Environmental Protection Authority

Guidance for the Assessment of Environmental Factors

(in accordance with the Environmental Protection Act 1986)

Rehabilitation of Terrestrial Ecosystems

No. 6

June 2006

Western Australia

FOREWORD

The Environmental Protection Authority (EPA) is an independent statutory authority and is the key provider of independent environmental advice to Government. The EPA's objectives are to protect the environment and to prevent, control and abate pollution and environmental harm. The EPA aims to achieve some of this through the development of environmental protection Guidance Statements.

This document is one in a series being issued by the EPA to assist proponents, consultants and the public generally to gain additional information about the EPA's thinking in relation to aspects of the EIA process and effective environmental management. The Guidance Statements assist proponents to achieve environmentally acceptable proposals and management plans. Consistent with the notion of continuous environmental improvement and adaptive environmental management, the EPA expects proponents to take all reasonable and practicable measures to protect the environment and to view the requirements of this Guidance as representing the minimum standards necessary for rehabilitation of ecosystems. This document is also designed to assist proponents to meet requirements of environmental auditing of completion criteria for such projects.

Whilst the EPA has provided this guidance to encourage best practice in setting appropriate and effective objectives for rehabilitation and assessing subsequent outcomes, it is conscious that the process has highlighted the need for additional knowledge to achieve such goals. Of particular importance is the role of long-term research in rehabilitated habitats to investigate the recovery of fauna and key ecosystem processes. It has also become apparent that more effective collaborations between proponents and responsible authorities will help to ensure effective rehabilitation of Western Australian habitats occurs in all cases. The overall objective of this process is to ensure the return of biodiversity in rehabilitated areas by the reestablishment of self-sustaining and functional ecosystems comprised of local provenance species.

This guidance:

- applies to terrestrial habitats and wetlands, excluding aquatic ecosystems such as lakes, estuaries and marine habitats;
- concerns land clearing where natural ecosystems will be reinstated;
- focuses on effective use of completion criteria to measure biodiversity in rehabilitation projects; and
- addresses general principles only. Additional consultation is required for project specific advice.

While guidance is provided specifically in relation to the Western Australian *Environmental Protection Act 1986*, proponents are reminded of any responsibilities they may have in regard to this issue under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*, the State *Mining Act 1978, the Conservation and Land Management Act 1984,* any other relevant Commonwealth and State Acts, as well as State Agreement Acts for individual proponents. The flowchart below shows the relationship between relevant Position Statements and this and other relevant Guidance Statements.

EPA Position Statements:
No. 2 Environmental Protection of Native Vegetation in Western Australia;
No.3 Terrestrial Biological Surveys as an element of Biodiversity Protection;
No. 5. Environmental Protection and Sustainability in Rangelands in WA;
No. 7 Principles of Environmental Protection;
No 9 Environmental Offset;

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EPA Guidance Statements

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Guidance No. 51 Flora and Vegetation Surveys	Guidance No. 56 Fauna Surveys	**Guidance No. 6 Rehabilitation of Terrestrial Ecosystems**	Guidance No. 10 Level of assessment for proposals in System 6 and part of System 1

This Guidance Statement has the status of "**Final**" which means it has been reviewed by stakeholders and the public. The EPA has signed off the Guidance Statement and published it although it will be updated regularly as required.

Walter Cox

CHAIRMAN

ENVIRONMENTAL PROTECTION AUTHORITY

26 June 2006

Contents

ACRONYMS

EPA	The Environmental Protection Authority
DEC	Effective 1 July 2006, the Department of Environment (DoE) and Conservation and Land Management (CALM) combined to form the new Department of Environment and Conservation (DEC)
DoIR	Department of Industry and Resources
EIA	Environmental Impact Assessment
WA	Western Australia
ANZMEC	Australian and New Zealand Minerals and Energy Council
SER	Society for Restoration Ecology International

Guidance Statement No. 6

Rehabilitation of Terrestrial Ecosystems

Key Words: rehabilitation, restoration, revegetation, disturbance, clearing, natural ecosystems, biodiversity, natural resources, mining, completion criteria, environmental impact assessment, monitoring, auditing

1. INTRODUCTION

1.1 Purpose

The primary purpose of this Guidance Statement is to ensure the return of biodiversity in rehabilitated areas by increasing the quality, uniformity, and efficiency of standards and processes for rehabilitation of native vegetation in Western Australia and to allow more effective monitoring and auditing of outcomes.

The Guidance Statement promotes the use of completion criteria and definitions for the rehabilitation of natural ecosystems which (i) allow success to be measured within realistic timeframes (ii) are sufficiently precise to allow outcomes to be effectively audited, but are also flexible when required, (iii) are based on sound scientific principles and (iv) acknowledge the consequences of permanent changes to landforms, soils and hydrology. These include standard criteria that apply to all projects, as well as site specific criteria used to measure the recovery of ecosystems relative to reference sites. Other key areas of discussion are the importance of scientific research and long-term monitoring of outcomes and effective management of information required to measure outcomes.

The generic process for publication of Guidance Statements is set out in Appendix 1. All of the Tables referred to in this document are located in Appendix 2 and case studies are summarised in Appendix 3.

This Guidance should be used when preparing documentation for the environmental impact assessment process of the Environmental Protection Authority (EPA). It should also be used to help produce management plans to rehabilitate vegetation that require EPA or Department of Environment and Conservation (DEC) approval. Management plans for mining projects will normally also require approval by the Department of Industry and Resources (DoIR).

Objectives of this Guidance Statement:

- promote greater awareness of the major limitations to rehabilitation success in WA and environmental impacts of permanent changes to ecosystems;

- contrast internationally recognised standards for assessing rehabilitation outcomes with those in current use in Western Australia;
- provide the general standards and a common framework for setting rehabilitation objectives for environmental impact assessment (EIA) in Western Australia;
- propose more uniform standards for the analysis, interpretation and reporting of outcomes for auditing purposes and greater accessibility of data;
- acknowledge the importance of scientific knowledge as a basis for effective rehabilitation; and
- list sources of further information and summarise stakeholder roles and responsibilities.

1.2 Policy context

1.2.1 State legislation

1.2.1.1 Environmental Protection Act 1986

This Act (EP Act) regulates many of the processes relevant to Environmental Impact Assessment (EIA) and auditing of projects where vegetation is cleared and rehabilitated. Environmentally significant projects are assessed by the Environmental Protection Authority (EPA) under Part 4 of the EP Act. The Act and the Regulations can be downloaded from the State Law Publisher (www.slp.wa.gov.au).

On 1 July 2005 The Department of Industry and Resources (DoIR) gained delegated responsibility for the administration, assessment and approval of native vegetation clearing permits for mineral and petroleum activities in Western Australia (www.doir.wa.gov.au/environment). The Department of Environment and Conservation (DEC) regulates native vegetation clearing associated with all other activities. A Memorandum of Understanding between DoIR and the EPA provides guidance as to when mineral and petroleum proposals should be referred to the EPA.

1.2.1.2 State Mining Act 1978 and Petroleum Acts 1967-1982

The Mining Act 1978, The Onshore Petroleum Act 1967 and Petroleum Pipelines Act 1969 are relevant to resource development projects where rehabilitation occurs. These acts are administered by DoIR. Detailed information on processes relevant to rehabilitation are available on the DoIR website (www.doir.wa.gov.au).

1.2.1.3 Other legislation in Western Australia

A range of other legislation is relevant to natural ecosystems in Western Australia. These include the Conservation and Land Management (CALM) Act 1984, and the Wildlife Conservation Act 1950, as well as State Agreement Acts for individual proponents. The Agriculture and Related Resources Protection Act 1976 and Noxious Weeds Regulations 1973 may also be relevant. Local Government also has a role in regulating projects.

1.2.2 The Commonwealth Environment Protection and Biodiversity Conservation Act 1999

Under this Act (EPBC Act), a proponent whose actions have a potential significant impact on a matter of National Environmental Significance must be referred to the Commonwealth Minister for the Environment for a decision as to whether assessment is required under the provisions of that Act. A bilateral agreement has been reached between Western Australia and the Commonwealth about approval under the EPBC Act. It is available on the Australian Government Department of Environment and Heritage web site (www.deh.gov.au/epbc).

1.2.3 National policy context

The State has committed to an agreed framework, principles and objectives for the protection of biodiversity with the adoption of the National Strategy for Ecologically Sustainable Development (Commonwealth of Australia 1992) and subsequently the National Strategy for the Conservation of Australia's Biological Diversity (Commonwealth of Australia 1996).

1.2.4 Related policies of the Environmental Protection Authority

1.2.4.1 Position Statement No. 2 on the protection of native vegetation

This statement outlines EPA policy on the protection of native vegetation in Western Australia, particularly in the agricultural area (EPA 2000).

1.2.4.2 Position Statement No. 3 on terrestrial biological surveys

This document concerns the use of biological surveys to assess the significance of biodiversity in Western Australia (EPA 2002).

1.2.4.3 Position Statement No. 7 Principles of environmental protection

This document includes key principles such as the precautionary principle, conservation of biological diversity, ecological integrity, shared responsibility, integrated environmental management, best practice, continuous improvement, accountability, transparency and enforcement, which are of particular relevance to this Guidance Statement (EPA 2004a).

1.2.4.4 Position Statement No. 9 Environmental offsets

This document summarises principles concerning the use of offsets to mitigate adverse environmental impacts (EPA 2005b).

1.2.4.5 Other position and guidance statements

Position Statement No. 6 - Towards Sustainability is relevant to projects where land is rehabilitated (EPA 2004d). Position Statements No. 4 - Environmental Protection of Wetlands (EPA 2005a), and No. 5 Environmental Protection and Ecological Sustainability of the Rangelands in Western Australia (EPA 2004e) are also relevant in certain circumstances. Guidance Statement 10 - Level of assessment for proposals affecting natural areas within System 6 region and the Swan Coastal Plain portion of the System 1 Region (EPA 2006) is relevant to proposals in those areas.

1.2.5 Other government policies

State and Commonwealth government departments listed in Table 2, provide relevant policy guidelines. The DoIR website provides information relevant to many rehabilitation projects. DEC provides guidance concerning dieback management, rare and priority flora and fauna species, significant plant communities, and rehabilitation of disturbed land. The WA Department of Agriculture provides guidance on weed management, soils and land capability assessment. Other relevant Western Australian Government Policies include the State Weed Plan (Department of Agriculture 2001b) and dieback management guidelines (CALM 2002).

1.3 Limitations of this Guidance

This Guidance Statement:

- concerns the rehabilitation of terrestrial ecosystems, including wetlands, but not aquatic or marine habitats;
- concerns cases of major disturbance to terrestrial ecosystems resulting from human activities where it is anticipated that native vegetation will be rehabilitated;
- does not concern land use change for natural resource management;
- primarily concerns the management of biodiversity, especially terrestrial vascular plants, but also concerns the re-establishment of habitats for animals, fungi and microorganisms;
- does not directly concern management of the abiotic rehabilitation environment (e.g. landform reconstruction);
- does not address more proposal-specific issues, which are the preserve of scoping statements or approved management plans;
- concerns effective monitoring and auditing of compliance with environmental conditions;
- applies to Western Australia;
- is the contemporary view of the EPA until such time as this document is subject to review;
- is not an instrument for predicting outcomes of deliberations by the EPA; and
- applies to proposals yet to come before the EPA.

2 BACKGROUND

The terms revegetation, restoration and rehabilitation refer to the process of returning vegetation to a *previous* or *normal* condition and *healthy* state (Section 6). However, most proponents and scientists view restoration to be distinct from ‘rehabilitation’ or ‘reclamation’ in that the latter activities do not necessarily lead to the recreation of pre-existing indigenous ecosystems (Cairns 1995, Lubke & Avis 1999, McDonald 2000). Restoration attempts to return vegetation to its original state, while rehabilitation acknowledges that vegetation will be permanently altered, but seeks to return a self-sustaining native plant community that is as close to the original as possible. The definition of rehabilitation used in this Guidance Statement is consistent with industry practice in WA and the majority of international practitioners (McDonald 2000, SER 2004).

Objectives and benchmarks for success (completion criteria) will necessarily vary between projects, depending on the degree of modification of landforms, the scale of projects, the local context and the types of plant communities to be rehabilitated. Full restoration of original plant communities is usually not possible due to permanent changes to landforms, soils and hydrology and projects are usually not monitored over sufficient timeframes to ascertain that ecosystems have fully recovered. Thus, while successful rehabilitation is required in every case, restoration is an aspirational target that is not fully achievable in most cases.

A key aim of rehabilitation is to ensure the long-term stability of soils, landforms and hydrology required for the sustainability of sites (Section 3.3). The second main purpose of rehabilitation is to partially or fully repair the capacity of ecosystems to provide habitats for biota and services for people (see Section 3.4.2). Consequences of failure to rehabilitate natural ecosystems to appropriate standards can include:

1. Reduction in the quality and quantity of habitats for plants, animals, fungi and microbes resulting in net loss of biodiversity.
2. Reductions in essential ecosystem functions such as carbon sequestration, water table stabilisation, etc.
3. Impacts on adjacent natural vegetation due to weed invasion, changes to hydrology, loss of connectivity, etc.
4. Environmental hazards and management costs that must be borne by society.
5. Reductions in the economic values of sites (forestry, grazing, tourism, etc.).
6. Loss of visual amenity and heritage values.
7. Failure to meet environmental conditions/commitments requiring additional remediation work or loss of bonds.
8. Loss of image and reputation for proponents.

