) on 30 June 2007. DoP subsequently approved the Strategy on 19 May 2008, without change. DECC, however, requested a number of minor alterations to the Strategy.

Since this time DoP has approved a further application for Project Approval from Coal & Allied for the HVO South Coal Project. The HVO South project approval (PA06_0261), requires that the Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy be reviewed and revised to include the Hunter River and Wollombi Brook stands of river red gum occurring within the HVO South project approval boundary (refer to Figure 1.2) and to satisfy the requirements of condition 30 of the development consent that requires:

1. conservation and restoration objectives;
2. short, medium and long term measures to be implemented; and
3. completion criteria.

River red gums (*Eucalyptus camaldulensis*) have become increasingly rare in the Hunter Valley, and the entire population occurring within the Hunter Valley is now listed as an Endangered Population under the NSW Threatened Species Conservation Act 1995 (TSC Act). Naturally-occurring river red gums are thought to be largely dependent on groundwater for the majority of their water requirements, occurring mostly in shallow alluvial groundwater systems in the Hunter Valley. Their habitats are therefore considered to be groundwater-dependent ecosystems (GDEs) which are subject to provisions of the Water Management Act 2000 (WM Act) (DLWC 2002).

A report on the results of river red gum surveys and investigations at HVO has been recently prepared (Draft Survey of River Red Gums at Hunter Valley Operations and Mount Thorley – Warkworth, Hunter Valley – Umwelt 2008a). This study also incorporated the establishment of *ex situ* monitoring sites to gather baseline data against which to compare, in future, the progress of recovery of the river red gums in Carrington Billabong and along the Hunter River and Wollombi Brook (Umwelt 2008a). The results of these studies have been referenced in the development of this Strategy.
FIGURE 1.1
Location of Carrington Billabong and HVO South and North Project Areas

Legend
- HVO North Development Consent Boundary
- HVO South Development Consent Boundary
- HVO Owned Lands
- Carrington Billabong

1.1 Purpose

This document sets out a strategy to restore and rehabilitate the Carrington Billabong in accordance with the HVO North development consent, and to manage stands of river red gums (Eucalyptus camaldulensis) occurring along the Hunter River and Wollombi Brook at HVO South in accordance with the HVO South project approval (refer to Figure 1.2). The approval conditions relating to this Strategy and the sections of this document in which they are addressed are outlined in Table 1.1 below.

### Table 1.1 – Project Approval Conditions

<table>
<thead>
<tr>
<th>Condition</th>
<th>Section</th>
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<tr>
<td>30. Within 12 months of the date of this approval, or otherwise agreed by the Director-General, the Proponent shall review, revise and provide a timetable for the implementation the HVO River Red Gum Strategy for the Hunter River and Wollombi Brook river red gum populations (as shown in Appendix 8), in consultation with DWE and DECC, and to the satisfaction of the Director-General. This strategy must be prepared by suitably qualified expert/s, and must include:</td>
<td>Entire document, specifically Section 5.3</td>
</tr>
<tr>
<td>(a) the conservation and restoration objectives for the river red gum populations;</td>
<td>Section 6.1</td>
</tr>
<tr>
<td>(b) a description of the short, medium and long term measures that would be implemented to conserve and restore the river red gum populations (including measures to address matters which affect the long term health and sustainability of the river red gums such as surface and ground water supply, and controlling weeds, livestock and feral animals); and</td>
<td>Section 5.0 and Appendix 2</td>
</tr>
<tr>
<td>(c) detailed assessment and completion criteria for the conservation and restoration of the river red gum populations.</td>
<td>Sections 6.2, 6.3 and Appendix 3</td>
</tr>
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</table>

1.2 Scope

This Strategy applies to the Carrington Billabong, which is situated in HVO North, as well as the Hunter River and Wollombi Brook stands of river red gum occurring within HVO South. Although not formally part of the strategy, the scope of this document also includes the management of stands at HVO located outside of the HVO South consent boundary (refer to Figure 1.2).

1.3 Document Structure

The structure of the HVO River Red Gum Rehabilitation and Restoration Strategy document comprises of the sections as outlined below.

- **Section 1** describes the purpose and scope of the document, regulatory framework as well as responsibilities for implementation of the strategy.
- **Section 2** describes the environmental context of the region including information from baseline surveys undertaken on river red gum stands within the area.
- **Section 3** provides an assessment of the baseline ecological condition for each of the river red gum stands and the key causal factors implicated in their decline.
• **Section 4** describes the iterative process undertaken with key stakeholders in the development of the strategy.

• **Section 5** provides an overview of the rehabilitation and restoration strategy, including the tiered management approach, key target management actions and the timing for implementation.

• **Section 6** describes the preliminary objectives and criteria, including the process for refining criteria based on monitoring results and feedback from consultation with key stakeholders.

• **Section 7** outlines the proposed monitoring program for each of the river red gum stands.

• **Section 8** outlines the additional opportunities that have been identified.

• **Section 9** details the requirements for reporting, review and continuous improvement.

• **Section 10** provides a list of the literature referred to in this report.

To ensure that the strategy document is concise and relatively static, detailed information or components to the strategy that are dynamic have been incorporated as appendices. Specifically, the following appendices have been developed as part of the strategy:

• **Appendix 1** – Ecological Condition Assessment for Specific Hunter River and Wollombi Brook Stands;

• **Appendix 2** – HVO River Red Gum Rehabilitation and Restoration Implementation Plan; and

• **Appendix 3** – Preliminary Completion Criteria and Performance Measures for Carrington Billabong and HVO South Priority Sites.

It is anticipated that where potential modifications are identified as a result of the outcomes of monitoring or ongoing review of the strategy, the relevant appendices may be updated independently of the main strategy document.

### 1.4 Regulatory Framework

#### 1.4.1 Threatened Species Conservation Act 1995

River red gum (*Eucalyptus camaldulensis*) was listed as an Endangered Population in the Hunter Catchment under Part 2 of Schedule 1 of the TSC Act in April 2005. The population was listed as endangered due to a lack of natural regeneration and the occurrence of significant dieback of the tree throughout its range in the Hunter. Additionally, the river red gum population in the Hunter Valley is at the eastern limit of its range in NSW and is disjunct from other occurrences of the tree in NSW. These factors combine to make the Hunter catchment population of high conservation value (NSW Scientific Committee 2005).

The NSW Scientific Committee made a preliminary determination to list Hunter Floodplain Red Gum Woodland as an endangered ecological community (EEC) under the TSC Act in July 2008. The preliminary listing for this community was made after the lodgement of the HVO South Environmental Assessment in February 2008. As yet a final determination has not been made in relation to this community by the NSW Scientific Committee. As required by the approvals at HVO, this Strategy has been prepared for river red gum populations at...
HVO. As a consequence of the management proposed in this strategy, the preliminary listed EEC will also benefit.

1.4.2 Water Management Act 2000

The WM Act provides for the protection, conservation and ecologically sustainable development of the water resources in NSW. The WM Act also provides for the requirement of rules to be set for the identification, establishment and maintenance of environmental water for all groundwater dependent ecosystems (GDEs) in NSW, through the development of management plans.

1.4.3 Development Approvals

Mining in the Carrington Pit was initially approved in 2000 by the then Department of Infrastructure, Planning and Natural Resources in accordance with the Environmental Planning and Assessment Act 1979 (EP&A Act) (DA 106-6-99).


In 2006 an application to extend the Carrington Pit was approved under DA 450-10-2003 (M1). The application was for mining in the Carrington Pit to extend further south and to the east of previously approved limit of mining. This would result in mining operations occurring close to the Carrington Billabong.

As part of this modification Coal & Allied was required to develop and implement a Rehabilitation and Restoration Strategy for Carrington Billabong. The preparation of this Strategy specifically related to Consent Condition 31, which stated:

By 30 June 2007, the Applicant shall prepare and implement a comprehensive Rehabilitation and Restoration Strategy for the Carrington billabong and river red gum population, in consultation with [the Department of Natural Resources], and to the satisfaction of the Director-General. This Strategy must be prepared by suitably qualified expert/s, and must include:

(a) the rehabilitation and restoration objectives for the billabong and associated river red gum population;

(b) a description of the short, medium and long term measures that would be implemented to rehabilitate and restore the billabong and associated river red gum population (including measures to address matters which affect the long term health and sustainability of the billabong and river red gums such as surface and ground water supply, and controlling weeds, livestock and feral animals); and

(c) detailed assessment and completion criteria for the rehabilitation and restoration of the billabong and associated river red gum population.

The Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy was prepared to fulfil the requirements of the Consent Condition 31 stated above. The strategy was submitted to DoP and the DECCW for review, and comments were received from DECCW; however the strategy was never finalised and instead it is to be replaced by the strategy contained herein.

The HVO South Coal Project was approved in March 2009 by DoP in accordance with the EP&A Act (PA 06_0261). As part of this project approval, Coal & Allied was required to develop a River Red Gum Restoration Strategy that additionally covered the Hunter River
and Wollombi Brook river red gum stands within the HVO south area. Condition 30 of Schedule 3 of this approval is included as Table 1.1.

1.5 Responsibilities for Implementation of Strategy

Responsibilities for review and approval of various aspects of the HVO River Red Gum Rehabilitation and Restoration Strategy are provided in Table 1.2.

Table 1.2 – Responsibilities for Implementation of Strategy

<table>
<thead>
<tr>
<th>Position</th>
<th>Responsibility</th>
</tr>
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<tbody>
<tr>
<td>HVO General Manager</td>
<td>• Provide that adequate resources are available for the implementation of the strategy.</td>
</tr>
<tr>
<td>Manager Environmental Services</td>
<td>• Coordinate the implementation of the strategy.</td>
</tr>
<tr>
<td></td>
<td>• Periodically review progress with meeting objectives and completion criteria, including rehabilitation monitoring.</td>
</tr>
<tr>
<td></td>
<td>• Periodic review of the Strategy.</td>
</tr>
<tr>
<td></td>
<td>• Provide adequate resources are allocated in the Coal &amp; Allied budget planning cycle for the implementation of this strategy.</td>
</tr>
</tbody>
</table>
2.0 Environmental Context of Region

2.1 Location and Land Use

Hunter Valley Operations is located approximately 20 kilometres west-north-west of Singleton, NSW (refer to Figure 1.1). HVO is surrounded mostly by mining and agricultural cropping and grazing land uses.

The activities at HVO comprise coal mining areas, coal preparation plants, rail loading facilities, administration areas and workshops. HVO activities are bisected by the Hunter River, which divides the mine into HVO North and HVO South. HVO North comprises West Pit, North Pit, Alluvial Lands and the Carrington Pit. HVO South comprises Cheshunt, Riverview and South Lemington Pits. The first mining operations in HVO commenced near West Pit in 1952 and mining of the Carrington Pit commenced in 2001.

The Hunter River forms a broad arc around HVO South, running at first northwards, then eastwards and finally southwards, where it is joined by Wollombi Brook, which enters from the south-west. Stands of river red gums occur along both the Hunter River and Wollombi Brook, and have been mapped by Umwelt (2008a).

Carrington Billabong is located within HVO North adjacent to the Hunter River (refer to Figure 1.1), west of North Pit and immediately south of Carrington Pit. It is situated on a former river channel about 200 metres to the north-east of the present day channel of the Hunter River. It is loosely connected to the Hunter River by one main and several lesser flood runners. There are no obvious impediments to surface water flow between the Hunter River and Carrington Billabong. The Carrington Billabong is fenced (completed mid 2008) to prevent cattle for grazing and camping.

2.2 Biophysical Setting

2.2.1 Geology

Carrington Billabong and the stands of river red gums along the Hunter River and Wollombi Brook are located on Quaternary alluviums (Kovac and Lawrie 1991; Beckett 1993), which are less than 1.8 million years old. Quaternary sediments are located along the channels and immediate surrounds of the major rivers and creeks of the central Hunter Valley (Peake 2006). Carrington Billabong is located above an ancient river bed (palaeochannel) of the Hunter River which now forms the floodplain of the river (Mackie Environmental Research 2005).

2.2.2 Soil

The soil landscape of this area is the Hunter alluvial soils, which occur on the level plains and river terraces of the Hunter River and Wollombi Brook with elevations of 20-60 metres above sea level (Kovac and Lawrie 1991). The soil fertility (chemical) is generally moderate to high, soil salinity is low to moderate and the water-holding capacity is generally moderate to high (Kovac and Lawrie 1991). Hunter alluvial soils are subject to minor bank erosion on watercourses and minor sheet and gully erosion on adjacent terraces (Kovac and Lawrie 1991).
2.2.3 River Geomorphology

Cook and Schneider (2006) recently applied the River Styles® framework to rivers, streams and creeks in the Hunter Catchment. The River Styles framework, developed by Brierley and Fryirs (2005), is a simple and effective internationally recognised method that provides consistent and comparable assessment of the biophysical health of watercourses.

Carrington Billabong and the Hunter River

This study identified the River Styles® category which each watercourse corresponds to, based on the identification of key geomorphic units and riparian vegetation function. The section of the Hunter River adjacent to Carrington Billabong and flowing through the entirety of HVO South was identified as ‘Partly Confined Valley Setting – Planform Controlled, Low Sinuosity, Gravel’. Watercourses within this category generally comprise a single, continuous, symmetric channel with gravel as the dominant substrate on the streambed. The channel sinuosity is low (i.e. the channel is close to straight with low levels of bending or curving) due to valley confinement and irregular bedrock steps which assist in controlling slope and sinuosity. The main controls within watercourses of this category are bedrock steps and infrastructure such as causeways and culverts. Large woody debris also assists in channel stability and hydraulic/geomorphic diversity. The condition of this section of the Hunter River was rated as ‘poor’ (i.e. degraded) with a ‘moderate recovery potential’.

The condition of a watercourse relates to linkages or connections with the floodplain and up and downstream reaches, and also assesses the effects of human disturbance on its current evolutionary stage.

Wollombi Brook

The geomorphic category of the Wollombi Brook section of HVO South was defined as a ‘Planform Controlled, Low Sinuosity Sand in Moderate Condition’. Watercourses within this category generally comprise a single, continuous, typically symmetric channel with a sand dominated substrate. Channel sinuosity is largely variable yet is generally low due to valley confinement and irregular bedrock steps that assist in controlling slope and sinuosity. The condition of this section of Wollombi Brook was rated as ‘moderate’ with a ‘high recovery potential’.

2.2.4 Freshwater Wetland Formation – Carrington Billabong

Carrington Billabong is an ephemeral freshwater wetland within the low-lying floodplains along the Hunter River. In general, wetlands play an important role in buffering against floods and contribute to natural hydrological cycles.

Ecological functions of wetlands include habitat, refuge, and food and water for native flora and fauna. Wetlands are highly sensitive to changes in the environment, and usually respond rapidly to changes in water supply or water quality. For this reason they are often used as indicators of ecological health.

2.2.5 Hydrology

The former Department of Water and Energy (now part of DECCW) has been undertaking monitoring of regional groundwater trends over a number of years, to contribute to the Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources. Its analysis suggests a high level of connectivity between surface and groundwaters (A. Raine pers. comm.). For the alluvial groundwaters in the Hunter, DECCW has not detected any long-term trends given the rapid response of the aquifers to stream flow. The aquifers tend to draw down during dry
periods as water is lost to stream base flow and evapotranspiration. They rapidly recharge following wet weather and increased stream flow.