In a resource-rich state like Western Australia, rehabilitation is an important component of managing minesites responsibly. A historical view of standards and practices pertaining to the rehabilitation of mines in Western Australia shows a gradual increase in standards expected and required over time, from past examples where abandonment without remediation occurred in many cases, to the current situation where rehabilitation to a high standard is expected and required

(Farrell 1993, Tacey et al. 1993, Allen et al. 2001). This has coincided with an increasing role of the EPA, DoIR, and DEC in planning and management. It is now common for projects to have Ministerial Conditions that specify requirements for Environmental Management Plans (Independent Review Committee 2002). Other changes include more stringent requirements concerning management of contaminated sites (tailings and waste rock dumps), licensing of pollutants in air, water or solid waste and water use licensing (Farrell 1993).

The EPA helps to ensure effective environmental management of projects. DoIR is the lead responsible agency for the majority of mining and petroleum projects where rehabilitation occurs. DEC provides advice in relation to management of the conservation reserve system, State Forest and other land managed under the CALM Act, as well as advice on biodiversity and rehabilitation techniques generally. Other key stakeholders for rehabilitation projects include local government and reference groups established to oversee State Agreement Acts, as well as landowners and pastoral leaseholders.

2.1 Diversity of flora, vegetation and landforms and other constraints to effective rehabilitation in Western Australia

Western Australia has a wide diversity of landscapes, soils and climates which support a highly diverse flora with many endemic species (CALM 2004b, Hopper & Gioia 2004). The Southwest of WA is a centre of exceptionally high plant species richness and endemism and is one of the world's 25 biodiversity hotspots which are conservation priorities (Meyers et al. 2000). The high biodiversity in this region is thought to result from a long evolutionary history without major tectonic disturbance or glaciation, which has allowed Gondwanan relics to coexist with more recently evolved species adapted to highly infertile soils and periodic disturbances such as fire (Hopper & Gioia 2004).

In addition to the southwest botanical province, recent surveys have revealed high levels of plant biodiversity and endemism in parts of the Pilbara, Kimberly and Goldfields regions of WA. The significance of species and communities is often poorly known due to the lack of regional surveys in these areas (CALM 2002).

Factors with the potential to limit effective rehabilitation of vegetation in WA are listed in Table 1. These factors are not universally applicable, as they vary between bioregions and locations and some also vary seasonally. There typically also is a high diversity in the structure of plant communities in WA ecosystems (Section 3.4.2). In general, rehabilitation of areas with highly diverse biotic and abiotic ecosystem components will be more challenging than rehabilitation of areas of lower diversity. Larger projects are also likely to encompass more of these factors than smaller projects. It needs to be acknowledged that in general ecosystem rehabilitation is likely to be more difficult in Western Australia than in most other parts of the world because of factors listed in Table 1. Constraining factors should not be used to justify lesser standards of rehabilitation, as they can be largely overcome with adequate experience, effective training, sufficient support from scientific research and sufficient commitment (Section 3.8).

2.2 Background information

2.2.1 Natural ecosystem rehabilitation in Western Australia

Summaries of rehabilitation objectives and completion criteria that are most commonly used for projects in WA are provided in Tables 3 and 4. Major problems are indicated in Table 1 and illustrated in Appendix 3. The most commonly encountered problems include underestimating the importance of constraints to successful rehabilitation, such as altered habitats or abundant weeds, and insufficient commitment to conclude projects to a stage where signoff is possible. As the lists in Table 3 show, there is a clear need for greater standardisation in the approaches and criteria used to assess outcomes of rehabilitation. A wide diversity of definitions and targets are used to assess rehabilitation in WA (Tables 3, 4). In many cases the definitions used do not ensure a sustainable ecosystem will result.

2.2.2 Stakeholders

The majority of projects involving rehabilitation of natural ecosystems assessed by the EPA are for mining and extractive industries that make temporary use of land then must return it to a sustainable environment. The EPA also commonly deals with applications to rehabilitate vegetation in land cleared for roads and other corridors and occasionally deals with applications to restore vegetation as an offset for permanent loss of significant vegetation. This guidance statement does not address rehabilitation for natural resource management, but community groups involved in such activities will often use similar completion criteria to those discussed below to assess the success of projects. Stakeholders and sources of rehabilitation knowledge are listed in Table 5.

The natural resource industries of Western Australia include over 770 operating mine sites and quarries for 50 different minerals. A cumulative total of 166,000 ha of vegetation in WA has been disturbed by mining operations and 25,000 ha rehabilitated (DoIR 2004). Costs associated with major rehabilitation projects generally exceed $20,000 per ha excluding landform reconstruction costs.

The Department of Industry and Resources (DoIR) has a key role in the mine closure processes, including managing rehabilitation following mining. This includes overseeing the implementation for securities, or Unconditional Performance Bonds, as part of the management of mine site rehabilitation under the Mining Act 1978. The purpose of these securities or bonds is to ensure the State is not exposed to any unacceptable cost in the event that a mine operator should fail to meet rehabilitation requirements on their tenement. However, these generally account for 1/3 or less of the cost of rehabilitation, so it is essential that adequate resources are available as part of adequate “life of mine planning” by mine operators.

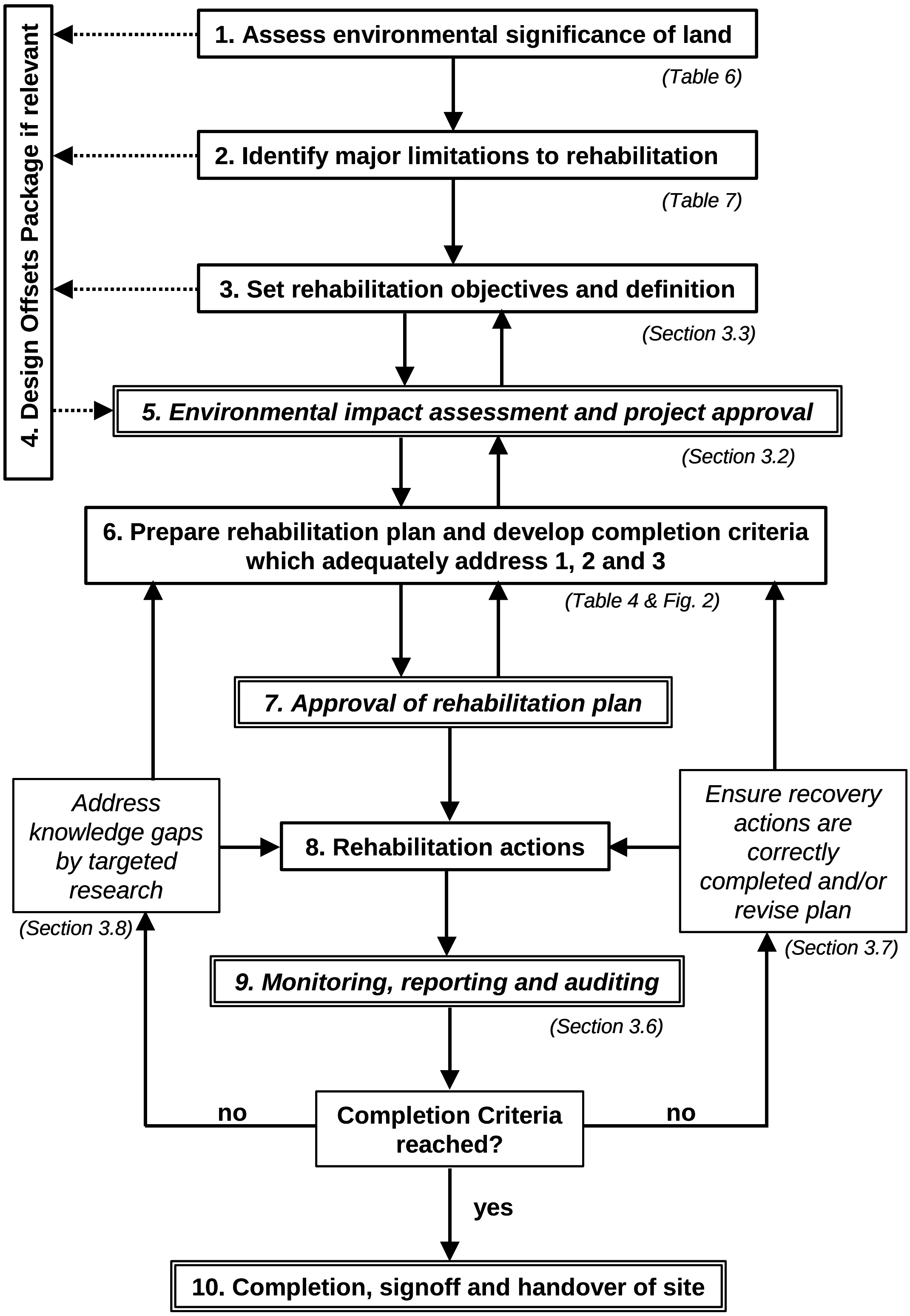

Figure 1. The main stages in the approval, planning, execution and auditing of ecosystem rehabilitation projects. Processes in boxes with double lines also involve responsible agencies and stakeholders.

3. THE GUIDANCE

3.1 The EPA's objectives and their application to rehabilitation

3.1.1 The environmental objectives

The primary EPA objective for rehabilitation is to minimise environmental impacts resulting from permanent change to ecosystems. This requires the return of rehabilitated areas to self-sustaining and functional ecosystems comprised of local provenance species. The EPA requires that rehabilitation plans are based on clear objectives and targets which can be effectively monitored and audited to confirm objectives are achieved. As discussed in Section 3.2, objectives for rehabilitation are typically used to assess the likelihood of a successful outcome at the project EIA stage (Fig. 1). Despite improvements in the standards of rehabilitation and the criteria used to evaluate the effectiveness in recent years, the EPA is of the opinion that there is still substantial room for improvement in these areas. Confirmation of successful rehabilitation of vegetation is a long-term undertaking that extends beyond the life of many projects. Consequently, realistic rehabilitation objectives should be set that allow the overall impact of proposals to be assessed for project approval (Section 3.3). In an biodiversity conservation sense, the rehabilitation of native vegetation is usually not expected to fully replace or improve upon the original values of ecosystems. The main areas of rehabilitation planning, practice and monitoring where improvements are needed are listed below.

A. Environmental Impact Assessment (EIA) and rehabilitation planning stages

- Undertake flora, vegetation and fauna surveys required to provide baseline information for environmental management and to assess environmental significance (Section 3.2).
- Compile accurate information about predicted permanent changes to landforms, soils and hydrology and their expected impacts on biodiversity. Data concerning soil properties are especially important.
- Predict the degree of long-term changes to biotic components of ecosystems likely to occur (especially the composition and structure of assemblages of plants and animals) using criteria in Table 7.
- Information about the diversity of plants and their capacity to recruit from seeds is especially important.
- Set rehabilitation objectives that take into account the complexity of constraints to effective rehabilitation listed in Table 1.
- Set completion criteria that are attainable in realistic timeframes and ensure rehabilitation objectives have been met.
- Use similar rehabilitation objectives and completion criteria within particular industries and within geographical regions when appropriate.
- Life of mine approaches are required where financial and logistical planning required for effective rehabilitation occurs early in the life of projects (ANZMEC 2000).
- An effective communication strategy, which includes stakeholder consultation, is required (ANZMEC 2000).

B. Operational stages

- Assign responsibility for rehabilitation activities.
- Establish research programs to trial rehabilitation methods early in the life of mines.
- Commence progressive rehabilitation by establishing landforms, soil profiles and vegetation.
- Ensure that effective communication, education, supervision and collaboration exists to undertake successful rehabilitation and monitor and report outcomes to responsible authorities.
- Produce auditable monitoring reports based on completion criteria and make them available to stakeholders (Section 3.6).
- Use adaptive science-based management approaches with sufficient flexibility to overcome unexpected problems. This may require management plans to be revised and signed off by responsible authorities (Section 3.7.1).

C. Assessment of projects

- Confirm that completion criteria targets are reached by submitting required reports in a timely manner.
- Ensure the long-term sustainability of sites and their suitability for agreed land uses. This ensures intergenerational equity, by confirming sites will not require long term management at the expense of others.
- Compile scientific datasets (measuring rehabilitation trajectories and the development of biotic and abiotic ecosystem properties) to validate use of short-term completion criteria targets.
- Ensure data are available to stakeholders (Section 3.6.1).
- Signoff on commitments and arrange handover of the site if required when pre-determined endpoints are reached.

3.2 Approaches and standards required for environmental impact assessment

The initial identification of relevant rehabilitation objectives should be undertaken by the proponent, in consultation with key stakeholders such as DoIR, the EPA and DEC, during the preparation of referral and scoping documents. This consultation is expected to continue during the development of environmental management plans concerning rehabilitation of ecosystems (Fig. 1).

Rehabilitation planning and project approval process are summarised in Stages 1-5 in Figure 1 and listed in A above. Existing information from desktop studies is normally supplemented by site visits and expert advice. Environmental objectives and corresponding commitments and draft conditions requiring action are listed in an EPA Bulletin. The Bulletin is subject to appeals and Ministerial consultation before being used as a basis for Environmental Conditions set by the Minister for the Environment. At this stage responsible authorities are nominated to approve future plans and compliance reports. These usually include DoIR, EPA, DEC and local government.

The information provided for the EIA process often does not include complete details of rehabilitation, which will later be included in a final Environmental Management Plan, Rehabilitation Plan, or Decommissioning Plan. These plans are reviewed and approved before rehabilitation commences. The EPA is of the opinion that wherever feasible, comprehensive rehabilitation plans should be made available and assessed during the main proposal approval stage of the EIA process. The approval of these plans would be facilitated by greater standardisation of approaches, especially for similar projects within the same geographic regions.

During the EIA process, the overall definition of rehabilitation is very important in ensuring favourable outcomes are achieved. Environmental impacts of projects which involve rehabilitation of ecosystems are determined from (A) the environmental significance of ecosystems, (B) the demonstrated capacity of proponents to effectively rehabilitate equivalent environments and (C) the magnitude and significance of factors constraining favourable outcomes (Table 1). The evidence required to assess these factors is summarised below.

A. Environmental significance

- The magnitude of environmental impacts if rehabilitation is not successful.
- Components of biodiversity, environmental assets and heritage values are listed in Table 6. The numeric values in Table 6 are only to be used as a guide to help to understand important factors.
- Significant flora and fauna species or communities and Conservation Category Wetlands and other biodiversity aspects of major significance, as explained in EPA Guidance Statements.
- Information provided by terrestrial flora, vegetation and fauna surveys interpreted by proponents, their consultants and responsible authorities (EPA 2004bc).
- The environmental objectives of the rehabilitation project.
- Proposed environmental offsets (EPA 2005b).
- The sustainability of planned long-term land use (EPA 2004d).
- Anticipated indirect environmental impacts on surrounding lands or waters.

B. Capacity and experience

- Favourable outcomes of past rehabilitation projects by the same proponent in similar habitats (case studies).
- Favourable outcomes of past rehabilitation projects by other proponents in similar habitats (case studies).
- Knowledge of typical outcomes in similar habitats available to responsible authorities.
- Knowledge and skills of the proponent and their consultants.
- The available pool of relevant skills and knowledge.
- Commitment to achieve best possible outcomes.

C. Factors which are likely to limit the success of revegetation

Table 7 can be used to summarise the scale and degree of permanent change to ecosystems as numeric values to help understand the relative importance of these factors. Threats to biodiversity that occur in the vicinity of major projects, such as increased frequency of disturbance, altered hydrology and dust, are normally addressed in environmental management plans. *It is important that realistic goals are set for rehabilitation projects that acknowledge the impact of limiting factors listed in Table 1.*

3.3 Setting effective objectives

The overall objective of a rehabilitation project should be stated as a definition. It is important that appropriate definitions of rehabilitation are used in environmental conditions, proponent's commitments, or management plans. Unfortunately it has been common to use an imprecise definition of rehabilitation in environmental review documents. Definitions that are not readily auditable include: to a high standard, best practicable, world's best practice, etc. (Table 3). To overcome these problems it is recommended that a more precise definition of rehabilitation be used. A proposed standard definition of rehabilitation of vegetation for Western Australia is provided below. This definition supports the overall environmental objectives of rehabilitation (Section 3.1.1) by incorporating the most important factors required to ensure sites are sustainable in the long term (Fig. 2). Some existing projects use definitions that include many of these components (Table 3).

The use of a standard definition should help to ensure there is a "level playing field" within industries. More clearly defined and transparent environmental standards reduce uncertainty for companies and investors (Allen et al. 2001). However, larger projects have greater environmental impacts and involve proponents with more resources and experience than smaller projects. Small projects, which involve scattered or lighter disturbance, such as borrow pits, would normally have fewer monitoring requirements than larger projects, but still require the same level of commitment.

There are situations where some of the standard aims of rehabilitation do not apply. These would include locations where the resulting landforms, soils and/or hydrology differ substantially from the pre-disturbance condition and cannot support the original vegetation types. In these cases, species from habitats that most closely resemble the new landforms should be used in rehabilitation. These situations are taken into account during the EIA process. In such cases offsets to mitigate unavoidable adverse environmental impacts on significant assets may be required (Section 3.5).

Proposed standard objectives for rehabilitation

- safe, stable and resilient landforms and soils;
- appropriate hydrology;
- providing visual amenity, retaining heritage values and suitable for agreed land uses;
- resilient and self sustaining vegetation comprised of local provenance species;
- reaching agreed numeric targets for vegetation recovery; and
- comprising habitats capable of supporting all types of biodiversity.

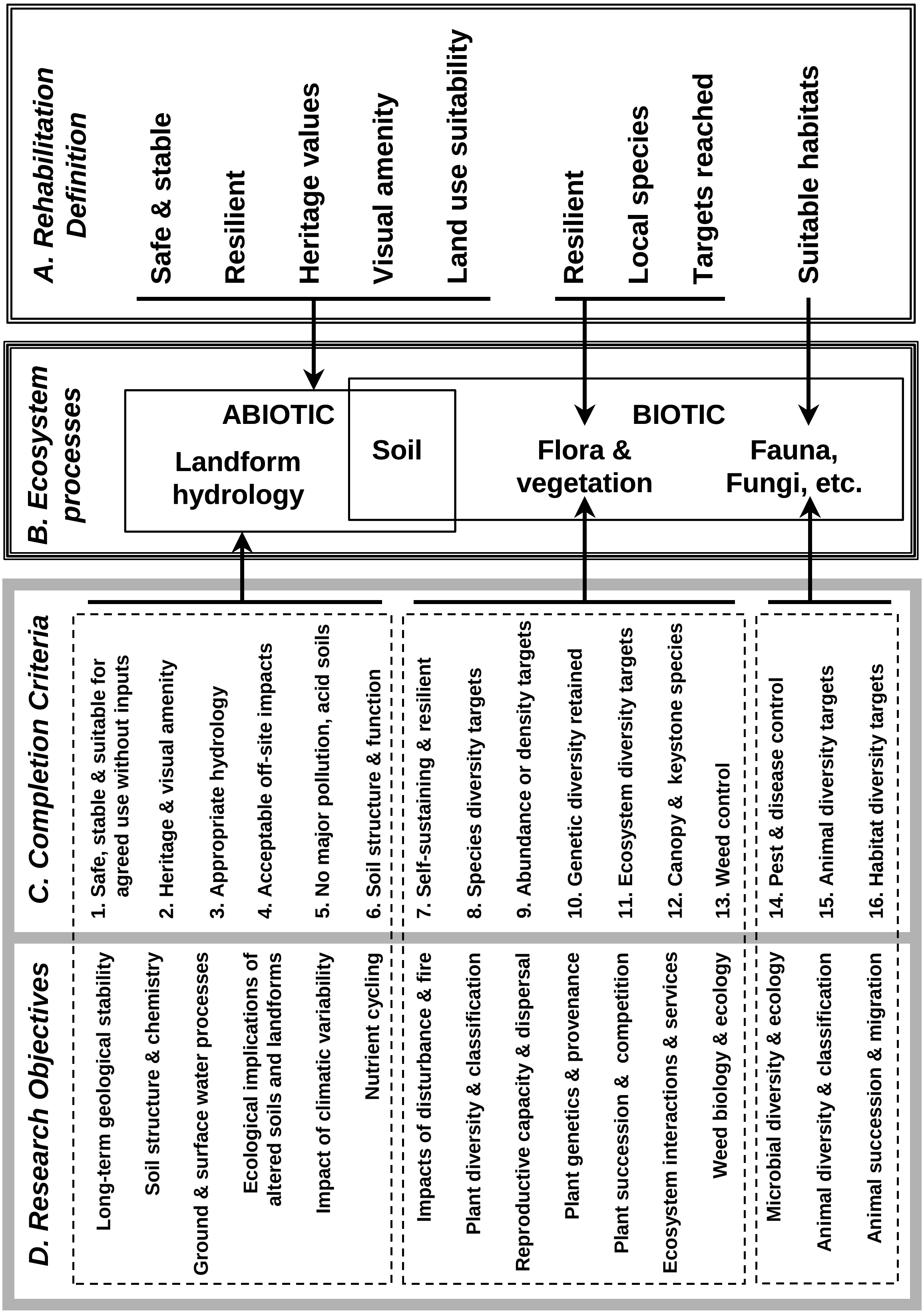

Figure 2. Diagram illustrating relationships between the (A) the definition, (B) processes required for sustainable ecosystems, (C) effective completion criteria and (D) research objectives required to provide knowledge for successful rehabilitation projects.

3.4 Effective completion criteria

Specific targets (defined by measured outcomes or milestones) are required for monitoring and reporting of rehabilitation projects. These targets are usually called *completion criteria*. Completion criteria must be sufficiently stringent to ensure that the overall objectives of rehabilitation have been met. These criteria must also be designed to allow effective reporting and auditing to define an endpoint for rehabilitation activities where sites can be handed over to a third party (Figure 1). Guidelines published by ANZMEC (2000) for completion criteria state they should be:

1. Specific enough to reflect unique set of environmental, social and economic circumstances.
2. Flexible enough to adapt to changing circumstances without compromising objectives.
3. Include environmental indicators suitable for demonstrating that rehabilitation trends are heading in the right direction.
4. Undergo periodic review resulting in modification if required due to changed circumstances or improved knowledge.
5. Based on targeted research which results in more informed decisions.

The three strategies used to evaluate rehabilitated landscapes include (i) direct comparison, (ii) attribute analysis and (iii) trajectory analysis (SER 2004). Each of these strategies requires a comprehensive understanding of a reference ecosystem.

- Direct comparisons result in completion criteria that can be directly measured, and are based on data from reference sites. Reference site data are based on detailed plant surveys and vegetation mapping.
- Attribute analysis seeks to confirm that essential criteria required for ecosystems to function have been reinstated. These criteria equate to the overall objectives of a rehabilitation project which ensure an ecosystem will continue to recover without further management inputs (Section 3.3).
- Trajectory analysis looks at trends in ecosystem properties and functions that gradually recover towards a reference condition.

The scientific literature on rehabilitation ecology contains vigorous scientific debate about the use of completion criteria and the scientific basis for defining them (Lamont 1978, Farrell 1993, Yates & Hobbs 1997, Westman 1991 - cited in Lubke & Avis 1998, Osborne & Brearley 1999, Ward 1999, Tongway & Hindley 2003, Sherriff et al. 2002, SER 2004, Thompson & Thompson 2004). In particular, the relative importance of ecological theory based monitoring approaches such as trajectory analysis and measurements of ecosystem processes (also known as ecosystem function analysis - Tongway & Hindley 2003) relative to the more easily measured species based indicators has not been resolved. Proponents of the former approaches state that completion criteria which address landscape integrity and ecosystem services are required to ensure rehabilitation has been successful (Ehrenfeld 2000, Tongway & Hindley 2003). However, any approach where species lists are entirely supplanted by measurements of ecosystem properties is also likely to prove unreliable (Goldstein 1999).

Biodiversity monitoring indicators that are used to investigate the sustainable management of forests and rangelands and for natural resource management (landcare) projects are often similar to the completion criteria used for rehabilitation projects (e.g. Yates & Hobbs 1997, Arnold et al. 1999, Lindenmayer et al. 2000, Tongway & Hindley 2003, NRMSC 2002). The focal species concept for selecting representative indicator species has been suggested (Brooker 2002), but others caution against placing too much reliance on criteria based on individual species (Lindenmayer et al. 2000, Lindenmayer & Fischer 2003).

A review of 68 rehabilitation projects located throughout the world found there was considerable variation in the use of completion criteria, with the majority only measuring a few ecosystem attributes (Ruiz-Jaen & Aide 2005). The most common attribute measured was plant species diversity (79% of studies) followed by vegetation cover or density (62%), and arthropod species diversity (35%). Ecological processes were also measured in many cases (60%), but this was not done consistently. In WA, the success of rehabilitation projects is primarily assessed by the use of direct comparison and attribute analysis targets (Table 3).

Most auditable completion criteria consist of short-term goals which can be set as precise numeric targets or questions with definitive answers (Table 4). However, it needs to be recognised that these short-term objectives require validation using knowledge gained from long-term research (Fig. 2). Long-term research helps to satisfy the expectations of the proponent, the public and responsible authorities that rehabilitated areas will be self-sustaining in the long term and biodiversity will return to acceptable levels (see Section 3.8).