**Carrington Billabong**

Carrington Billabong is subject to periodic flooding which occurs during periods of high flow in the Hunter River. With the drought conditions experienced until June 2007 in the Hunter Valley, and the installation of Glenbawn Dam as a flood mitigation measure (1958), it is thought that Carrington Billabong and the stands of rivers red gums along the Hunter River and Wollombi Brook have been experiencing much lower frequencies of flooding than in the past. The level of surface water runoff that would normally flow into the Hunter River via Carrington Billabong is also thought to be likely to decrease during the life of the Carrington Pit as a result of the Carrington Pit extension (Mackie Environmental Research 2005). An annual assessment of the groundwater impacts at Carrington Billabong is undertaken and the results are presented in the Annual Environmental Management Report (AEMR).

The groundwater of the Carrington Billabong area had not been recharged by rainfall (Mackie Environmental Research 2005), however since the June 2007 and the resumption of wetter weather patterns flood event groundwater levels have recovered, largely due to increased aquifer recharge upslope (Coal & Allied 2008). Recent mining activities in the Carrington Pit had also lowered the water table by 2-3 metres (ERM 2005). Due to the predicted impacts associated with de-watering of the alluvial aquifers, a groundwater barrier is being constructed between Carrington Pit and the Carrington Billabong with expected completion in the first half of 2010. The barrier will mitigate groundwater leakage, and will also inhibit long-term leakage of leachate from spoils emplaced within the mine void (Mackie Environmental Research 2005).

The specific inundation history of Carrington Billabong due to rainfall runoff from the immediate watershed is not known, although in the last nine years it is thought to have flooded on at least four or five occasions. It is known to have been inundated in April 2000, December 2001, May 2002 and possibly late July 2002 (J. Pola pers. comm.). It is not thought to have been extensively flooded in the five years between July 2002 and May 2007, although photographs taken by ERM show very minor inundation in October 2004. In June 2007 the Hunter Valley was subject to a significant storm event that resulted in flooding throughout much of the mid and lower Hunter. During this event Carrington Billabong was inundated from the Hunter River for a period of about six weeks (J. Wearne pers comm. 2010). A small area of ponded water was retained in the southern section of Carrington Billabong for several months after June 2007. The pond created is the lowest part of the billabong and in the past has also retained water after flooding for the longest period. All seedlings of river red gums that have been recently naturally recruited in Carrington Billabong are found on the margins of this pond. The study area has not been inundated by flood since 2007.

Mackie Environmental Research (2005) reports that: the alluvium around the Hunter River at Carrington Billabong attains a thickness of 15-20 metres and supports gravels that were contiguously deposited with silts and clays; the alluvium has a saturated thickness of up to seven metres, and supports brackish to saline water with an electrical conductivity range of typically 7,000 to 11,000 µS/cm (4200 to 6600 mg/L) and it is likely that the poor quality has resulted from sustained upwards leakage of coal measures groundwater into the basal sections of the alluvium, although it is likely that mining has depressurised the system and reduced the rate of upwards leakage. River red gums are known to be able to tolerate salinity levels of up to about 10,000 µS/cm (Primary Industries and Resources SA 2000).
Hunter River and Wollombi Brook

The banks of both the Hunter River and Wollombi Brook are Quaternary to recent alluvial deposits, consisting of silts, clays, sands and gravels found in river sediments and floodplains (ERM 2008). The depth of alluvium along the Hunter River and Wollombi Brook are estimated to vary between two and 20 metres, and form shallow aquifers but only to a limited extent; these aquifers are potentially in connection with surface water bodies (ERM 2008).

ERM also monitored water flow at gauging stations along both the Hunter River and Wollombi Brook. The average flow at the gauging station on Wollombi Brook in Warkworth was 468 ML/day, with a maximum flow of 322, 576 ML/day recorded on 26 February 1955. The average flow recorded at a gauging station located 10 kilometres upstream from HVO on the Hunter River was 100ML/day, with a maximum flow of 208, 070 ML/day recorded on 5 March 1977. The average flow recorded at a gauging station located six kilometres downstream of the junction between the Hunter River and Wollombi Brook was 1121 ML/day, with a maximum flow of 115, 815 recorded on 10 August 1998.

ERM (2008) suggested that a conservative estimate for the 100 year ARI flood event was 59.1 metres AHD for both the Hunter River and Wollombi Brook. Two major flood events have been recorded in Wollombi Brook, the larger of the two was in June 1949 and the smaller in February 1955; the largest flood event recorded in the Hunter River was in February 1955 (with flood waters reaching 42.2 metres AHD in Singleton) (ERM 2008). The 100 year ARI flood level at the Hunter River is estimated to vary between 59.1 metres AHD at its junction with Wollombi Brook, and 73.2 metres AHD adjacent to Dam 4S at HVO South (ERM 2008).

Results from monitoring that took place at seven locations along the Hunter River (ERM 2008), indicated that water quality was significantly influenced by weather and flow conditions; with high levels of TSS and low levels of pH and electrical conductivity associated with high flow levels.

From monitoring that took place at three locations along Wollombi Brook (ERM 2008) electrical conductivity levels ranged between 480 µS/cm and 3390 µS/cm, with the brook historically recorded as being saline as well as areas of the brook being frequently dry. The pH ranges of Wollombi Brook were neutral to alkaline, ranging between 7.4 and 9.2.

2.2.6 Vegetation

Carrington Billabong

Carrington Billabong supports open woodland covering an area of 5.7 hectares. The vegetation of Carrington Billabong was mapped by Peake (2006) (see Section 2.3.2) as the Hunter Floodplain Red Gum Woodland Complex (Map Unit 13), which is equivalent to the preliminarily listed EEC, river red gum woodland.

Peake indicated that this community often comprises river red gum as the sole canopy species, however forest red gum (E. tereticornis), yellow box (E. melliodora) and rough-barked apple (Angophora floribunda) can also co-dominate in places, or they may also be exclusively dominant. River oak (Casuarina cunninghamiana subsp. cunninghamiana) also commonly occurs within this community, particularly along unstable river banks. Shrubs are generally absent and the groundcover is strongly influenced by the degree of, and time since, disturbance (Peake 2006). Section 2.3.2 provides more detail on the outcomes of the Hunter Remnant Vegetation Project, which mapped the vegetation of the central Hunter Valley, and the ecological context of Carrington Billabong and HVO South.
In Carrington Billabong, the red gum woodland is highly modified, reduced to an aged stand of river red gums (*E. camaldulensis*) over a disturbed understorey that comprises almost exclusively of weeds. Yellow box (*E. melliodora*) has also been recorded in the billabong. The location was managed in the past for cattle grazing and cattle used the red gum remnant heavily for shade and shelter.

**Hunter River and Wollombi Brook**

Vegetation along the Hunter River and Wollombi Brook in the study area forms a typically broken, narrow stand of one to two trees wide growing on the riverbank. Remnants also occur on the adjacent floodplain in positions similar to Carrington Billabong. Some locations support a larger, more extensive community. Many of the locations classed as priority sites in Section 5.1.2 include these larger remnants.

Species composition in remnants on the Hunter and Wollombi Brook stream bank and floodplain is very similar to Carrington Billabong. Common and dominant trees along the riverbanks include river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*), rough-barked apple (*Angophora floribunda*) and river red gum (*E. camaldulensis*). River red gum (*E. camaldulensis*) and yellow box (*E. melliodora*) also occur on the floodplain. In most remnants, the understorey is modified and has a dominance of weed species, particularly the floodplain sites.

### 2.3 Baseline Surveys

#### 2.3.1 HVO Environmental Assessment Reports

**HVO North**

The environmental assessment reports prepared for the Carrington Pit include:

- Carrington Pit EIS (ERM 1999);
- West Pit Extension and Minor Modifications EIS (ERM 2003); and
- Carrington Pit Extension SEE (ERM 2005).

The ecological surveys for the two EIS reports did not extend down to the Hunter River and therefore the Carrington Billabong and associated river red gums were not assessed.

The SEE prepared for the extension to Carrington Pit (ERM 2005) included an ecological assessment of the billabong and river red gums. The SEE was completed after the listing of the river red gum population under the TSC Act and consequently the potential impacts of the Carrington Pit extension were assessed under Section 5A of the EP&A Act. This assessment concluded that the extension to Carrington Pit was unlikely to have a significant impact on the river red gum population.

The SEE did, however, discuss a number of potential indirect impacts on the river red gum population that could result from the Carrington Pit extension. Mitigation measures to reduce the potential impacts were recommended and have been implemented.

**HVO South**

The 2008 Environmental Assessment was prepared for the recovery of an additional 84 million tonnes of coal from the HVO South area (ERM 2008). This report identified the
need for the protection of river red gums as well as for their associated groundwater. As river red gums are groundwater-dependent, the permitted water withdrawal from Wollombi Brook and the Hunter River associated with these mining operations may affect the populations of river red gum in this area. This report recommended the continuation of a 150 metre buffer zone to the Hunter River and Wollombi Brook to mitigate against potential impacts, although it was considered unlikely that the current flood regimes would be significantly impacted by the development. This report also indicates the necessity for Coal & Allied to implement a River Red Gum Rehabilitation and Restoration Strategy, which is the purpose of this document.

The Hunter Valley Operations South Coal Project Environmental Assessment Report (ERM 2008) was prepared to assess the potential impacts from the project.

For the purposes of this EA, ERM undertook field surveys in 2006 as well as a desktop review of the area. These investigations identified a total of 48 hectares of remnant vegetation, some of which consisted of the TSC Act listed endangered population *Eucalyptus camaldulensis* (river red gum) in the Hunter Catchment; including several stands along the Hunter River and Wollombi Brook. These populations were generally assessed to be in poor condition and highly impacted by cattle grazing as well as erosion.

Potential direct impacts to this population were expected to include increases to dust levels as well as microclimatic changes. Although these potential changes were not predicted to have a significant impact, Umwelt was engaged to prepare the *Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy* to ensure the long term viability of the population in the Hunter, and to improve the conditions of its habitat.

This environmental assessment found that the extension would have no significant impacts on this population, conversely indicating that the project would promote the retention and enhancement of areas of remnant vegetation.

### 2.3.2 Vegetation of the Central Hunter Valley (Peake 2006)

The study by Peake (2006) was conducted on behalf of the Hunter – Central Rivers Catchment Management Authority (HCRCMA) and is referred to as the Hunter Remnant Vegetation Project. That study area covered 315,000 hectares stretching from Scone in the north to Denman in the south-west and Branxton in the south-east. This work included the botanical survey of 327 sites and mapping of approximately 60,000 hectares of forest or woodland remnants between 1996 and 2006. Peake (2006) found that the native forests and woodlands of the central Hunter Valley have probably been reduced by approximately 76 per cent (238,000 hectares) since Europeans arrived in Australia.

Peake (2006) recorded 1127 plant species, of which 25 were significant. Peake (2006) also recorded twelve plant populations that were considered to be regionally endangered, of which three were listed under the TSC Act 1995.

Twenty-two of the 35 natural vegetation communities identified met the criteria for listing under state or Commonwealth legislation, however only five were listed at that time. One of the significant communities, which was not listed under the legislation and which was considered by Peake (2006) to be under extreme threat, is the Hunter Floodplain Red Gum Woodland Complex (MU 13). This community is dominated by river red gum which is often present as the sole dominant canopy species. Forest red gum, rough-barked apple and yellow box also commonly occur within this community.

The NSW Scientific Committee made a preliminary determination to list Hunter Floodplain Red Gum Woodland as an EEC in July 2008. It covers the entire Carrington Billabong stand, as well as all other stands of river red gums along the Hunter River and Wollombi Brook in
the HVO South project area. As required by the approvals at HVO, this Strategy has been prepared for river red gum populations at HVO.

Shrubs are generally absent from the Hunter Floodplain Red Gum Woodland Complex and the groundcover has been significantly altered, but is thought to have been dominated by a range of native grasses, forbs, sedges and rushes. The composition of the groundcover is strongly influenced by the surrounding vegetation and the degree of disturbance. The community is threatened by invasion of groundcover weed species, which are generally associated with agricultural practices.

The community is strongly associated with floodplains of major watercourses and consequently occurs on alluvial soils. It is thought probable by Peake (2006) that river red gums occur in areas that receive reasonably regular flooding and where standing water is usually present for several days or weeks after flooding.

The condition of the community was assessed to be poor to very poor, resulting from widespread clearing, intensive use for agriculture and weed invasion. The remaining remnants of the Hunter Floodplain Red Gum Woodland Complex are small to very small in size with over 90 per cent of remnants covering less than 10 hectares in area (Peake 2006). Recruitment of river red gums is low, with most sites containing old or senescent trees, a high proportion of which are affected by dieback. Peake (2006) suggests that sites in a relatively good condition may recover if appropriate management practices are employed.

The Hunter Floodplain Red Gum Woodland Complex, comprising stands of river red gums, is thought to have had at least 90 per cent of its pre-European distribution cleared (Peake 2006). It is likely that, prior to European settlement, the community comprised an open woodland of large trees, with relatively few shrubs but a dense, luxurious groundcover that included tall grasses and a diverse range of herb species.

2.3.3 Assessment of Current Status and Recommendations for Management and Recovery Actions for Endangered Population of River Red Gum in the Hunter Valley (Umwelt 2007)

A survey of river red gums in the Hunter Valley was undertaken during 2006 to assess the contemporary status of the population. The endangered population was surveyed over five days, during which 25 out of 39 known sites were visited. A number of further potential and possible river red gum locations were identified through satellite imagery.

The study identified 28 known populations in the Hunter Valley, covering a total area of only 83 hectares and constituting about 1840 trees, and occurring over a range of at least 2000 km². It was estimated that prior to European arrival river red gum-dominated woodlands are likely to have covered 10,000-20,000 hectares. No stands were known to occur within conservation reserves.

A health assessment of river red gums found that 28 per cent of trees assessed were considered healthy with no obvious dieback occurring in the canopy. Approximately 53 per cent of trees were considered to be stressed and 10 per cent slightly stressed. Two per cent were recorded as near-dead and 7 per cent were recorded as dead. The survey also found recruitment of river red gums was generally low at the majority of sites.

The main threats to the river red gum population were identified as floodplain alienation, grazing, weed invasion and establishment, poor recruitment, dieback and fire. Genetic pollution through the use of fertile hybrids in revegetation programs was also considered to pose a potential serious threat to the endangered population.
Recommendations were made on recovery planning and implementation, including the development of management strategies at specific sites and preparation of a formal recovery plan. Recommendations were also made on the consideration of river red gum-dominated woodlands for listing as critically endangered under NSW and Commonwealth legislation and areas to be targeted for further surveys.

Umwelt more recently completed a follow-up study to this in which most sites surveyed in 2006 were re-visited and monitored during April-June 2008. The results of this report (Umwelt 2009a) are provided below in Section 2.3.4. Carrington Billabong was not specifically re-visited for the study due to the regular monitoring that had been undertaken on behalf of Coal & Allied.

### 2.3.4 Hunter River Red Gum – Post-flood Assessment and Description of Ecological Character (Umwelt 2009a)

The lack of flood events due to floodplain alienation and river regulation is recognised as a significant risk to the endangered population of river red gum in the Hunter Catchment. There was a major flood event in June 2007, which provided the opportunity to reassess sites studied during the pre-flood survey undertaken by Umwelt in 2006 (as described in Section 2.3.3). This report also presented plot-based floristic data aimed at assisting with the classification of the vegetation community in which river red gum occurs in the Hunter.

The post-flood survey was undertaken in May and June of 2008, and involved the assessment of 32 remnant river red gum sites. Each site had an individual tree health assessment undertaken as well as a rapid remnant health assessment. Plot-based floristic surveys were also undertaken at 24 of these sites, with an additional four plot-based surveys undertaken at non-river red gum sites to assist with community classification.

The results indicated that the river red gums appeared to show no net benefit or detriment as a consequence of the June 2007 flooding event. A small number of individuals did exhibit some small changes to certain health attributes, however, these changes ranged between both positive and negative.

The major findings of this report in terms of changes post-flooding were the increase in introduced flora species present, and a small amount of natural seedling recruitment in areas which had been subjected to prolonged inundation.

Floristic compositions of the sites were analysed by means of agglomerative cluster analysis. The results of the analysis were inconclusive, i.e. there was not enough data to support the possibility that there is a river red gum community that is distinguishable from the current Hunter Floodplain Red Gum Woodland.

### 2.3.5 Carrington Billabong – River Red Gums Baseline Survey Hunter Valley Operations Draft (HLA-Envirosciences 2007)

HLA-Envirosciences was commissioned by Coal & Allied to undertake a baseline survey of the river red gums within Carrington Billabong. The baseline survey was undertaken in February 2007 in which 34 trees (approximately one quarter) within the billabong were sampled and tagged for future monitoring. Data were collected for a number of parameters including physical measurements, tree health and threats, with a photo taken of each tree sampled. In addition to the sampling of individual trees, two transects were conducted through the billabong to collect data on the structure and composition of the vegetation, evidence of feral and native animals, erosion and other types of disturbance.
The survey recorded the average canopy cover of the river red gums as 45 per cent with a crown health rating of 3. Dieback was recorded for 62 per cent of trees sampled, and 65 per cent exhibited epicormic growth. Of the trees sampled, 79 per cent were found to be hollow-bearing. Carrington Billabong was found to have little or no understorey and the site was considered stable with no signs of erosion.

The results of the survey by HLA-Envirosciences were incorporated into the HVO river red gum monitoring report (Umwelt 2008a) and were considered in the preparation of this report.

2.3.6 Coal & Allied River Red Gum Survey and Assessment (Umwelt 2008a)

As part of the development of this Strategy Umwelt was commissioned to undertake a detailed survey of the condition of the Carrington Billabong river red gum population and the distribution of river red gums across HVO (refer to Figure 1.2 for location). The survey involved non-stereoscopic aerial photograph interpretation (API) and field survey.

The results of this field survey were mapped onto an overlay of the aerial photograph of Coal & Allied properties by the person who undertook field work, using the on-screen digitising function of the MapInfo geographic information system (GIS).

In addition, during the development of the initial Carrington Billabong Strategy and in consultation with relevant agency representatives, it was considered appropriate to establish a 'control' site that was well away from Carrington Billabong, to be used as a reference site. The purpose of this was to have a remnant of river red gum against which changes over time resulting from management actions in Carrington Billabong could be compared.

To this end, a stand at Camyr Allyn, between Aberdeen and Scone, was chosen (see Figure 2.1). This stand is the largest known stand of river red gum in the Hunter Valley, covering some 14.5 hectares, and it had been previously surveyed as part of the Hunter Remnant Vegetation Project, and found to be the healthiest stand in the Hunter (Peake 2006). It is recognised that there are a number of variables that may influence the validity of this site being used as a control site. Despite this, the monitoring of the site is useful at this stage to help to understand the various factors that influence the health and regeneration of river red gum stands. The Camyr Allyn site is situated in a highly regulated catchment in which extensive groundwater monitoring has been undertaken. It will be useful in future to obtain the relevant data from DECCW for groundwater trends for both the Camyr Allyn and Carrington Billabong sites to assess for any links between groundwater-dependency at both sites.

The results of the control site survey are reported in Umwelt (2008a), and have been used in the development of this Strategy.

2.3.7 Dartbrook Underground Mine River Red Gum Trials

DECCW, the HCRCMA and Anglo Coal are currently carrying out a trial river red gum restoration study at a site at Dartbrook, near Aberdeen. The aim of the project is to restore the water balance of an existing stand of river red gums with the aid of artificial flooding events to recharge soil moisture levels. The anticipated outcome of the study is an improvement in river red gum tree health and the recruitment of trees through natural regeneration.

The specific objectives of the study are to:

- reintroduce periodic water inundation of the remnant;
FIGURE 2.1
Location of River Red Gum Stand at Camyr Allyn

Source: DEC 2006 (base), Umwelt 2006a

Legend
- Camyr Allyn Stand Site
facilitate the natural regeneration of the river red gum community;

- remove exotic plant species competing for resources with regeneration river red gums;
- remove grazing impacts from the remnant; and
- monitor the results of the project through changes in soil properties and vegetation patterns.

The implementation plan (Dartbrook Coal Mine 2006) states that the artificial flooding will be undertaken twice per year, the first to promote the vegetative growth of existing trees followed by a flood event post seed fall. Regular monitoring of the river red gum health and recruitment, flora species (including weeds) presence and abundance and soil moisture content will be undertaken to assess the effectiveness of increased flooding on the health of the river red gum population. Adaptive management will also be used to determine whether changes to the flooding regime or other methods require modification.

Studies that have been undertaken to date include a survey plan showing the locations of trees, monitoring plots, earth bunds, irrigation systems and other relevant components, a revegetation plan and a water balance study to determine the water required for artificial flooding. Some groundcover and tree species have been planted, and weeding has been undertaken. Due to high level water restrictions in the area resulting from the recent drought, artificial flooding had been delayed for at least six months.

In early June 2007 flooding in the Hunter River enabled water to be drawn from the river and the first artificial flooding event was undertaken. Since then four monitoring events have been conducted, however the data are still preliminary and do not provide any substantiated conclusions of the success or otherwise of the artificial flooding (Umwelt 2008b 2008c, 2009b, 2009c, 2010), however preliminary findings do indicate that a natural mass seeding event took place as a result of this induced prolonged period of inundation.

2.3.8 Hunter Catchment Dieback Studies (Russell 1993 and Staheyeff & Peake 2003)

In 1993 the Hunter Catchment Management Trust (now the Hunter – Central Rivers Catchment Management Authority) undertook a preliminary study of tree dieback in parts of the Hunter Catchment (Russell 1993). The study was undertaken in response to the concerns of many landholders, and aimed to understand the extent and severity of the problem. One of the tree species that was assessed, albeit only in a secondary fashion, was river red gum. The report found that:

river red gums have declined in areas of the western catchment, such as the Wybong district, affected by salinity problems.

In early 2002 the former Hunter Catchment Management Trust determined to follow up on the 1993 study to assess the change in status of dieback during the seven year time interval. Staheyeff and Peake (2003) prepared a draft report, which included the assessment of two stands of river red gum – at Aberdeen and Plashett, near Jerrys Plains. It found that the incidence of dieback at both sites was moderate to severe, and speculated that changed hydrology was probably the main causal factor.
2.3.9 Taxonomic Revision of River Red Gum (McDonald, Brooker & Butcher 2009)

*Eucalyptus camaldulensis* is one of the most widely distributed eucalypt species in Australia; known to occur in a variety of different climatic zones as well as along the majority of major Australian river systems. It is due to this known adaptation to various different environmental conditions, and the morphological variation displayed in the species, that studies have been undertaken which have now defined sub-specific taxa, namely subsp. *acuta*, subsp. *arida*, subsp. *camaldulensis*, subsp. *minima*, subsp. *obtusa*, subsp. *refulgens*, and subsp., *simulata*.

This study considered the morphology, distribution and genetic relationships of *E. camaldulensis* and ultimately recognised a total of seven subspecies of *E. camaldulensis*, their main differences being in relation to the following features:

- bark character;
- lignotuber presence;
- seedling leaf shape;
- juvenile leaf shape;
- adult leaf colour;
- adult leaf reticulation;
- operculum at anthesis;
- stamens in bud; and
- flowering time.

It also identified each subspecies as having largely geographically distinct distributions, although none were completely isolated. According to this study, the subspecies occurring at HVO South, and indeed across the whole Hunter Valley, would be *Eucalyptus camaldulensis* subsp. *camaldulensis*.

These seven subspecies of *Eucalyptus camaldulensis* have yet to be formally accepted by the National Herbarium of NSW (Botanic Gardens Trust 2010).

2.3.10 Miscellaneous Reports

A variety of other documents, published papers and unpublished reports were reviewed to assist in the development of the Strategy. These variously covered studies of river red gums, groundwater issues and wetland and riverine studies.

River red gum studies that were reviewed comprised: Brett Lane and Associates (2005); Cliftin (undated); Eddy (undated); Glazebrook and Robertson (1999); Hill (2003); Murray-Darling Basin Commission (2003); Peake and Tame (2001); Peake et al. (2003); Soil Conservation Service (1990); and Wilson (1995).

Groundwater policy and studies that were reviewed comprised: DLWC (2000); DLWC (2002); Lamontagne et al. (2003); and Mackie Environmental Research (2005).
Wetland and riverine vegetation studies that were reviewed included: Kingsford (2000); Robertson and James (2007); Robertson and Rowling (2000); and Zedler (2000).

In addition to these, the development of draft completion criteria for Carrington Billabong had regard to Nichols (2005), while the overall report took into regard Rio Tinto’s *Guide to Integrating Biodiversity into Operation Activities* manual (Rio Tinto 2004).

The full reference for each of the above citations is provided in Section 10.0.
3.0 Baseline Ecological Condition Assessment

3.1 Background and Context

To enable the Strategy to address the key causal factors that have contributed to the decline of river red gums in Carrington Billabong and at HVO South, it is necessary to first assess the most pertinent outcomes of ecological investigations in both areas. The causal factors are those issues that have been identified and recognised to contribute to the decline of the river red gum populations in both areas. Addressing these issues, either in full or at least in part, will assist in the reversal of the decline and will help to promote the development of river red gum stands that have the ability to persist in the long-term. The expression, or symptoms, of the causal factors are the matters that will require ongoing monitoring to assess their continued incidence. The results of previous monitoring (Umwelt 2007; Umwelt 2008d) and future monitoring will assist to confirm the level of influence that the key causal factors continue to have on the ecological health of river red gums at Carrington Billabong and HVO South.

The baseline survey undertaken at the Camyr Allyn control site (Umwelt 2008a – see Section 2.3.6 regarding the selection of this control site to compare to Carrington Billabong; Figure 2.1 displays the site’s location) found that the river red gum trees and remnant present there were generally more diverse, in better health and suffering less from weed impacts. It is recognised that this site is not a true comparison to the Carrington Billabong site due to its location, size, lack of a defined billabong and presumably different land use history, however it still exhibits many similar biophysical characteristics and is therefore useful as a comparison. There was also substantial evidence at Camyr Allyn of previous recruitment. The continued collection of data from this site will enable ongoing comparisons to be made between Carrington Billabong and Camyr Allyn, to determine if the implemented management actions at Carrington Billabong are having a positive effect. It will also assist in the management of the HVO South stands. Furthermore, the control site will provide a reference point against which catchment-wide processes that might be impacting river red gums can be assessed.

3.2 Summary of Carrington Billabong Ecological Condition Assessment

The results of baseline monitoring that was conducted by HLA-Envirosiences and Umwelt at Carrington Billabong are provided in Umwelt (2008d).

At Carrington Billabong, monitoring consisted of four 20 metre by 20 metre permanent flora sampling plots over three survey periods. According to these monitoring surveys, a total of 85 different plant taxa were present at Carrington Billabong, inclusive of 44 introduced species and 41 native species. Indicating that over 50 per cent of plant species at Carrington Billabong were introduced species. Dominant plant families were Asteraceae, Chenopodiaceae and Poaceae. Dominant (cover abundance greater than 20 per cent) flora species over the survey periods were more consistent for the native flora species than the introduced flora species, however the introduced *Galenia pubescens* was consistently present throughout.

Surveys at Carrington Billabong identified a total of 140 adult river red gum trees (refer to Figure 3.1), most of which were assessed as being in poor condition. Of these 140 trees, 10 per cent were old growth and 90 per cent were adult trees; the presence of an old growth tree was defined as a tree containing hollows and a large DBH (generally greater than 1 metre) whereas an adult tree was defined as a tree capable of reproduction. Over
50 per cent of trees showed evidence of flowering or fruiting during each monitoring period; and just over 50 per cent were classified as being in the size class of between 50 and 100 centimetres in diameter at breast height.

The Carrington Billabong site was also compared to the control site, Camyr Allyn, near Aberdeen, over three monitoring events. The Camyr Allyn site record a total of 87 different flora taxa, including 45 weed species (52 per cent) and 42 native species (48 per cent). Camyr Allyn similarly to Carrington Billabong had the following three dominant flora families, Asteraceae, Poaceae, and Chenopodiaceae.

A total of nine adult river red gum trees were surveyed at Camyr Allyn, the majority of these trees were assessed as being in poor condition, with the majority in at least a slight state of stress. Of these trees 55.6 per cent were adult trees and the remaining 44.4 per cent were old growth trees; with over half of the trees either in a state of flowering or fruiting.

The floristic results between Camyr Allyn and Carrington Billabong were not considered to be substantially different; with all monitoring sites found to support a high diversity of introduced species. Interestingly, both sites showed an increase in weed species present in response to the June 2007 storm event; and sites that were being grazed during the time of surveys had lower densities and heights of introduced species than non-grazed areas.

The health of river red gums was assessed as being in a state of less stress at Camyr Allyn (as predicted), than those trees surveys at Carrington Billabong. No observable changes were recorded to the health of trees at Carrington Billabong over the three monitoring periods despite changes in management practices, such as the removal of grazing. However, positive impacts from such management practices may require a longer period of time before results become apparent. These poor levels of tree health and general poor condition of the billabong were attributed to:

- competition for water and nutrients by weed species;
- fragmentation and edge effects;
- modifications of flooding regimes;
- localised modifications to hydrology;
- soil compaction, altered soil nutrient balance, and loss of topsoil from prolonged cattle grazing;
- tree root damage and natural recruitment suppression from cattle trampling; and
- defoliation from large groups of galahs and cockatoos.

Although their overall conditions were assessed as being poor, there were few signs on the trees of fungal or insect attack, nor was any mistletoe observed at either Carrington Billabong or Camyr Allyn.

Recruitment was observed at Carrington Billabong in the last surveying period, however no such recruitment was observed at Camyr Allyn. The naturally recruited seedlings at Carrington Billabong were in poor condition, showing significant signs of stress particularly in respect of foliage loss. All seedlings showed a decrease in health over time, despite the fact that growth was still observed.
It was recommended that the health and biodiversity of the sites at Carrington Billabong continue to be monitored for any changes in health and that the sites be subjected to weed management and fencing. From surveys of both sites, a total of eight different noxious weeds were identified, and a total of 22 environmental weeds were identified, no *Weeds of National Significance* (as identified in Thorp and Lynch 2000) were recorded. These species need to be carefully monitored and controlled to ensure that they do not further spread or impact the native species present. A weed management plan specific to the needs of Carrington Billabong was developed to meet the needs of this sensitive site.

As impacts from cattle was considered to be another significant issue for the populations of river red gums, it was also recommended that these areas were fenced to excluded grazing cattle, this fencing has since been undertaken (refer to Figure 3.1).

The results show that Carrington Billabong has been impacted over time, most likely through a number of events including:

- alteration of the water regime through irrigation;
- alteration of the water regime after the commissioning of Glenbawn Dam in 1958 and recently modified surface runoff;
- unrestricted grazing across most of the billabong;
- pest plants and animals; and
- previous vegetation clearance.

These factors have contributed to the decline of the billabong as a whole, as well as the river red gums more specifically.