Dynamic properties of ecosystems are referred to as ecosystem processes, and those which also provide benefits to people are referred to as ecosystem services (Eamus et al. 2005). These properties are summarised in Figure 3, which shows how completion criteria are linked to essential processes in rehabilitated landscapes. *If completion criteria are set which are not sufficiently stringent to ensure ecosystem processes and services have been restored, then it will not be possible to state with confidence that restored habitats are sustainable.*

3.4.1 Standard completion criteria for abiotic factors

There are a wide diversity of projects which involve rehabilitation of ecosystems in WA, so it is not possible to provide project specific values for completion criteria. Figure 2 lists 16 of the most commonly used completion criteria, and shows how they are linked to long-term research objectives. Table 4 lists completion criteria that are relevant to all projects or small projects with less severe environmental impacts.

- Examples of small projects include short corridors for roads or utilities and borrow pits.
- Examples of large projects where a high standard of rehabilitation of ecosystems is expected include mines, quarries and long corridors which impact on native vegetation.

The 6 standard completion criteria listed below apply to both large and small projects and have the primary goal of reinstating the visual appearance of sites and preventing unreasonable future management costs, or risks to land owners and the public. These factors are discussed briefly below (listed using numbers consistent with tables and figures). This guidance primarily concerns aspects of biodiversity in rehabilitation projects; so additional advice is required to adequately address the abiotic standard completion criteria (from DoIR, DEC and published guidelines in Table 2). A timeframe for achieving completion criteria is essential.

1. Safety, stability, sustainability and suitability
The overall health and safety of humans, stability of soils, landforms and hydrology, long-term sustainability without additional management inputs and suitability for agreed land uses is always required for rehabilitated areas. These four requirements are often split into separate completion criteria (Table 4). Suitability for agreed land uses is required to ensure the economic value of sites for agriculture, grazing, forestry, tourism, recreation, etc. is retained. The long-term sustainability of sites avoids intergenerational inequity (EPA 2004a).

2. Visual amenity and heritage
Recovering visual amenity is normally a key objective of rehabilitation. Visual amenity is defined by community expectations. Significant Aboriginal or European heritage values originally present at sites should also be retained. In some cases educational and scientific values are also important. Permanent changes to visual amenity would be considered at the EIA stage for major projects.

3. Pollution
Pollution in rehabilitated areas (e.g. acid drainage) must be managed to prevent environmental impacts in accordance with regulatory processes.

4. Off-site impacts
Significant adverse off-site impacts must be avoided. These include any biotic or abiotic process occurring at a rehabilitated site with the potential to have substantial adverse impacts on adjacent lands, wetlands or waterways. Some possible examples would include facilitating the spread of weeds or dieback, or major impacts on hydrology.

5. Hydrology
Completion criteria that measure flows and availability of surface and groundwater should be provided if there are major changes to hydrology. Appropriate hydrology is required for effective establishment of vegetation, to protect wetlands and to ensure site stability.

6. Soils
Maintenance of soil properties is a key aspect of rehabilitation, as soil profiles and structures must ensure vegetation establishment and resistance to erosion. Soil components that vary with depth include texture, bulk density and chemical properties and these soil properties should be used to set measurable completion criteria concerning soil structure and function. Effective topsoil and subsoil management is essential to ensure adequate plant growth and normal root distribution patterns. Direct-returning topsoil can be the most effective way of maximising plant diversity (Appendix 3). Ecosystem Function Analysis (EFA) provides tools for measuring processes linked to soil stability and vegetation recovery (Tongway & Hindley 2003).

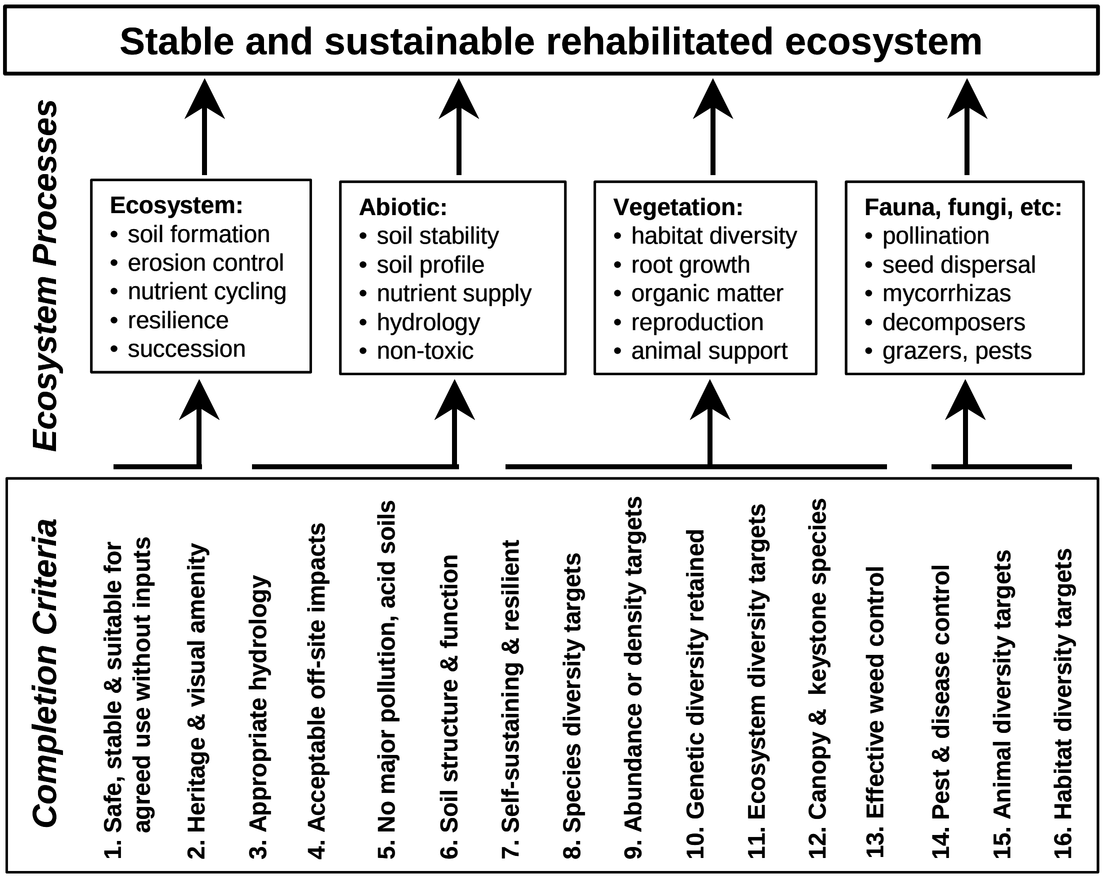

Figure 3. Effective completion criteria ensure that ecosystem processes required for stability and sustainability have been restored.

3.4.2 Completion criteria for biodiversity

All rehabilitation projects require completion criteria that adequately address the recovery of biodiversity and the management of key threatening processes (Table 4). Larger projects will normally include completion criteria that provide greater certainty that ecosystem diversity and functionality is restored relative to small projects. As is shown in Figure 3, sustainable ecosystems require complex interactions between plants, animals, fungi and microbes to allow processes such as pollination, seed dispersal and plant nutrient acquisition to occur. However, due to logistical constraints, only selected organisms can be quantified in surveys of rehabilitated areas to provide direct comparison based completion criteria. Consequently, it is necessary to validate choices of organisms for use as completion criteria to represent ecosystem biota.

Plant diversity is established as the most common completion criteria used and is often assumed to be effective surrogate for all other types of organisms (Table 4). However, the EPA recommends that completion criteria which demonstrate that animal diversity and/or animal habitat diversity is on a suitable trajectory to recovery should also be used. Scientific studies in Western Australia have established that the species diversity of particular groups of organisms such as reptiles, birds, ants and fungi recovers with time in rehabilitated sites, but such studies have been confined to relatively few locations (Gardner & Malajczuk 1988, Majer & Nichols 1998, Thompson 2002, Armstrong & Nichols 2000, Nichols & Nichols 2003). Scientific studies have also found different populations of species occurring in rehabilitated and undisturbed habitats (Comer & Wooller 2002. Price et al. 2005, Norman et al. 2006). Further work is required to validate recovery trends for fauna in a wide range of habitats, as is discussed in Section 3.8. It should be noted that most arguments for inclusion of completion criteria based on animal diversity also apply to fungi, which are very important ecosystem components. Understanding plant reproductive capacity, soil nutrient cycling, fungus diversity, etc. are important research goals (Section 3.8), but routine measurement of these variables is expected to normally be beyond the scope and capacity of rehabilitation projects.

Plant species diversity is usually the primary basis for biotic completion criteria because:

1. It is feasible to identify the majority of species present in plots.
2. Sampling times are much shorter than would be required to reveal the majority of other organisms inhabiting or frequenting an area.
3. Plant surveys are most effective if conducted when the majority of species flower (EPA 2004b), but they can still provide valuable information at other times, provided that botanists have sufficient experience in the local area.
4. Comprehensive data from pre-disturbance botanical surveys is usually available for comparison.
5. The majority of plant taxa in most regions are known (but many require further taxonomic work, especially in more remote parts of WA).
6. Relationships between vegetation communities, soils and landforms can be established.
7. Research has established links between plant diversity and animal or fungal diversity, at least in certain circumstances (see above).
8. Links between plant diversity and ecosystem functions have been established, at least in certain circumstances.
9. Outcomes of fauna surveys are influenced by survey effort, seasonal variations in climatic conditions and other factors (EPA 2004b) that must be carefully considered when results are used for comparative purposes.
10. There is currently insufficient knowledge about fungal or microbial biodiversity in WA to use survey data for comparative purposes.
11. It is generally assumed that fungi and fauna will generally disperse to new habitats more readily than plants if favourable habitat conditions return, provided that there are effective means of dispersal via linkages to nearby intact habitats.

A key objective of rehabilitation is that ecosystems must be self-sustaining and/or capable of being sustainably managed without unwarranted additional expense. This requires rehabilitated ecosystems to be resilient, which is unlikely to be the case if keystone species are lacking. Keystone species that provide essential ecosystem functions include vegetation required to stabilise landforms, soils and hydrology and provide animals with shelter, food and nesting sites (Fig. 3).

A second key objective of rehabilitation is to return sufficient representation of species to allow vegetation to be identified as belonging to a nominated plant community type (floristic community, or vegetation complex). This requires (1) the majority of local native species to be returned, (2) the relative abundance of key species, especially dominants such as trees to be similar to reference plots and (3) the absence of substantial cover of non-local species and weeds.

Biodiversity consists of three major components (A) species diversity, (B) ecosystem diversity and (C) genetic diversity (Commonwealth of Australia 1996). The EPA believes that there needs to be more consistent use of completion criteria for biodiversity in rehabilitated areas which address all three of these components, as listed in Table 4 and discussed below.

7. Resilient and self-sustaining vegetation

- This is a frequently used completion criteria that relies on the other completion criteria listed below, especially plant species diversity, vegetation cover, weed management and disease control.
- The successful recovery of ecosystems is also dependant on exclusion of fire and other disturbances (rubbish dumping vehicle access, livestock access, etc.). This is especially important in the early stages of plant establishment, before soil seed banks are replenished and when young plants are highly vulnerable.
- Plant reproduction is reliant on recolonisation of sites by vertebrate and invertebrate pollinators and seed distributors (see 15 below).
- Plant reproductive capacity (e.g. seed production) or resilience to disturbance events such as fire are most often dealt with as long-term research objectives (Section 3.8).

8. Plant species diversity

- Completion criteria providing auditable measures of the species richness of local native plants are required.
- Specified targets based on reference plot data are usually set at 60-80% of pre-existing taxa.
- Setting appropriate targets requires past experience in similar habitats and knowledge of the proportion of plant species that are unlikely to recruit or can be propagated from seeds in the short term.
- Biodiversity targets are based on accurate pre-disturbance species lists where species are assigned to vegetation types, as recommended in Guidance Statement 51 (EPA 2004).
- Species lists should be specific to landforms and soils, by recognising the ecological diversity of plant communities (see 14 below).
- Specific targets are set for rare or priority plant taxa in consultation with DEC when these are to be reintroduced.
- Separate plant diversity targets for different ages of rehabilitation, should not be used unless they are based on sufficient knowledge of succession in similar habitats. It is better to continue monitoring until targets are met.
- Off-site impacts can be investigated by monitored plant diversity in reference plots in adjacent terrestrial or aquatic ecosystems (completion criteria 4).

9. Plant abundance and cover

- Sustainable rehabilitation requires the cover of vegetation to be sufficient to stabilise landforms and soils and exclude weeds.
- The number of stems of native plants in a given area is often used as a completion criteria for plant cover. However, it may be difficult to set

meaningful values for these targets, because plants growing in rehabilitated areas are unlikely to be the same average size as those in reference systems. These targets are also relatively time-consuming to measure.

- In most cases, completion criteria based on relative cover (% of area) will be most effective and efficient. This is the relative area occupied by native plants, weeds and bare ground measured in permanent plots or transects.
- Setting effective completion criteria targets requires knowledge of recovery trends in specific plant communities.
- Permanent quadrants and/or transects are used to measure biodiversity targets. Permanent photographic-monitoring points should also be established.