Because the health of the billabong and the river red gums are intricately linked, the Strategy addresses the rehabilitation of the billabong and the river red gums together.

### 3.3 Summary of Hunter River and Wollombi Brook Stands Ecological Condition Assessment

#### 3.3.1 Background and General Condition

The results of baseline monitoring that was conducted by Umwelt at HVO South are provided in Umwelt (2008d).

River red gum stands identified in Appendix 8 of the HVO South project approval were surveyed in November 2009 for the current work and May 2008 for previous work.

River red gum stands in the HVO South project area are significantly modified from their original state in floristic composition, structure and connectivity. Most stands are small and isolated and highly affected by weed invasion and tree dieback. Natural recruitment of native species, including river red gums, is greatly reduced to absent and native diversity is generally low. In all sites, weeds dominate the understorey, particularly the ground cover, and probably restrict natural native recruitment. Listed below are the 16 most widespread and dominant weeds recorded in study area, listed from most to least widespread:

- greater beggar’s ticks (*Bidens subalternans*);
- **galaenia** *(Galenia pubescens)*;
- **castor oil plant** *(Ricinus communis)*;
- **Paddy's lucerne** *(Sida rhombifolia)*;
- **wandering Jew** *(Tradescantia fluminensis)*;
- **pepper tree** *(Schinus areira)*;
- **balloon vine** *(Cardiospermum grandiflorum)*;
- **prairie grass** *(Bromus cartharticus)*;
- **fierce thornapple** *(Datura ferox)*;
- **black-berry nightshade** *(Solanum nigrum)*;
- **lucerne** *(Medicago sativa)*;
- **African olive** *(Olea europaea subsp. cuspidata)*;
- **kikuyu grass** *(Pennisetum clandestinum)*;
- **curled dock** *(Rumex crispus)*;
- **rambling dock** *(Acetosa sagittata)*; and
- **blue morning glory** *(Ipomoea indica)*.

None of these plants are listed on the **Noxious Weeds Act** in the Singleton LGA.

River red gum stands in the Hunter occur in three landscape positions: streambanks, floodplains (closed depressions) and floodplains (shedding). River red gum remnants in the study area were classified into one of these forms based on position in the landscape flood history:

- **Form 1**: River bank and river bed;
- **Form 2**: Floodplain, and water-holding: i.e. closed depressions that holds/ponds water in major over-bank floods such as the June 2007 flood. Carrington Billabong is an example of this form; and
- **Form 3**: Floodplain and water shedding: i.e. alluvial plain/flat that does not hold/pond water in major over-bank floods such as the June 2007 flood. Remnant numbers 24 and 25 are examples of this form.

All three forms of river red gum woodland are part of the EEC, and are represented in the study area. The woodland remnants are grouped into these forms to provide more information on their character, which is important for developing suitable management strategies.

The floodplain forms generally have the highest level of modification and degradation. These forms generally also support the oldest river red gum trees, probably as remnants retained by previous land managers for stock shelter. It has been observed that the older trees tend to exhibit the highest level of dieback, which may reflect their higher resource requirements not being satisfied, particularly water, compared to younger trees. This phenomenon is seen
in the floodplain remnants at Carrington Billabong and remnant numbers 23, 24 and 31 (refer to Figure 1.2). The average score for dieback in floodplain remnants was 1.6, indicating dieback of over 10 per cent, where as in streambank sites it was less than 10 per cent (Umwelt 2008d and unpublished data). In addition, floodplain sites may have been subjected to higher levels of stock utilisation, and consequent impacts such as soil compaction, soil stripping and soil enrichment. Floodplain remnants are often more isolated than streambank remnants which more commonly have connectivity through gallery forest remnants.

Streambank remnants were found to support an overall younger population of river red gum trees and recorded higher levels of natural recruitment – possibly due to the greater availability of water and lower impact by stock, historically. However, streambank sites were also subject to more erosion, with bank undercutting and slumping the most serious erosional processes observed. Streambank sites also support a higher native diversity, although weeds are still a significant impact, with balloon vine, wandering Jew, peppertree and blue morning glory problematic. Streambank erosion was significantly higher at sites with stock access. Fencing of these areas or otherwise excluding stock is essential.

Resources for restoration and management of river red gum remnants should be targeted at sites where greater success is more achievable. As a guide, remnants have been classified according to a three-tier system. Section 5.1 provides details on the reasoning behind the three-tier approach to the investment of resources and funds, and documents the goals and objectives for each category.

Overall, all sites require some or all of the following:

- fencing and stock access control;
- weed management: particularly targeted control of serious weeds;
- support of naturally recruited natives, through weed control around the seedlings until they have become established;
- supplementary planting of natives to boost natural regeneration; and
- erosion control/bank stabilisation on streambanks.

### 3.3.2 Ecological Condition of Individual Remnant Stands

A summary of the ecological condition assessments for all remnant stands located on the Hunter River or Wollombi Brook on HVO land (refer to Figure 1.2) is included as Appendix 1.

### 3.4 Discussion of Results and Causal Factors

The key results obtained from the survey of the Carrington Billabong and other river red gums along the Hunter River and Wollombi Brook (Umwelt 2008a) are:

- there is generally relatively low recruitment of river red gums;
- many old trees are dying or have already died;
- a high proportion of adult trees are suffering dieback;
- in most places there are few native groundcover species;
• there is an abundance of herbaceous weed species; and

• notwithstanding that shrubs are not always naturally abundant in river red gum woodland, there is nonetheless very low diversity and abundance in shrub or low tree species.

Taking into consideration the key results, as well as information gained from consultation with other experts and from an assessment of relevant literature, the key causal factors that are likely to be contributing to the decline of river red gums at Carrington Billabong and HVO South are:

• alteration of the water regime through irrigation;

• alteration of the water regime after the commissioning of Glenbawn Dam in 1958 and recently modified surface runoff;

• access to most remnant stands has mostly been unrestricted, which has enabled relatively uncontrolled livestock access over a long period. The resulting impacts include soil compaction, rubbing damage on trees from livestock, excessive nutrient addition, weed transport and grazing of saplings;

• historical vegetation clearance has meant that most remnants are ecologically denuded: most have effectively no ecological connectivity to nearby remnants; their area of coverage are mostly small; most have a high edge to area ratio, resulting in a small ‘core’ and large ‘edge’ habitats; and their structural and floristic compositions have been heavily modified over time through human activities, which has continued to suppress the natural recovery of the remnants;

• the remnant populations have been affected by numerous drought conditions, the most recent being the past 3-5 years, while the worst drought on record was in the 1940s;

• based upon key findings from the groundwater assessment undertaken by ERM for the Carrington Pit Extension SEE (2005), connectivity between Carrington Billabong and the groundwater aquifer was confirmed; these findings also indicated that reductions to water table levels were at least partially attributable to drought and mining activities. Consequently it is likely that local mining activities have interfered with the water usage regime of the river red gums at Carrington Billabong, although the extent of this is believed to be relatively minor; and

• the surface water catchment around Carrington Billabong has been temporarily modified due to local mining activities such that surface water runoff to the billabong is currently reduced.

These factors are most likely to have significantly contributed to the decline of the remnant populations at Carrington Billabong and HVO South and are manifested in the poor health, poor recruitment, tree death, high weed incidence and low diversity that are exhibited as symptoms of the remnants’ ecological decline.

Of the above matters, the latter four are considered the most important and are similarly the most difficult to address.

If groundwater disconnection at Carrington Billabong is confirmed, this issue will need further investigation, especially given that the trees in the remnant population are likely to be nourished by inundation from the Hunter River which has possibly occurred less frequently as referenced previously (Section 2.2.5). The probable decline in surface water nourishment is likely to have exacerbated any problems related to groundwater deficiency, and is also very difficult to remedy without irrigation.
The other pertinent matter, that of the ecological denudation of the remnants, is more readily addressed than the water management issues, albeit there will be a significant amount of time required before the landscape scale ecological matters can be remedied. The issue of uncontrolled access is able to be rapidly addressed and modified at priority sites, and has already been addressed at Carrington Billabong.
4.0 Strategy Development

4.1 Stakeholder Consultation

The Strategy contained in this report was developed over a period of four years. The development period comprised two phases:

- initially, the development of the draft Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy; and

- the development of the HVO River Red Gum Rehabilitation and Restoration Strategy, which supersedes the initial draft Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy to include Carrington Billabong and stands within the HVO South project area.

Discussions with relevant regulatory authorities were undertaken from 2005 onwards. At the approval stage for both the Carrington Pit extension and the HVO South project, draft consent conditions were issued regarding the preparation of the Strategy, and Coal & Allied personnel consulted with government agencies and other experts regarding the draft conditions.

On both occasions once the final consent conditions were released, Coal & Allied personnel set about identifying the key stakeholders whose involvement would be critical in developing the Strategy. Coal & Allied also issued a brief and sought tenders from appropriate organisations to undertake the preparation of the Strategy. The key stakeholders who have been consulted with during the development of the Strategy include:

- DoP;
- DECC (now DECCW);
- Department of Water and Energy (DWE; including staff of the former Department of Natural Resources, DNR) – now part of DECCW;
- Singleton Council (SC);
- Department of Primary Industries – Mineral Resources (DPI-MR) (now Industry and Investment NSW (I&I NSW));
- Hunter – Central Rivers Catchment Management Authority (HCRCMA); and
- Hunter Valley Operations Community Consultative Committee (HVO CCC).

4.1.1 Consultation for the Development of the Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy

Although the consent conditions for the Carrington Pit extension only refer to satisfying DNR’s requirements, Coal & Allied liaised with all of the abovementioned authorities and organisations to ensure a greater opportunity for comment and review.

In March 2007 Umwelt was engaged to prepare the first Strategy. Coal & Allied personnel, and Umwelt staff, initially met with most stakeholders on 22 March 2007, at a forum designed to brief stakeholders on the planned approach for the preparation of the Strategy and to enable stakeholders to provide feedback or advice. Representatives of DoP, SSC, DPI-MR,
DECC and HCRCMA were present at the meeting. (DNR were invited but were not able to attend this meeting).

Since 2005 Coal & Allied staff has kept the HVO CCC informed about the river red gums, the Carrington Billabong and the requirement to prepare the Strategy.

A targeted consultation meeting was held on 10 May 2007, during which staff from DWE and DECC were briefed on the Strategy and the latter were guided around the Carrington Billabong site. Other participants in the meeting were Coal & Allied personnel, Umwelt staff, John Pola, a surface water expert of JP Environmental, and Col Mackie, a groundwater expert of Mackie Environmental Research. DECC staff provided significant input at this stage into the most appropriate management actions to assist in the recovery of Carrington Billabong.

In addition to the consultation documented above, Umwelt staff and Coal & Allied personnel did, throughout the Strategy’s development, consult particularly with DECC and HCRCMA staff.

Finally, Coal & Allied personnel and Umwelt staff consulted with Anglo Coal regarding a study established at Dartbrook, near Aberdeen, in which different treatments are being applied to plots of river red gums in an experimental flooding program (see Section 2.3.6).

A draft Strategy was submitted to DoP and DECC on 30 June 2007. DoP subsequently approved the Strategy on 19 May 2008, without change. DECC, however, requested a number of minor alterations to the Strategy, which were addressed, together with new information obtained from additional monitoring of Carrington Billabong. Prior to the approval of the Strategy, however, the project approval conditions for the HVO South project required its modification and re-submission, as indicated in Section 1.4.3. The alterations to the original strategy are included in this document.

4.1.2 Consultation for the Development of the HVO River Red Gum Rehabilitation and Restoration Strategy

On 28 October 2009, Coal & Allied and Umwelt staff met with DECCW representatives to discuss the planned approach to the modification of the previous draft strategy and the development of the new strategy to cover the HVO South project. In particular, the proposed tiered approach to management obligations, as documented in Section 5.1, was discussed in detail, with agreement from all that this type of approach was the most appropriate to ensure the best targeting of resources to achieve the best environmental outcome.

4.2 River Red Gum Data Collection

During the past four years, Coal & Allied has commissioned the collection of various data pertaining to river red gums at HVO. This includes data collected during the preparation of the West Pit Extension EIS and Carrington Pit Extension SEE (ERM 2003 & 2005), as well as assessments undertaken for the HVO South Coal Project (ERM 2008).

Prior to commissioning the preparation of this Strategy, Coal & Allied commissioned HLA-Envirosciences to commence baseline monitoring of river red gums at Carrington Billabong (see Section 2.3.5). Data collected in this exercise were incorporated into the development of the Strategy, and complemented further data collected by Umwelt.
In addition to the above sources, further data on river red gums generally in the Hunter Valley were obtained from Peake (2006), Umwelt (2007, 2009), Peake and Tame (2001) and Peake et al. (2003) (see Sections 2.3.2, 2.3.3, 2.3.4 and 2.3.10, respectively). Where appropriate, these data were incorporated into this document and assisted in the development of the Strategy.
5.0 Overview of River Red Gum Rehabilitation and Restoration Strategy

5.1 Tiered Management Approach

To achieve an effective environmental outcome, and to ensure that resources can be allocated properly and targeted to sites where an appreciable improvement in ecological health can be realised, a three tier management approach has been developed. The three tiered management approach involves the management of land under the categories of high, intermediate or low level management. A description of the three tiers is provided in the following sub-sections, and the three-tier system as it pertains to each river red gum stand is displayed in Figure 1.2.

5.1.1 High Level Management – Carrington Billabong

The stand of river red gums located at Carrington Billabong is proposed for the highest level of management (refer to Figure 3.1). This site has been thoroughly and extensively investigated, and lies close to mining operations. Coal & Allied committed to high level management of the stand, which was reflected in the consent conditions for the Carrington Pit Extension Statement of Environmental Effects (SEE) and the development of the previous Strategy to conduct appropriate rehabilitation and restoration efforts. The goals and objectives proposed as part of high level management are documented in Section 6.1.

5.1.2 Intermediate Level Management – Priority Sites

Intermediate level management is proposed at sites that have reasonable ecological integrity and where intervention is more likely than not to result in positive outcomes for river red gums. These sites are likely to be currently more resilient than others, or to become substantially more resilient as a result of intervention. Resources will be largely shared between the area of high level management (Carrington Billabong) and sites targeted for intermediate level management. These sites are termed ‘priority sites.’ The 11 priority sites, which occur in eight locations, proposed for intermediate level management are shown in Figure 1.2 and comprise:

- Site 14 (on the Hunter River);
- Site 17 (on the Hunter River);
- Sites 24 and 25 (on the Hunter River);
- Site 54 (on Wollombi Brook);
- Site 51 (on Wollombi Brook);
- Site 53 (on Wollombi Brook);
- Site 7 (adjacent to Carrington Billabong); and
- Sites 31, 32 and 33 (on the Hunter River).

The goals, objectives proposed as part of intermediate level management are documented in Section 6.1.
5.1.3 Low Level Management – Low Priority Sites

Low level management is proposed at sites that are in relatively poor ecological condition, and consequently have low integrity and very limited recovery potential (refer to Figure 1.2). These sites are termed ‘low priority sites’. At these sites the level of intervention required to return them to fully functioning, resilient ecosystems would be significant and costly. Such intervention would take away resources from priority sites where the likelihood of recovery is high. Importantly, none of these sites will be impacted by mining based on current approvals.

These sites will be managed largely in the same way that other areas of non-operation land at HVO are managed – that is, the regular weed control, pest control, grazing management and monitoring that Coal & Allied conducts across its non-operational lands will include these sites to ensure that their ecological condition is maintained. If, in future, monitoring of these sites suggests that intervention is appropriate, Coal & Allied will reassess the Strategy and consider redirecting resources to improve their likelihood of recovery. This could include, for example, situations in which a significant regeneration occurs in response to a flood, and there is a marked improvement in the potential for a stand to enlarge, improve in structural and floristic diversity, and for its resilience to significantly improve.