10. Weed management

- This is an essential prerequisite for rehabilitation of Australian ecosystems (Yates & Hobbs 1997, Prober et al. 2002).
- It requires demonstration that;
  (a) the relative cover of minor weeds is low and stable or preferably declining,
  (b) major environmental weeds capable of becoming dominant at the expense of native plants in ecosystems are absent and
  (c) Declared weeds are managed as required by regulations.
- Monitoring standards would normally be based on the relative abundance of weeds in reference locations. However, lower targets should be set if weeds are abundant in these areas.

11. Pests and diseases

- Effective management of alien or native species of animals, fungi or microbes, that can have a major impact of plant survival and productivity, is required in rehabilitated areas.
- Dieback is a major problem in many areas of Southwestern Australia (CALM 2000, 2004a, Dieback Working Group 2005). It is necessary to avoid the spread of dieback during operations and provide effective dieback management in rehabilitated areas.
- Animal grazing also requires effective management.
- Evidence of effective management requires quantification and/or mapping to establish that pests and diseases are effectively contained.

12. Plant genetic diversity

- Local provenance is an essential concept required to make decisions about how seeds should be collected and used (Mortlock 1999, McKay et al. 2005). In the absence of information on the genetic diversity of species it is best to restrict seed collection to a narrowly defined geographic region.
- Rehabilitated vegetation should consist of local native plant species which are well adapted to landforms, soils and climate of the rehabilitation site.
- This requires seed or planting stocks derived from the local area within the same plant communities and habitats (i.e. use correct provenance and ecotype).
- Use of local provenance seeds also avoids problems with future changes to plant names and ensures that only local species are planted.

- Documentation of seed collection locations is required to establish the provenance of seed.
- Direct propagule return from properly managed topsoil and canopy-stored seeds should be maximised whenever possible.

13. Dominant plant species and plant strata

- It is often appropriate to set different cover and diversity targets for plants that belong to different strata (e.g. herbs, shrubs, grasses, trees) to restore vegetation structural complexity and visual amenity.
- Separate relative cover or abundance targets should also be set for the dominant species in habitats. These plants provide food and shelter for animals as keystone species.
- Dominant plants should be present at appropriate relative densities and there should be good evidence that sufficient relative cover of these species will eventually be established.

14. Diversity of ecological communities

- Ecosystem diversity is the variety of habitats, biotic communities and ecological processes (Commonwealth of Australia 1996). It is usually not practical to measure all of these components, but variation in relative dominance of plants across sites provides a useful measure of the structural diversity of ecosystems.
- Completion criteria tailored to specific areas of sites with substantial variations in soils and landforms will help to ensure successful rehabilitation. These targets would be species lists which are subsets of a list for the whole site, based on the most similar available reference plots.
- Ecosystem diversity can be represented by calculating a diversity index which allows comparisons between ecosystems.
- Variation in the spatial distribution of vegetation is also required to properly restore visual amenity (completion criteria 2).

15. Animal diversity

- It is recommended that completion criteria based on the diversity of indicative groups of animal species such as birds, reptiles, or invertebrates are included, especially for extensive rehabilitation projects. Long-term monitoring of animal diversity is also an important research objective (Section 3.8).
- Monitoring of faunal diversity requires accurate pre-disturbance species lists as recommended in Guidance Statement 56 (EPA 2004b).

16. Habitat diversity

- In most cases it will not be feasible to establish that animal, fungal and microbial diversity has been restored. However, evidence should be provided to establish that an ecosystem can provides a suitable diversity of habitats for all components of biodiversity.
- This evidence includes the presence at appropriate densities of important plant species and the diversity of habitat types within rehabilitated areas relative to reference sites (completion criteria 13 and 14 above).
- Rehabilitation design should incorporate the return of appropriate structural habitat components, such as logs and rocks, as effective habitats and refuges for animals and provide measurable completion criteria for

these components. These types of habitats for fauna would otherwise not be present for many decades.

- Landform design should also contribute to habitat diversity.
- Long-term flora and fauna monitoring as a scientific research objective is required to confirm that there is sufficient habitat diversity (Section 3.8).

3.5 Offsets and sustainability

Recent government policies concerning sustainability and offsets relate directly to the environmental consequences of clearing of native vegetation and the requirement for rehabilitation. In particular, the concepts of “no net environmental loss” and “net environmental benefits” should be addressed in environmental review documents. Projects that cause clearing of significant native vegetation should consider offsets in an attempt to achieve “no net loss” of environmental assets as discussed in the EPA policy document Position Statement No. 9.

It is very important to choose suitable sites for rehabilitation in cases where it is part of an environmental offset package to ensure resulting habitats are of sufficient quality to replace habitats lost elsewhere.

Evaluating the overall impact of major projects within a sustainability context requires the anticipation that rehabilitation will be effective in returning land to a “previous state or some other safe, productive use” (Government of Western Australia 2003, EPA 2004d).

3.6 Presenting and reporting

Processes involved in the auditing of environmental impacts of projects are summarised in steps 9-10 in Figure 1. The DEC has a key role auditing the compliance of proponents in cases where Ministerial Conditions or proponents commitments exist that are relevant to the rehabilitation. Responsible authorities for assessing compliance with these requirements also include DoIR as well as local government.

Monitoring and reporting of outcomes is required to demonstrate that rehabilitation has been successful or identify problems that need to be addressed by further actions. A monitoring program requires (i) adequate technical expertise, (ii) a proper experimental designs, (iii) clearly defined objectives and outcomes and (iv) sufficient and sustained commitment and resources (Lindenmayer & Burgman 2005). Rehabilitation projects require outcomes linked to explicitly stated completion criteria, such as those listed in the previous sections, to quantify success.

3.6.1. Requirements for data acquisition and presentation

The EPA requires survey work conducted or commissioned by proponents that is of an acceptable standard and of sufficient rigor (EPA 2002, 2004bc). Data that are of key relevance should be presented to relevant authorities in the form of compliance reports that can be readily interpreted. These reports must be presented in a timely manner when required by the conditions, commitments or requirements arising from environmental management plans.

Statements of compliance must be supported by verifiable evidence. This may be presented in appendices to the compliance report, but must (as a minimum) be clearly and unambiguously referenced in the compliance report. Reports concerning compliance with environmental conditions, proponent's commitments and requirements arising from management plans should be presented in the following format:

- the report should be submitted with a cover letter stating clearly:
  - the name of the project to which it refers;
  - the proponent's name;
  - the number of the Ministerial Statement (if any) through which approval was granted;
  - (if relevant) the condition and / or proponents commitment number(s) which the report addresses; and
- in cases where the rehabilitation report relates to a project covered by a Ministerial Statement, the report should sequentially address all of the Ministerial Conditions and proponents commitments, as numbered in the agreed audit table and provide evidence that demonstrates the degree of compliance;
- where the rehabilitation report relates to actions required under an environmental management plan, evidence that addresses the level of compliance with each requirement in the management plan should also be included in the report;
- photographs, especially from standard fixed reference points, are a useful method of demonstrating compliance; and
- standards for acquiring and presenting vegetation, flora and fauna data follow advice in Guidance Statements 51 and 56 (EPA 2004bc).

3.6.2 Sharing information

The EPA has a policy that data from environmental review processes is publicly accessible (EPA 2004bc). A key outcome of any successful revegetation program is the knowledge and skills gained by environmental managers and practitioners. It is recommended that such knowledge be consolidated centrally and made more accessible to rehabilitation practitioners and the public. This information is of great value for assessing the potential success of new projects in similar habitats.

Data on rehabilitation outcomes should be compiled as case studies on a regional basis. Unfortunately, there are problems with the accessibility of existing information about rehabilitation of ecosystems in WA, as it is relatively uncommon for it to be published in the scientific literature. It is recommended that rehabilitation practitioners make greater use of the relevant scientific journals to disseminate information, especially those of the Ecological Society of Australia (ESA) and the Society for Restoration Ecology International (SER).

3.6.3 Record keeping for the purposes of an audit

It is highly desirable that the source data from flora and vegetation surveys conducted to provide baseline data for, and to assess rehabilitation outcomes be maintained by the proponent (or the consultant on behalf of the proponent, but the responsibility for this is with the proponent) in a readily available format for a minimum period following the survey so that:

- subsequent supplementary, time-sequence, or monitoring studies are possible;
- survey limitations are transparent to data users; and
- the surveys themselves are verifiable and auditable by a third party.

Accordingly, the base data collected in surveys (including details of sample timing, precise location, etc.) should be retained in the form originally collected, and electronically, for a minimum of 7 years after the survey is completed.

The EPA advises that there may be random audits of surveys and reports. In some cases these data may be subject to peer review by an independent botanist.

3.7 Dealing with adverse outcomes

Consequences of the failure to rehabilitate ecosystems are listed in Section 2. Particular cases where responsible agencies determine that rehabilitation has not been successful are dealt with on a case-by-case basis. In general it would normally be expected that additional resources be made available, to allow successful completion of a project. A revised management plan, which addresses deficiencies identified in an earlier plan, may be required (Fig. 1). It is important to include some flexibility in rehabilitation plans, which should be reviewed periodically and revised when new information and knowledge about rehabilitation practices becomes available (ANZMEC 2000, Ehrenfeld 2000). Risk management based contingency measures should be included within rehabilitation plans to manage the risk from major factors potentially limiting success listed in Table 1.

Flexible approaches to rehabilitation planning, which are often referred to as “adaptive science-based management approaches” should be utilised where they are appropriate. *In cases where adaptive approaches are used it needs to be clearly stated in management plans that flexibility exists in the approaches taken to meet set standards, but not in the standards themselves.*

In cases where rehabilitation is not deemed to be successful, a security or Unconditional Performance Bond may be used to fund additional works that are required (Section 2.2.2). Environmental risk management approaches will minimise the likelihood of adverse outcomes.

3.8 Knowledge and skills required for effective rehabilitation

Due to the constraints listed in Table 2, rehabilitation practitioners in WA require a high degree of knowledge and experience. Shortages of technical knowledge and skills required by the rehabilitation industry have been acknowledged (Tonkinson et al. 1999). However, there is a substantial body of knowledge concerning rehabilitation in Western Australia available from government, universities and industry bodies, many of which are listed in Table 5. This includes knowledge and information required to assess rehabilitation outcomes, establish appropriate biodiversity based completion criteria and understand the structure and composition of plant communities, as well as practical skills required to propagate plants and reconstruct landforms and hydrology. Scientific research which results in more effective and efficient rehabilitation or a greater ability to set realistic objectives and completion criteria is of great economic importance in Western Australia (Allen et al. 2001). Figure 4 demonstrates how this information is required to guide rehabilitation projects.

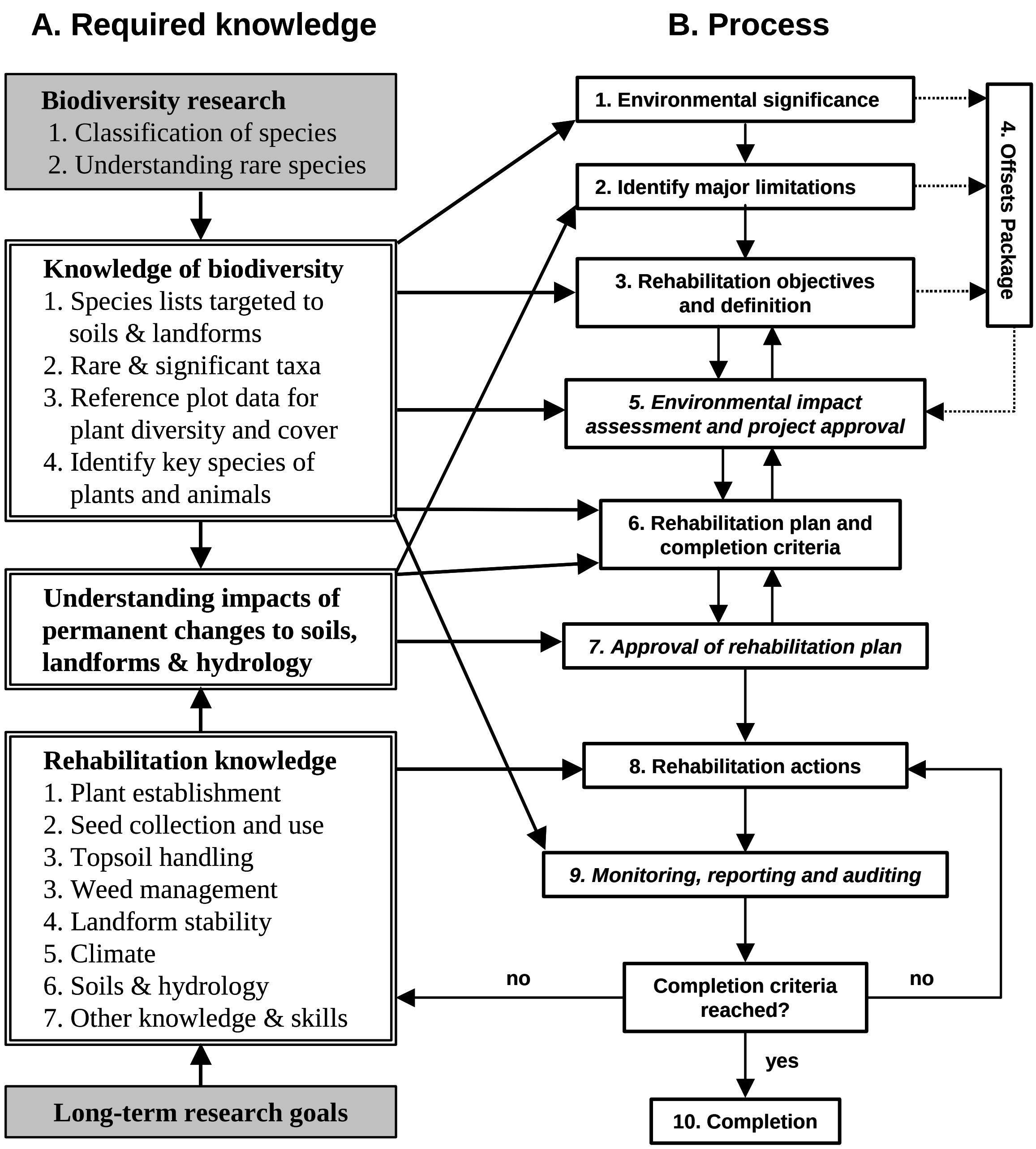

Figure 4. A. Knowledge is an essential resource for rehabilitation practitioners. Examples of long-term research objectives are shown in Figure 2D. **B**. Processes follow the order in Figure 1.

Rigorous scientific approaches required for effective rehabilitation projects include:

1. The use of factorial experimental designs which allow the impacts of different environmental factors on rehabilitation to be investigated;
2. Appropriate use of statistical analysis and visual displays (graphs) to allow effective interpretation of results; and

3. The adequate use of regional biodiversity knowledge to determine the significance of results.

Scientific research is of critical importance to overcome constraints to efficient and effective rehabilitation in WA (Table 1) and to provide scientific knowledge required to design completion criteria (Fig. 2). Expert advice is available from the agencies and organisations listed in Table 5. The following list provides some key examples of directly relevant research leading to a better understanding of:

- the impact of changes to hydrology, soils and landforms on vegetation (Beverley & Croton 2002, Cramer & Hobbs 2002, Zencich et al. 2002, Murray et al. 2003, Price et al. 2005);
- rehabilitation procedures (Tacey 1979, Ward et al. 1996);
- landform stability (Evans 2000, Loch 2000);
- successional processes and competition between species in recovering ecosystems (Yates & Hobbs 1997, Arnold et al. 1999, Prober et al. 2002, Jefferson 2004);
- the relationship between seed mix composition and plant diversity in rehabilitated areas (Norman et al. 2006);
- the importance of plant life histories, such as reseeders, resprouters, annuals and geophytes (Roche et al. 1997, Bell 2001, Grant & Loneragan 2003);
- the recovery of animal diversity and animal habitats after disturbance (Cromer & Wooller 2002, Ludwig et al. 2003, Nichols & Nichols 2003);
- the recovery of beneficial services provided by animals such as pollination (Saffer et al. 2000, Comer & Wooller 2002);
- the recolonisation of disturbed habitats by beneficial fungal and microbes (Gardner & Malajczuk 1988, Brundrett et al. 1996);
- understanding how seed biology and topsoil handling impact on plant recruitment (Koch et al. 1996, Roche et al. 1997, Rokich et al. 2000, 2002);
- understanding the ecology and propagation plants which do not recolonise post-disturbance habitats (von Perger et al. 1994, Grant & Koch 2003);
- genetic research especially relating to provenance issues (van Leeuwen 1995, Mortlock 1999, Kraus & Koch 2004, McKay et al. 2005);
- animal grazing impacts (Pettit & Froend 2000, Yates et al. 2000, Koch et al. 2004);
- the recovery of soil properties and nutrient cycling processes (Todd et al. 2000, Ward 2000);
- the impacts of major disturbance events, especially fire, on vegetation (Dixon & Barrett 2003, Yates et al. 2003, Ross et al. 2004, Smith et al. 2004);
- detecting and managing plant diseases, especially *Phytophthora* dieback (Colquhoun & Petersen 1994);
- biology and ecology of environmental weeds (Butler & Fairfax 2003, Keighery & Longman 2004, Ross et al. 2004, Cummings et al. 2005);
- systematic inventories of the State's biodiversity resulting in consolidated and readily accessible information (CALM 2002, EPA 2004bc);
- classification of organisms to provide data on biodiversity, especially in regions with many unnamed species (CALM 2002, EPA 2004bc); and
- studies of short-range endemic animal species and stygofauna (Harvey 2002, EPA 2003).

3.8.1 Long-term studies

It is unrealistic to expect rehabilitated plant communities to closely resemble pre-existing plant communities in the short term (Farrell 1993, McDonald 2000, Sherriff et al. 2002, SER 2004). However, there are many practical examples of successful rehabilitation where a large proportion of species have been returned and where intact apparently stable vegetation has resulted (see case studies in Appendix 3). To fully assess the outcomes of rehabilitation attempts it is necessary in some cases to continue to measure key indicators of biodiversity after handover of sites. This requires permanent biodiversity monitoring plots to be established in restored areas with corresponding reference plots in adjacent undisturbed vegetation. It is recommended that in some cases these be designated as Long Term Ecological Research (LTER) sites in representative rehabilitated habitats with paired sites in representative natural habitats. LTER studies are internationally recognised as essential tools for ecological research (http://www.ilternet.edu/). There are no LTER sites registered in WA. LTER research would provide essential information to guide future EIA and rehabilitation planning.

4 APPLICATION

4.1 Area

This Guidance Statement applies throughout the State of Western Australia and will apply to all new proposals. Limitations of this Guidance Statement are listed in Section 1.3.

4.2 Duration and review

The duration of this Guidance Statement is for five years, unless circumstances require it to be reviewed earlier.

5 RESPONSIBILITIES

5.1 Environmental Protection Authority responsibilities

The EPA will apply this Guidance Statement when assessing relevant proposals. It is also anticipated that the approaches outlined here will assist in setting benchmarking standards to assess compliance with Ministerial Conditions for existing projects.

5.2 Department of Environment and Conservation responsibilities

The DEC, through the EPA Service Unit (EPASU), will assist the EPA in applying this Guidance Statement in environmental impact assessment and in conducting its functions under Part IV of the EP Act.

The DEC, through the EPASU, will provide more specific advice to proponents and environmental consultants, as required, in relation to detailed interpretation of aspects of this guidance and in relation to specific assessments, within available resources.

The DEC Environmental Audit Section is responsible for evaluating the level of compliance of proponents with Ministerial Statements. This includes Conditions imposed by the Minister for the Environment, the proponent's commitments and requirements arising from management plans. The Environmental Audit Section is responsible for recommending the clearance of each of the conditions and commitments when completed and recommending taking enforcement action when the required standard has not been achieved.

5.3 Other government agencies

Collaboration between the EPA, DEC and DoIR is often required to assess the outcomes of rehabilitation projects where Ministerial Conditions have been set. Regional collaborations within these agencies may also be required. Other WA government agencies involved in rehabilitation projects include Main Roads and Water Corporation.

5.4 Proponent responsibilities

Assessment is likely to be assisted if proponents demonstrate to the EPA that the requirements of this Guidance Statement are incorporated into proposals.

The anticipation of satisfactory rehabilitation outcomes is an integral part of the EIA process for projects involving substantial clearing of native vegetation. *It is recommended that more precise information on environmental impacts and the expected outcomes of rehabilitation attempts be presented during the EIA stages of projects.*

5.5 Environmental practitioner (including consultant) responsibilities

Environmental practitioners should exercise due professional diligence in the preparation of environmental review documents, plans for rehabilitation of vegetation and monitoring reports. Environmental review documents and flora and vegetation survey reports should contain an acknowledgment that the EPA's EIA process is one of the specific purposes for which the document or report has been prepared and that the document is suitable for this purpose. Documents and/or reports that do not do so will not be accepted by the EPA for the purposes of EIA.

It is expected that required standards for rehabilitation are met or exceeded. The EPA urges practitioners to ensure that they fully understand the inherent context and level of meaning of terms before they apply them. Particular use should be made of this document in this regard.

A full and frank statement of predicted environmental impacts is expected at all levels of environmental assessment documentation.

6. DEFINITIONS AND ACRONYMS

The following definitions are complied from a variety of sources, especially the Society for Ecological Restoration International (2004), the Chamber of Minerals and Energy (1999) and Guidance and Position Statements that are available on the EPA website (www.epa.wa.gov.au).

Abiotic (physical) ecosystem components - The non-living components of an ecosystem that sustain biota. These include soil and other substrates, atmospheric or aqueous media, climate, topography, nutrients, salinity, etc.

Auditing outcomes - Assessment of the degree of achievement towards successful completion of required objectives (completion criteria) based on compliance reports which provide monitoring data and state when goals have been attained. Responsible authorities audit information provided with the eventual goal of closure of a site.

Biological diversity/biodiversity - The variety of all life forms - the different plants, animals and microorganisms, the genes they contain, and the ecosystems of which they form a part (see Guidance Statement 51 for fully definitions of these components). It is not static, but constantly changing; it is increased by genetic change and evolutionary processes and reduced by processes such as habitat degradation, population decline, and extinction (Commonwealth of Australia 1996).

Biotic ecosystem components - Populations of species comprising an ecosystem (communities, assemblages, etc.). These can be classified using taxonomic hierarchies (family, genus, species, etc.), life forms (tree shrub, etc), or functional roles, (primary producers, herbivores, carnivores, etc.).

Canopy species - the uppermost strata of vegetation providing shelter and other keystone functions to biota in ecosystems and is a major component of visual amenity.

Closure - A whole of life process which includes rehabilitation and decommissioning and culminates in tenement relinquishment.

Completion criteria - Qualitative or quantitative standards of performance used to measure the success or otherwise of rehabilitation actions required for closure of a site (Farrell 1993, Chamber of Minerals and Energy 2004).

Compliance reports - Reports produced to present and interpret monitoring data to allow auditing of outcomes relative to environmental conditions and performance indicators (completion criteria).

Decommissioning - Occurs near or at the end of a project involving removal of unwanted infrastructure, construction of final landforms and rehabilitation.

Diseases - Organisms (pathogens) that cause adverse outcomes (symptoms) in another organism (host). Dieback of native plants caused by *Phytophthora* species is an example serious plant disease that is a major problem in Western Australia (CALM 2000).

Disturbance - Any process resulting in substantial damage to the biotic and abiotic properties of ecosystems. Disturbance results in reduction in biodiversity and alteration to soils, landforms and hydrology. There are different degrees of disturbance resulting in:
1. Damage - acute changes that may be temporary;
2. Destruction - loss of all life, or;
3. Transformation - resulting in conversion to a different kind of ecosystem

Ecological trajectory - Developmental (successional) pathway of an ecosystem through time, starting with a disturbed ecosystem and progressing to a desired state of recovery. These trajectories involve biotic and abiotic properties and are established by sequential measurements.

Ecosystem - The biota (plants, animals, fungi and microorganisms) occurring in a given area, along with the abiotic environment that sustains it (landforms, soils, hydrology) and their interactions.

Ecosystem health or integrity - The state or condition of an ecosystem as assessed by measurements of dynamic attributes (biotic and abiotic) that can be assigned to normal or abnormal ranges.

Ecosystem processes - Interconnected processes that sustain the biodiversity of ecosystems, and drive the self-directed development of that ecosystem. Such processes involve all components of ecosystems, biotic and abiotic and include nutrient cycling/conservation, maintenance of appropriate hydrological regimes, soil quality, etc.

Ecosystem services - Particular dynamic aspects of ecosystems which provide requirements for biotic and abiotic components. In a narrow sense, ecosystem services are defined "as goods and services that are provided by or are attributes of ecosystems which benefit humans" (Eamus et al. 2005).

Ecotype - Plant genotypes which are adapted to local environmental conditions.

Environmental Assets:

Critical Assets - the most important environmental assets that must be protected and conserved.

High Value Assets - environmental assets that are in good to excellent condition and considered to be of value by community and government.

Low to Medium Value Assets - environmental assets that are somewhat degraded.

Environmental harm - Direct or indirect harm resulting from the removal or damage to native flora or fauna, habitat, or environmental values (see Environmental Protection Act 1986).

Environmental impact assessment (EIA) - An orderly and systematic process for evaluating a proposal, including its alternatives and its effect on the environment, and the mitigation and management of those effects. The process extends from the initial concept of the proposal through implementation to commissioning and operation and, where appropriate, decommissioning.

Environmental offsets - Environmentally beneficial activities undertaken to counterbalance adverse environmental impacts to High Value Assets, aspiring to achieve "no net environmental loss" or a "net environmental benefit" outcome. These may consist of *direct* or *contributing* offsetts. The latter consist of activities that complement or enhance direct offset activity. Refer to EPA Position Statement No. 9 for more information.