The goals and objectives proposed as part of low level management are documented in Section 6.1.

5.2 Overview of Management Actions

Details regarding the execution of the HVO River Red Gum Rehabilitation and Restoration Strategy are presented in Appendix 2. A summary of the target actions for the specific stands are outlined in Sections 5.2.1 to 5.2.4 below.

5.2.1 Carrington Billabong

Target actions that are likely to contribute to the improvement of the remnant populations of the Carrington Billabong are detailed as follows:

- establish and maintain appropriate fencing around the remnant (the fencing should cover an area significantly larger than the remnant population to facilitate recruitment and support the expansion of the remnant over time);
- undertake groundwater monitoring, and monitor extent and duration of inundation in Carrington Billabong after flood events, and review data;
- undertake regular ecological monitoring making use of existing baseline monitoring;
- undertake an appropriate weed and pest control program;
- monitor the response of the river red gums post-flooding;
- monitor frequency and duration of flood events;
- encourage the natural recruitment of river red gums (which may require soil ripping);
- establish a seed harvesting and propagation program; and
• encourage natural regeneration of other native species, especially grasses, forbs and select shrubs.

5.2.2 Priority Sites

Target actions that are likely to contribute to the improvement of the remnant populations of the priority sites are detailed as follows:

• establish and maintain appropriate fencing around the remnants (the fencing should cover areas larger than the remnant populations to facilitate recruitment and support the expansion of the remnants over time);

• where existing groundwater monitoring sites are proximate, review data obtained from such monitoring;

• undertake regular ecological monitoring making use of existing baseline monitoring;

• undertake an appropriate weed and pest control program;

• monitor the response of the river red gums post-flooding;

• encourage the natural recruitment of river red gums through the control of weeds and management of grazing; and

• encourage natural regeneration of other native species, especially grasses, forbs and select shrubs.

5.2.3 Low Priority Sites

Target actions that are likely to contribute to the improvement of the remnant populations of the low priority sites are detailed as follows:

• undertake appropriate weed control and feral fauna management;

• ensure grazing is at such rates that minimise disturbance to recruitment; and

• review regular ecological monitoring undertaken elsewhere at HVO South and make use of relevant information and apply to low priority sites to aid in their management.

5.3 Timing for Strategy

Table 5.1 lists the planned schedule of actions, indicating when they are expected to occur in relation to DoP approval of the Strategy.

<table>
<thead>
<tr>
<th>Action</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategy approval DoP.</td>
<td>Anticipated Q2 2010</td>
</tr>
<tr>
<td>Establishment of interim stock fencing at Carrington Billabong and remove stock.</td>
<td>Complete</td>
</tr>
<tr>
<td>Establish signage at Carrington Billabong.</td>
<td>Complete</td>
</tr>
<tr>
<td>Ensure Carrington Billabong is incorporated into the HVO Weed and Pest Control Plans.</td>
<td>Complete</td>
</tr>
</tbody>
</table>
### Table 5.1 – Planned Schedule of Actions for the Strategy (cont)

<table>
<thead>
<tr>
<th>Action</th>
<th>Timeframe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Continue monitoring program at Carrington Billabong and at representative priority sites as per monitoring schedule.</td>
<td>Continue from Q2 2010</td>
</tr>
<tr>
<td>Ensure priority sites are incorporated into the HVO Weed and Pest Control Plans.</td>
<td>Q4 2010</td>
</tr>
<tr>
<td>Implement weed and pest control as recommended in HVO Weed and Pest Control Plans.</td>
<td>In accordance with weed and pest control schedule.</td>
</tr>
<tr>
<td>Erect expanded permanent fencing at Carrington Billabong.</td>
<td>Complete</td>
</tr>
<tr>
<td>Undertake review of fencing requirements and design appropriate fencing outcomes for priority sites.</td>
<td>Q4 2010</td>
</tr>
<tr>
<td>Erect appropriate fencing or undertaken any maintenance needs on existing fencing at priority sites.</td>
<td>Q4 2011</td>
</tr>
<tr>
<td>Respond to monitoring requirements, such as ripping/scarifying and planting or flooding at Carrington Billabong; or planting, weeding, fencing maintenance at priority sites.</td>
<td>As determined by monitoring results.</td>
</tr>
<tr>
<td>Review of monitoring and ongoing management.</td>
<td>Annually reported in AEMR.</td>
</tr>
</tbody>
</table>
6.0 Preliminary Objectives and Criteria

To assist Coal & Allied in determining whether the rehabilitation and management of river red gums at the Carrington Billabong and HVO South has been effective, it is essential to establish criteria against which the sites can be assessed.

The development of completion or performance criteria needs to be balanced and dynamic given that they are a function of several variables that might influence the recovery or otherwise of river red gum stands. Many variables operate at catchment or regional scales outside the influence of the proponent, such as river flows and pest outbreaks. Other factors that operate at continental or even global scales, such as climatic influences (including droughts or floods brought about by La Niña and El Niño events), could significantly influence the long-term viability of the river red gum stands. To this end, the completion and performance criteria are designed to provide an appropriate benchmark against which to assess the management of the Carrington Billabong river red gums and HVO South priority sites and the resulting improvements.

6.1 Goals and Objectives

Goals and objectives that have been developed specifically for the three tiers of proposed management strategies as outlined above are documented in Table 6.1.

Table 6.1 – Goals and Objectives for HVO River Red Gum Rehabilitation and Restoration Strategy

<table>
<thead>
<tr>
<th>Goals</th>
<th>Objectives</th>
<th>Carrington Billabong</th>
<th>Priority Sites</th>
<th>Low Priority Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>To reduce the impacts of threatening processes on the stands.</td>
<td>• To suppress or eradicate the in situ environmental factors that are acting to reduce the viability of this remnant populations.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td></td>
<td>• To improve the conditions within this population such that it can withstand reasonable periods of stress, predation and shortage of water supply.</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>To aid the establishment of the appropriate conditions to promote the health of the river red gum populations.</td>
<td>• To identify the likely ex situ factors that are contributing to the reduction in viability of this population and the health of the billabong and act, where possible, to control those factors or to take account of those factors in management approaches if they are not able to be directly controlled.</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>
Table 6.1 – Goals and Objectives for HVO River Red Gum Rehabilitation and Restoration Strategy (cont)

<table>
<thead>
<tr>
<th>Goals</th>
<th>Objectives</th>
<th>Carrington Billabong</th>
<th>Priority Sites</th>
<th>Low Priority Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>• To ensure that the results of ongoing monitoring are appropriately used to modify the management regime in response to new or unexpected information.</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Increase the understanding of the water requirements of river red gums.</td>
<td>• Develop an understanding of water requirements through the timely monitoring of responses of river red gums to flood and storm events.</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>To enhance the river red gum population to enable it to persist as a viable, functioning populations.</td>
<td>• To assist this population to continue to self-propagate to ensure ample replacement of senescing trees with juvenile recruits.</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To support the establishment of a self-sustaining, functional and viable ecosystem that resembles what is likely to have been present in Carrington Billabong prior to European settlement.</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• To support the establishment of a self-sustaining, functional and viable ecosystems.</td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>To increase biodiversity including residence habitat, foraging habitat and native flora and fauna species.</td>
<td>• To increase habitat for the identified and potential native flora and fauna species.</td>
<td>✓</td>
<td>✓</td>
<td></td>
</tr>
</tbody>
</table>

6.2 Preliminary Criteria

6.2.1 Carrington Billabong

Both general and specific preliminary criteria are proposed for Carrington Billabong. Specific performance measures are also established to enable the measurement of the key components of each of the relevant criteria over the course of the Strategy’s implementation, rather than simply reviewing results after a period of time following implementation of the management actions.
The preliminary completion criteria should be reviewed after each monitoring event and reassessed for their applicability, particularly in light of uncontrollable catchment, regional or climatic factors. It is acknowledged that uncontrollable factors may result in a decline in the condition of the river red gums and therefore the indicators and criteria may not be able to be met.

A thorough review of the preliminary completion criteria is intended to be undertaken after the Year 5 monitoring (autumn 2012 – monitoring commenced in autumn 2007, see Section 7.0) reporting is complete, and at that stage Coal & Allied will seek the endorsement of DoP for any recommended changes to the completion criteria.

The preliminary completion criteria and performance measures are presented in Table 1 in Appendix 3.

### 6.2.2 Priority Sites

It is proposed to establish performance criteria to measure the progress of management actions at priority sites. The priority sites will not be affected by any approved mining-related activities, therefore it is appropriate to intervene in their recovery in a less comprehensive manner than is the case at Carrington Billabong. As a result of this, the preliminary performance criteria are designed to measure the effectiveness of more targeted outcomes.

The preliminary completion criteria and performance measures are presented in Table 2 in Appendix 3.

### 6.2.3 Low Priority Sites

All other stands of river red gum present in the HVO South project approval area or in HVO North will be subject to Coal & Allied’s regular land management actions, that is weed management, pest management, stock and fence management and maintenance and monitoring. The management commitments are presented in Table 6.2.

**Table 6.2 – Management Commitments for Low Priority Sites**

<table>
<thead>
<tr>
<th>Management Issue</th>
<th>Management Commitment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regeneration</td>
<td>Facilitate the opportunity, where practicable, for the encouragement of natural regeneration of river red gums.</td>
</tr>
<tr>
<td>Ecological Condition of Remnant</td>
<td>The remnant shows an overall improvement in condition compared to baseline results (consider grazing and feral animal impacts).</td>
</tr>
<tr>
<td>Surface Water and Sediment and Erosion Control</td>
<td>Currently-approved mining activities will not impact on the provision of surface water to sites, and will not detrimentally affect sites through erosion or increased sediment load.</td>
</tr>
<tr>
<td>Fencing and Access Control</td>
<td>An assessment will be made to determine if any sites need to be fenced off, if practicable and where the ecological integrity of sites warrants such, or to determine if grazing can be otherwise managed or removed to facilitate the improvement of ecological condition of sites.</td>
</tr>
<tr>
<td>Pest and Weed Management</td>
<td>Pest and weed control inspections will occur on a biannual basis. Weed control will target river red gums sites if pest or weed problems are detected.</td>
</tr>
</tbody>
</table>
6.3 Process for Reviewing and Refining Criteria

As detailed in Section 6.2 above, the preliminary completion criteria have been established to provide an appropriate benchmark against which to assess the management of the Carrington Billabong river red gums and HVO South priority sites and the resulting improvements. Based on the outcomes of rehabilitation monitoring (see Section 7.0), Coal & Allied will seek to formalise the closure criteria in consultation with government and external stakeholders. This may require the refinement of the preliminary criteria to account for monitoring research, stakeholders views and the modification of restoration techniques where required to facilitate that sign-off has been achieved.
7.0 Overview of Monitoring Program

Coal & Allied has undertaken monitoring of river red gums across HVO since early 2007, commencing initially with baseline monitoring at Carrington Billabong and continuing with baseline monitoring at a number of stands of river red gums at HVO. This has been followed-up with 6-month and 12-month monitoring of sites. Coal & Allied is committed to continuing an appropriate level of monitoring of river red gums at HVO South, as well as ongoing intensive monitoring of Carrington Billabong. The detailed monitoring program that has been developed for the river red gums is outlined in the Sections 7.1 to 7.3 below.

7.1 Carrington Billabong

7.1.1 Monitoring Objectives

The monitoring program for Carrington Billabong will build upon the baseline survey that was conducted in April 2007 (see Umwelt 2008a for details) together with 6-month and 12-month monitoring conducted in spring 2007 and autumn 2008 (see Umwelt 2008d). Appropriate monitoring will continue for a period of at least 10 years. After 10 years the need for future monitoring will be assessed.

The objectives of the monitoring program at Carrington Billabong are:

- to determine if there is any improvement or deterioration in river red gums within Carrington Billabong;
- to determine if there is any improvement or deterioration of the natural habitat at Carrington Billabong; and
- to provide management recommendations to achieve further improvements in the ecological management of the site to assist in the recovery of river red gums and their habitat.

7.1.2 Baseline Flora Survey

A baseline survey has been completed, comprising an initial survey undertaken by HLA-Envirosciences (2007) and a comprehensive survey undertaken by Umwelt (2008a). The baseline survey comprised the following components:

- unique identification tagging and GPS way-pointing of every mature river red gum;
- a tree health assessment, which included the assessment of:
  - age class;
  - diameter at breast height (DBH);
  - canopy (living foliage) percentage density;
  - canopy health (foliage dieback and epicormic growth);
  - evidence of flowering/fruiting;
  - evidence of insect and/or fungal damage; and
  - other relevant information (e.g. direct threats to individual); and
flora health assessment, including the following components:

- floristic survey of two permanent 20 x 20 metre plots;
- survey of two permanent 10 x 10 metre plots for recruitment only;
- photo-monitoring of each mature tree; and
- photo-monitoring of the site from other fixed points.

7.1.3 Future Monitoring Events

The information from the baseline survey, and the 6- and 12-month monitoring, will be used as a comparison with future results. The continued survey of monitoring sites will be undertaken by a suitably qualified and experienced ecologist. All future monitoring should be preferably undertaken in the same season to minimise the risk of biasing the data as a result of seasonal factors.

The design of future monitoring events should take into consideration the modification of the sampling design so that flora assessments are undertaken along an elevation gradient within the billabong. Sites will also need to cover the expanded area that has been fenced off to facilitate the regeneration and revegetation of river red gum across a larger area connecting with the Hunter River. Furthermore, the area and depth of inundation will be recorded during monitoring events, as well as water quality, where applicable. Given that monitoring events are unlikely to opportunistically coincide with flood events, Coal & Allied staff will attempt to undertake monitoring of the billabong after significant storm or flood events, subject to a risk assessment determining it is safe to proceed and will record key information such as area and depth of inundation, and water quality.

The monitoring program will continue while mining is occurring in the Carrington Pit with the frequency reassessed after each monitoring event (refer to Table 7.1 for proposed monitoring timing).

Table 7.1 – Proposed Monitoring Timing at Carrington Billabong

<table>
<thead>
<tr>
<th>Season and Year</th>
<th>Monitoring Event</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autumn 2007</td>
<td>Baseline survey.</td>
<td>Already completed.</td>
</tr>
<tr>
<td>Spring 2007</td>
<td>First 6 month monitoring survey.</td>
<td>Targeted survey to provide feedback on any initial changes to the site following June 2007 inundation – completed.</td>
</tr>
<tr>
<td>Autumn 2017</td>
<td>Year 10 monitoring survey.</td>
<td>Tailor to suit specific purpose.</td>
</tr>
</tbody>
</table>

The six-month monitoring event during the first year of the monitoring program was a targeted survey to assess the health of the Carrington Billabong (including both river red gums and the general ecosystem) following the June 2007 inundation event.

A review of the recommended monitoring program and frequency will be undertaken after the Year 3 and Year 5 monitoring results are reviewed.
7.1.4  Groundwater Monitoring

Coal & Allied undertakes regular groundwater monitoring across its operations. The results of all relevant groundwater monitoring will be made available to the persons undertaking the ecological monitoring and reporting and will be assessed to determine the impact that fluctuating groundwater levels may have on the health of Carrington Billabong.

7.1.5  Reporting on Monitoring Results

Reports on the outcomes of each monitoring event will be provided to Coal & Allied within eight weeks of each monitoring survey. If appropriate, verbal advice will be provided to appropriate Coal & Allied personnel as soon as possible if any specific issues are detected which might require immediate remediation or eradication.

Reporting may include as appropriate:

- details on the monitoring methods, prevailing weather conditions and general hydrological information, such as notes on recent flooding or records of groundwater movement;
- all results, in summarised format in the report but included in their entirety in appendices;
- compare and contrast the results from the monitoring event against those obtained from previous monitoring;
- a comprehensive discussion of the interpretation of the results and what they mean in relation to the rehabilitation of Carrington Billabong;
- recommendations on specific actions required to alleviate any particular issues, or to encourage other outcomes, including the need for planting, soil disturbance, flooding or modifications to the fencing and access; and
- recommendations on future monitoring frequency.

7.2  Priority Sites

7.2.1  Monitoring Objectives

The monitoring program for priority sites will build upon the baseline survey that was conducted in April 2007 (see Umwelt 2008a for details), together with 6-month and 12-month monitoring conducted in spring 2007 and autumn 2008 (see Umwelt 2008d), and will continue for a period of at least 6 years. After six years the need for future monitoring should be assessed.

The objectives of the monitoring program at priority sites are:

- to determine if there is any improvement or deterioration in river red gums at priority sites;
- to determine if there is any improvement or deterioration of the natural habitat at priority sites; and
- to provide management recommendations to achieve further improvements in the ecological management of the priority sites to assist in the recovery of river red gums and their habitat.
7.2.2 Baseline Monitoring

A baseline survey has been completed, comprising an initial survey undertaken by HLA-Envirosiences (2007) and a comprehensive survey undertaken by Umwelt (2007). The baseline survey comprised 14 sites where only ecological health assessments were undertaken and eleven sites where both ecological health assessments and permanent photo monitoring points were established. Sites at which photo monitoring was established comprised Sites 7, 17, 18, 22, 24, 31, 33, 40, 42, 45 and 51. Sites where photo monitoring was not undertaken comprised Sites 1, 3, 14, 20, 30, 32, 46, 48, 53, 54, 66, 68 and 70.

These permanent monitoring sites consisted of ecological health assessments which were assessed using a semi-quantitative, rapid assessment technique, where sites were scored for each ecological health attribute by the surveyor after they had walked through the remnant. The attributes recorded were:

- grazing by stock;
- logging or clearing;
- weed invasion;
- clearing or mowing of understorey;
- dieback in crown;
- canopy plants age diversity/regeneration;
- native diversity of mid-strata;
- native diversity of lower strata;
- erosion;
- time since last flood;
- fire history;
- connectivity of remnant; and
- remnant shape.

Dominant and/or common plant species were also recorded in the vicinity of each ecological health assessment location to help characterise and describe the vegetation at each site. This floristic survey was not systematic without the use of plot-based sampling or recording of cover abundance for each plant.

At each of the photo monitoring sites a single metal stake with a metal tag was used as a marker. At each of these sites a total of eight photographs were taken, aligned with each of the eight primary compass bearings.

7.2.3 Future Monitoring Events

The information from the baseline survey will be used as a comparison with future results. The continued survey of monitoring sites will be undertaken by a suitably qualified and experienced ecologist. All future monitoring will be preferably undertaken in the same
season to minimise the risk of biasing the data as a result of seasonal factors. **Table 7.2** documents the proposed monitoring timing.

**Table 7.2 - Proposed Monitoring Timing at Priority Sites**

<table>
<thead>
<tr>
<th>Season and Year</th>
<th>Monitoring Event</th>
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<td>Spring 2007</td>
<td>First 6 month monitoring survey.</td>
<td>Targeted survey to provide feedback on any initial changes to the site following June 2007 inundation – completed.</td>
</tr>
</tbody>
</table>

A review of the recommended monitoring program and frequency will be undertaken after the Year 3 monitoring results are reviewed. Coal & Allied will consider the need for any future monitoring of priority sites after the Year 6 monitoring results are reported.

### 7.2.4 Groundwater Monitoring

Coal & Allied undertakes regular groundwater monitoring across its operations. The results of all relevant groundwater monitoring will be made available to the persons undertaking the ecological monitoring and reporting and will be assessed to determine the impact that fluctuating groundwater levels may have on the health of priority sites.

### 7.2.5 Reporting on Monitoring Results

Reports on the outcomes of each monitoring event will be provided to Coal & Allied within eight weeks of each monitoring survey. If appropriate, verbal advice should be provided to appropriate Coal & Allied personnel as soon as possible if any specific issues are detected which might require immediate remediation or eradication.

Reporting may include as appropriate:

- details on the monitoring methods, prevailing weather conditions and general hydrological information, such as notes on recent flooding or records of groundwater movement;
- all results, in summarised format in the report but included in their entirety in appendices;
- compare and contrast the results from the monitoring event against those obtained from previous monitoring;
- a comprehensive discussion of the interpretation of the results and what they mean in relation to the rehabilitation of priority sites;
- recommendations on specific actions required to alleviate any particular issues, or to encourage other outcomes, including the need for planting, soil disturbance, flooding or modifications to the fencing and access; and
- recommendations on future monitoring frequency.
7.3 Low Priority Sites

No specific monitoring is proposed for low priority sites. However, Coal & Allied undertakes regular inspections of all land under its control, including areas where river red gums occur along the Hunter River and Wollombi Brook. During such future inspections the following matters at any river red gum stands will be assessed:

- prevalence of noxious weeds and significant environmental weeds, including abundance and threats posed;
- presence of signs of pest species and threats posed to river red gums by their activity;
- presence of significant erosion that might threatened the viability of river red gums;
- any significant recruitment or senescence of river red gums; and
- the condition of fencing, where present, and the need for any maintenance works.

The outcomes of any such monitoring will be reported to the Environmental Coordinator, who will then determine the appropriate course of action to remediate any issues or threats posed.
8.0 Additional Opportunities

Coal & Allied personnel will review any other potential opportunities that may assist in the rehabilitation and improved management of river red gums on Coal & Allied properties. If potential opportunities are identified they will be examined and considered for inclusion as part of the Strategy at the next scheduled review.

8.1 General Opportunities

General opportunities of particular additional benefit may be derived from:

- liaison with relevant HCRCMA and DECCW staff regarding broader river red gum management and assistance, particularly the ongoing inclusion of Carrington Billabong and other sites in a DECCW-managed regional river red gum monitoring program;

- assist DECCW, universities and other government and non-government agencies to develop future research projects, such as landscape modelling to determine the pre-European distribution of river red gums in the Hunter Valley and subsequent assessment of rehabilitation priorities based on where river red gums will be able to persist;

- investigations into soil health;

- liaison with Anglo Coal with a view to sharing information on river red gum rehabilitation approaches, particularly in relation to irrigation and inundation;

- assistance with the UNE river red gum genetic study by providing access to Carrington Billabong, and possibly other remnants of river red gum on Coal & Allied property, to enable the researcher to collect samples (detailed in Section 8.2); and

- other mutually beneficial opportunities that may be identified over time will be investigated and assessed on their merits by Coal & Allied.

8.2 River Red Gum Genetic Study

The introduction of non-natural hybrid river red gums to the Hunter Valley for revegetation projects and farm forestry has been identified as having the potential to seriously impact on the survival of potentially genetically distinct river red gums in the valley (e.g. Hill 2003; Peake 2006). There exists abundant evidence that hybridised genetic pools should not be mixed with threatened native gene pools (e.g. Potts and Wiltshire 1997; Daniels and Sheil 1999; Potts et al. 2001; Hill 2003; Meddings et al. 2003; Potts et al. 2003). Peake (2006) indicated that further research into this is urgently required before further hybrid introductions continue in the Hunter Valley.

The University of New England, Armidale, is conducting a study into the genetics of river red gum populations within the Hunter Valley. The intention of the project is to assess the levels of in-breeding or out-breeding within and between river red gum populations, as well as seed viability, to help determine the long-term viability of river red gum populations for natural recruitment potential and revegetation management (P. Nelson pers. comm. to L. Adlem).

The study will be conducted as a PhD-level project commencing in 2007 and running for four years. Coal & Allied has made river red gum stands on HVO available to UNE for data collection for the study.
9.0 Reporting and Review of Strategy

The review process will consider:

- the results of monitoring undertaken as recommended by this Strategy;
- feedback from UNE regarding the progress and results of the river red gum genetic study;
- progress and results of the Anglo Coal Dartbrook experiment; and
- leading practice information from regulatory authorities and specialists.

The review of outcomes and recommendations of each monitoring event will have a strong and direct link to the future management of the river red gums at both Carrington Billabong and the broader Coal & Allied properties.

This positive feedback loop will ensure that the outcomes of each monitoring event are carefully assessed and considered for future management.

Coal & Allied will report on the outcomes of the management actions and monitoring results in the HVO AEMR.

This Strategy will be managed and reviewed in accordance with the document management requirements. Future revisions will be provided to relevant government agencies if comprehensive changes are made.
10.0 References


DLWC – See Department of Land and Water Conservation.


Primary Industries And Resources SA (2000) Testing for soil and water salinity. Fact Sheet No. 66/00. Government of South Australia


Personal Communications:

A. McIntyre 2007 Andrew McIntyre, Manager – Biodiversity Conservation, DECCW, Coffs Harbour.

P. Nelson 2007 Penelope Nelson, PhD candidate, University of New England, Armidale, personal communication to Lorna Adlem, Hunter – Central Rivers Catchment Management Authority.


A. Raine 2008 Allan Raine, Acting Aquatic Sciences Manager, Department of Water and Energy.

H. Robertson 2007 Hugh Robertson, former Wetlands and Water Officer, DECCW, Coffs Harbour.

J. Weame 2010 Former Environmental Coordinator – Project Approvals, Hunter Valley Services, Coal & Allied.
APPENDIX 1

Summary of Ecological Condition Assessment for Specific Hunter River and Wollombi Brook Stands
Appendix 1 – Summary of Ecological Condition Assessment for Specific Hunter River and Wollombi Brook Stands

A summary of the ecological condition assessments for specific Hunter River and Wollombi Brook on HVO land (refer to Figure 1.2 of the Strategy Document) is outlined below. In each case a remnant is regarded as a unit of vegetation sharing similar characteristics. In most cases remnants are separated from one another by distances greater than 50 metres, however in some cases remnants can virtually abut; in these cases the condition, structure or floristic compositions of each remnant varies significantly.

1.0 Condition of Remnant 14

This remnant forms part of a local corridor along the Hunter River Bank and supports 45 to 55 mature river red gum trees. Natural recruitment of river red gum is occurring with an estimated 10 to 20 seedlings recorded. This site scored 29 out of 39 in ecological condition assessment on 26 November 2009, reflecting low levels of dieback, absence of stock utilisation, presence of natural canopy recruitment and moderate native diversity in the understorey.

The remnant is restricted to the bank of the river and has a relatively narrow core, hence is subject to significant edge affects. Severe bank slumping and wash outs are occurring. Weed invasion is severe, especially in the understorey, with several weeds having significant impact. Wandering Jew (Tradescantia fluminensis) and Galenia pubescens dominate large areas of the streambank, and balloon vine (Cardiospermum grandiflorum) is smothering native plants in the low tree and canopy strata. Castor oil plant (Ricinus communis) and fennel (Foeniculum vulgare) are also problematic. Although a fence is in place on the top of the streambank, it has fallen in several areas and is also being undercut by erosion.

2.0 Condition of Remnant 17

This remnant is one of the largest and most diverse in the study area, with an estimated area of 1.4 hectares and a relatively large core as a result of its non-linear shape. This remnant supports 60 to 80 mature river red gum trees. Natural recruitment of river red gums is occurring with an estimated 20 to 30 seedlings recorded. It is connected to the Hunter River corridor. Ecological condition assessment on 26 November 2009 scored 35 out of 39, based on the scoring system employed in (Umwelt 2008d), with minor canopy dieback and moderate natural regeneration and native diversity in the understorey. These strengths establish this remnant as a priority for restoration management in the study area.

The remnant is subjected to severe weed invasion of the ground cover and understorey, with some problematic weeds recorded including balloon vine (Cardiospermum grandiflorum), boxthorn (Lycium ferocissimum), wandering Jew (Tradescantia fluminensis) and African olive (Olea europaea subsp. cuspidata). These and other weeds occurring in the remnant have the ability to significantly limit native recruitment in all strata and jeopardise the ecological functions essential for long-term survival. Although this remnant is set on the floodplain on an inside meander of the Hunter River where sedimentation occurs and streambank erosion is a lesser issue, there was evidence of some floodplain stripping in the remnant. These disturbances have benefited rapid recruiting weeds such as wandering Jew (Tradescantia fluminensis).
3.0 Condition of Remnants 24 and 25

These remnants are one of the few floodplain river red gum stands in the study area with more than a few mature river red gum trees, therefore despite their relatively poor ecological condition, they are important sites for restoration and management. Although these two remnants are isolated from each other, they occur within the same landscape unit and their proximity to each other facilitates concurrent management. Additionally, they support about 20 mature river red gum trees, including several old growth trees that are highly reproductive and are an important seed source.

These remnants also occur immediately adjacent to successful plantings of younger river red gum and other native trees along the base of the nearby levee, which increases the size and connectivity of these remnants. Further management efforts should be aimed at broader connection of the plantings and remnants, creating a single river red gum stand with a deeper core.

These remnants scored a low 24 out of 39 in ecological condition assessment on 26 November 2009, reflecting their high levels of canopy dieback and weed invasion (of the understorey); low levels of native diversity and natural regeneration; and isolation. The community is reduced to a stand of scattered older trees of river red gum over a highly modified understorey of mainly exotic grasses. The low tree and shrub strata are absent. *Galenia pubescens*, castor oil plant (*Ricinus communis*), *Bromus cartharticus* and several other weeds are present in high numbers.

4.0 Condition of Remnant 54

This river red gum stand occurs on the streambank of Redbank Creek and has a relatively dry habitat compared to other river red gum sites in the study area that occur on the alluvial floodplain and major rivers. This remnant extends along Redbank Creek to Wollombi Brook, where it connects with a gallery forest of river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) with scattered stands of river red gum, which extends in a mostly unbroken line to the Hunter River.

This remnant supports 35 to 45 mature river red gum trees and natural recruitment is occurring with about 10 seedlings recorded. Ecological condition assessment on 26 November 2009 scored 32 out of 39, with the only negative features related to canopy age diversity and native diversity of mid strata. The low level of weed invasion, dieback and erosion and the good connectivity indicate that remediation efforts have a relatively higher likelihood of success in this location. Although weeds generally affect less than 10% of the remnant, *Galenia pubescens*, African boxthorn (*Lycium ferocissimum*) and balloon vine (*Cardiospermum grandiflorum*) dominate in thickets that have the potential to spread and significantly impact the community.

5.0 Condition of Remnant 51

This is a significant streambank remnant in the study area, supporting a floristic and structurally diverse community that would respond well to remedial management. This remnant supports about 15 mature river red gum trees on the south bank of Wollombi Creek and the small tributary that meets the river at this site. A large number of river red gum seedlings and young mature trees have established in a sandy deposition at the bottom of the stream, with an estimated 60 to 75 seedlings recorded. This remnant is part of the river forest corridor and is connected in both directions on Wollombi Brook. However, there is no floodplain vegetation adjacent to this site, so edge affects are significant due to the linear...
nature of the remnant. Additionally, cattle have full access to the site from the south and are causing bank erosion and soil enrichment.