Environmental review document - A document (used in environmental impact assessment) describing a proposal or plan for human development activity, the pre-existing environment of the area to be affected and the potential environmental impacts of the proposal or plan (including flora and vegetation). The preparation of an environmental review document may precede or be required as a component of the formal EIA process under the EP Act.

Environmental value - are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which requires protection from the effects of pollution and harm. (ANZECC and ARMCANZ, 2000; see Environmental Protection Act 1986).

Environmental weed - A weed causing environmental harm to a natural ecosystem.

Exotic species - A species (plant, animal, fungus, or microbe) introduced to an area where it does not previously occur, usually through relatively recent human activity.

Habitat - The natural environment of an organism or a community, including all biotic and abiotic elements; a suitable place for it to live (Commonwealth of Australia 1996). Vegetation can become a reasonable surrogate for outlining habitat when its main components, structure and the associated landform are also described.

Incentives - Something that induces or encourages people to act on a particular matter.).

Indigenous (local) native species - Species known to occur in a narrowly defined geographic region, in specified plant community types and/or on certain soils and landform. Lists of species are obtained from biological surveys that occur before disturbance or in reference areas with matching habitat types.

Intergenerational Equity - The present generation should ensure the health, diversity and productivity of the environment are maintained or enhanced for the benefit of future generations. This implies the present generation has a stewardship role in the maintenance of natural capitol and responsibility to ensure its wise use (Environmental Protection Act 1986, 2003).

Keystone species - Species with a major role supporting other species by providing food, shelter or habitat. These often are canopy of dominant species in ecosystems.

Local provenance - Material used to propagate plants (most often seed) collected from a narrowly defined geographic area, which closely matches the plant community types and physical environment where it is to be used (see provenance).

Long-term ecological research (LTER) sites - see Section 3.5.1.

Ministerial Conditions (Environmental Conditions) - Conditions set by the Minister for the Environment when approving projects**.**

Mitigation - Mitigation, in an environmental context, refers to a sequence of considerations designed to help manage adverse environmental impacts, which includes (in order of preference) (EPA 2005b):

1. Avoidance - avoiding the adverse environmental impact all together;
2. Minimisation - limiting the degree or magnitude of the adverse impact;
3. Rectification - repairing, rehabilitating or restoring the impacted site as soon as possible;
4. Reduction - gradually eliminating the adverse impact over time by preservation and maintenance operations during the life of the action; and,
5. Offsets - undertaking such activities that counterbalance an adverse, residual environmental impact.

Monitoring outcomes - The process of measuring outcomes from a rehabilitation project so its success or lack of success can be ascertained. Measured outcomes are presented in compliance reports (see completion criteria).

Mutualistic associations - Associations involving two organisms resulting in benefits to both. Common examples include mycorrhizal fungus and nitrogen fixing bacterial associations where plants benefit by improved access to mineral nutrients in exchange for energy provided to these microorganisms.

'Net benefit' concept: - (Synonyms: "net gain", 'net improvement') The 'net benefit' concept aims to ensure more environmental gains occur compared to environmental losses. It refers to an overall improvement in the total extent, quality, ecological integrity and security of environmental assets and their values. The concept is subject to cumulative gains and losses within a specific area, region or project.

'No net loss' concept - (Synonyms: "zero net impact", "no net difference") The 'no net loss' concept aims to ensure that environmental loss is balanced by an environmental gain, so that there is no overall significant environmental difference. It refers to no overall loss of the total extent, quality, ecological integrity and security of environmental assets and their values.

Precautionary Principle - Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing measures to prevent environmental degradation. Decision making should be guided by (a) a careful evaluation to avoid serious or irreversible damage to the environment wherever possible and (b) an assessment of risk-weighted consequences of the options (Environmental Protection Act 1986, 2003).

Proponents Commitments: - Actions that the proponent has committed to undertake as a result of an Environmental Impact Assessment, and that are formally included as outcomes to be completed in the Ministerial Statement that is approved by the Minister for the Environment.

Provenance (see florabank - http://www.florabank.org.au)**:**

1. Seed or plant material collected from a natural population.
2. A measure of genetic diversity below the species level describing the pattern of genetic variation by a species over its geographic range. These patterns are often closely associated with the ecological conditions in which the species has evolved.

Reference ecosystem - Ecosystem or landscape units used to provide a model for planning a restoration project. Measurements from reference systems (fixed reference points or plots where biodiversity is measured) are normally used to set appropriate levels measurable targets for rehabilitation projects.

Rehabilitation - In restoration ecology rehabilitation (reclamation) is normally defined as a process where disturbed land is returned to a stable, productive and self-sustaining condition, taking future land use into account. This process differs from the narrower definition of restoration by not aspiring to fully replace all of the original components of an ecosystem. However, the current document promotes a narrow definition of rehabilitation, which aims to maximise the return of biodiversity by reinstating self-sustaining and functional ecosystems based on local species.

Relinquishment - Final approval by the relevant regulating authority that agreed targets have been met.

Remediation - To clean up or mitigate contamination of soil or water.

Resilience / resistance / ecosystem stability - The ability of an ecosystem to maintain structural and functional attributes in the face of severe impacts by external factors. The resilience of an ecosystem is also referred to as its sustainability.

Responsible Authority - Government department empowered to approve and/or oversee activities.

Restoration - The Macquarie Dictionary (reference) defines restoration and rehabilitation “to bring something back to a former, original or normal condition, or to a state of health, soundness and vigour”. More specifically, ecological restoration is distinguished from rehabilitation as the process of fully repairing the composition, structure, function and dynamics of pre-existing indigenous ecosystems (e.g. Cairns 1995, McDonald 2000).

Revegetation - Return vegetation (indigenous or otherwise) to an area.

Succession - The natural process of ecosystem recovery from disturbance. In most cases, species characteristic of recently disturbed habitats are gradually e[placed by species characteristic of mature plant communities.

Sustainability - Meeting the needs of current and future generations through the integration of environmental protection, social advancement and economic prosperity (Government of Western Australia, 2003).

Sustainability (ecological) - Processes and practices that maintain the biodiversity and productivity of ecosystems.

Trajectory analysis - trends in ecosystem properties and functions that gradually recover towards a reference condition.

Weed - Any species (native, or more frequently exotic to a region) “which has the potential to have detrimental effects on economic, social, or conservation values” (ARMCANZ, ANZECC and Forestry Ministers 1997). Weeds spread aggressively, especially in disturbed habitats, and cause substantial loss of habitat for other species. See Groves et al. 2005 and lists of recognised weeds.

Wetland - An area of seasonally, intermittently or permanently waterlogged or inundated land, whether natural or otherwise, and includes a lake, swamp, marsh, spring, dampland, tidal flat or estuary (Environmental Protection Act 1986, 2003).

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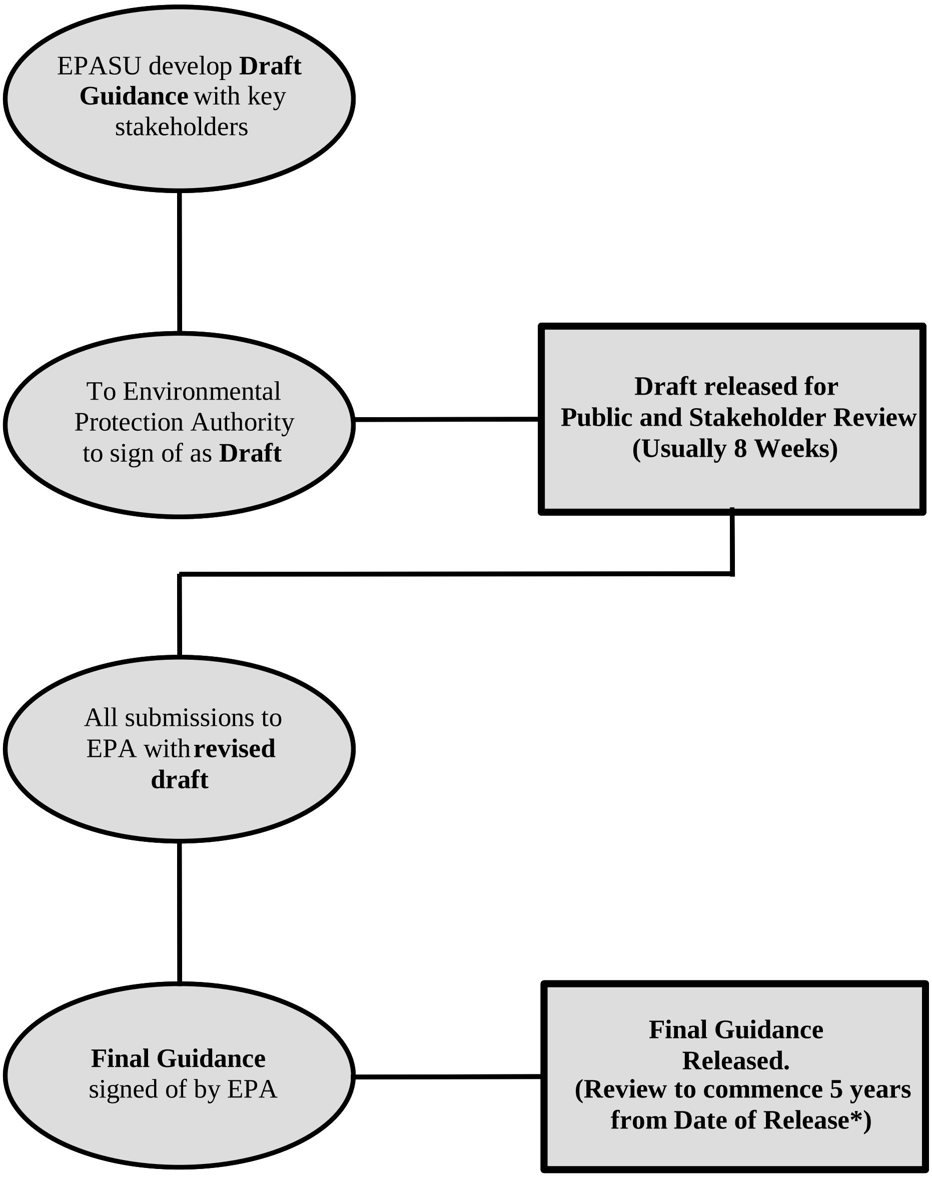
APPENDIX 1

GENERIC FLOW DIAGRAM FOR THE GUIDANCE STATEMENT PROCESS



*Guidance may be reviewed earlier if circumstances require it.

APPENDIX 2

Table 1. Factors that constrain rehabilitation successes in WA and some resulting problems.

Constraining Factors	Associated Problems
A. Abiotic factors	
1. Altered Landforms and soils 2. Saline groundwater 3. Groundwater dependent vegetation 4. Soils or rocks that become acidic or toxic 5. Unreliable rainfall and climate especially in arid regions	• Unstable landforms • Major factors limiting plant growth • Inadequate root growth • Altered landforms, soils, salinity, or hydrology impact on vegetation • Insufficient flexibility in plans • Insufficient time for vegetation establishment
B. Biodiversity factors	
6. A high degree of plant species biodiversity and endemism in many bioregions 7. High variability in plant spatial diversity (ecosystem diversity) 8. Inadequate knowledge of plant and animal 9. biodiversity, reproduction 10. Complex interactions and functions of biodiversity components in ecosystems 11. Threatened species and communities of species 12. Genetic diversity within taxa 13. Problems with seed germination or acquisition	• Inadequate definitions and objectives of rehabilitation • Pre-existing vegetation types not re-established • Completion criteria not based on plant survey data • Simplified plant species lists used for seeding/planting • Use of non-local provenance plants • Loss of ecosystem functions such as pollinators, dispersal agents, etc.
C. Impacts on biodiversity	
14. Environmental weeds that rapidly invade natural ecosystems after disturbance 15. Grazing by alien and indigenous animals 16. Diseases and pests, especially *Phytophthora* dieback 17. Changes to fire regimes 18. Plants and animals with highly specific habitats 19. Plants intolerant to changes in soil fertility	• Insufficient cover and/or diversity of native plants • Lack of resilience (sustainability) of vegetation • Inadequate soil stability • Important species missing • Locally significant species missing • Long-term impacts on biodiversity
D. Planning, reporting and auditing	
20. Incomplete understanding of ecosystems and complex interactions between organisms 21. Practitioners require a high degree of knowledge, experience and skills 22. Scientific knowledge is required to solve problems 23. Transportation costs and geographic isolation 24. Commitment and awareness of responsibilities 25. Communication between stakeholders 26. Land use and land tenure	• Insufficient time frames for monitoring • Inadequate definitions and objectives • Inadequate monitoring data • Completion criteria which are not auditable • Insufficient understanding of responsibilities, or lack of commitment • Long-term responsibilities for sites unclear • Insufficient communication • Long-term land use unclear or incompatible • Rehabilitation not successful

Table 2. Examples of existing guidelines concerning rehabilitation of vegetation for WA.