Ecological condition assessment on 26 November 2009 scored 30 out of 39, with problems linked to stock grazing, weed invasion of the understorey, bank erosion and the linear shape of the remnant. However, the strengths of the remnant that establish it as a priority for restoration management include the low level of canopy dieback, the occurrence of natural regeneration of natives and its connection to the river corridor.

6.0 Condition of Remnant 53

This remnant is connected to remnant 51 and is in similar condition, although stock access is not an issue on the upper levels of the Wollombi Brook streambank. However, cattle do access the lower streambank at this location from the opposite side of the stream. This remnant supports a relatively large mature river red gum population on the north bank of Wollombi Brook that also extends along an ephemeral tributary that cuts through the floodplain at this location. The unit is in very poor condition on this floodplain stream due to cattle access, clearing and erosion. On this floodplain stream the community is reduced to scattered river red gum over a heavily grazed pasture.

The remnant on Wollombi Brook and the adjacent floodplain stream together supports 40 to 60 mature river red gum trees. About 10 mature trees grow on the floodplain stream and several older trees here have significant dieback. Natural recruitment of river red gum is occurring on the streambank and bed of Wollombi Brook with over 50 seedlings estimated to be present. The tree and seedling numbers may be higher than this since it was not possible to access some areas due to the very steep bank at this location. Two ecological condition assessments were carried out on 26 November 2009: (1) in the remnant along the floodplain stream and (2) in the remnant on Wollombi Brook streambank. The floodplain stream scored 26 out of 39 reflecting its high level of dieback, grazing pressure, weed invasion and low natural regeneration. The remnant on Wollombi Brook streambank remnant scored 30 out of 39, with less dieback and stock grazing found.

Several weeds of concern occur here including Galenia pubescens, balloon vine (Cardiospermum grandiflorum), African boxthorn (Lycium ferocissimum), wandering Jew (Tradescantia fluminescens) and African olive (Olea europaea subsp. cuspidata). These threaten native recruitment in all strata and the ecological functions essential for long-term survival.

7.0 Condition of Remnant 7

This remnant is on the north bank of the Hunter River adjacent to Carrington Billabong. It supports 30 to 50 mature river red gum trees with low levels of dieback. Fencing has already been constructed by Coal & Allied to connect this streambank remnant to Carrington Billabong and in the long term the goal is for the two remnants to become connected through regeneration (see Section 6.1.1). It scored 25 out of 39 in ecological assessment during April 2007. Erosion on the streambank is occurring and weeds are a significant problem, particularly in the understorey. This remnant has strengths in low dieback levels and connectivity through the Hunter River corridor.
8.0 Condition of Remnants 31, 32 and 33

These remnants include one floodplain remnant (31), and two streambank remnants: remnant 32 occurs on the southbank on the Hunter River and remnant 33 occurs on a backwater in an ancient meander of the Hunter River. These three remnants are connected and management should treat all together.

Remnant 31 is one of the few reasonably large floodplain stands of river red gum in the study area, with 21 mature and two old-growth trees recorded in April 2007. Although this remnant is highly modified, being reduced to scattered trees over a modified pasture, it has value through its connection to the adjacent river red gum remnants and its importance as one of the few floodplain remnants. Although the ecological condition assessment in 2007 was only 26 out of 39, and dieback was significant, these features make it a priority for restoration management. Fencing and stock control, with necessary weed management, needs to be maintained for the benefit of regeneration in this remnant.

Remnants 32 and 33 scored lower in the 2007 ecological assessment, with respective scores of 23 and 24. The main issues with these remnants include serious weed invasion and poor native diversity and regeneration. However, in 2007 grazing by cattle was ongoing. Stock access control and weed management should benefit these sites and encourage natural regeneration.
APPENDIX 2

Hunter Valley Operations South River Red Gum Rehabilitation and Restoration Implementation Plan
Appendix 2:
Hunter Valley Operations South River Red Gum Rehabilitation and Restoration Implementation Plan

March 2010
Appendix 2

Hunter Valley Operations River Red Gum Rehabilitation and Restoration Implementation Plan

Prepared by
Umwelt (Australia) Pty Limited
on behalf of
EMGA Mitchell McLennan

Project Director: Travis Peake
Project Manager: Liza Hill
Report No. 2730/R01/A2/Final Date: March 2010
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1.0 Introduction

Hunter Valley Operations (HVO) is an open cut mine located 24 kilometres north-west of Singleton in the Hunter Valley region of New South Wales. HVO is owned and operated by Coal & Allied Operations Pty Limited (Coal & Allied) and consists of Hunter Valley Operations South (HVO South) and Hunter Valley Operations North (HVO North) operations.

In accordance with approval conditions associated with the expansion to the Carrington Pit (HVO North Operations) and for the HVO South Project, Coal & Allied has developed the ‘HVO River Red Gum Rehabilitation and Restoration Strategy’ (Umwelt 2010), herein referred to the Strategy Document. The Strategy Document sets out a strategy to restore and rehabilitate the Carrington Billabong at HVO North, and to manage stands of river red gums (Eucalyptus camaldulensis) occurring along the Hunter River and Wollombi Brook at HVO South in accordance with the HVO South project approval (refer to Figure 1.2 of the Strategy Document).

This document has been developed to provide further guidance on the implementation of the strategy, particularly in relation to the targeted actions listed in Sections 5.0 of the Strategy Document. The management actions include increased maintenance activities, specific research and focussed monitoring which will all contribute to the rehabilitation and restoration of the river red gums and their associated environment across HVO South. The majority of management actions are related to the rehabilitation and restoration of Carrington Billabong, due to the high level of commitment focussed on the recovery of this site.

The following sections provide further information on each of these issues, as they pertain to Carrington Billabong, the priority sites, and the low priority sites.

Based on the outcomes of monitoring or as a result of the development or more effective rehabilitation and or restoration techniques, this document will be reviewed and updated accordingly.

2.0 Strategy for Carrington Billabong

2.1 Fencing and Access Control

The river red gums in Carrington Billabong have suffered extensively from the various impacts of grazing. Grazing by macropods, particularly the eastern grey kangaroo (Macropus giganteus), is extensive, particularly around the base of mature and immature river red gums.

Uncontrolled access by stock can result in the loss of biodiversity through limited natural regeneration, increased nutrients and tree damage through stock rubbing and soil erosion. Furthermore, human access could potentially result in damage to the site if unauthorised personnel entered and were unaware of the site’s environmental significance.

In order to manage stock and human access to the site, the establishment and maintenance of appropriate fencing is critical. Fencing may also facilitate the exclusion of pests, both native and introduced.

During the initial development of the Strategy it was proposed to undertake a two-step process to ensure that access to the site is controlled:

1. establish immediate restrictive fencing with locked access gates around the existing stand of river red gums; and
2. fence off a larger area by the beginning of autumn 2008 to facilitate the expansion of the remnant through regeneration and possibly revegetation.

This program has been completed (refer to Figure 3.1 of Strategy Document), with the resulting fenced area being substantial to facilitate the regeneration and revegetation of river red gum across a broad area connecting with the Hunter River.

The area will be appropriately signed and access to the billabong and regenerating area will be restricted in accordance with the following procedures:

- Environmental Procedure EP 5.1 – Rehabilitation; and

Coal & Allied will review monitoring results to determine if fencing that will restrict access by feral animals and macropods is necessary (macropod-proof fencing). This may reduce the impacts of grazing on juvenile eucalypts and groundcover, however the need for such fencing will be assessed through future monitoring.

### 2.2 Regeneration

The term ‘regeneration’ is used to identify areas where native vegetation will be allowed to return naturally to a particular area, generally by removing existing impacts such as weed density or physical disturbances such as grazing. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground-disturbing activities. Assisted regeneration will be employed where it is identified that passive regeneration is not successful.

Actions that may be used to assist in the passive regeneration of native vegetation will include:

- removal of stock;
- fencing to prevent access by stock and vehicles;
- restrictions to human access;
- signage to identify regeneration areas;
- selective weeding; and
- control of feral animals such as rabbits and goats.

Assisted regeneration will be employed based on the results of monitoring and may include:

- soil disturbance (ripping);
- supplementary seeding with locally collected native seed;
- tubestock planting of local provenance target species; and
- extensive weed removal.
Due to its disturbance history, much of Carrington Billabong is likely to require assisted regeneration. However, this should only commence if the outcomes of the monitoring (refer to Section 7.1 of Strategy Document), particularly the response to the effects of the June 2007 flood event, indicate this is necessary.

In particular the areas delineated for fencing closer to the Hunter River are more likely to need assisted revegetation due to their more substantial grazing and cropping history.

Consultation with Anglo Coal regarding their river red gum re-establishment program at Dartbrook is proposed to be undertaken to ensure that the results of artificial flooding are used to inform the recovery of the Carrington Billabong stand.

Revegetation planning will reference recent guides such as Schneider (2007) and Peake (2003) to ensure that appropriate revegetation techniques are employed to re-establish the floristic and structural diversity within the high conservation value Carrington Billabong.

2.3 Weed Control

Non-native plants (weeds) are widespread and abundant in Carrington Billabong. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration and modify habitat. Weeds may be classified as noxious or environmental. Noxious weeds are those listed under the *Noxious Weeds Act 1993.*

Weed density is likely to increase initially with increased fencing and the removal of stock. This may limit the natural regeneration of native plants. Weed control will be carried out to reduce the density of weeds to a point that allows natural regeneration to occur.

Weed monitoring is undertaken across the Coal & Allied properties on a six-monthly basis in relevant areas, or as directed by the Environmental Coordinator. Weed inspections and management will follow Environmental Procedure EP 10.2 – Flora and Fauna.

The focus of weed control will be on the noxious weeds identified at Carrington Billabong (see Umwelt 2008a), however, major environmental weeds will also be addressed where appropriate.

Several methods exist to control weeds in natural sites (refer to Table 2.1). These methods will be considered for application to Carrington Billabong and appropriate techniques will be employed to control or remove weeds. Advice will be sought from appropriate experts to determine which techniques are more appropriate for different parts of Carrington Billabong.
**Table 2.1 – Weed Control Techniques**

<table>
<thead>
<tr>
<th>Technique</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘Crash’ Grazing</td>
<td>‘Crash’ grazing comprises intense grazing of an area for a short period. Crash grazing can work effectively if stocking occurs during times when native ground cover species are dormant, such as in winter, resulting in the directed grazing of introduced species. Adequate permanent and temporary fencing is required for this method to work effectively and to ensure that juvenile trees are not grazed. Crash grazing must be limited to periods when the wetland is dry, or access to wet areas must be restricted through the use of temporary fencing.</td>
</tr>
<tr>
<td>Selective Hand Picking</td>
<td>The aim of this method is to create as little disturbance to the soil as possible and to avoid damage to all native species. Selective hand picking of weed species is labour-intensive but is generally very effective and only target weed species are removed.</td>
</tr>
<tr>
<td>Weed Mats or other</td>
<td>The use of weed mats may be necessary in the event that supplementary plantings of river red gums are necessary. In this case weeds mats (or hay, mulch or old sacks) would be placed one metre around the base of each seedling for the first two years to allow plants to develop strong root systems free of competition. The need for weed matting will be assessed if planting is necessary, and if monitoring or other expert advice determines that they are necessary. Weed mats will also suppress natural regeneration, so they would only be used selectively such as around native seedlings.</td>
</tr>
<tr>
<td>Suppressants</td>
<td></td>
</tr>
</tbody>
</table>
| Herbicide Application       | Herbicides may be used to control problematic weeds that are not able to be managed through mechanical means. Herbicide use will consider:  
  • native plant sensitivity to chemicals;  
  • manufacturer’s directions;  
  • weather conditions (no spraying on windy or wet days);  
  • potential days of dry weather following application;  
  • appropriate method for application e.g. foliar spray, wiper, injection, cut stump, drill-and-fill, frilling, basal bark, and bark strip-and-paint;  
  • the appropriate herbicide type and application method will be determined by the weed species to be targeted;  
  • location of water bodies and watercourses (herbicides can cause unwanted damage to non-target plants and other non-target organisms such as frogs and aquatic life, as well as causing water contamination which will affect landholders and water users downstream); and  
  • herbicide mobility, persistence and toxicity.  
  
  The use of a weed control method other than herbicides will be considered if there is a reasonable likelihood of damage to non-target organisms in or around a water course. If herbicide use is undertaken in proximity to water course the guidelines for herbicide use in and around water (Ainsworth and Bowcher 2005) will be taken into consideration.                                      |
2.4 Pest Control

Pests impacting the Carrington Billabong and river red gums include hares, rabbits, insect and fungus. In addition wild dogs, foxes and cats can impact upon the native fauna. Pest control techniques are discussed in Table 2.2.

Table 2.2 – Pest Control Techniques

<table>
<thead>
<tr>
<th>Pest</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabbit and Hare</td>
<td>Infestations of rabbits and hares can result in the loss of ecosystem biodiversity through grazing and the construction of warrens. Where appropriate, rabbits and hares will be controlled through a number of means such as disease, poisoning and warren destruction. If rabbit or hare numbers are considered high enough to warrant control of these species the use of 1080 poison (sodium monofluoracetate) combined with warren destruction will be considered, as it is likely to provide the most effective outcome. 1080 poison would only be used under the supervision of a suitably qualified operator and all carcasses would be collected to prevent poisoning of predators. Warren destruction will prevent rabbits surviving the summer months and rearing young and is highly labour intensive and results in severe soil disturbance.</td>
</tr>
<tr>
<td>Insect and Fungus</td>
<td>Insect and fungus attacks can contribute to tree dieback, especially in trees that are in highly stressed situations, and are usually indicators of an unhealthy ecosystem which is unable to cope with attacks by these organisms. In rural areas, tree dieback is often caused by repeated defoliation by native insects. Trees that have suffered severe defoliation can then become susceptible to fungi, which cause lesions in the branches, causing them to suffer dieback. Tree dieback resulting from insect or fungus attacks should be closely monitored and addressed if a serious problem becomes evident. The management of insect and fungus infestation in particular, and tree dieback in general, at Carrington Billabong will use the principles recommended by Nadolny (2000), that is focusing on retaining as many juvenile eucalypts as possible, controlling livestock access and increasing fauna habitat and structural diversity of vegetation to encourage a diversity of wildlife species.</td>
</tr>
<tr>
<td>Wild Dogs, Foxes and Cats</td>
<td>Wild dogs, foxes and cats are predatory species and can result in the decline of native fauna in the area, resulting in a reduced level of biodiversity. Control of these feral populations would be managed through an ongoing trapping and 1080 baiting program to ensure the numbers of these populations are kept at a minimum to allow for an increase in biodiversity in the area.</td>
</tr>
</tbody>
</table>

2.5 Seed Harvesting and Propagation

If planting is required in Carrington Billabong, it is proposed to use local provenance species whose seeds are collected from within Carrington Billabong or other nearby similar stands of river red gum. Regardless of whether planting is undertaken in Carrington Billabong, it is proposed to use the site for seed harvesting to assist in the rehabilitation of other relevant sites at Coal & Allied.

Any seed collection will be undertaken in accordance with Environmental Procedure EP10.2 – Flora and Fauna.
2.6 Other Potential Future Actions

During the implementation of the Strategy, it is possible that alternative management actions are identified and considered appropriate to implement to assist with the rehabilitation and restoration of Carrington Billabong. The implementation of the Strategy must therefore be flexible and be able to respond to new information.

While it is not possible at this stage to predict what further actions will be required, Table 2.3 indicates what actions may be considered in the near future.