Title	**Source** (see reference list for Web address)
Code for Environmental Management	Australian Minerals Industry (2000)
Mine closure guidelines for Mineral Operations in Western Australia	The Chamber of Minerals and Energy of Western Australia Inc. (2004)
Strategic Framework for Mine Closure	Australian and New Zealand Minerals and Energy Council (ANZMEC) (2000)
Mine Rehabilitation Handbook, 2nd Edition	Minerals Council of Australia (1998)
Minerals Industry Code of Environmental Management	Minerals Council of Australia (2000)
Guidelines for Mining in Arid Environments	Department of Industry and Resources of WA (DoIR) (1996)
Guidelines to help you get Environmental Approval for Mining Projects in Western Australia	Department of Minerals and Energy Western Australia, East Perth. March (1998)
Information Series No. 9: Prospecting, Exploring and Mining on Pastoral leases	Department of Industry and Resources of WA (DoIR) (2003)
Information Series No. 11: Guidelines for Mineral Exploration and Mining within Conservation Reserves and other Environmentally Sensitive Lands	Department of Industry and Resources of WA (DoIR) (1998)
Information Series No. 16: Managing Declare rare Flora in Mineral Exploration and Mining	Department of Industry and Resources of WA (DoIR)
Policy Statement No. 10 Rehabilitation of Disturbed Land	Department of Conservation and Land Management (1986)
Rehabilitation and Revegetation: Best Practice Environmental Management in Mining	Environment Australia (1995)
Landform Design for Rehabilitation: Best Practice Environmental Management in Mining	Environment Australia (1998)
The SER International Primer on Ecological Restoration	The Society for Ecological Restoration (2004)
Guidelines for Managing Ecological Restoration Projects	The Society for Ecological Restoration (2000)
River Restoration - Revegetation Case Studies from South-west Western Australia	Water & Rivers Commission (DoE) (1999)
Management of *Phytophthora* Dieback in Extractive Industries	Dieback Working Group (2005)

Table 3. Examples of objectives used for rehabilitation in WA during project planning stages and their effectiveness.

Criteria	Advantages	Disadvantages
Best possible or practicable, using best available techniques, to a high standard, or world's best practice	• Rehabilitation will always succeed	• Not auditable. Does not ensure adequate outcomes
Follow nominated guidelines, or reach agreed standards, to satisfaction of regulators, or develop approved recovery plan	• Interactive approach involving regulators • Recovery plans can apply to multiple sites with similar habitats	• Environmental impacts difficult to anticipate during project approval • Complex approval processes required
Maintain landform stability Majority of plant species returned Restore vegetation cover Manage weeds Use local species	• These are essential objectives • Plant diversity and cover are relatively easy to assess	• Other objectives are required • These objectives require more precise definitions to be auditable
Use adaptive management approaches based on scientific principles	• Acknowledges the need for continuing improvement based on evaluation of outcomes and the acquisition of knowledge and skills • Acknowledges that initial management plans may not be adequate • Acknowledges flexibility is required to attain goals	• Auditable targets are also required • Initial attempts may not succeed

Table 4. Standard completion criteria with their estimated frequency of current use and recommended use in large or small rehabilitation projects in WA.

Criteria[1]	Use[2]	Small[3,4]	Large[3,4]
A. Abiotic habitat (ecosystem structure)			
1A. Health and safety issues are adequately addressed	++++	Y	Y
1B. Landforms are stable	++++	Y	Y
1C. Suitable for agreed land use and economic values retained	++++	Y	Y
1D. Sustainability without additional inputs	+++	Y	Y
2A. Visual amenity meets agreed standards	++	Y	Y
2B. Heritage values maintained (cultural, historical, archaeological)	++	Y	Y
2C. Educational and scientific significance is retained	+		WR
3. No significant problems with pollutants	++++	Y	Y
4. Avoid off-site impacts on lands and waterways	++	Y	Y
5. Hydrology (water quality and availability) is appropriate	+++	WR	Y
6. Reconstruct soil structure and profiles	++	WR	Y
B. Biota (living ecosystem components)			
7. Vegetation is resilient and self-sustaining	+++	Y	Y
8A. Plant species diversity reaches targets	++++	Y	Y
8B. Reintroduce species of conservation significance	++	WR	Y
9. Plant abundance or cover reaches targets	++	Y	Y
10. Adequate control of weeds	+++	Y	Y
11A. Pests and diseases are properly managed	++	WR	Y
11B. Control grazing, especially by feral animals	+	WR	Y
12. Maintain plant genetic diversity (local provenance)	++	Y	Y
13. Restore dominant plant species	++	Y	Y
14. Restore diversity of ecological communities	+	WR	Y
15. Animal diversity reaches set targets	+		WR
16. Animal habitats are present or can be expected to return	+	WR	Y

Notes: 1. The numbering of completion criteria follows Figure 2 and Section 3.4.

2. The estimated frequency of use in WA at the time of writing (+ = rare, ++ = uncommon, +++ = common, ++++ = most projects).

3. Large and small refer to project size as defined in the text (Section 3.4).

4. Completion criteria use: Y = required, WR = when relevant.

Table 5. Major stakeholders and sources of information.

Organisation	Address
GOVERNMENT	
Department of Environment and Conservation (DEC), Formerly DoE and CALM	www.environment.wa.gov.au, www.calm.wa.gov.au
Environmental Protection Authority (EPA)	www.epa.wa.gov.au
Department of Industry and Resources WA (DoIR)	www.doir.wa.gov.au
Swan River Trust	www.environment.wa.gov.au
Commonwealth Department of Energy, Tourism and Resources	www.dist.gov.au
Commonwealth Department of the Environment and Heritage (DEH)	www.deh.gov.au
INDUSTRY BODIES	
Revegetation Industry Association of WA (RIAWA)	www.riawa.com.au
Minerals Council of Australia (MCA)	www.minerals.org.au
The Chamber of Minerals and Energy of Western Australia Inc	www.cmewa.com
Association of Mining and Exploration Companies (Inc) (AMEC)	amec.vivid.global.net.au
Australian Centre for Minerals Extension and Research (ACMER)	www.acmer.com.au
The Minerals and Energy Research Institute of Western Australia (MERIWA)	www.doir.wa.gov.au/meriwa
Australian and New Zealand Minerals and Energy Council (ANZMEC)	www.dist.gov.au www.minerals.org.au
Australian Mineral Industries Research Association (AMIRA)	www.amira.com.au
Extractive Industries Committee, Chamber of Commerce and Industry of Western Australia	www.cciwa.com
Goldfields Environmental Management Group (GEMG)	www.gemg.org.au
Environmental Consultants Association of WA (ECA)	www.eca.org.au
CONSERVATION	
Conservation Council of Western Australia (Inc.)	www.conservationwa.asn.au
Wildflower Society of Western Australia (Inc.)	members.ozemail.com/~wildflowers
The Ecological Society of Australia (ESA)	www.ecolsoc.org.au
The Society for Ecological Restoration (SER)	www.ser.org
Australian Network for Plant Conservation (ANPC)	www.anbg.gov.au/anpc
The Australian Association of Bush Regenerators (AABR)	www.aabr.com.au
APACE	web.argo.net.au/apace
Greening Western Australia	www.greeningaustralia.org.au
Dieback Working Group	www.dwg.org.au
Weeds Australia	http://www.weeds.org.au/
Environmental Weeds Action Network (Inc.) (EWAN)	members.iinet.net.au/~ewan
State Weed Plan Steering Group	
RESEARCH	
Botanic Gardens and Parks Authority	www.bgpa.wa.gov.au
Agriculture Western Australia	www.agric.wa.gov.au
CSIRO	www.csiro.au
Curtin University	www.curtin.edu.au
The University of Western Australia	www.uwa.edu.au
Edith Cowan University	www.ecu.edu.au
Murdoch University	www.murdoch.edu.au

Table 6. Proposed scale to help assess environmental significance.

CRITERIA	SCORE					
1. Natural Value Scale	**5**	**4**	**3**	**2**	**1**	**Score**
1. Area to be disturbed	conservation reserves	excellent quality intact native vegetation	good quality native vegetation	isolated or weedy & degraded remnants	fully cleared land	
2. Adjacent land						
3. Regional context	unique / unreserved	rare / poorly reserved	common / some in reserves	fairly common / well reserved	not relevant	
4. Species diversity of flora	very high	high	medium	low	very Low	
5. Ecosystem diversity of vegetation						
6. Animal habitat diversity & value						
7. Linkages to native vegetation	continuous	some cleared land	good linkages	poor linkages	fully isolated	
8. Significant species / communities	major impacts on values of national & state significance	substantial impacts on significant areas	some impacts cannot be addressed through management	indirect or limited impacts can be addressed through management	not relevant	
9. Restricted landforms / plant communities						
10. Heritage and other values						
Total Natural Value Score (for comparative use only):						

Table 7. Proposed scale to help assess the significance of limitations to rehabilitation.

CRITERIA	SCORE					
Difficulty Scale	**1**	**2**	**3**	**4**	**5**	**Score**
1. Land clearing scale	a few m^2	a few ha	many ha	a few km^2	many km^2	
2. Drought / rainfall unpredictability	very low risk, or not relevant	low risk, but of some relevance	moderate risk, some problems are expected	substantial problems are expected	major problems are expected	
3. Temperature harshness & unpredictability						
4. Diseases and pests (especially dieback)						
5. Environmental weeds						
6. Seed germination / availability						
7. Soil / landform stability						
8. Soil structure & chemistry	unaltered	minor / temporary impacts	some long-term impacts on vegetation expected	substantial impacts on vegetation expected	unlikely to support original vegetation	
9. Hydrology						
10. Landform structure						
11. Connectivity for seed dispersal, etc.	continuous	some cleared land	good linkages	poor linkages	fully isolated	
12. Ecosystem resilience (capacity to withstand fire, weeds, etc.)	highly resilient	resilient	fairly resilient	susceptible	highly susceptible	
Total Difficulty Score (for comparative use only):						

Notes about Tables 6 & 7:
These tables can assist rehabilitation planning by highlighting major issues, which are represented by higher numbers in these scales and total scores. These scores are not for EIA purposes.

APPENDIX 3

Case studies illustrating major Issues impacting on the success rehabilitation of native vegetation in WA

	**1. Constraints to rehabilitation** Substantially altered soils and landforms often constrain the success of rehabilitation. The importance of these factors needs to be adequately considered during the planning stages or rehabilitation projects. In many cases changes to soils, landforms and hydrology make the full restoration of vegetation impractical.
	**2. Soil profiles** The distribution of soil components with increasing depth is usually altered substantially by operations. Soil profile reconstruction requires an understanding of the distribution of roots and water in the undisturbed soil profile.
	**3. Soil quality** A quarry where an altered soil profile, with proximity to saline groundwater have prevented re-establishment of the original vegetation communities.

 Lisa Chandler	**4. Landform stability (substrates)** Major problems with erosion in a waste rock dump which was not correctly constructed. It is an essential requirement that rehabilitated areas are stable and will not require additional management costs.
	**5. Landform stability (vegetation cover)** Maximising early returns of plant diversity prevents soil erosion. Plant cover and diversity targets are required to ensure rehabilitated land is sustainable.
	**6. Weeds** Direct seeding is usually not a viable option on weedy sites and planting of seedlings is also likely to fail. In this case, low planting densities failed to establish visual amenity or help reduce weed cover.
	**7. Realistic expectations** It is unrealistic to expect native vegetation to become established in habitats dominated by weeds. In this case, effective weed management should have occurred before attempts to establish native species. This situation is especially common in urban areas.

8. Local provenance

Plant re-establishment of seed or seedlings originating from seed collected locally ensures plants are adapted to local environmental and soil conditions.

Planting of non-local species or plans grown from seed collected elsewhere was common in the past.

Non-local provenance (*Banksia menziesii* from northern sandplain planted in Perth). This shrub-like growth form seems to be more susceptible to attack by insects and fungi when grown in Perth.

9. Topsoil use

The easiest way to retain genetic diversity is to maximise returns of local native species from direct returned topsoil.

10. Pests and diseases

It is necessary to control the spread of pests and diseases present in rehabilitated areas. This example shows localised spread of dieback disease (*Phytophthora* sp.) after accidental introduction.

	**11. Fire, grazing and other and disturbances** The resilience of rehabilitated vegetation to fire and other disturbance events is likely to vary from that of undisturbed vegetation.
	**12. Animal habitat diversity** The presence, distribution and abundance of key plant species determine the habitat quality of rehabilitated areas for animal species. These are Carnaby's Cockatoos.
	**13. Plant recruitment from seeds** This *Banksia attenuata* seedling demonstrates natural recruitment from seed. Plants vary considerably in their capacity to recruit from seed or underground structures (rhizomes, bulbs, corms, lignotubers, etc.). Plants that normally recruit from seed are more likely to be present in Rehabilitated ecosystems.
	**14. Communication and consultation** Inadequate communication and consultation between stakeholders can occur in cases where different proponents and responsible agencies are involved. Lack of reporting and auditing of outcomes can also be a problem when responsible authorities have insufficient resources.

	**15. End uses** An example of wetland creation in sand mine dredge pits where new habitats for plants and animals. In this case conversion of pasture to wetland has resulted in a net environmental benefit.