Table 2.3 – Future Opportunities for Management Actions

<table>
<thead>
<tr>
<th>Opportunity</th>
<th>Detail</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revegetation</td>
<td>Revegetation of Carrington Billabong, by means other than passive ones such as natural regeneration, will be used if it is determined that river red gums are not recruiting adequately. Revegetation will take the form of either tubestock planting, or direct seeding, or both, and adequate water will be provided to seedlings. If undertaken, Coal &amp; Allied propose to use local provenance material that is collected as seed from Carrington Billabong, or other nearby river red gum remnants, in order to maintain genetic integrity.</td>
</tr>
<tr>
<td>Artificial Flooding</td>
<td>Artificial flooding has been considered by Coal &amp; Allied to provide nourishment to seedlings and help reduce competition from weed species by causing their death from inundation. As the volume of water likely to be required to simulate natural flooding is likely to be substantial, endorsement from DECCW would be required. Advice received from DECCW staff (H. Robertson and A. McIntyre pers. comm. 2007) during the development of the initial draft Strategy indicates that irrigating the site, except for the irrigation of tubestock or direct seeded plant, is not appropriate unless the supply of water is very substantial and is able to inundate Carrington Billabong for lengthy periods of time, presumably at least weeks and preferably months. At the present time there is not the appropriate capacity required to supply river water in the volume required.</td>
</tr>
<tr>
<td>Fauna Diversity and Fauna Habitat Monitoring</td>
<td>Coal &amp; Allied will consider any benefit that might be derived from monitoring select fauna species and key habitat features, such as tree hollows and the presence of bird perching sites and logs. The assessment of fauna species would rely on recording readily available data, and would most likely comprise the monitoring of birds, frogs, mammals and signs of fauna usage. The collection of such data could be useful in assessing the provision of habitat to fauna species and how it changes over time as Carrington Billabong is rehabilitated.</td>
</tr>
<tr>
<td>Establishment of Trial Sites</td>
<td>Coal &amp; Allied will consider the establishment of trial sites at Carrington Billabong and the application of various management treatments. If trials are established these will be done with appropriate consideration of any existing or previous trials carried out by others (e.g. at Dartbrook). The types of trial management regimes that may be considered include weeding, watering (irrigation or inundation), planting and pest control, as well as combinations of the above.</td>
</tr>
</tbody>
</table>
3.0 Strategy for Priority Sites

3.1 Fencing and Access Control

River red gums at many sites at HVO South, particularly those occurring on floodplains, have suffered extensively from the various impacts of grazing. Grazing by macropods, particularly the eastern grey kangaroo (*Macropus giganteus*), is extensive, particularly around the base of mature and immature river red gums.

Uncontrolled access by stock can result in the loss of biodiversity through limited natural regeneration, increased nutrients and tree damage through stock rubbing and soil erosion. Furthermore, human access could potentially result in damage to the site if unauthorised personnel entered and were unaware of the site’s environmental significance.

In order to manage stock and human access to the sites, the establishment and maintenance of appropriate fencing is critical. Fencing may also facilitate the exclusion of pests, both native and introduced.

Coal & Allied will undertake a review of the existing fencing around the priority sites and will seek to establish or upgrade, where required, fencing to restrict stock access. Fencing will be located appropriately to enable remnants to expand naturally over time through natural regeneration, and will avoid areas at high risk of damage from floods and erosion.

The areas will be appropriately signed and access to the stands will be restricted in accordance with the following procedures:

- Environmental Procedure EP 5.1 – Rehabilitation; and

Coal & Allied will review any future monitoring results to determine the effectiveness of fencing, and will undertake regular maintenance inspections and works to ensure that fences are sound and working as designed.

3.2 Regeneration

The term ‘regeneration’ is used to identify areas where native vegetation will be allowed to return naturally to a particular area, generally by removing existing impacts such as weed density or physical disturbances such as grazing. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground-disturbing activities.

Actions that may be used to assist in the passive regeneration of native vegetation will include:

- removal of stock;
- fencing to prevent access by stock and vehicles;
- restrictions to human access;
- signage to identify regeneration areas;
- selective weeding; and
• control of feral animals such as rabbits.

Coal & Allied will consider the use of assisted regeneration based on the results of monitoring. This may include:

• soil disturbance (ripping);
• supplementary seeding with locally collected native seed;
• tubestock planting of local provenance target species; and
• extensive weed removal.

3.3 Weed Control

Non-native plants (weeds) are widespread and abundant at most priority sites. Many of these species occur in riparian zones, and the control of such weeds is difficult because propagules of weeds enter the Coal & Allied properties via transport down the Hunter River and Wollombi Brook. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration and modify habitat. Weeds may be classified as noxious or environmental. Noxious weeds are those listed under the Noxious Weeds Act 1993.

Weed density is likely to increase initially at those sites where increased fencing is required and stock are removed. This may limit the natural regeneration of native plants. Weed control will be carried out to reduce the density of weeds to a point that allows natural regeneration to occur.

Weed monitoring is undertaken across the Coal & Allied properties on a six-monthly basis in relevant areas, or as directed by the Environmental Coordinator. Weed inspections and management will follow Environmental Procedure EP 10.2 – Flora and Fauna.

The focus of weed control will be on noxious weeds, however major environmental weeds will also be addressed where appropriate. The weed control technique to be employed will depend on the weeds requiring control and the advice given by weed specialists. The techniques outlined in Table 2.1 will be considered as appropriate.

3.4 Pest Control

Pests impacting priority sites include hares, rabbits, insect and fungus. In addition wild dogs, foxes and cats can impact upon the native fauna. Pest control will be undertaken in accordance with Environmental Procedure EP 10.2 – Flora and Fauna, and will consider the range of approaches outlined in Table 2.2.

3.5 Seed Harvesting and Propagation

If planting is required at any priority sites, it is proposed to use local provenance species whose seeds are collected from within the target site or other nearby similar stands of river red gum. Any of the priority sites could potentially be used for seed harvesting to assist in the rehabilitation of other relevant sites at Coal & Allied.
Any seed collection will be undertaken in accordance with Environmental Procedure EP10.2 – Flora and Fauna.

3.6 Other Potential Future Actions

During the implementation of the Strategy, it is possible that alternative management actions are identified and considered appropriate to implement to assist with the management of priority sites. The Strategy must therefore be flexible and be able to respond to new information. Any new information regarding site management or river red gum management that is obtained in future, particularly as part of the restoration and rehabilitation of Carrington Billabong, will be applied in the management of the priority sites, where appropriate.

4.0 Strategy for Low Priority Sites

4.1 Fencing and Access Control

Some of the low priority sites are fenced off from grazing, or do not have any active stock grazing present, while others are grazed or partially grazed. Some sites occur where there are natural barriers preventing the intrusion of stock. For those sites that are currently fenced, or will require fencing in future for other purposes, Coal & Allied will ensure that all fences are appropriately designed for the task and maintained properly. Fences are regularly monitored to ensure that they are in a good state of repair.

4.2 Regeneration

The term ‘regeneration’ is used to identify areas where native vegetation will be allowed to return naturally to a particular area, generally by removing existing impacts such as weed density or physical disturbances such as grazing. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground-disturbing activities.

Actions that may be used to assist in the passive regeneration of native vegetation will include:

- maintenance of fencing to ensure stock exclusion, where appropriate fencing already exists;
- selective weeding; and
- control of feral animals such as rabbits and goats.

4.3 Weed Control

Non-native plants (weeds) are widespread and abundant in many stands of river red gums across HVO. Many of these species occur in riparian zones, and the control of such weeds is difficult because propagules of weeds enter the Coal & Allied properties via transport down the Hunter River and Wollombi Brook. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration
and modify habitat. Weeds may be classified as noxious or environmental. Noxious weeds are those listed under the *Noxious Weeds Act 1993*.

Weed monitoring is undertaken across the Coal & Allied properties on a six-monthly basis in relevant areas, or as directed by the Environmental Coordinator. Weed inspections and management will follow Environmental Procedure EP 10.2 – Flora and Fauna.

The focus of weed control is the noxious weeds, however, major environmental weeds will also be addressed where appropriate.

The weed control technique to be employed will depend on the weeds requiring control and the advice given by weed specialists. The techniques outlined in Table 2.1 will be considered as appropriate.

### 4.4 Pest Control

Pests impacting low priority sites include hares, rabbits, insect and fungus. In addition wild dogs, foxes and cats can impact upon the native fauna. Pest control will be undertaken in accordance with Environmental Procedure EP 10.2 – Flora and Fauna, and will consider the range of approaches outlined in Table 2.2.

### 4.5 Seed Harvesting and Propagation

If planting is undertaken at any of the low priority sites it is proposed to use local provenance species whose seeds are collected from within the target site or other nearby similar stands of river red gum. Any of these sites could potentially be used for seed harvesting to assist in the rehabilitation of other relevant sites at Coal & Allied.

Any seed collection will be undertaken in accordance with Environmental Procedure EP10.2 – Flora and Fauna.
APPENDIX 3

Preliminary Completion Criteria and Performance Measures for Carrington Billabong and HVO South Priority Sites
Appendix 3 – Preliminary Completion Criteria and Performance Measures for Carrington Billabong and HVO South Priority Sites

Table 1 – Preliminary Completion Criteria and Performance Measures for Carrington Billabong

<table>
<thead>
<tr>
<th>Management Issue</th>
<th>Preliminary 10-year Completion Criteria</th>
<th>Year 5 Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revegetation and Regeneration</td>
<td>Native species assemblages within Carrington Billabong are improved as compared to Year 5 results.</td>
<td>Native species assemblages within Carrington Billabong are showing evidence of the potential to progress towards those of the target vegetation community, a healthy open woodland dominated by river red gum, with other occasional floodplain trees and shrubs, with a diverse groundcover that is not dominated throughout by weeds.</td>
</tr>
<tr>
<td></td>
<td>The remnant displays:</td>
<td>The remnant displays:</td>
</tr>
<tr>
<td></td>
<td>• juveniles in various strata (1-5 years/5-10 years/10-15 years);</td>
<td>• increase in recruitment numbers of river red gum juveniles (&lt; 5 year old);</td>
</tr>
<tr>
<td></td>
<td>• evidence of natural regeneration of native species;</td>
<td>• at least 50% of juveniles monitored during baseline survey remain;</td>
</tr>
<tr>
<td></td>
<td>• evidence of increase in native species in the ground stratum compared to Year 5 results; and</td>
<td>• evidence of natural regeneration of other native species; and</td>
</tr>
<tr>
<td></td>
<td>• each stratum is dominated by native species.</td>
<td>• suitable areas are available to promote regeneration.</td>
</tr>
<tr>
<td>Ecological Condition of Remnant</td>
<td>The monitored remnant shows no net loss in extent or quality from Year 5 results unless unavoidable external factors have contributed towards a decline.</td>
<td>The remnant shows an overall improvement in condition compared to baseline results (consider grazing and feral animal impacts).</td>
</tr>
<tr>
<td></td>
<td>The canopy cover of river red gum is higher than Year 5 results, unless unavoidable external factors have contributed towards a decline.</td>
<td>The canopy cover of river red gum is higher than that recorded in the baseline survey, unless unavoidable external factors have contributed towards a decline.</td>
</tr>
<tr>
<td>Fauna Diversity and Habitat</td>
<td>Improvement of diversity of habitat to encourage native fauna species compared to results from Carrington Pit Extension SEE Ecology Survey.</td>
<td>If there is the loss of more than 10% of tree hollows through tree-fall then nest boxes are erected to ensure no further overall loss of hollows.</td>
</tr>
<tr>
<td>Surface Water</td>
<td>Rehabilitation of mining activities north of the billabong in progress.</td>
<td>Mining activities are not impacting on the surface area of the billabong in relation to sediment and erosion.</td>
</tr>
<tr>
<td>Groundwater</td>
<td>The barrier wall has been installed.</td>
<td>Groundwater and pit seepage monitoring results are reviewed biannually.</td>
</tr>
</tbody>
</table>
Table 1 – Preliminary Completion Criteria and Performance Measures for Carrington Billabong (cont)

<table>
<thead>
<tr>
<th>Management Issue</th>
<th>Preliminary 10-year Completion Criteria</th>
<th>Year 5 Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fencing and Access Control</strong></td>
<td>Fencing to protect the billabong, remnants and regeneration areas is established and maintained.</td>
<td>Stock-proof fences are installed to protect the billabong and regenerating areas, but enable appropriate native fauna movement and protection.</td>
</tr>
<tr>
<td><strong>Pest and Weed Management</strong></td>
<td>Pest and weed control program is effective and does not require increased management.</td>
<td>Pest and weed control inspections program occurs biannually. Weed control is implemented as required.</td>
</tr>
<tr>
<td><strong>Final Landform and Drainage</strong></td>
<td>The surface water catchment area for the billabong is reinstated in accordance with the Carrington Pit Mining Operations Plan.</td>
<td>Carrington Pit Mining Operations Plan is reviewed to ensure final landform includes surface water drainage for the billabong.</td>
</tr>
</tbody>
</table>

Table 2 – Preliminary Performance Criteria and Measures for Priority Sites

<table>
<thead>
<tr>
<th>Management Issue</th>
<th>Preliminary 10-year Performance Criteria</th>
<th>Year 5 Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Regeneration</strong></td>
<td>Native species assemblages at each site are improved as compared to Year 5 results.</td>
<td>Native species assemblages at each site are showing evidence of the potential to progress towards those of the target vegetation community, a healthy open woodland dominated by river red gum, with other occasional floodplain trees and shrubs, with a diverse groundcover that is not dominated throughout by weeds.</td>
</tr>
<tr>
<td></td>
<td>The remnant displays:</td>
<td>The remnant displays:</td>
</tr>
<tr>
<td></td>
<td>• juveniles in various strata.</td>
<td>• increase in recruitment numbers of river red gum juveniles (&lt;5 years old) and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• suitable areas are available to promote regeneration.</td>
</tr>
<tr>
<td><strong>Ecological Condition of Remnant</strong></td>
<td>The monitored remnant shows no net loss in extent or quality from Year 5 results unless unavoidable external factors have contributed towards a decline.</td>
<td>The remnant shows an overall improvement in condition compared to baseline results (consider grazing and feral animal impacts).</td>
</tr>
<tr>
<td></td>
<td>The canopy cover of river red gum is higher than Year 5 results, unless unavoidable external factors have contributed towards a decline.</td>
<td>The canopy cover of river red gum is higher than that recorded in the baseline survey, unless unavoidable external factors have contributed towards a decline.</td>
</tr>
</tbody>
</table>
Table 2 – Preliminary Performance Criteria and Measures for Priority Sites (cont)

<table>
<thead>
<tr>
<th>Management Issue</th>
<th>Preliminary 10-year Performance Criteria</th>
<th>Year 5 Performance Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Surface Water</strong></td>
<td>Mining activities are not impacting the sites in relation to water supply, sediment and erosion.</td>
<td>Mining activities are not impacting the sites in relation to water supply, sediment and erosion.</td>
</tr>
<tr>
<td><strong>Fencing and Access Control</strong></td>
<td>Stock-proof fences are appropriately maintained and inspected on a regular basis.</td>
<td>Stock-proof fences are installed around sites, including enough area around stands to allow for suitable regeneration-based expansion of the sites. Fencing will enable appropriate native fauna movement and protection.</td>
</tr>
<tr>
<td><strong>Pest and Weed Management</strong></td>
<td>Pest and weed control program is effective and does not require increased management.</td>
<td>Pest and weed control inspections occur biannually. Weed control is implemented as required.</td>
</tr>
</tbody>
</table>